50-255 PALISADES CPC

INSERVICE TESTING OF SELECTED SAFETY-RELATED PUMPS
RELIEF REQUEST FOR CONTAINMENT SPRAY AND LOW
PRESSURE SAFETY INJECTION PUMPS

REC'D W/LTR DTD 9/18/95...9509210278

ATTACHMENT 1

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

**INSERVICE TESTING OF SELECTED SAFETY-RELATED PUMPS
RELIEF REQUEST FOR CONTAINMENT SPRAY
AND
LOW PRESSURE SAFETY INJECTION PUMPS**

RELIEF REQUEST

SYSTEM: Containment Spray
Low Pressure Safety Injection

PUMP: Containment Spray Pumps (P-55A, P-54B, P-54C)
Low Pressure Safety Injection Pumps (P-67A, P-67B)

CLASS: Class 2

FUNCTION:

The safety-related Code pumps listed above perform a specific function in shutting down the reactor or mitigating the consequences of an accident as defined in the Palisades Plant FSAR.

TEST REQUIREMENT:

Pump vibration measurement acceptance criteria shall be in accordance with OMa-1988 Part 6, Table 3a.

RELIEF REQUESTED:

CPCo requests relief from the alert limits specified in OM-6 and proposes the following vibration acceptance criteria limits for the Containment Spray and Low Pressure Safety Injection Pumps.

The required action limits will be a as specified in OM-6, Table 3a for all vibration locations and channels; the limit is >.490 IPS-RMS (corrected for RMS).

Alert limits will be determined as follows based on pump vibration test data collected between 1991 and mid-1995. For channels with reference values adequately below the OM-6 specified alert limit, .228 IPS-RMS (corrected for RMS) will be utilized per Table 3a. If the channel was consistently close to or above .228 IPS-RMS, the mean value plus four standard deviations will be used for the alert limit. The resulting values of the new Alert limits are listed in Attachment 2.

BASIS FOR RELIEF:

The Containment Spray Pumps and the Low Pressure Safety Injection Pumps are tested quarterly using flow circuits of limited capacity; no alternative flowpaths exist for on-line testing. As a result, the Containment Spray Pumps are tested at approximately 10% of rated capacity and the Low Pressure Safety Injection Pumps are tested at approximately 6% of rated capacity. For centrifugal pumps of this size, vibrations are considerably higher at lower

flowrates than at normal operating flowrates due to energy dissipation, internal recirculation, and subsequent cavitation effects. These reduced pump flowrates result in higher, yet consistent, vibration levels measured during surveillance testing. Correspondence from the vendor (Ingersoll-Rand), dated June 22, 1987 (Attachment 3), states that a flowrate of 1140 gpm (≈35% of rated capacity) should be used for Low Pressure Safety Injection Pump testing. The letter goes on to state, however, that as the pump operated within acceptable vibration levels at the originally recommended minimum flow of 163 gpm, mechanical problems would not be expected. Due to their similar design and capacity, flowrate of the same magnitude is assumed to be required for acceptable Containment Spray Pump performance.

Pump recirculation is described in detail in McGraw-Hill's "Pump Handbook," 2_{nd} edition. Operation of centrifugal pumps at reduced flowrates and associated problems are also addressed in Igor Karassik's "Centrifugal Pump Clinic," 2_{nd} edition.

Results from two Containment Spray Pump special tests at 38% of rated capacity (2/11/91 and 4/7/92) and a Low pressure Safety Injection Pump performance test (1/19/91-1/20/91) showed all vibration levels to be below the maximum alert limit specified in OM-6. The pumps were determined to be mechanically sound and operating acceptable following the performance of these tests. These higher flow tests confirm that reduced flowrate testing causes internal recirculation which in turn leads to higher vibration readings. Subsequent tests for all five pumps at the reduced flowrates currently being used show vibrations in IPS-RMS that fall in the alert range as defined by OM-6.

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

Based on this discussion, the vibration levels at reduced flowrates are acceptable, expected, and do not prohibit useful predictive testing. However, application of the OM-6 alert limits for vibrations would inappropriately require these pumps to be regularly placed on alert and tested at double the normal test frequency, or would require significant system redesign and modification. This additional testing burden would not be warranted and would only contribute to pump degradation due to low flowrate testing. Furthermore, no benefit can be expected from this additional testing or from any system modification. Therefore, in accordance with 10CFR50.55a(a)(3)(ii), implementation of the >.325 IPS-Peak or >.228 IPS-RMS (corrected for RMS) alert range limit for these specific pumps represents an undue hardship without a compensating increase in quality or safety. Additionally, it is impractical to meet the vibration alert requirements because the pumps must be tested at low flowrates through mini-recirc lines due to system design.

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

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

ATTACHMENT 2

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

INSERVICE TESTING OF SELECTED SAFETY-RELATED PUMPS
RELIEF REQUEST FOR CONTAINMENT SPRAY
AND
LOW PRESSURE SAFETY INJECTION PUMPS

PROPOSED VIBRATION REFERENCE VALUES AND ACCEPTANCE CRITERIA

VIBRATION REFERENCES AND RANGES (PROPOSED)

P-67A PUMP VIBRATIONS

POINT ID	CHANNEL ID	REFERENCE VIBRATIONS (IPS-RMS)	ACCEPTABLE RANGE (IPS-RMS)	ALERT RANGE (IPS-RMS)	REQUIRED ACTION RANGE (IPS-RMS)
0118	1 (V)	.180	VIBES ≤ .271	.271 < VIBES ≤ .490	VIBES > .490
	2 (A)	.100	VIBES ≤ .228	.228 < VIBES ≤ .490	VIBES > .490
	3 (H)	.210	VIBES ≤ .400	.400 < VIBES ≤ .490	VIBES > .490

P-67B PUMP VIBRATIONS

POINT ID	CHANNEL ID	REFERENCE VIBRATIONS (IPS-RMS)	ACCEPTABLE RANGE (IPS-RMS)	ALERT RANGE (IPS-RMS)	REQUIRED ACTION RANGE (IPS-RMS)
0936	1 (V)	.170	VIBES ≤ .242	.242 < VIBES ≤ .490	VIBES > .490
	2 (A)	.110	VIBES ≤ .228	.228 < VIBES ≤ .490	VIBES > .490
	3 (H)	.190	VIBES ≤ .359	.359 < VIBES ≤ .490	VIBES > .490

P-54A PUMP VIBRATIONS

POINT ID	CHANNEL ID	REFERENCE VIBRATIONS (IPS-RMS)	ACCEPTABLE RANGE (IPS-RMS)	ALERT RANGE (IPS-RMS)	REQUIRED ACTION RANGE (IPS-RMS)
0922	1 (V)	.230	VIBES ≤ .337	.337 < VIBES ≤ .490	VIBES > .490
	2 (A)	.130	VIBES ≤ .228	.228 < VIBES ≤ .490	VIBES > .490
	3 (H)	.250	VIBES ≤ .325	.325 < VIBES ≤ .490	VIBES > .490

P-54B PUMP VIBRATIONS

POINT ID	CHANNEL ID	REFERENCE VIBRATIONS (IPS-RMS)	ACCEPTABLE RANGE (IPS-RMS)	ALERT RANGE (IPS-RMS)	REQUIRED ACTION RANGE (IPS-RMS)
0933	1 (V)	.300	VIBES ≤ .331	.331 < VIBES ≤ .490	VIBES > .490
	2 (A)	.200	VIBES ≤ .304	.304 < VIBES ≤ .490	VIBES > .490
	3 (H)	.340	VIBES ≤ .416	.416 < VIBES ≤ .490	VIBES > .490

P-54C PUMP VIBRATIONS

POINT ID	CHANNEL ID	REFERENCE VIBRATIONS (IPS-RMS)	ACCEPTABLE RANGE (IPS-RMS)	ALERT RANGE (IPS-RMS)	REQUIRED ACTION RANGE (IPS-RMS)
0930	1 (V)	.190	VIBES ≤ .256	.256 < VIBES ≤ .490	VIBES > .490
	2 (A)	.160	VIBES ≤ .228	.228 < VIBES ≤ .490	VIBES > .490
	3 (H)	.300	VIBES ≤ .352	.352 < VIBES ≤ .490	VIBES > .490

ATTACHMENT 3

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

INGERSOLL-RAND LETTER OF JUNE 22, 1987

INGERSOLL-RAND
PUMPS

Engineered Pump Division
Ingersoll-Rand Company
942 Memorial Parkway
Phillipsburg, NJ 08865

22 JE 87

Consumers Power
Palisades Nuclear Power
27780 Blue Star Memorial Highway
Covert, Mi. 49043

Attention: Mr. Stanley G. Kupka

Reference: Ingersoll-Rand's 8X21AL Pump (LPSI)
S/N A67-393/4

Dear Mr. Kupka:

In response to your 4/20/87 letter to Michael J. Banchero, we offer the following:

(1) The originally recommended minimum flow of 163 GPM was based entirely on thermal criteria. This criteria established a flow value that would permit operation at low flows without heating the pumped liquid to a flash point. This criteria obviously results in mechanical problems (i.e. vibration related damage). We cannot quantify operational hours versus mechanical damage.

(2) To be assured of no mechanical problems, we would recommend increasing the minimum flow to 1140 GPM for any testing and any extended periods of operation. However, if the pump operates within acceptable vibration levels while at 163 GPM, we would not expect any mechanical problems.

(3) Operation at shut-off condition (zero flow) should be avoided for any length of time.

Please advise if we can be of further assistance.

Sincerely,

Richard J. Lesniak
Field Service Engineer
Customer Relations Department
Engineered Pump Division

cc: Michael J.Banchero - I-R Detroit Sales

ATTACHMENT 4

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

LOW PRESSURE SAFETY INJECTION PUMPS

PUMP TEST DATA

ID: P-67A / QO-20
Location: Aux Bldg, East Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 9:00 AM

Parameter Statistics

start: '91 Nov 22
end : '95 Jun 30

Par	Name	Units	No. of Meas. Total Average	Maximum Minimum Range	Stand. Dev. Variance Median
5	PUMP CH#1	IPS-RMS	14 2.680 0.191	0.223 0.151 0.072	0.020 4.148e-4 0.193
6	PUMP CH#2	IPS-RMS	14 1.664 0.119	0.179 0.104 0.075	0.020 3.866e-4 0.114
7	PUMP CH#3	IPS-RMS	14 3.525 0.252	0.326 0.186 0.140	0.037 0.001 0.246

ID: P-67B / QO-20
Location: Aux Bldg, West Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 9:02 AM

Parameter Statistics

start: '91 Jun 05
end : '95 Jun 30

Par	Name	Units	No. of Meas. Total Average	Maximum Minimum Range	Stand. Dev. Variance Median
5	PUMP CH#1	IPS-RMS	15 2.673 0.178	0.214 0.154 0.060	0.016 2.478e-4 0.179
6	PUMP CH#2	IPS-RMS	15 1.667 0.111	0.122 0.104 0.018	0.006 4.020e-5 0.108
7	PUMP CH#3	IPS-RMS	15 3.052 0.203	0.278 0.110 0.168	0.039 0.002 0.201

H -

ID: P-67A / QO-20 **Date:** '95 Sep 11, 09:13

Location: Aux Bldg, East Engineering Safeguards, 570'

Description: INSERVICE TEST PROCEDURE - LOW PRESSURE SAFETY INJECTION PUMPS

Measurement Values

Parameter No.		5	6	7	
Name		PUMP CH#1 V	PUMP CH#2 A	PUMP CH#3 H	
Meas. No.	Units / Time	IPS-RMS	IPS-RMS	IPS-RMS	
1	Nov 22, 1991	0.151	0.107	0.239	
2	Apr 11, 1992	0.195	0.109	0.231	
3	Jul 09, 1992	0.168	0.104	0.213	
4	Oct 22, 1992	0.212	0.105	0.257	
5	Jan 21, 1993	0.175	0.114	0.294	
6	May 14, 1993	0.209	0.104	0.219	
7	Oct 31, 1993	0.201	0.109	0.236	
~~8~~	~~Oct 31, 1993~~	~~0.184~~	~~0.237~~	~~0.299~~	BAD DATA POINTS - MAGNETIC MOUNT USED
9	Dec 22, 1993	0.210	0.133	0.326	
10	Feb 11, 1994	0.183	0.121	0.290	
11	Jun 11, 1994	0.223	0.115	0.260	
12	Sep 19, 1994	0.205	0.131	0.252	
13	Dec 05, 1994	0.169	0.114	0.186	
14	Mar 12, 1995	0.190	0.179	0.286	
15	Jun 30, 1995	0.191	0.120	0.236	

H

I[illegible]-67B / 00-20 **Date :** '95 Sep 11, 09:18

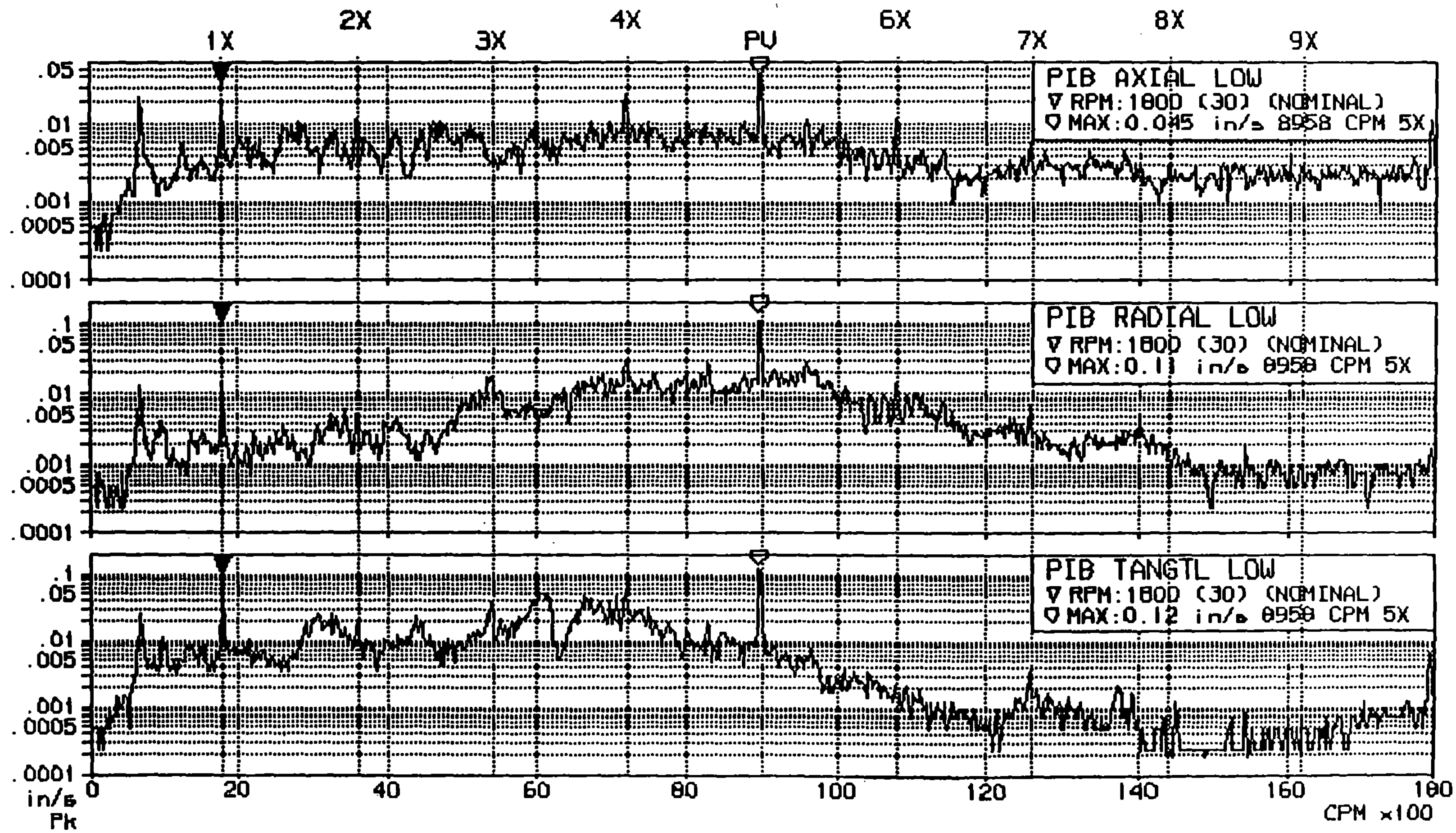
Location : Aux Bldg, West Engineering Safeguards, 570'

Description : INSERVICE TEST PROCEDURE - LOW PRESSURE SAFETY INJECTION PUMPS

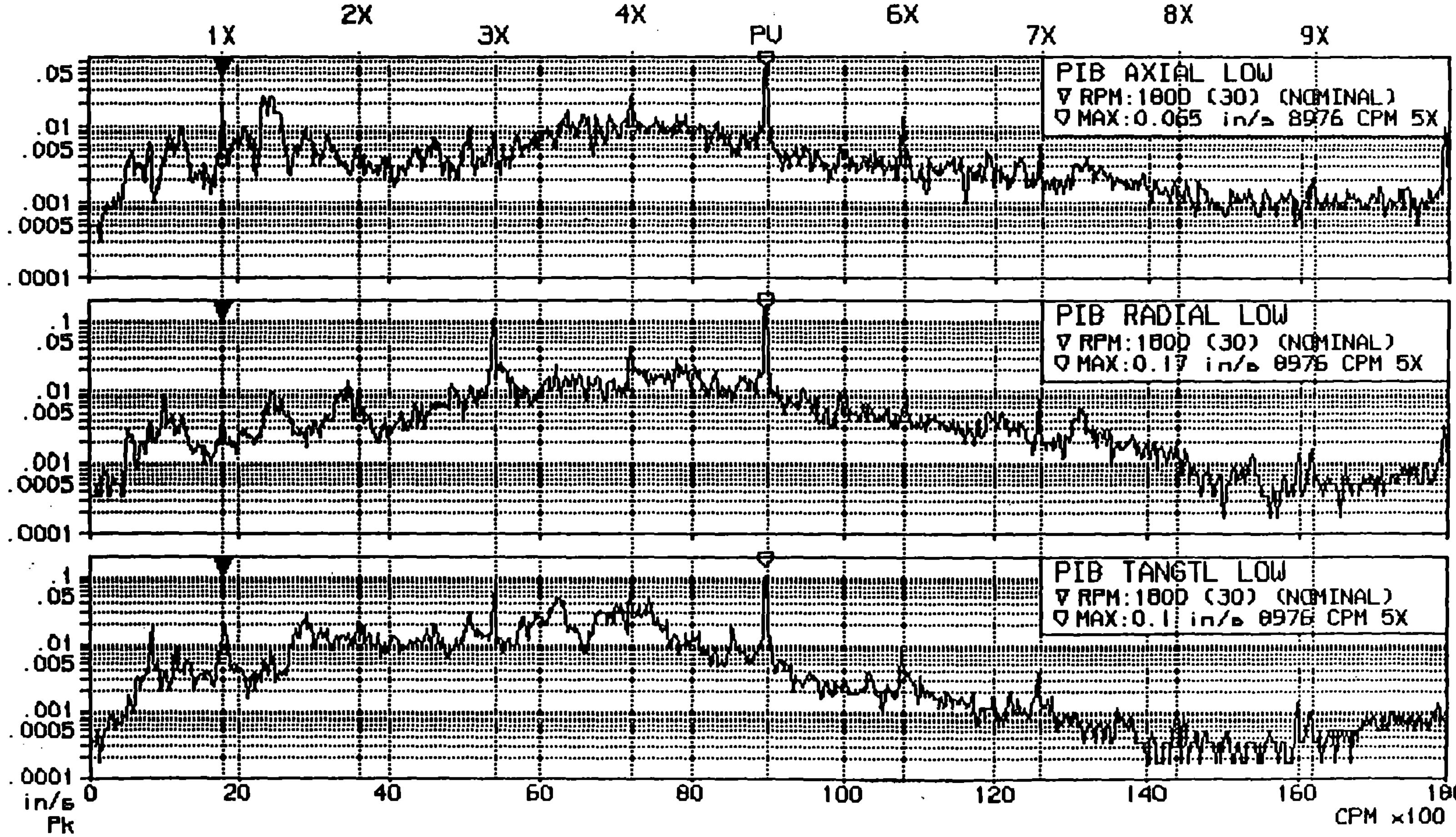
Measurement Values

Parameter No.		5	6	7
Name		PUMP CH#1 V	PUMP CH#2 A	PUMP CH#3 H
Meas. No.	Units / Time	IPS-RMS	IPS-RMS	IPS-RMS
1	Jun 05, 1991	0.169	0.107	0.110
2	Aug 28, 1991	0.160	0.107	0.201
3	Nov 22, 1991	0.169	0.106	0.213
4	Apr 11, 1992	0.179	0.114	0.187
5	Jul 09, 1992	0.166	0.108	0.150
6	Oct 22, 1992	0.185	0.104	0.214
7	Jan 22, 1993	0.171	0.105	0.182
8	Apr 28, 1993	0.168	0.121	0.236
9	Oct 31, 1993	0.196	0.115	0.278
10	Feb 11, 1994	0.180	0.104	0.225
11	Jun 11, 1994	0.200	0.111	0.199
12	Sep 19, 1994	0.180	0.107	0.236
13	Dec 04, 1994	0.154	0.119	0.199
14	Mar 13, 1995	0.181	0.122	0.192
15	Jun 30, 1995	0.214	0.118	0.230

PLANT: CONSUMERS POWER - PAL   AREA: PLANT NOT INCLUDING COOLING TOWERS   30Aug95
MACHINE: P-67A LOW PRESSURE SAFETY INJECTION PUMP [OK]   MID: 49
LOCATION: PUMP INBOARD [3AL]   DATE: 30 Jun 1995/02:29:57 RPM: 1800
LEGEND: 30 Jun 1995
FREQ: 1800 CPM   ORDER: 1 X   LEVEL: .0196 in/s



PLANT: CONSUMERS POWER - PAL   AREA: PLANT NOT INCLUDING COOLING TOWERS   30Aug95
MACHINE: P-67B LOW PRESSURE SAFETY INJECTION PUMP [OK]   MID: 50
LOCATION: PUMP INBOARD [3AL]   DATE: 30 Jun 1995/04:09:07 RPM: 1800
LEGEND: 30 Jun 1995
FREQ: 1800 CPM   ORDER: 1 X   LEVEL: .0194 in/s



ATTACHMENT 5

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

LOW PRESSURE SAFETY INJECTION PUMPS

PERFORMANCE TEST REPORT FROM SPECIAL TEST T-261
FEBRUARY 1991

To:	Special Test T-261 File	CONSUMERS POWER COMPANY
From:	JPMiksa *JP Miksa*	
Date:	February 5, 1991	
Subject:	Palisades Low Pressure Safety Injection Pump Performance Test Report	Internal Correspondence
CC	MDKing, Palisades KEOsborne, Palisades RVVan Wagner, Palisades RJ Gerling, Palisades RJFrigo, Palisades	WLFord, Palisades

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TITLE

T - 261 "Low Pressure Safety Injection Pumps P-67A and P-67B Performance Test"

PURPOSE

To access the performance of the Low Pressure Safety Injection Pumps after conducting major maintence on P-67A and replacement of P-67B's motor.

PRECAUTIONS

This test was run with the reactor head removed and the core off loaded. Under these conditions varying shutdown cooling flow was not a concern for plant safety. Therefore this test did not affect reactor safety.

TEST REPORT SUMMARY

Results of this test show that LPSI pumps exceed the FSAR design requirements. Increases in brake horsepower was seen with corresponding decreases in pump efficiency due to P-67A's impeller replacement and P-67B's motor replacement. Both pump and motor peak vibration levels were well below plant acceptance values. The data gathered by this test will form the baseline for further pump testing.

TEST RESULTS

BACKGROUND

T-261 was run on January 19, 1991 "C" shift (P-67A) and January 20, 1991 "A" shift (P-67B). The test varies Low Pressure Safety Injection (LPSI) flow by manipulation of the motor operated LPSI "injection" valves. Five differing flow values are used between 4500 gpm and 400 gpm. The following parameters were recorded during the test:

Parameter	Description
Flow	Four LPSI cold leg flow meters totaled
Suction Pressure	Discharge gauge of pump not being tested
Discharge Pressure	Discharge gauge of pump being tested

Motor Current	One phase of pump motor breaker's current transformer
Pump and Motor Vibration	Axial, Vertical, Horizontal displacement velocities of pump and motor

All of these parameters were recorded at each of the five flow values except for motor vibrations which were only taken at the 3000 gpm flow range and at the 400 gpm flow range.

The results of this running of T-261 were expected to deviate from past values due to the type of maintence conducted on the pumps during this outage. Outage maintence which would effect results are:

P-67A 1) Installation of a larger impeller - 19 3/4" vs 19 3/8" (ref. SC-86-244)
2) Shaft replacement
3) Thrust Bearing replacement

P-67B 1) Pump Motor replaced

The installation of a larger impeller, with replacement of the shaft, and thrust bearings was due to galling between the stuffing box bushing and the original impeller (see D-PAL-90-320 for more details). The reason for going to a larger impeller was to increase the margin between FSAR design flow and actual pump flow. It should be noted that at present P-67A and P-67B have the same size impellers installed. P-67B's motor was replaced as an electrical preventive maintence measure. The replacement motor was originally on P-67A before it was replaced and refurbished.

This was the second time T-261 has been run. It was originally ran on 11/07/88. Test values from 11/07/88 have been included for comparison. Reference values for P-67A are from the 08/18/86 running of T-209 (ref. Pal. Cart. 7657, Frm. 0773) and for P-67B from the 09/10/86 running of T-255 (ref. Pal. Cart. 7657, Frm. 0792).

DISCUSSION

In order to better evaluate P-67A and P-67B's performance raw and calculated data from EA-T-261-01(ref. att.1) was plotted against reference values and previously run tests. Below is a brief discussion on each graph(ref. att. 5 & 6):

1) Differential Pressure VS. Flow
These graphs are intended to show overall pump performance and how it meets Palisade's FSAR requirements.

a) P-67A
This graph shows that by increasing the impeller diameter we have increased the FSAR design margin as follows:

I) At 3000 gpm FSAR design flow differential pressure (DP) is 350 ft our tested DP is now 167 psid or 385 ft. This gives a margin of 35 ft as compared to the margin of 7 ft (from the 11/07/88 test) or an 80% increase in margin resulting in a new margin of 9% over design.

II) At 4500 gpm FSAR maximum flow differential pressure is 250 ft our tested DP is 123 psid or 284 ft. This gives a margin of 34 ft or 12% over maximum flow DP.

b) P-67B
This graph shows that 01/20/91 results fall within 2% of 11/07/88 values and within 1% of

reference values at the maximum data deviation point of approximately 500 gpm flow. We have reestablished the following FSAR design margins:

i) At 3000 gpm FSAR design flow differential pressure is 350 ft. Our tested DP is 164 psid or 378 ft for a margin of 28 ft or 7%.

ii) At 4500 gpm FSAR maximum flow differential pressure is 250 ft. Our tested DP is 121 psid or 279 ft for a margin of 29 ft or 10%.

c) Comparing P-67A to P-67B we see that with the same size impeller in each pump our design and maximum flow differential pressure margins are within 2% of each other.

2) Differential Pressure vs. Flow with 5% Error Bands

These graphs are intended to show the precision of measured test values to reference values. (ie. repeatability of test results)

a) P-67A

This graph shows that even with an impeller diameter increase pump differential pressures are still within 5% of reference. Therefore while we effectively increased our margin over design we still did not significantly effect pump characteristics.

b) P-67B

This graph shows excellent precision of test results to with-in 1% of reference values. This also indicates little change in the mechanical condition of P-67B since it's reference curve was developed.

3) Vibration vs. Flow

These graphs are intended to show pump vibration response with flow (also ref. att. 2 & 3).

a) P-67A

This graph shows that pump vibration is lowest at design flows of 3000 gpm and highest at low flow shut-off head conditions. All vibration levels are acceptable with the highest being PMEV at 0.17 ips. (Note: 0.30 ips is considered the acceptable limit in the Palisades pump program.)

b) P-67B

This graph also shows that pump vibration is lowest at design flows of 3000 gpm and highest at low flow shut-off head conditions. All vibration levels are acceptable with the highest being PMEV & PMEH at 0.135 ips. (Note: 0.30 ips is considered the acceptable limit in the Palisades pump program.)

c) Motor Vibration

Motor vibration versus flow was not graphed since the peak values did not exceed 0.1 ips. However general trends of increased vibration with increased flow and P-67B's values being nearly double that of P-67A's can be seen from the raw data.

4) Brake Horsepower vs Flow

These graphs are intended to show the power input of the pump's motors needed to deliver the measured flow rates.

a) P-67A

This graph shows an overall increase in horsepower over reference values. However previous reference values and test data were taken with a smaller impeller and therefore higher values would be expected. It should be noted that motor full load amps are 92 and

amp readings at 4335 gpm are 90. Therefore the motor is still capable of delivering enough power to support pump maximum flow requirements.

b) P-67B

This graph also shows an overall increase in Brake Horsepower over reference values. This increase is due to the replacement of P-67B's motor with a refurbished motor. Motor current draw at 4340 gpm was 93 amps which is slightly above the full load amp rating of 92 amps. However, this is not a concern since we are approaching the maximum pump flow design rating of 4500 gpm and are still well with-in the service factor of the motor which is 1.15 of full load amps or 105.8 amps. Note design flow of 3000 gpm which is also shutdown cooling flow produces amp readings of 84 amps which is well below the full load amp rating of the motor.

5) Brake Horsepower vs Flow with 10% Error Band

These graphs are intended to show the magnitude in changes of brake horsepower and the precision of collected data to reference data.

a) P-67A

This graph shows that even with an increase in impeller diameter brake horsepower is still within 10% of reference brake horsepower values.

b) P-67B

This graph shows that brake horsepower has increased greater that 10% above reference values. As previously mentioned this is attributed to replacement of P-67B's motor.

c) The brake horsepower data shows some scatter and therefore a sensitivity test to its dependence on measured amps will be done. From EA-T-261-01 sh 4(ref. att. 1):

P-67A - BHP = 4.34A

P-67B - BHP = 4.48A

Actual test readings of amps are multiplied by 30 therefore the equations become:

P-67A - BHP = 130.2A (read)

P-67B - BHP = 134.4A (read)

Test readings were taken to the 0.1 (tenth of an amp) a deviation of 0.1 amp would result in a deviation of 13 bhp which would be 5% of measured bhp at the lowest flow condition and 3% of measured bhp at the highest flow condition. With a meter accuracy of +/- 0.1 amps differences in measured values from true values could cause up to a 5% error in bhp. Also the test requires current measurement of only one phase, if all three phases were read and an average taken a more accurate bhp figure could be derived. Based on this information a contributing cause to high brake horsepower values could also be attributed to instrument error.

6) Pump Efficiency vs Flow with 5% Error Band

These graphs are intended to show changes in pump efficiency with flow and the precision of collected data to reference data.

a) P-67A

This graph shows P-67A to be most efficient at its design flow of 3000 gpm. It also shows that even with an increase in impeller diameter pump efficiency did not deviate from reference by more than 5%.

b) P-67B

This graph shows P-67B's efficiency to have dropped by more than 5% from reference

values. This is directly attributed to the increase in bhp resulting from the replacement of P-67B's motor. It also shows its greatest efficiency point is at its design flow of 3000 gpm.

Instrument error can effect test results as seen above. What follows is a brief description of the error which could be induced by instrumentation used in this procedure:

1) Pressure Gauges
   Suction and discharge pressure gauges were pre and post-test calibrated. The discharge pressure gauge did not deviate from calibrated values. The suction pressure gauge was out of calibration by as high as 0.1 psi in the test data measured range and 0.4 psi in the range not used by the test. Since test values for psig are plotted to the nearest 1.0 psig a 0.1 psi deviation from calibration will not significantly effect the results of this test.

2) Ammeter
   Discussed in previous section.

3) Flow Meters
   The flow meters used in this test had an accuracy of +/- .05% which would be a maximum deviation of .002 volts. Since readings were taken to the second decimal place only (ie. 2.41 volts) this error will not effect test data.

CONCLUSION

Test results show we have successfully increased the performance of our pumps with the installation of larger impellers. A larger margin between pump operation and FSAR design requirements now Unfortunately a larger impeller (P-67A) and replacement motors (P-67B) decreased our pump efficiency especially at low flow values. This is not a concern since pumps operate at low flow conditions for short test periods only. Results of this testing will form the baseline data for further pump testing to track pump degradation.

Recommendations

Due to the large effects small variations in measured current have on test results it is appropriate to revise T-261 to record current readings on all three phases and then average the results to calculate brake horsepower.

Attachments

1) EA-T-261-01, "Correlation of Test Data from T-261"
2) P-67A vibration data
3) P-67B vibration data
4) Test gauge calibration data sheets
5) P-67A Performance Graphs
6) P-67B Performance Graphs
7) Copy of completed T-261

Consumers Power
POWERING MICHIGAN'S PROGRESS

PALISADES NUCLEAR PLANT
ENGINEERING ANALYSIS WORK SHEET

EA- T-261-01

Title CORRELATION OF TEST DATA FROM T-261 "LOW PRESSURE SAFETY INJECTION PUMPS P-67A AND P-67B PERFORMANCE TEST"

INITIATION AND REVIEW

Rev #	Description	Initiated By	Initiated Date	Initiator Appd By	Review Method Check (✓) Alt Calc	Review Method Check (✓) Det Rvw	Review Method Check (✓) Qual Test	Technically reviewed By	Technically reviewed Date	Reviewer Appd By
0	Original Issue	JPMiksa	02/01 91	[signature]		X		[signature]	2/18/91	[signature]

Ref. / Comment

OBJECTIVE

To correlate raw data from T-261's 1/20/91 running in order to evaluate P-67A & B's performance. Note, test data evaluation will be done in T-261's test report.

ANALYSIS INPUT

The following raw test data transferred from T-261's 1/20/91 running:

P-67A:

Flow (gpm)	Discharge Pressure (psig)	Suction Pressure (psig)	Current (Amps)	Pump Vibration (ips) PMEA	PMEH	PMEV
495	214.05	30.33	54	.12	.064	.17
1400	212.05	29.63	60	.045	.056	.16
2355	205.05	28.63	72	.032	.026	.076
3160	187.05	27.43	81	.030	.020	.048
4335	151.05	24.93	90	.028	.026	.075

Flow (gpm)	Motor Vibration (ips) MPEH	MPEV	MMEA	MMEH	MMEV
495	.044	.021	.010	.046	.022
3160	.052	.018	.012	.052	.042

Ref. / Comment

P-67B

Flow (gpm)	Discharge Pressure (psig)	Suction Pressure (psig)	Current (Amps)	Pump Vibration (ips)		
				PMEA	PMEH	PMEV
520	216.63	32.05	51	.052	.135	.135
1540	210.63	31.05	66	.029	.084	.074
2415	202.63	30.25	75	.022	.05	.064
3100	188.63	29.05	84	.030	.025	.040
4340	151.63	26.75	93	.047	.058	.061

Flow (gpm)	Motor Vibration (ips)				
	MPEH	MPEV	MMEA	MMEH	MMEV
520	.10	.067	.092	.10	.10
3100	.10	.040	.078	.098	.080

Note vibration data is peak values only.

ASSUMPTIONS

1) A 1% borated water solution has approximately the same specific gravity as water.

ANALYSIS

This analysis will calculate pump differential pressure, liquid horsepower, brake horsepower, and pump efficiency.

1) Pump Differential Pressure

Differential Pressure (DP) = Discharge Pressure - Suction Pressure

P-67A Differential Pressure

Flow	495	1400	2355	3160	4335
DP	183.72	182.42	176.42	159.62	126.12

Ref. / Comment

P-67B Differential Pressure

Flow	520	1540	2415	3100	4340
DP	184.58	179.58	172.38	159.58	124.88

2) Liquid Horsepower

Governing equation:

$$lhp = Q\,H\,(sp.\ gr.)\,/\,3960$$

Where

Q - Pump Flow in gallons per minute
H - Pump differential pressure in feet
sp. gr. - Specific gravity of pumped fluid = 1.0 for 1% borated water

Then

$$H\ (feet) = H\ (psig)\,/\,.4335$$

and

$$lhp = Q\,H\,(psig)\ 1.0\,/\,(3960)\,(.4335) = Q\,H\,/\,1717$$

Pump Handbook 2nd ed. I.J.Karassik W.C.Krantzsch W.H. Fraser J.P.Messina

Goulds Pump Manual 5th ed.

P-67A Liquid Horsepower

Flow	495	1400	2355	3160	4335
lhp	53	149	242	293	319

P-67B Liquid Horsepower

Flow	520	1540	2415	3100	4340
lhp	56	161	243	288	316

3) Brake Horsepower

Governing equation:

$$bhp = P_{active}\,\eta_m$$

Where

$$P_{active} = KVA(PF)\,/\,1000$$

and

K = Constant = 1.73 for 3 phase AC motors
V = Bus Voltage = 2400V
A = amps per phase
PF = Power Factor
η_m = Efficiency of motor

Equation & constant from Motor App. Handbook 1969 R.W.Smeaton

Bus Voltage from control room logs 1/19/91 C shift, 1/20/91 A [illegible]

Ref. / Comment

This will yield brake horsepower in terms of kilowatts which we must convert to horsepower. This is done with the following conversion factor:

bhp (hp) = bhp (kw) (1.341) — Goulds Pump Manual 5th ed.

Substituting into our governing equation yields:

$$bph\ (hp) = [KVA\ (PF)\ 1.341 / 1000]\ \eta_m$$

Then substituting in our constant and bus voltage yields the following working equation:

$$bhp\ (hp) = 5.57\ A\ (PF)\eta_m$$

To calculate P-67A's brake horsepower we use an average efficiency of .935 and average power factor of .834 to get the following equation: — Pal. Vend. File M1-GB sh. 1243

bhp (hp) = 4.34 A

P-67A Brake Horsepower

Flow	495	1400	2355	3160	4335
bhp	234	260	313	352	391

To calculate P-67B's brake horsepower we use an average efficiency of .947 and average power factor of .85 to get the following equation: — Pal. Vend. File M1-GB sh. 1243

bhp (hp) = 4.48 A

P-67B Brake Horsepower

Flow	520	1540	2415	3100	4340
bhp	229	296	336	417	377

4) Pump Efficiency

Governing equation:

$$\eta_p = (lhp / bhp)\ 100$$

Goulds Pump Manual 5th ed

P-67A Efficiency

Flow	495	1400	2355	3160	4335
η_p	23.9	61.9	77.6	83.2	81.6

Ref. / Comment

P-67B Efficiency

Flow	520	1540	2415	3100	4340
η_p	24.5	54.4	72.3	76.5	75.8

CONCLUSION

This pump data will be plotted and evaluated against pump reference data in T-261 test report. All values calculated by this engineering analysis meet the objective of allowing for comparison of pump performance.

Form 3698 9-89

PALISADES NUCLEAR PLANT

ENGINEERING ANALYSIS CHECKLIST

Items Affected By This EA	Affected Yes	Affected No	Revision Required	Identify*	Closeout
1. Other EAs	☐	☒			
2. Design Documents Elec E-38 through E-49	☐	☒			
3. Design Documents Mech M259, M664, M665	☐	☒			
4.0 LICENSING DOCUMENTS					
4.1 Final Safety Analysis Report (FSAR)	☐	☒			
4.2 Technical Specifications	☐	☒			
4.3 Standing Order 54	☐	☒			
5.0 PROCEDURES					
5.1 Administrative Procedures	☐	☒			
5.2 Working Procedures	☐	☒			
5.3 Tech Spec Surveillance Procedures	☐	☒			
6.0 OTHER DOCUMENTS					
6.1 Q-List	☐	☒			
6.2 Plant Drawings	☐	☒			
6.3 Equipment Data Base	☐	☒			
6.4 Spare Parts (Stock/MMS)	☐	☒			
6.5 Fire Protection Program Report (FPPR)	☐	☒			
6.6 Design Basis Documents	☐	☒			
6.7 Operating Checklists	☐	☒			
6.8 SPCC/PIPP Oil and Hazardous Material Spill Prevention Plan	☐	☒			
6.9 EEQ Documents	☐	☒			

Do any of the following documents need to be generated as a result of this EA:

	Yes	No	
1. Corrective Action Document?	☐	☒	Reference ________
2. Safety Evaluation?	☐	☒	Reference ________
3. EEQ Evaluation Sheet?	☐	☒	Reference ________
Is PRC Review of this EA Required?	☐	☒	

Completed By J P Mikesa (signature) Date 2/1/91

*Identify Section, No, Drawing, Document, etc.

EA-T-261-0 Re. 0

TECHNICAL REVIEW CHECKLIST

This checklist provides guidance for the review of engineering analyses. Answer questions Yes or NO, or N/A if they do not Apply. Document all comments on 3110 form. Satisfactory Resolution of comments and completion of this checklist is noted by Technically Reviewed Signature on the Initiation and Review record block of form 3619.

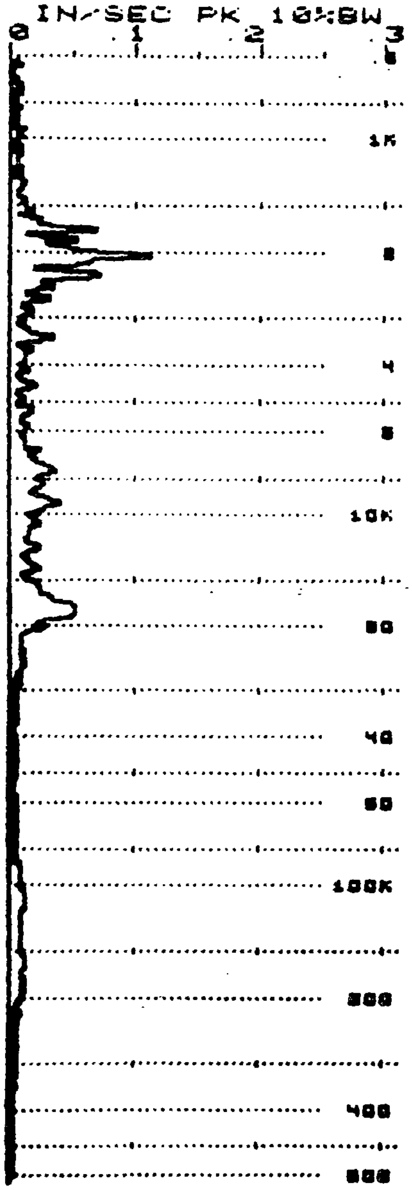
		(Y, N, N/A)
1.	Are all constants, variables and formulas correct and properly applied?	Y
2.	Are all inputs and assumptions valid and the Basis for their use documented?	Y
3.	Is Vendor Information used as inputs addressed correctly in the analysis?	Y
4.	If the analysis argument departs from Vendor Information/Recommendations, is the departure justification documented?	N/A
5.	Have the proper input codes, standards and design principles been specified?	Y
6.	Have the input codes, standards and design principles been properly applied?	Y
7.	Has the use of engineering judgement been documented and justified?	Y
8.	Has the objective of the analysis been met?	Y
9.	Are all calculated values correct?	Y
10.	Are assumptions accurately described and reasonable?	Y
11.	Have administrative requirements such as numbering and format been satisfied?	Y
12.	Have any minor (Insignificant) errors been identified? If Yes; Identify on 3110 form and justify insignificance.	N
13.	Does analysis involve welding? If Yes; verify the following information is accurately represented on analysis drawing(s).	N

- Type of Weld
- Size of Weld
- Material Being Joined
- Thickness of Material Being Joined
- Location of Weld(s)
- Appropriate Weld Symbology

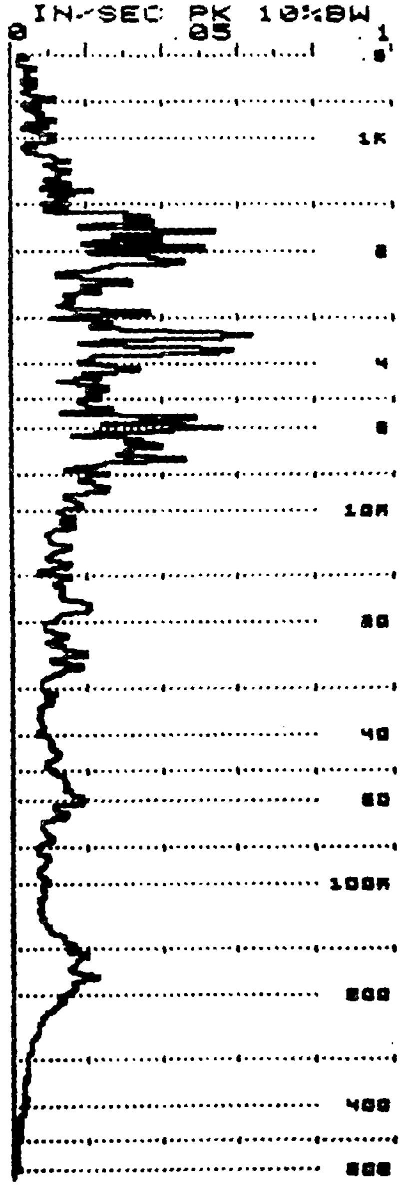
[signature] 2/18/91

P-67A Vibration

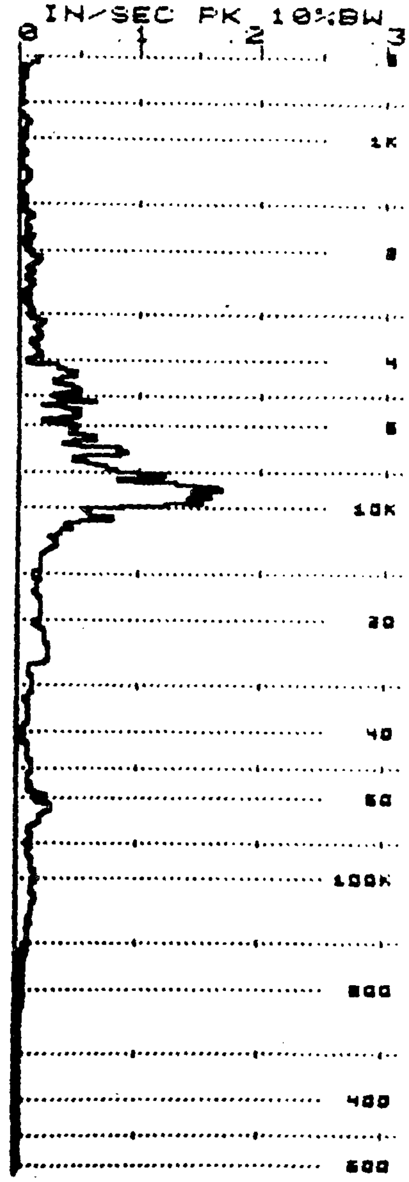
IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP AX
COND 500 GPM
OA .14(.11-.19)
IN/SEC PK 10%BW



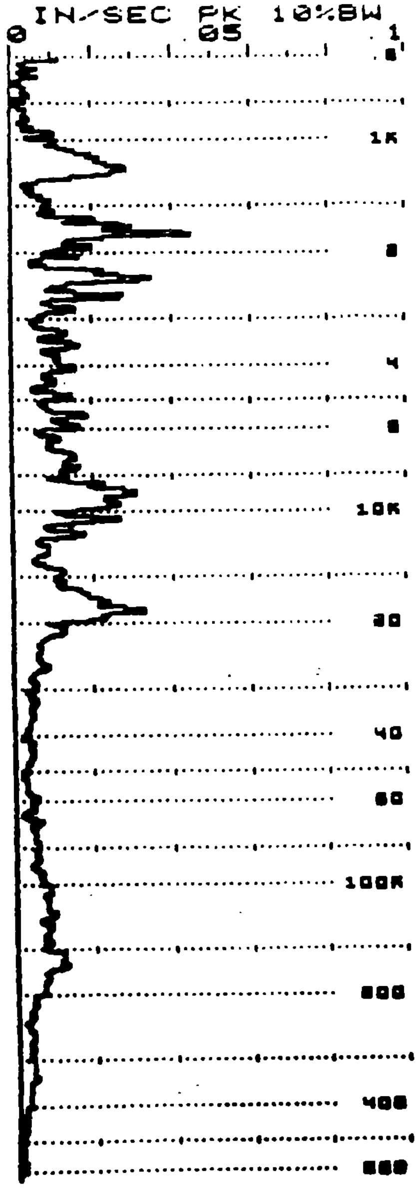
IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP HOR
COND 500 GPM
CAUTION: OVERSCALE
MAY CAUSE ERRORS
OA .13(.10-.13)
IN/SEC PK 10%BW



IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP VERT
COND 500 GPM
OA .25(.19-.30)
IN/SEC PK 10%BW



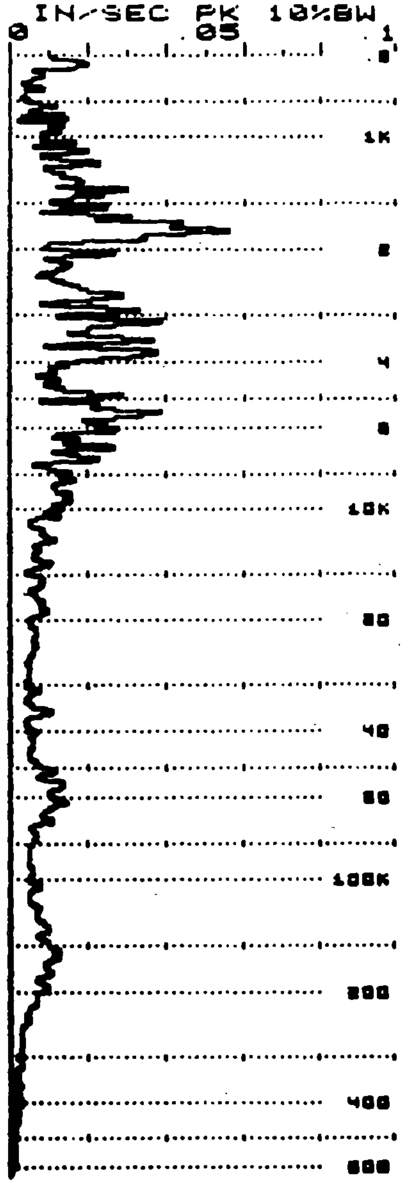
IRD MECHANALYSIS
DATE__1-19-91______
MACH__P-67A______
POSIT__PP AX____
COND__1500__GPM__
OA .095(.075-.12)



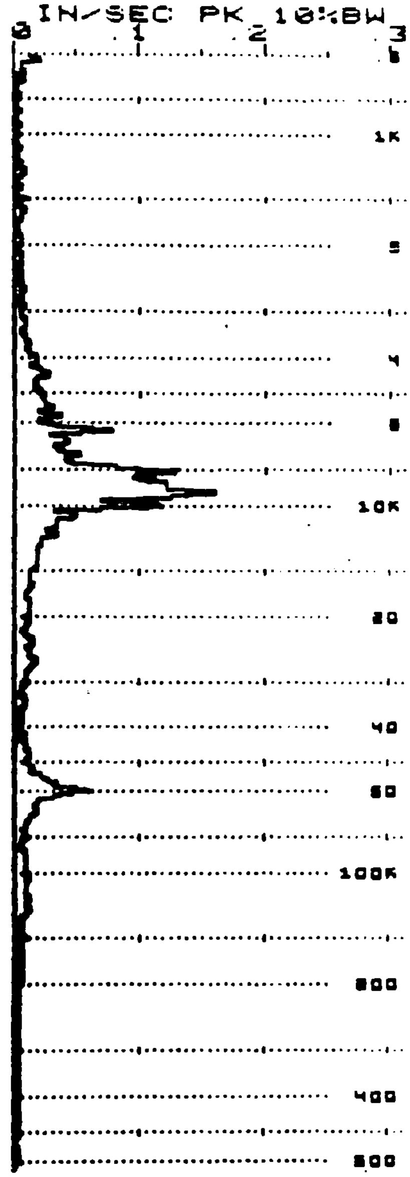
IRD MECHANALYSIS
DATE__1-19-91____
MACH__P-67A______
POSIT__PP HOR___
COND___1500 GPM_

CAUTION: OVERSCALE
MAY CAUSE ERRORS

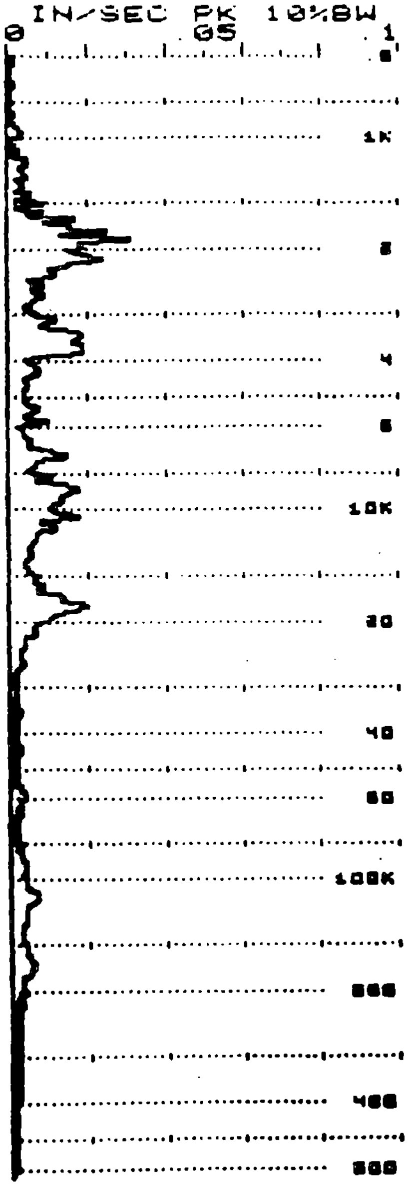
OA .11(.088-.13)



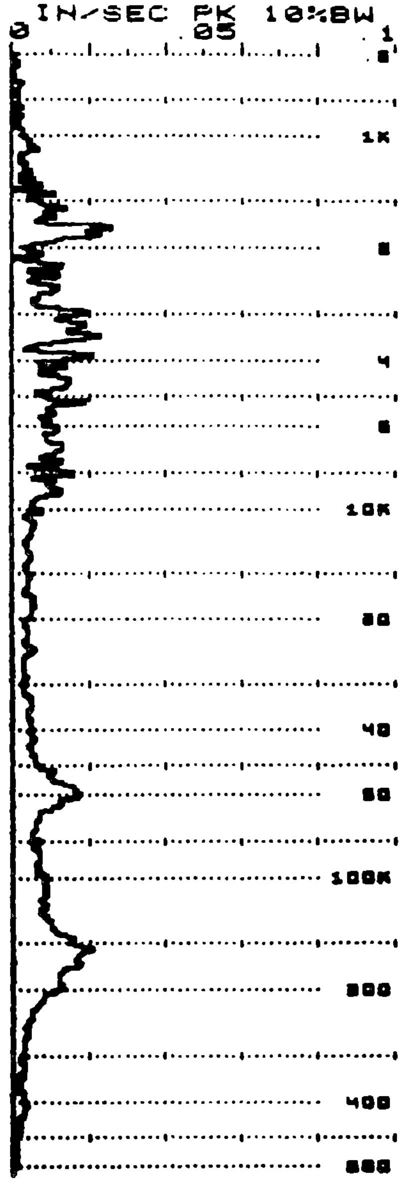
IRD MECHANALYSIS
DATE__1-19-91_____
MACH__P-67A______
POSIT___PP VERT__
COND____1500 GPM
OA .21(.15-.32)



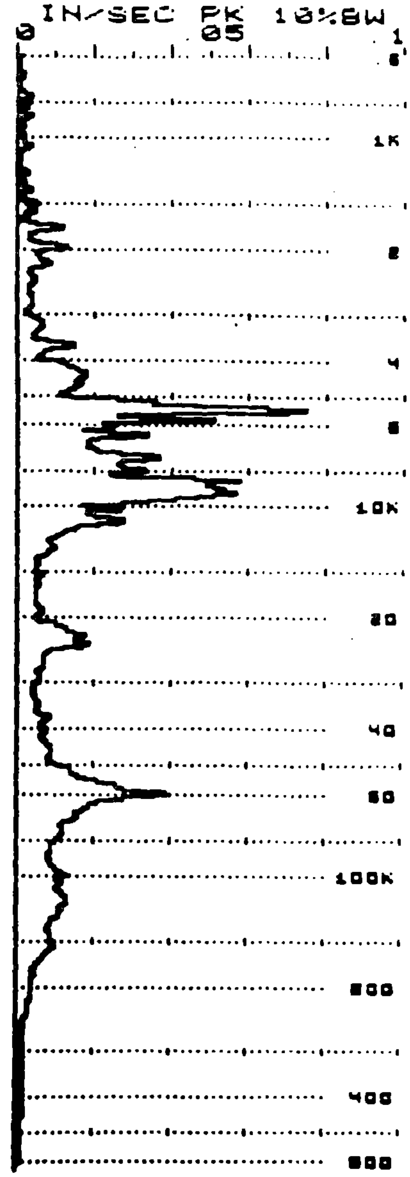
IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP AX
COND 2500 GPM
OA .056(.040- .083)
IN/SEC PK 10%BW



IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP HOR
COND 2500 GPM
OA .072(.062-.084)
IN/SEC PK 10%BW



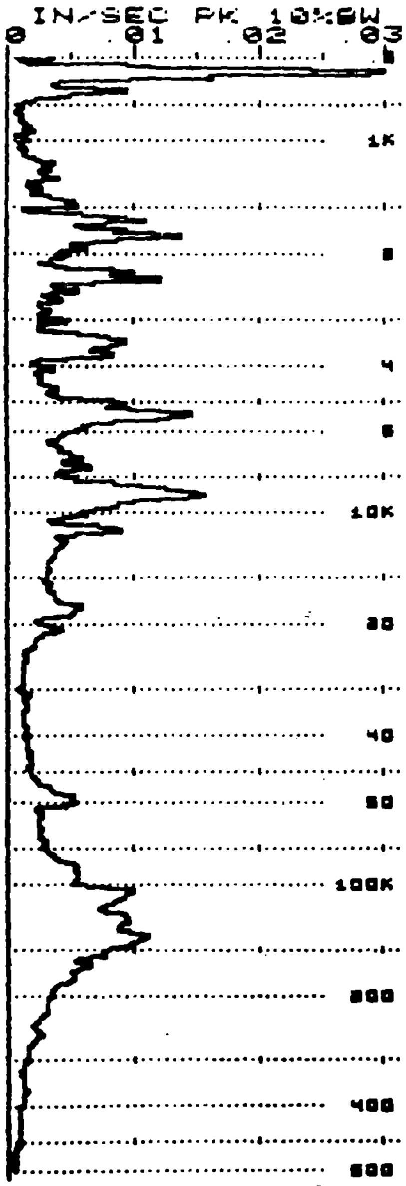
IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP VERT
COND 2500 GPM
OA .10(.081-.12)
IN/SEC PK 10%BW



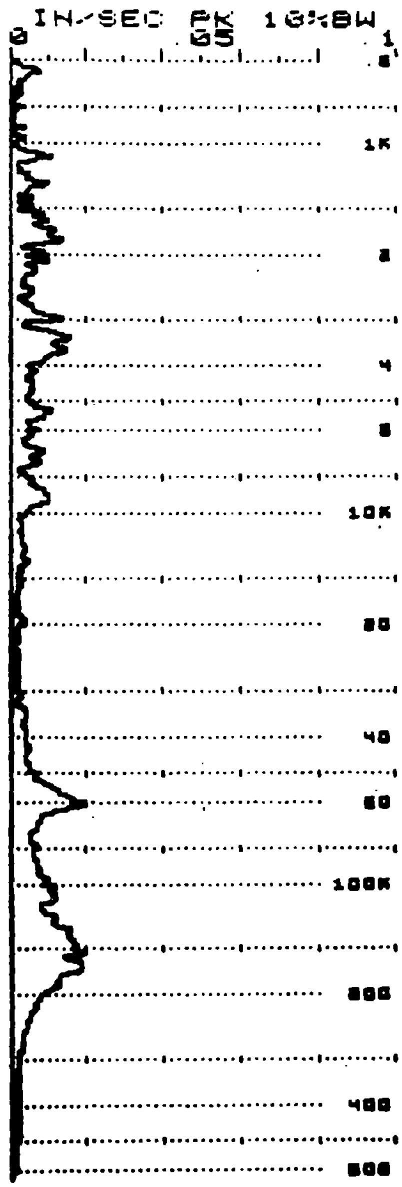
P-67A Vibration 1-19-91 Pump (2500 gpm)

IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP AX
COND 3100 GPM

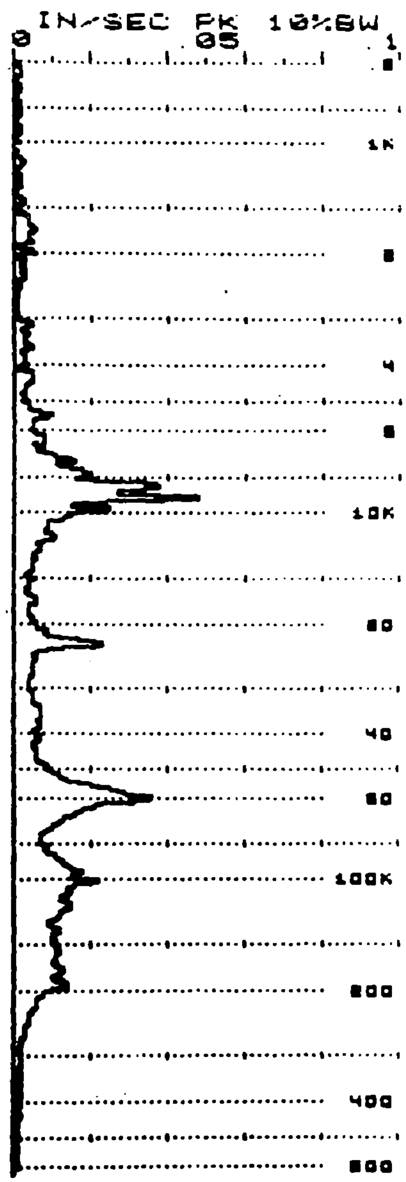
CAUTION OVERSCALE MAY CAUSE ERRORS
OA .040(.035- .040)



IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP HOR
COND 3100 GPM
OA .059(.053- .067)

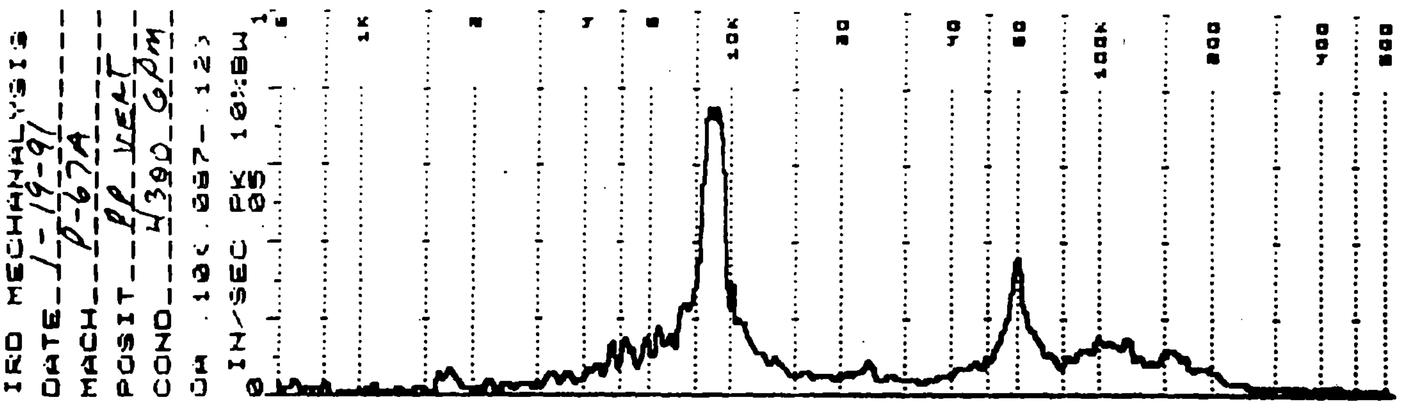


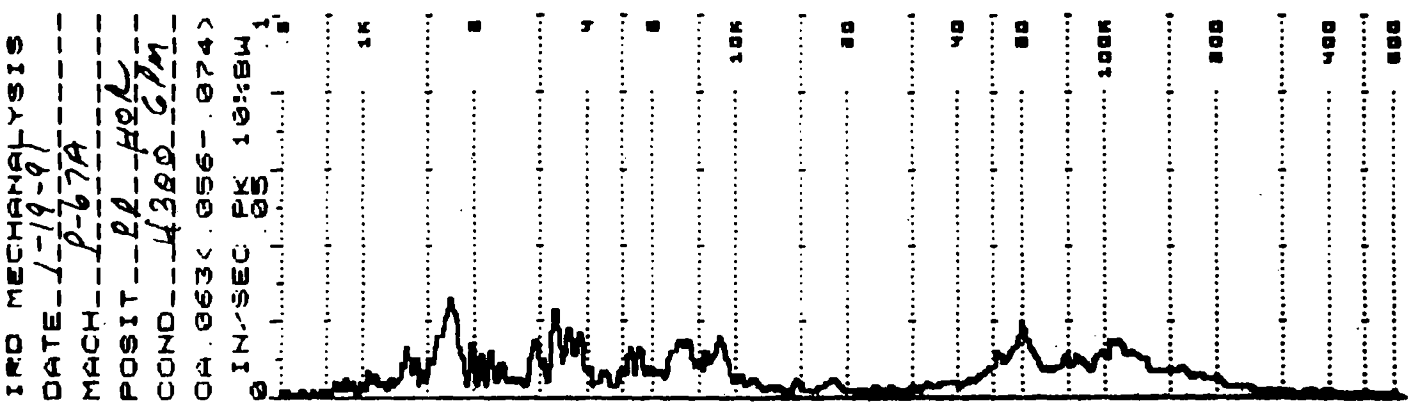
IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT PP VERT
COND 3100 GPM
OA .081(.069- .093)

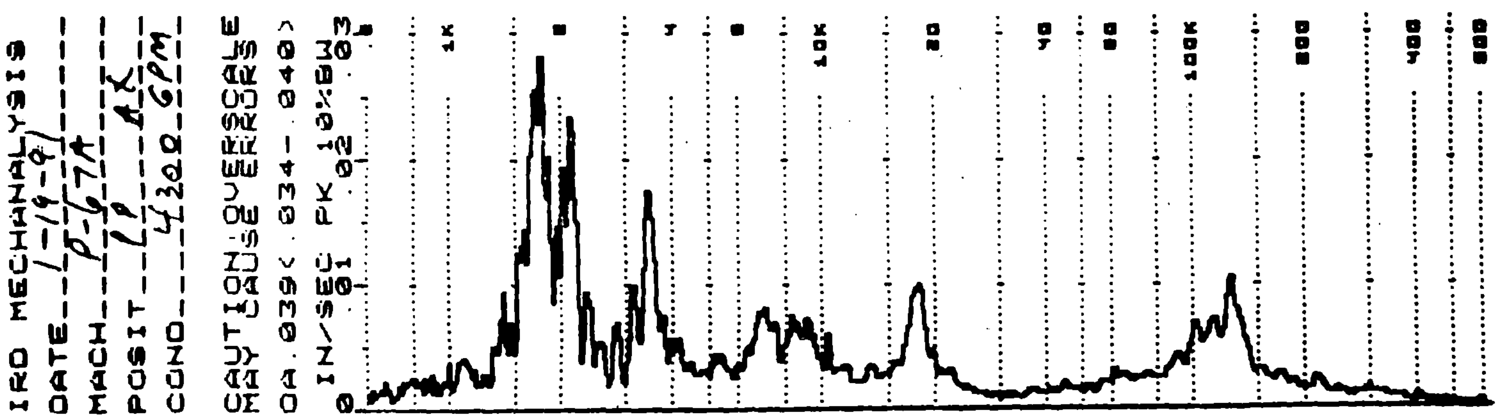


P-67A Vibration

P-67A Vibration 1-19-91 Pump (4300 gpm)

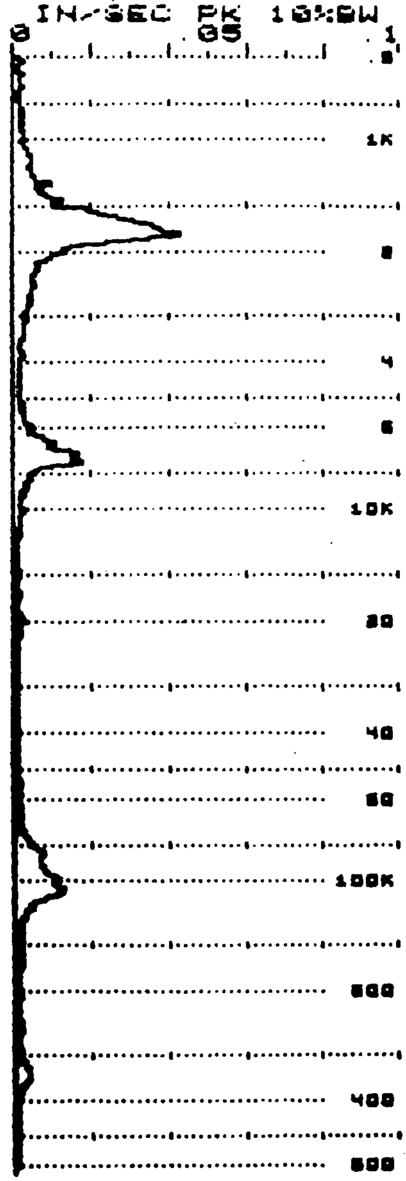






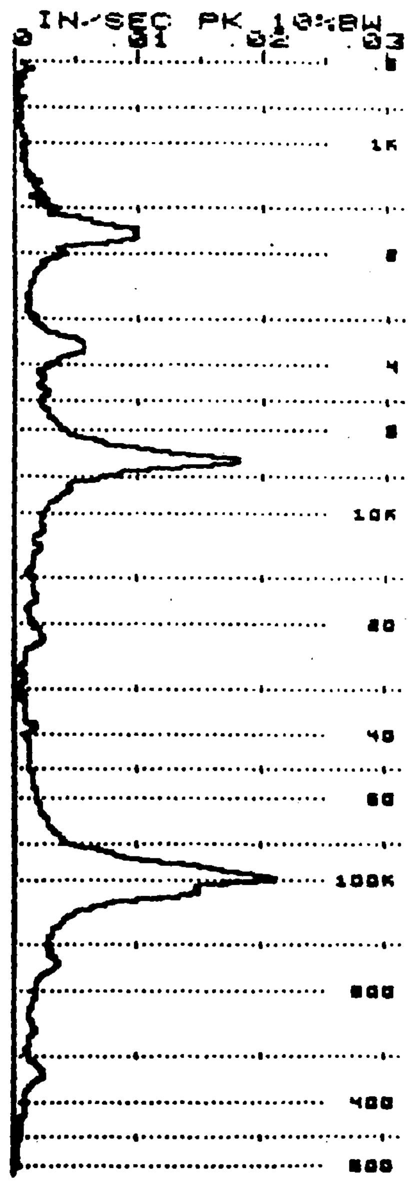
P-67A Vibration 1-19-91 Motor Inboard (cont'd.)

IRD MECHANALYSIS
DATE 1-19-91
MACH P-67 A
POSIT INB MTR HOR
COND 500 GPM
OA .057(.050- .069)



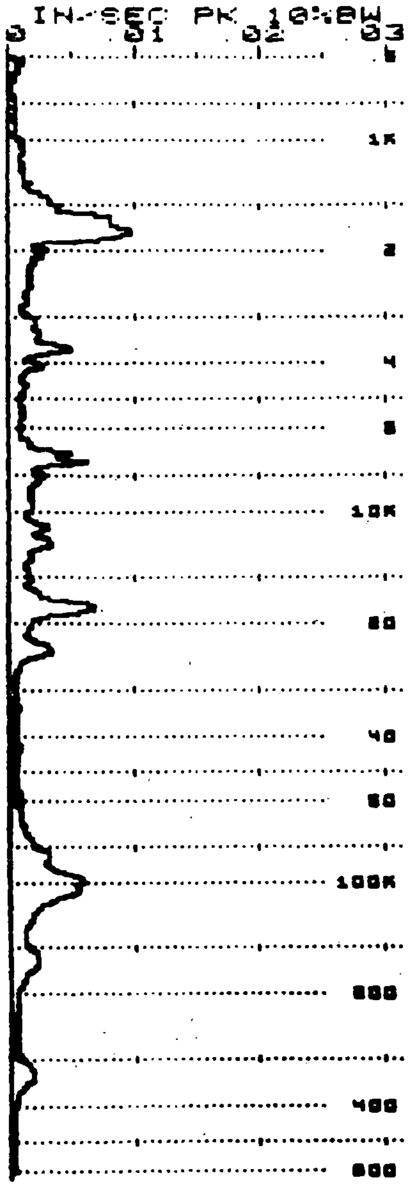
IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT INB MTR VERT
COND 500 GPM

CAUTION: OVERSCALE MAY CAUSE ERRORS
OA .038(.035- .040)



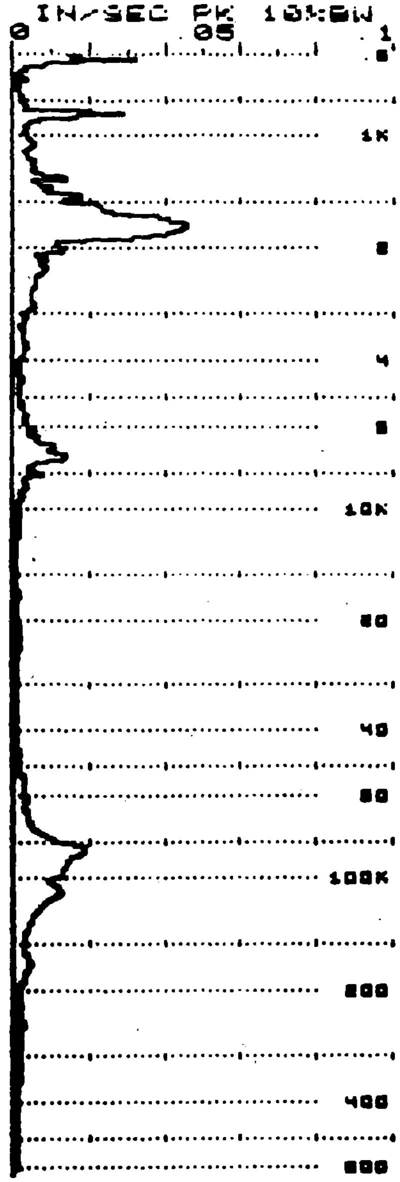
P-67A Vibration 1-19-91

IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT OIB MTR AX
COND 500 GPM
OA .019 (.016- .022)

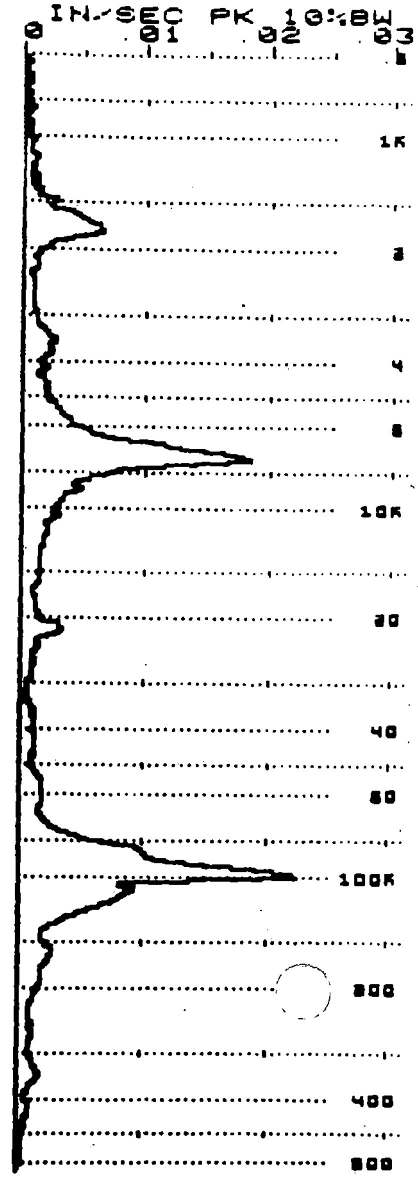


IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT OIB MTR HOR
COND 500 GPM

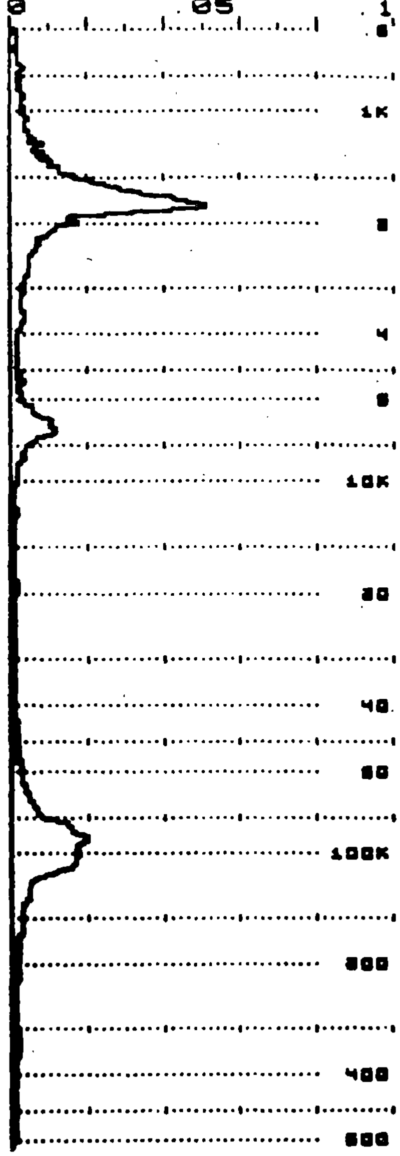
CAUTION: OVERSCALE
MAY CAUSE ERRORS
OA .11 (.058- .13)



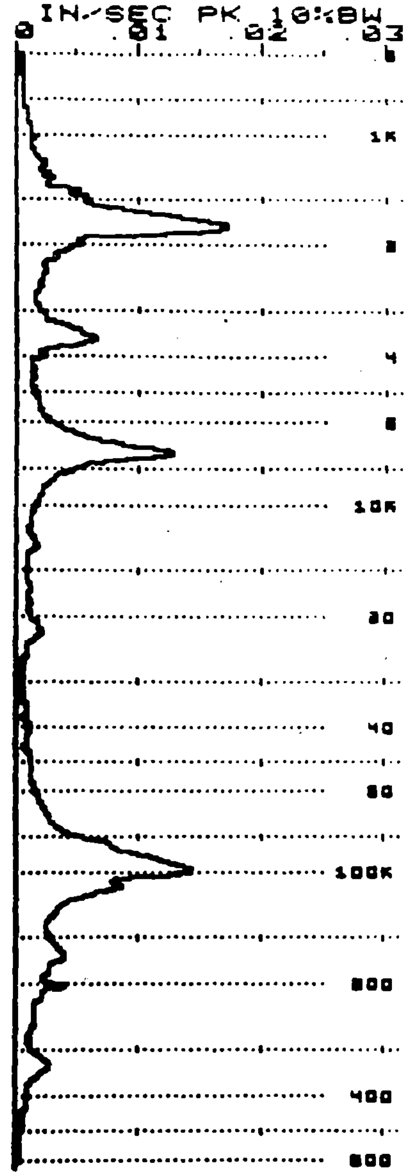
IRD MECHANALYSIS
DATE 1-19-91
MACH P-67A
POSIT OIB MTR VERT
COND 500 GPM
OA .033 (.027- .039)



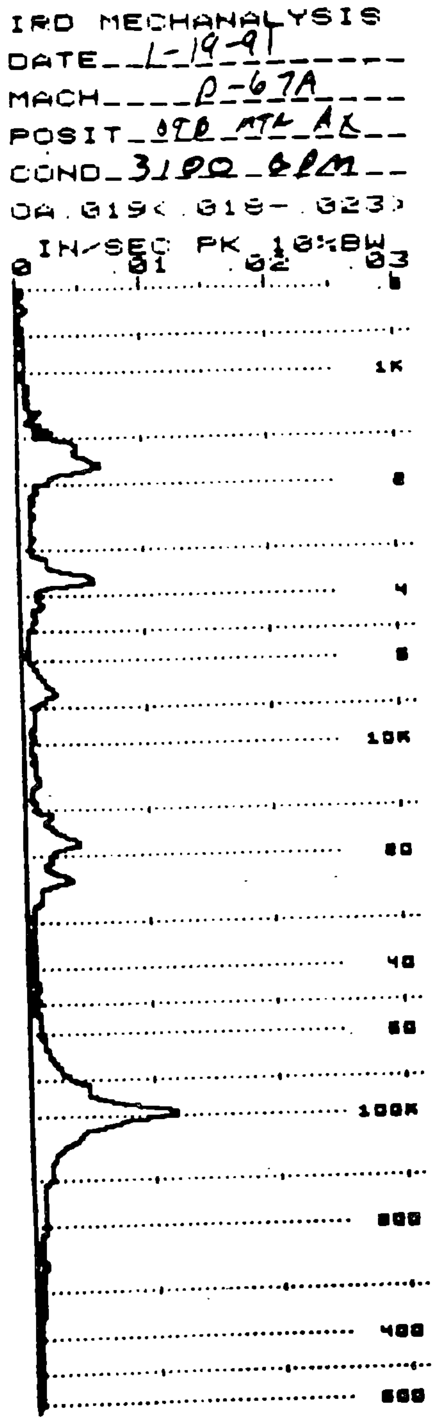
IRD MECHANALYSIS
DATE 1-14-91
MACH P-67A
POSIT INB MTR HOR
COND 3100 GPM
OA .066(.059-.071)

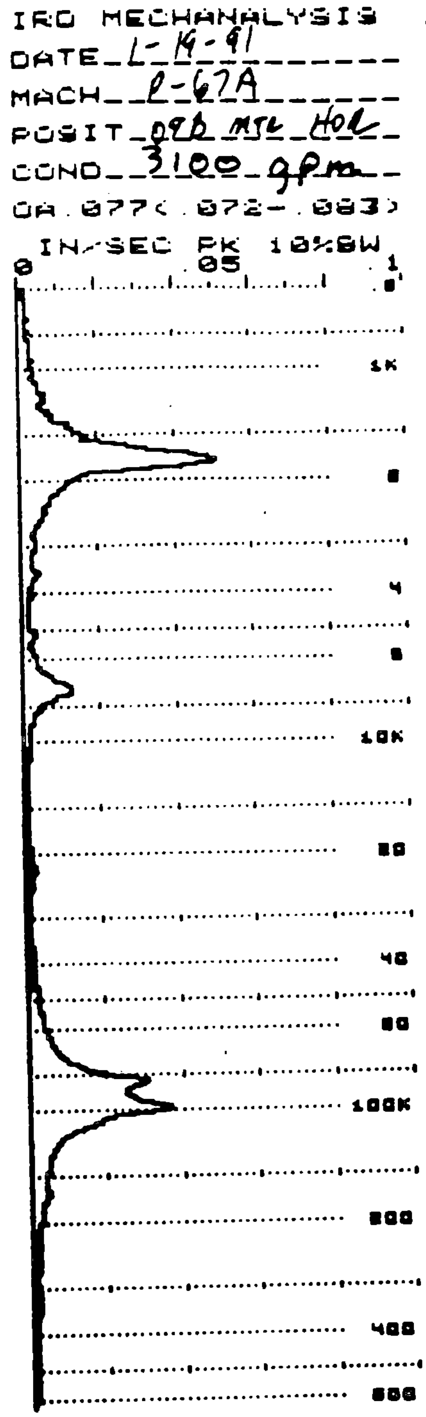


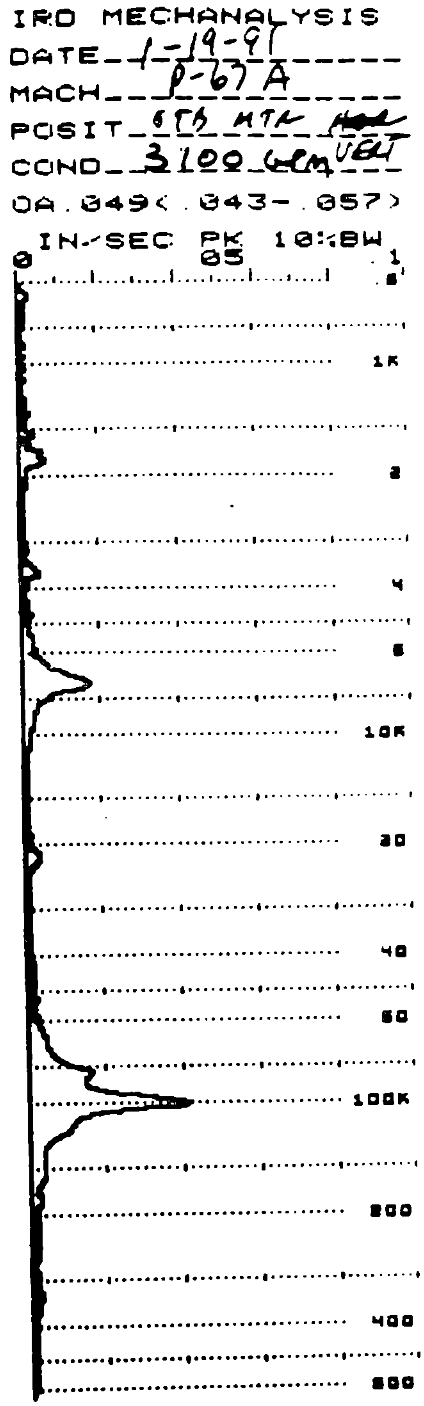
IRD MECHANALYSIS
DATE 1-14-91
MACH P-67A
POSIT INB MTR VERT
COND 3100 GPM
CAUTION:OVERSCALE
MAY CAUSE ERRORS
OA .033(.030-.040)



P-67A Vibration 1-14-91 Motor Inboard (...)





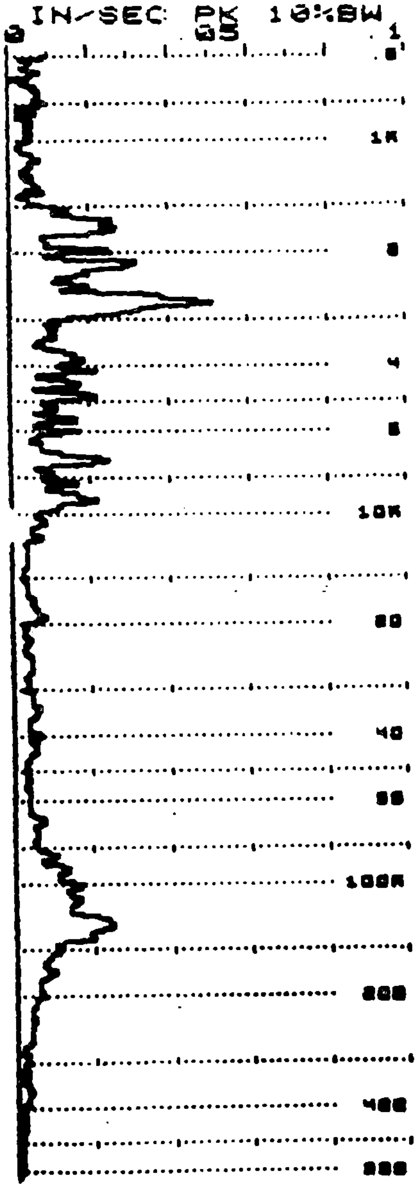


P-67A Vibration 1-14-91 Motor

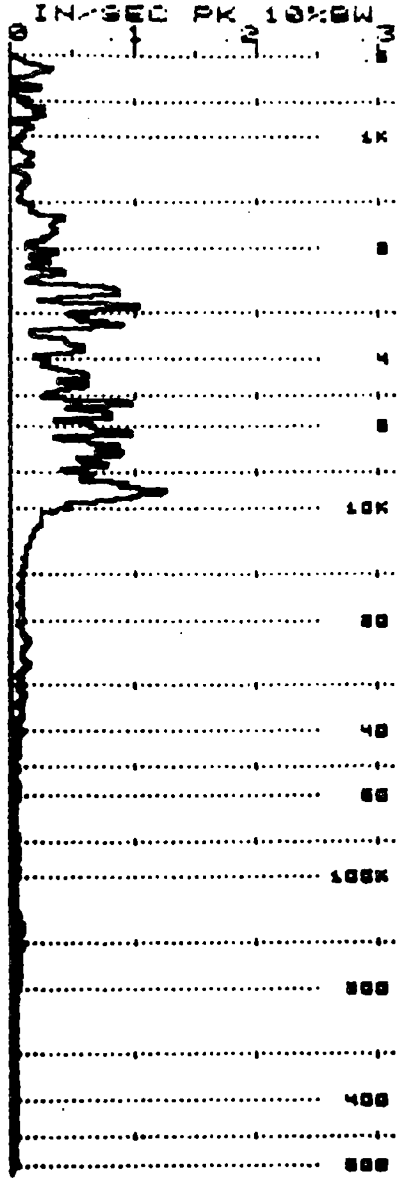
Attachment 5

P-67B Vibration 1-20-91 Pump

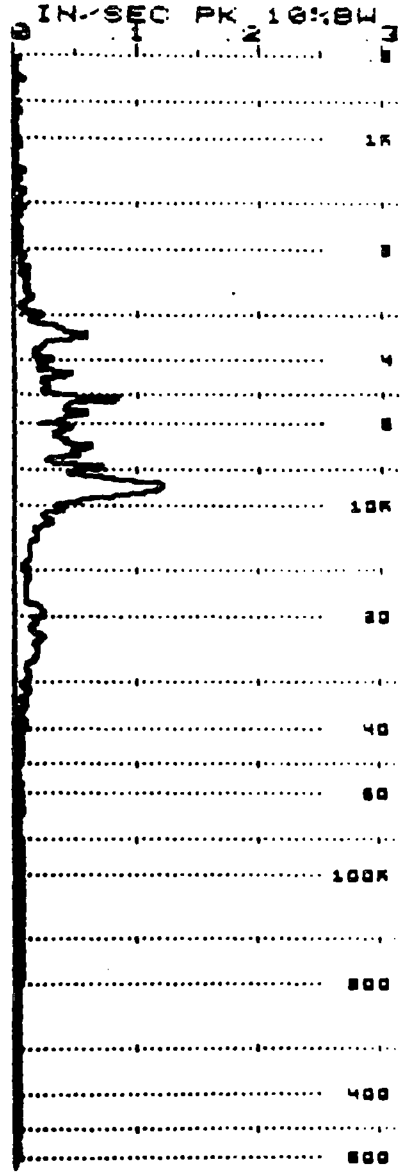
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT PP HK
COND 500 GPM
OA .082(.069-.099)



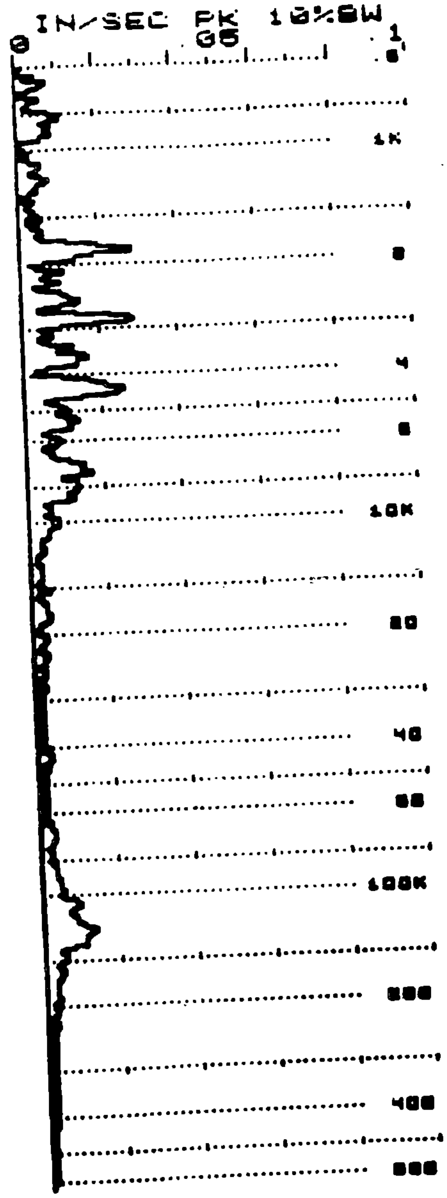
IRD MECHANALYSIS
DATE 1-20-90
MACH P-67B
POSIT PP HOR
COND 500 GPM
OA .23(.19-.29)



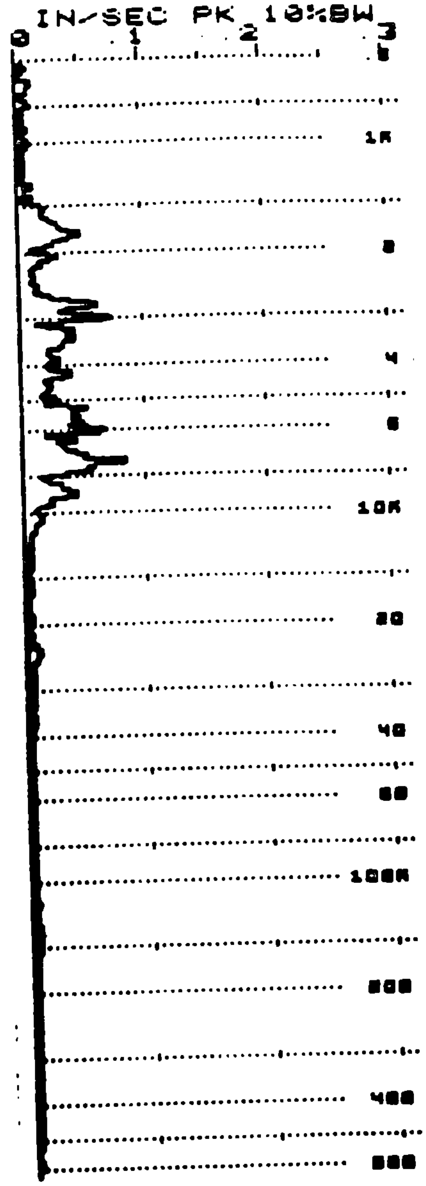
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT PP VERT
COND 500 GPM
OA .18(.14-.23)



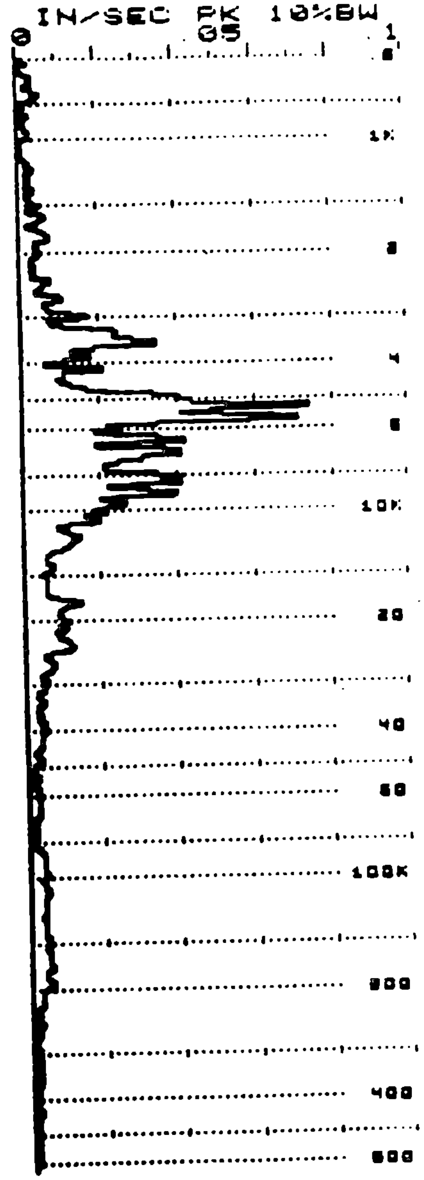
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT PP AX
COND 1500 GPM
OA .053(.042-.070)
IN/SEC PK 10%BW



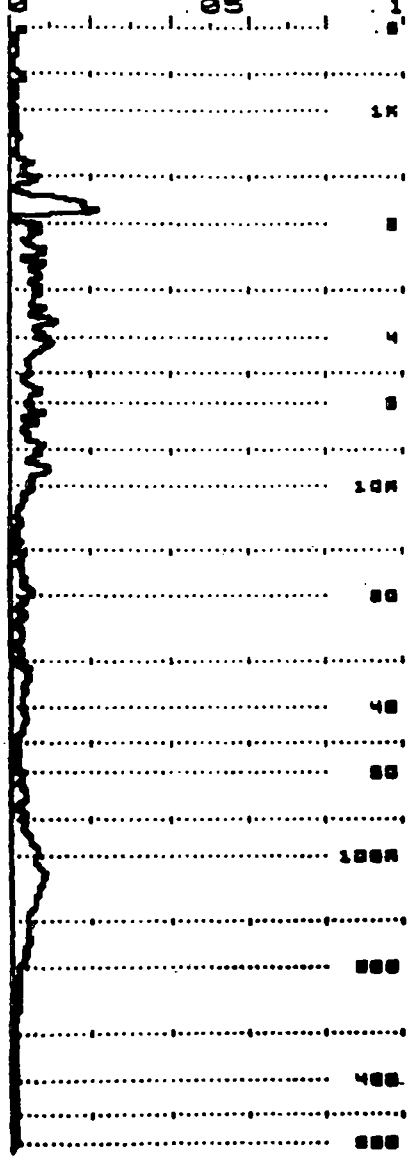
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT PP HOR
COND 1500 GPM
OA .13(.11-.19)
IN/SEC PK 10%BW



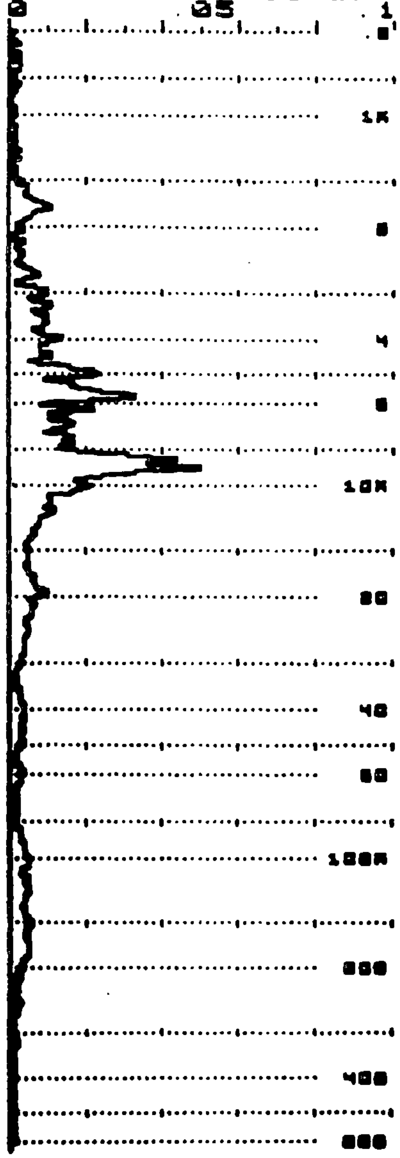
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT PP VERT
COND 1500 GPM
OA .096(.076-.11)
IN/SEC PK 10%BW



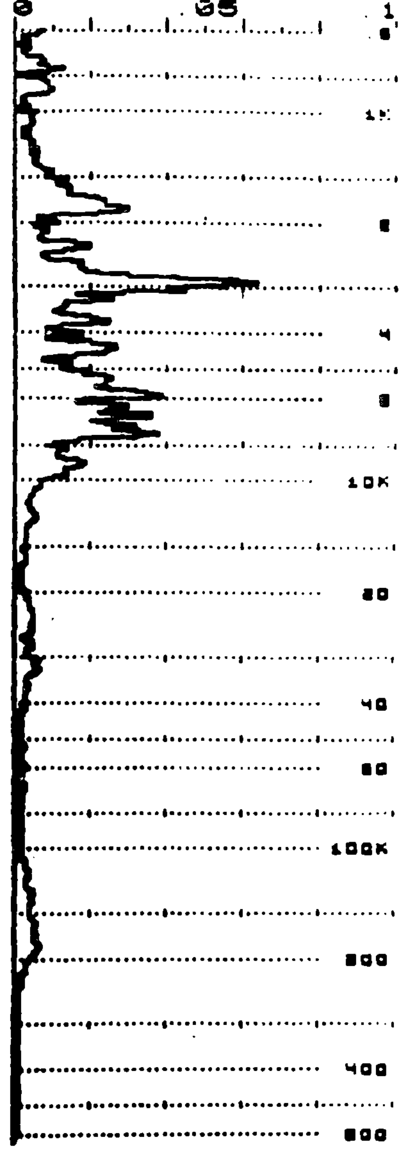
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT PP AX
COND 2500 GPM
OA .042< .036- .054>
IN/SEC PK 10%BW



IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT IP VERT
COND 2500 GPM
OA .071< .060- .090>
IN/SEC PK 10%BW



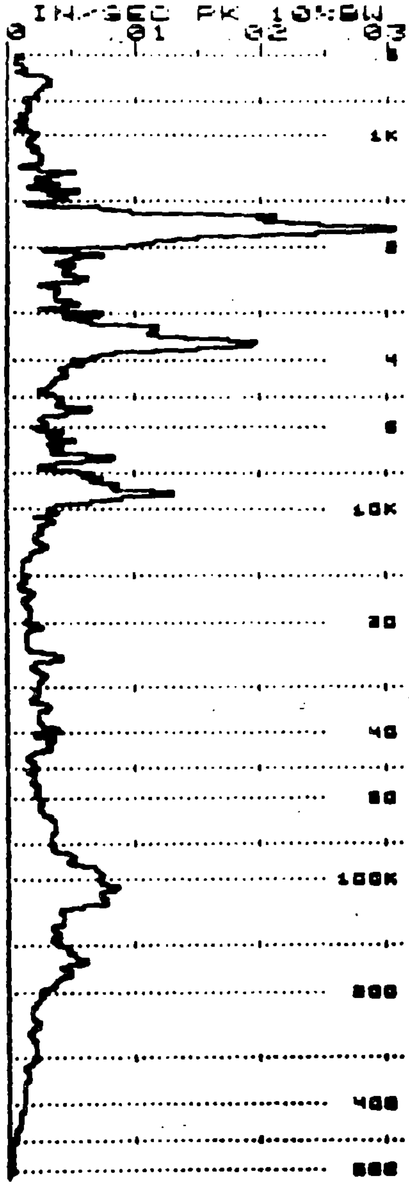
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT PP VERT
COND 2500 GPM
OA .086< .064- .11>
IN/SEC PK 10%BW



IRD MECHANALYSIS
DATE 1-20-91
MACH P-678
POSIT PP AX
COND 3100 GPM

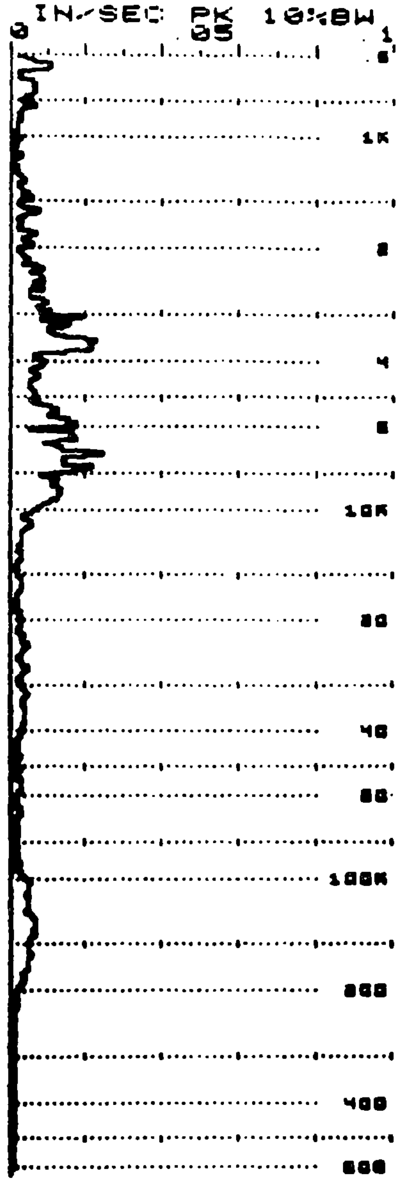
CAUTION: OVERSCALE
MAY CAUSE ERRORS

OA .036< .031- .040>



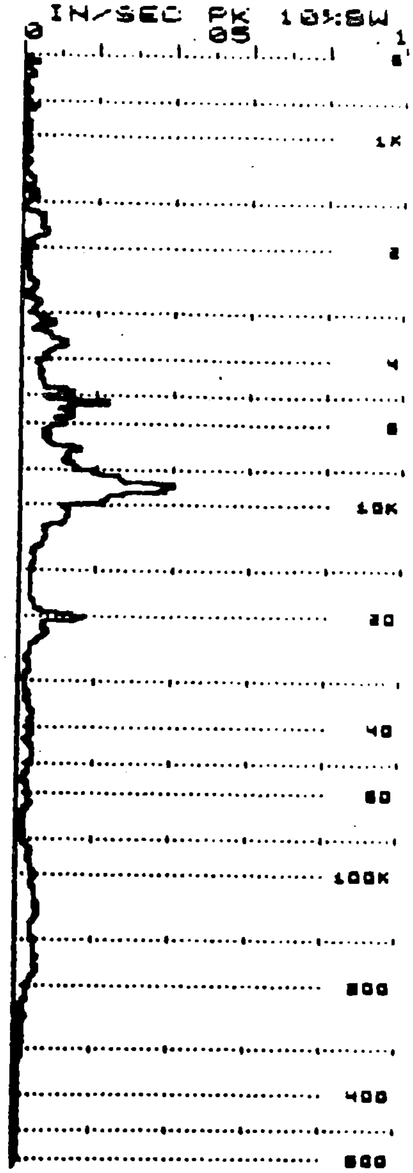
IRD MECHANALYSIS
DATE 1-20-91
MACH P-678
POSIT PP HOR
COND 3100 GPM

OA .056< .043- .072>



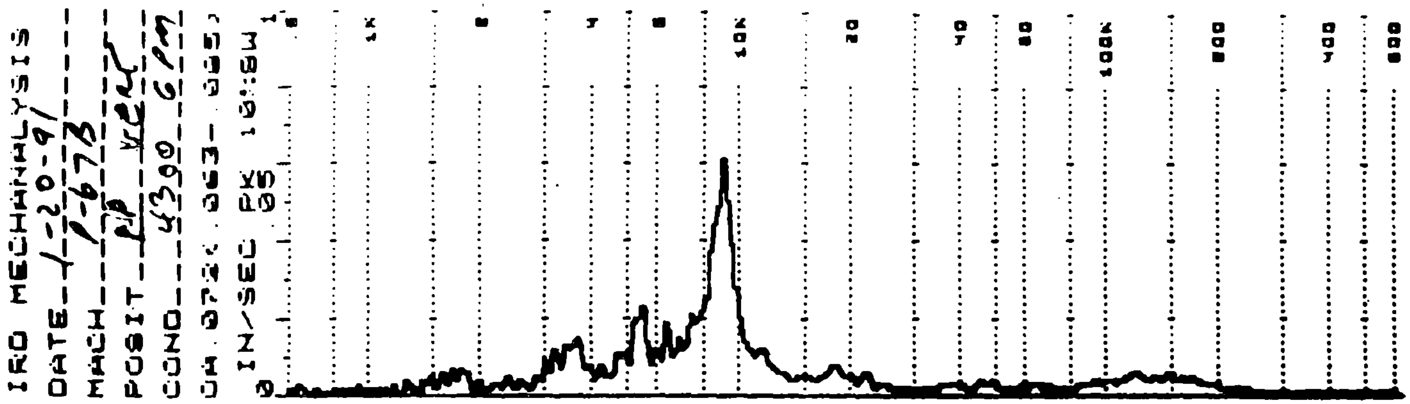
IRD MECHANALYSIS
DATE 1-20-91
MACH P-678
POSIT PP VERT
COND 3100 GPM

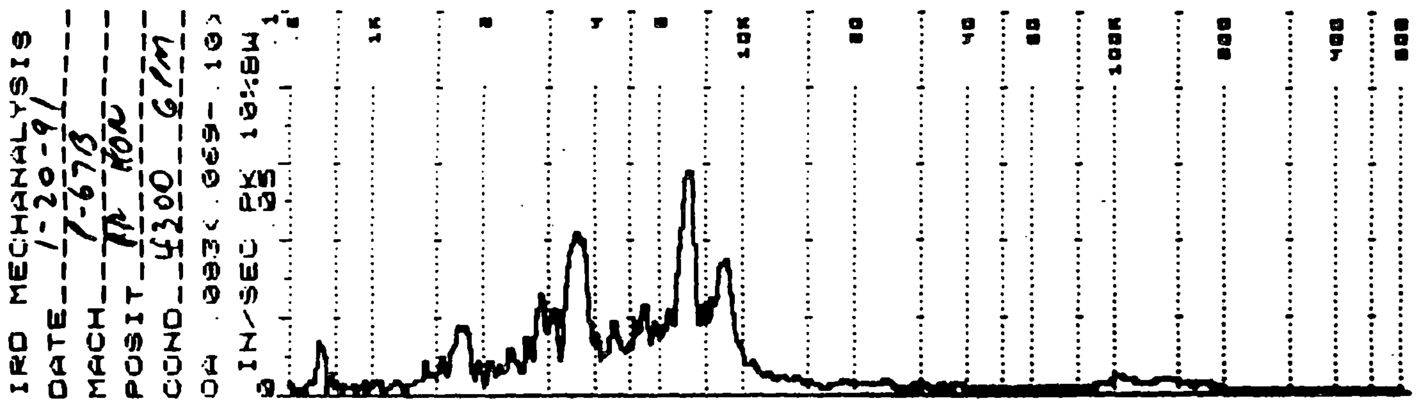
OA .056< .047- .068>

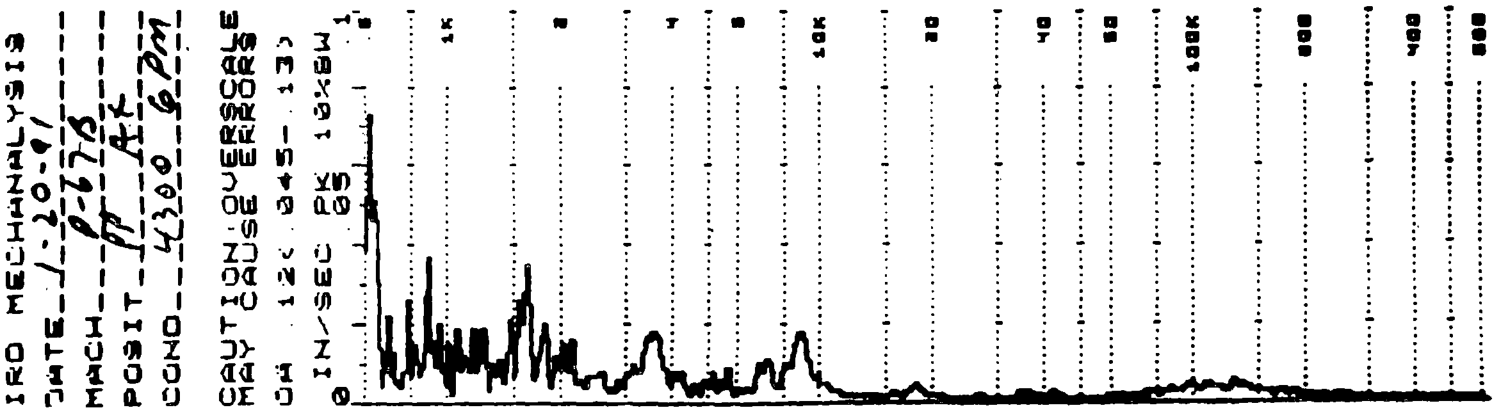


P-678 Vibration

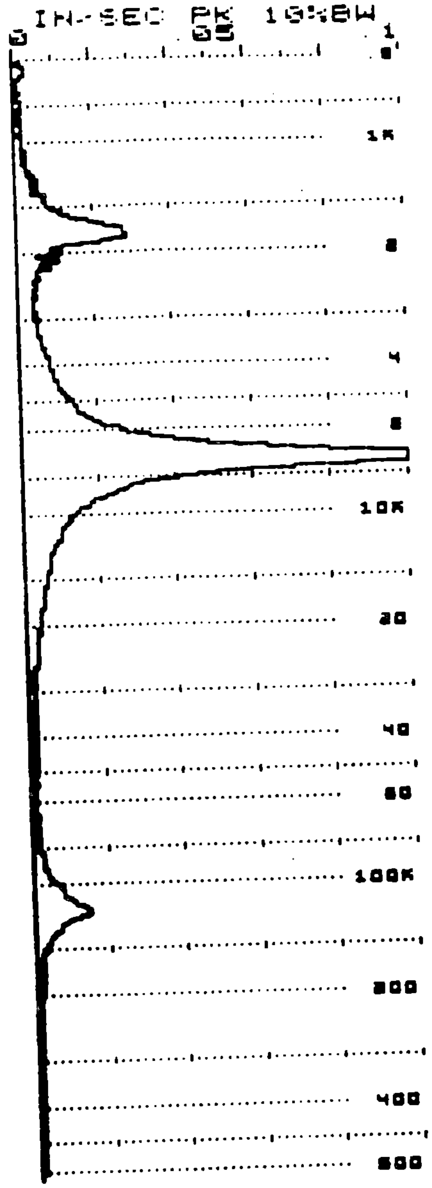
P-67B Vibration 1-20-91 Pump ([illegible] gpm)



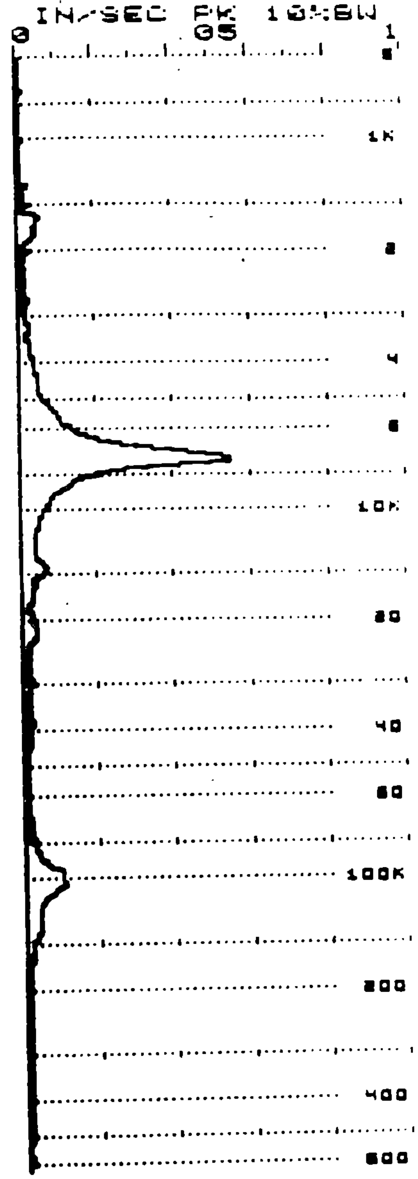




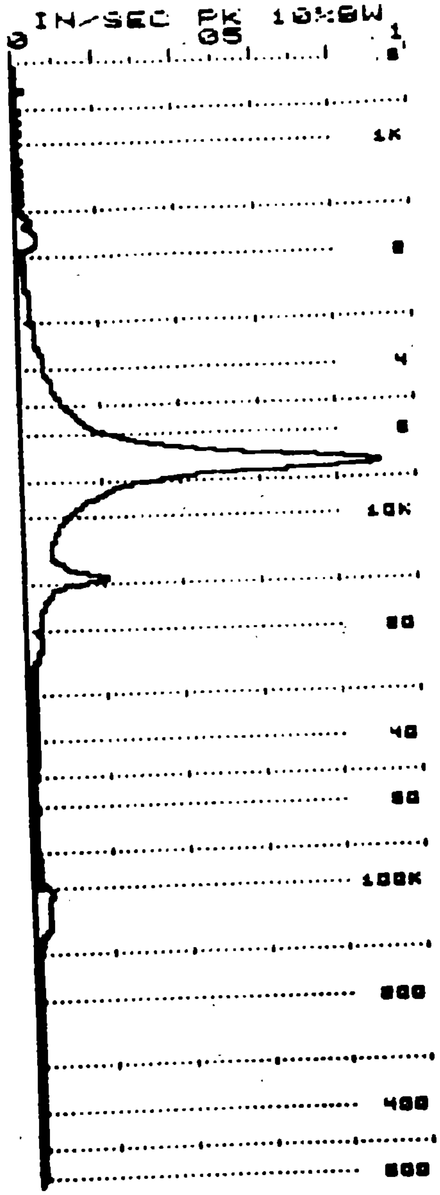
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT NB MTR HOR
COND 500 GPM
OA .12< .12- .12>



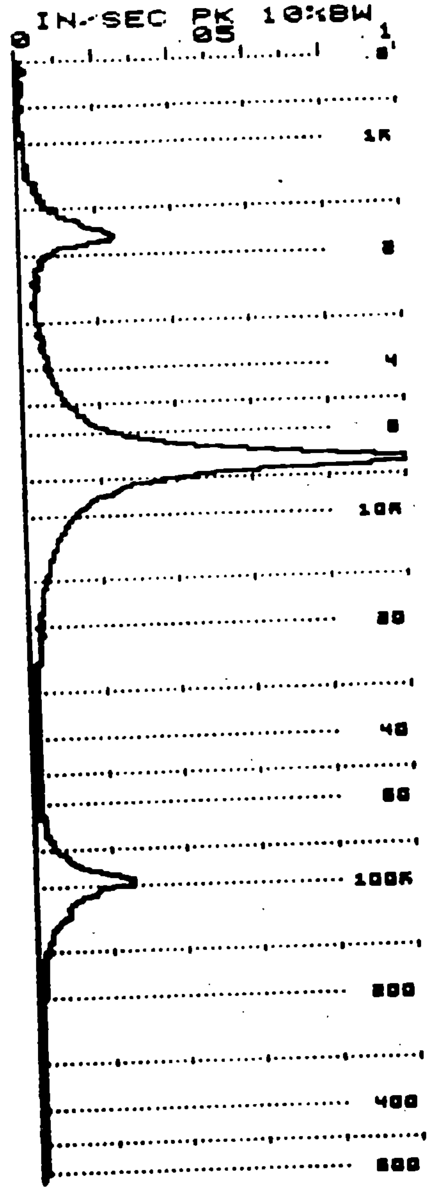
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT NS MTR VERT
COND 500 GPM
OA .060< .058- .062>



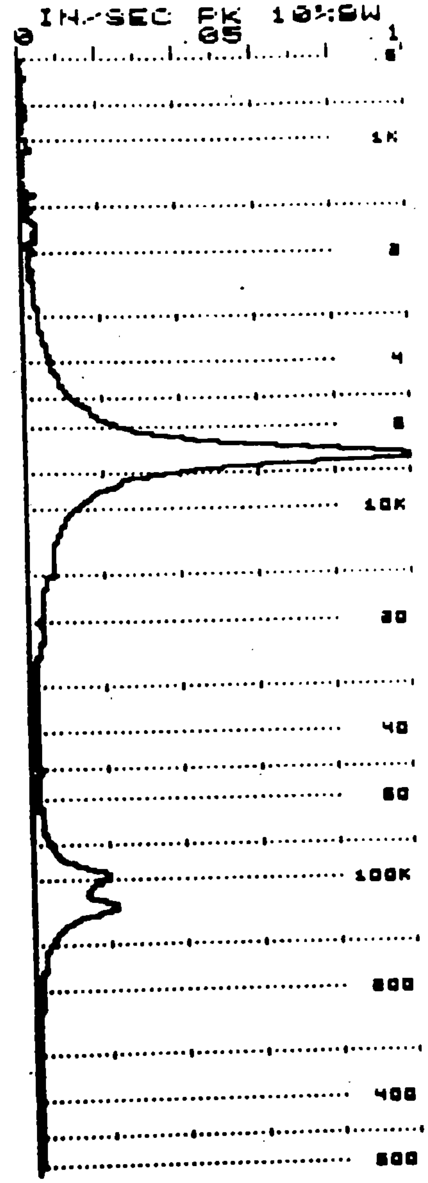
IRD MECHANALYSIS
DATE__1-20-91______
MACH__P-678________
POSIT_OTB MTR AX___
COND__500 GPM______
OA .096< .095- .099>



IRD MECHANALYSIS
DATE__1-20-91______
MACH__P-678________
POSIT_OTB MTR HOR__
COND__500 GPM______
OA .11< .11- .12>

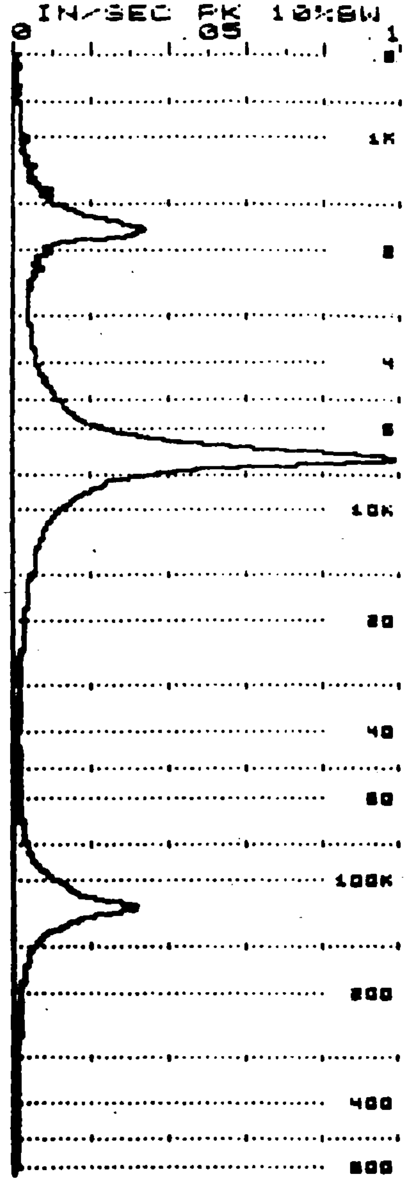


IRD MECHANALYSIS
DATE__1-20-91______
MACH__P-678________
POSIT_OTB MTR VERT_
COND__500 GPM______
OA .11< .11- .11>

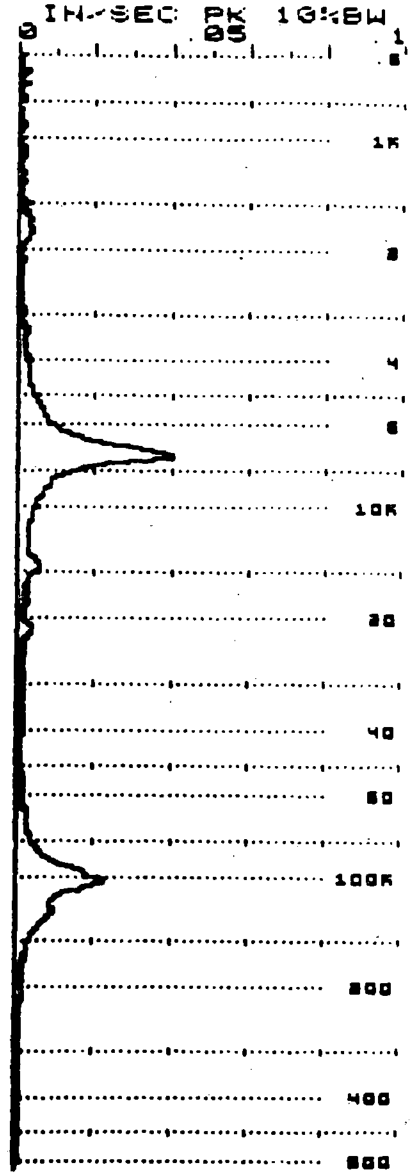


P-678 Vibration 1-20-91 Motor Outboard (500 gpm)

IRD MECHANALYSIS
DATE 1-20-91
MACH P-678
POSIT INB MTR HOR
COND 3100 GPM
OA .11(.11- .12)
IN/SEC PK 10%BW

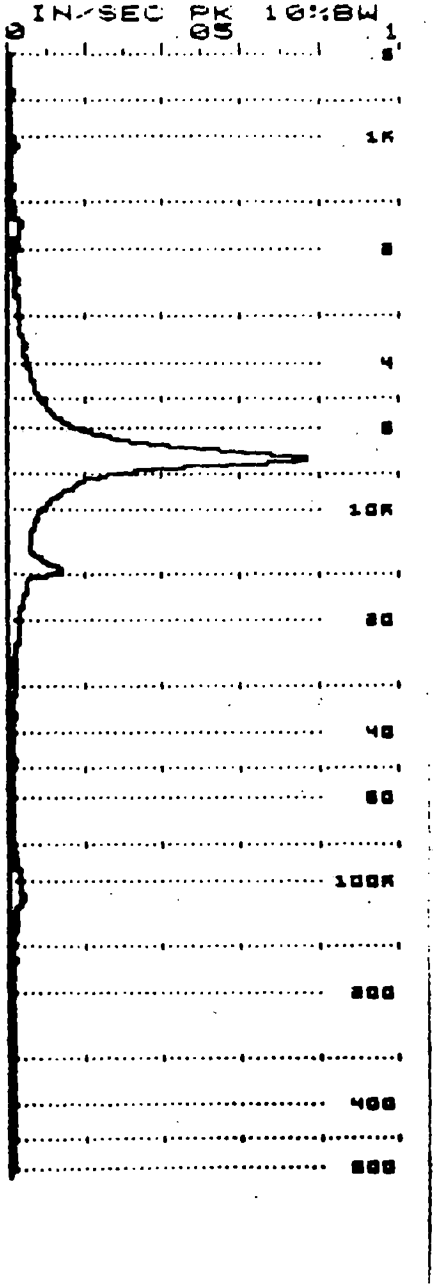


IRD MECHANALYSIS
DATE 1-20-91
MACH P-678
POSIT INB MTR VERT
COND 3100 GPM
OA .053(.052- .054)
IN/SEC PK 10%BW

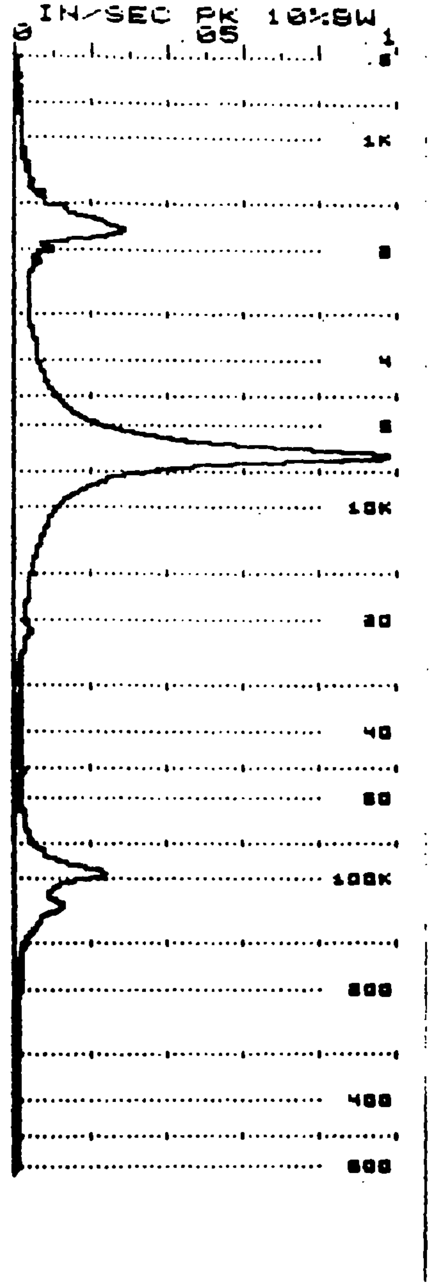


P-678 Vibration 1-20-91 Motor Inboard (3100 gpm)

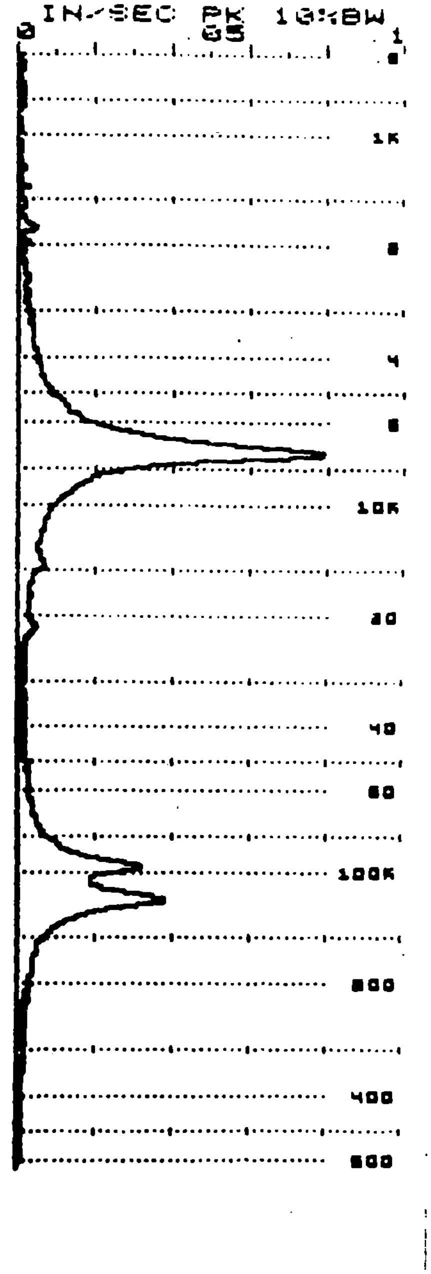
IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT OIB MTR AX
COND 3100 GPM
OA .080(.078-.082)
IN/SEC PK 10%BW



IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT OIB MTR HOR
COND 3100 GPM
OA .11(.10-.11)
IN/SEC PK 10%BW



IRD MECHANALYSIS
DATE 1-20-91
MACH P-67B
POSIT OIB MTR VERT
COND 3100 GPM
OA .097(.096-.098)
IN/SEC PK 10%BW



P-67B Vibration 1-20-91

PRE-CAL

DESIRED INPUT	* AS FOUND	FINAL
0	0	0
80	80	80
160	160	160
200	200	200
240	240	240
320	320	320
400	400	400

Remarks T-261

POST-CAL

DESIRED INPUT	AS FOUND
0	0
80	80
160	160
200	200
240	240
320	319
400	400

Remarks T-261

CONTROLLED COPY

* FOR INFORMATION ONLY

Pre Calibration Equipment	CPCo No.	Cal Date	Cal Due
HEISE TEST GAUGE	8428-00895	12-11-90	4-9-9

Performed By [illegible] Date 1-17-91

Reviewed By [illegible] Date 1/17/91

Post Calibration Equipment	CPCo No.	Cal Date	Cal Due
Test Gauge	8428-00895	12-11-90	4-9-91

Performed By [illegible] Date 1-20-91

Reviewed By [illegible] Date 1-20-91

TYPE Ashcroft Test Gauge RANGE 0-60PSIG TOLERANCE ± .5[illegible] ± .3 PS

PRE-CAL

DESIRED INPUT	* AS FOUND	FINAL
0	0	0
10	10.0	10.0
20	20.0	20.0
30	30.0	30.0
40	39.8	39.8
50	49.8	49.8
60	59.8	59.8

POST-CAL

DESIRED INPUT	AS FOUND	* FINAL
0	0	
10	9.9	
20	19.9	
30	29.9	
40	39.8	
50	49.7	
60	59.6 (circled)	

CONTROLLED COPY

Remarks T-261

Remarks T-261, gauge is contaminated

* FOR INFORMATION ONLY

Pre Calibration Equipment	CPCo No.	Cal Date	Cal Due Date
TEST GAUGE	8428-01315	11-14-90	3-14-91

Performed By [illegible] Date 1-17-91

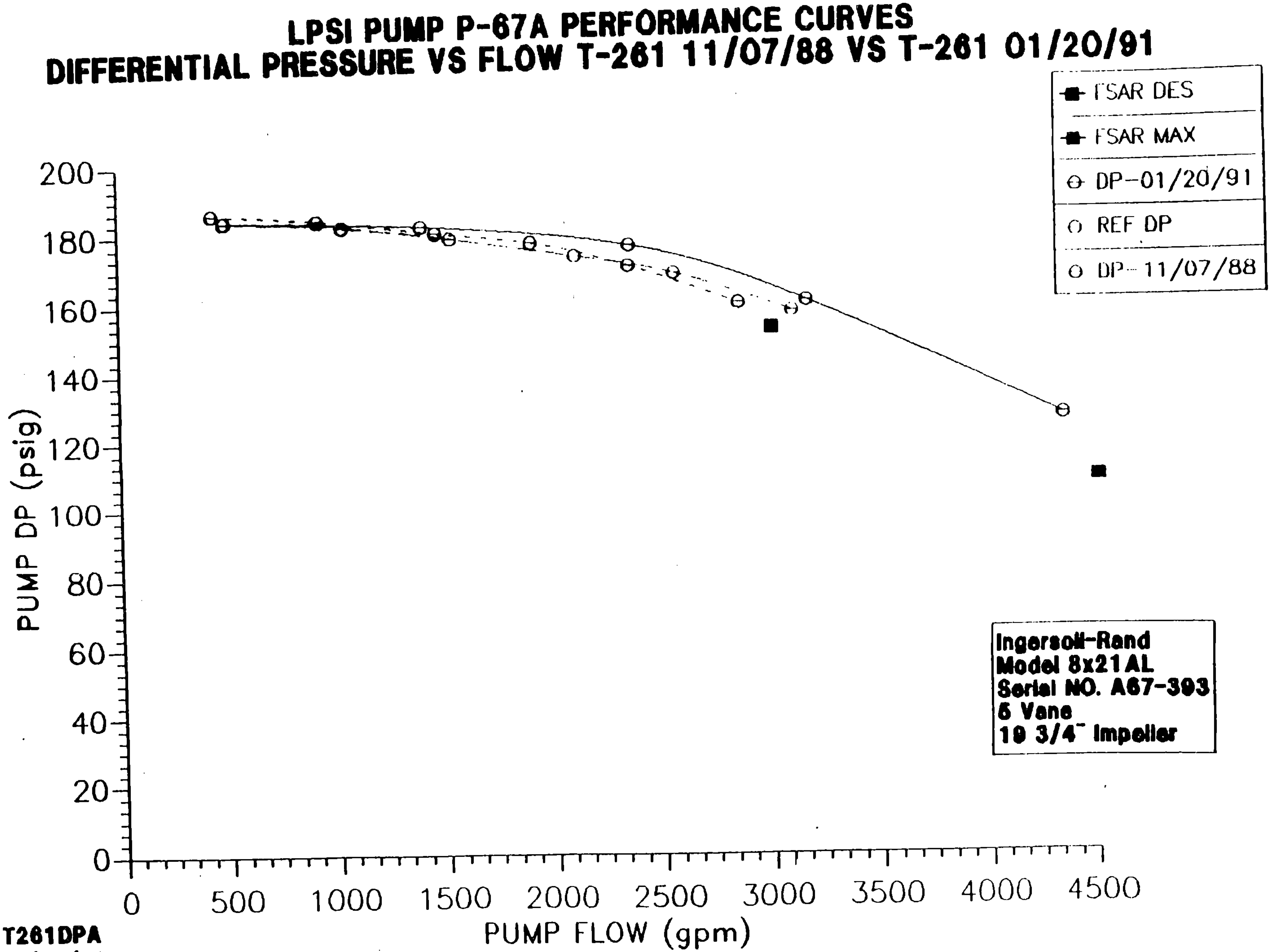
Reviewed By [illegible] Date 1/17/91

Post Calibration Equipment	CPCo No.	Cal Date	Cal Due Date
Test Gauge	8428-01315	11-14-90	3-14-91

Performed By [illegible] Date 1-20-91

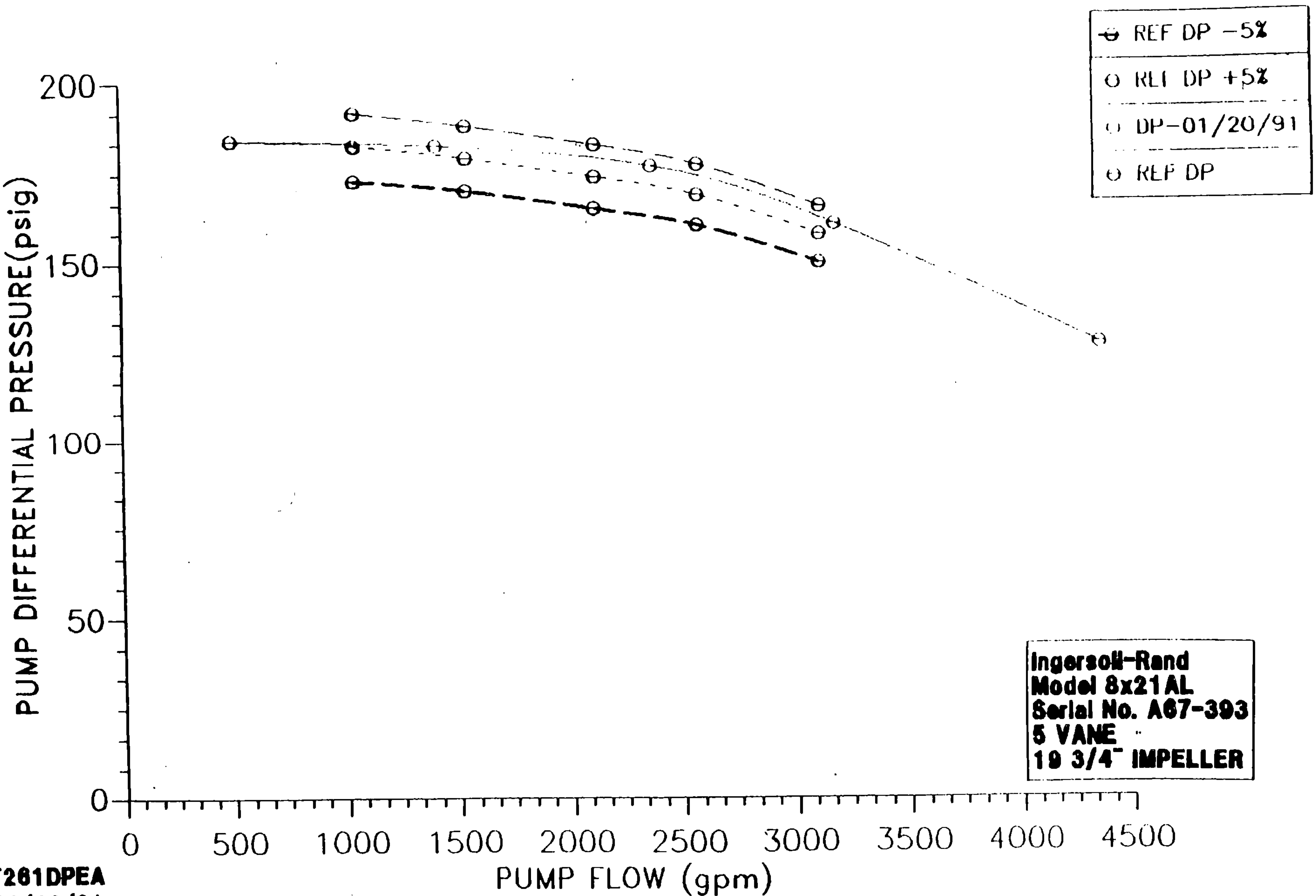
Reviewed By [illegible] Date 1-20-91

950-22[illegible]X



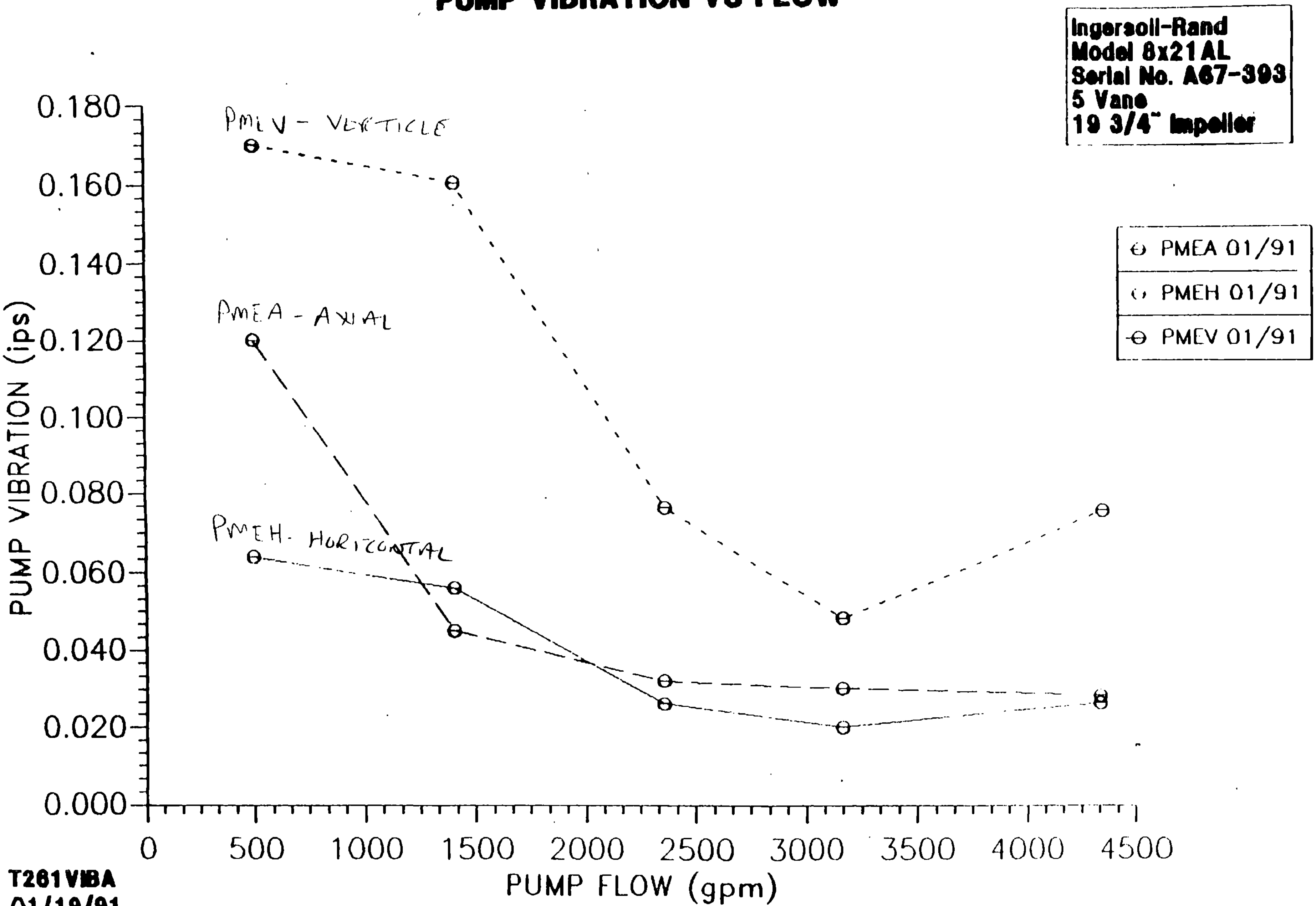
T261DPA
01/19/91

LPSI PUMP P-67A PERFORMANCE CURVES
PUMP DIFFERENTIAL PRESSURE VS REFERENCE DP WITH 5% ERROR BAND



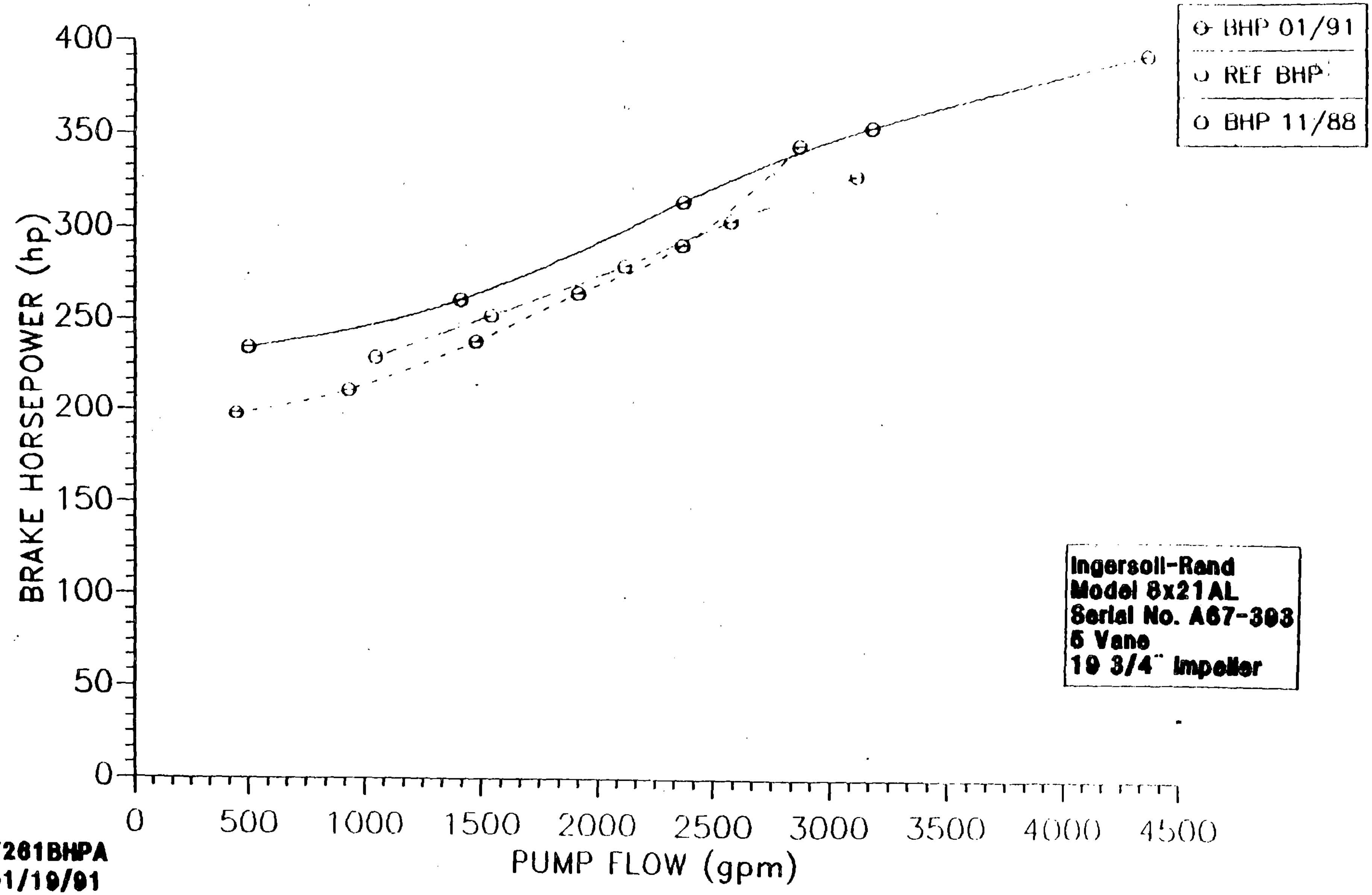
T261DPEA
01/19/91

LPSI PUMP P-67A PERFORMANCE CURVES
PUMP VIBRATION VS FLOW



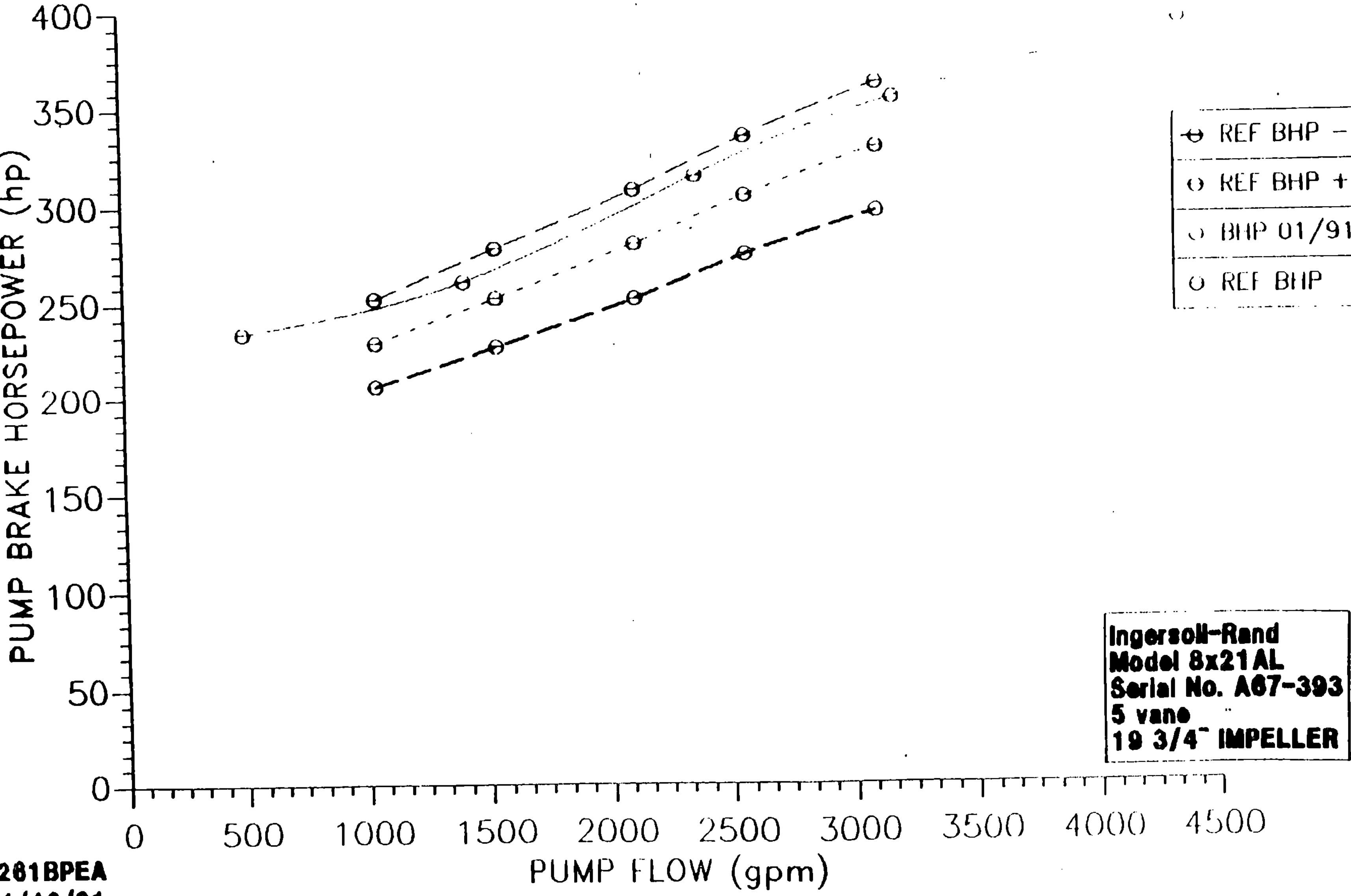
T261VIBA
01/19/91

LPSI PUMP P-67A PERFORMANCE CURVES
BRAKE HORSEPOWER VS FLOW T-261 11/07/88 VS T-261 01/20/91



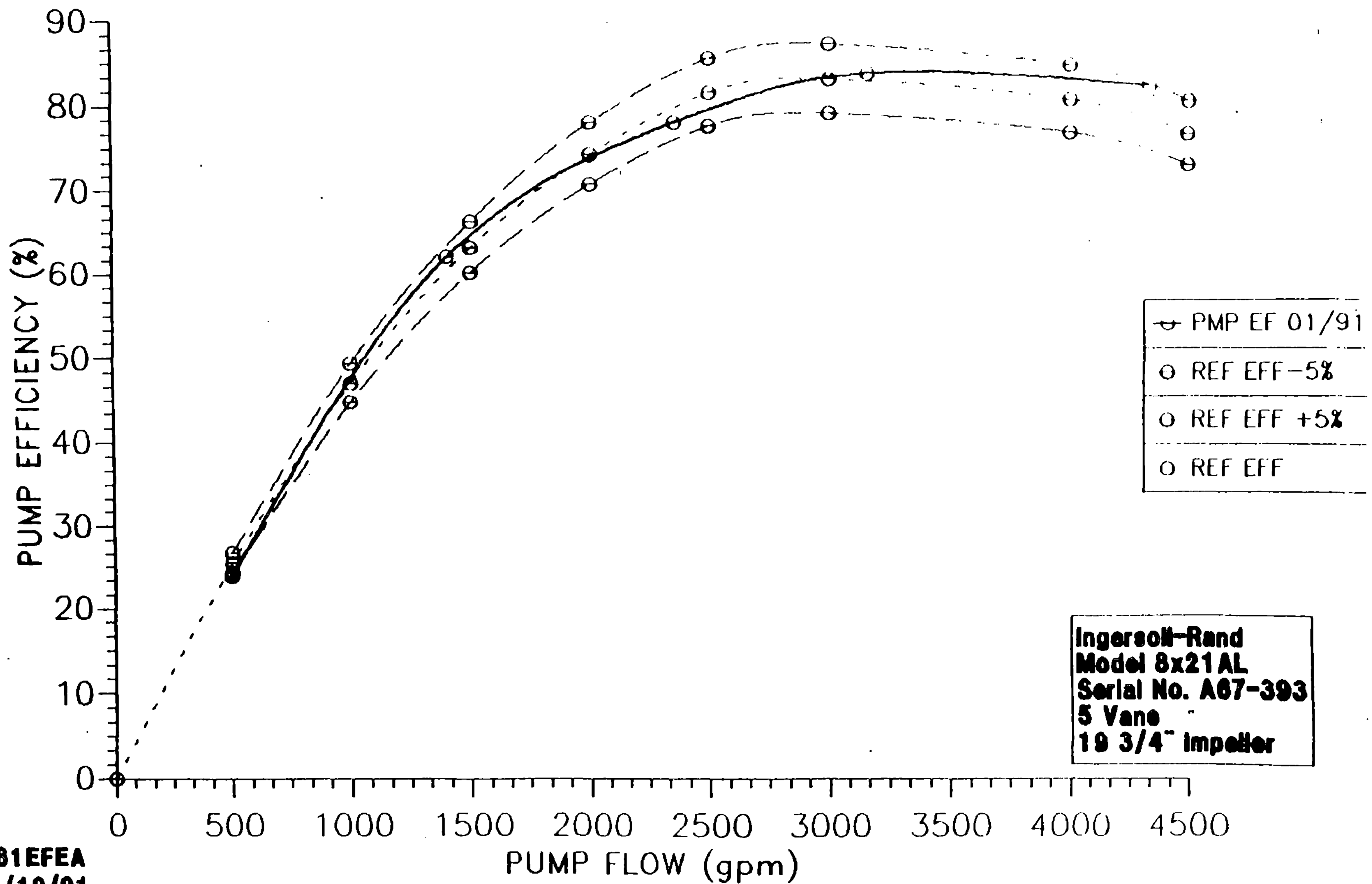
T261BHPA
01/19/91

LPSI PUMP P-67A PERFORMANCE CURVES
PUMP BRAKE HORSEPOWER VS REFERENCE BHP WITH 10% ERROR BAND



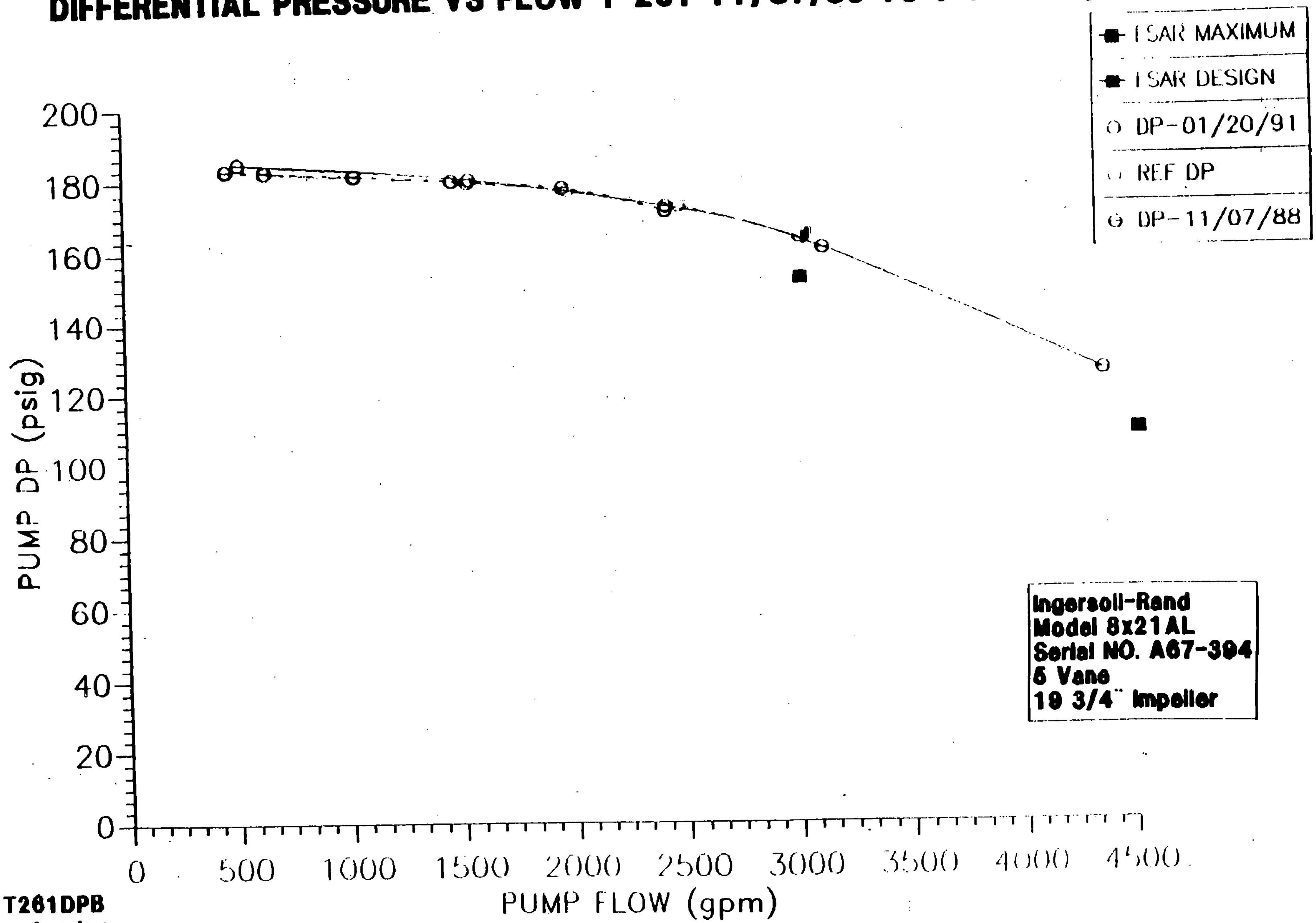
T261BPEA
01/19/91

LPSI PUMP P-67A PERFORMANCE CURVES
PUMP EFFICIENCY VS FLOW WITH 5% ERROR BAND



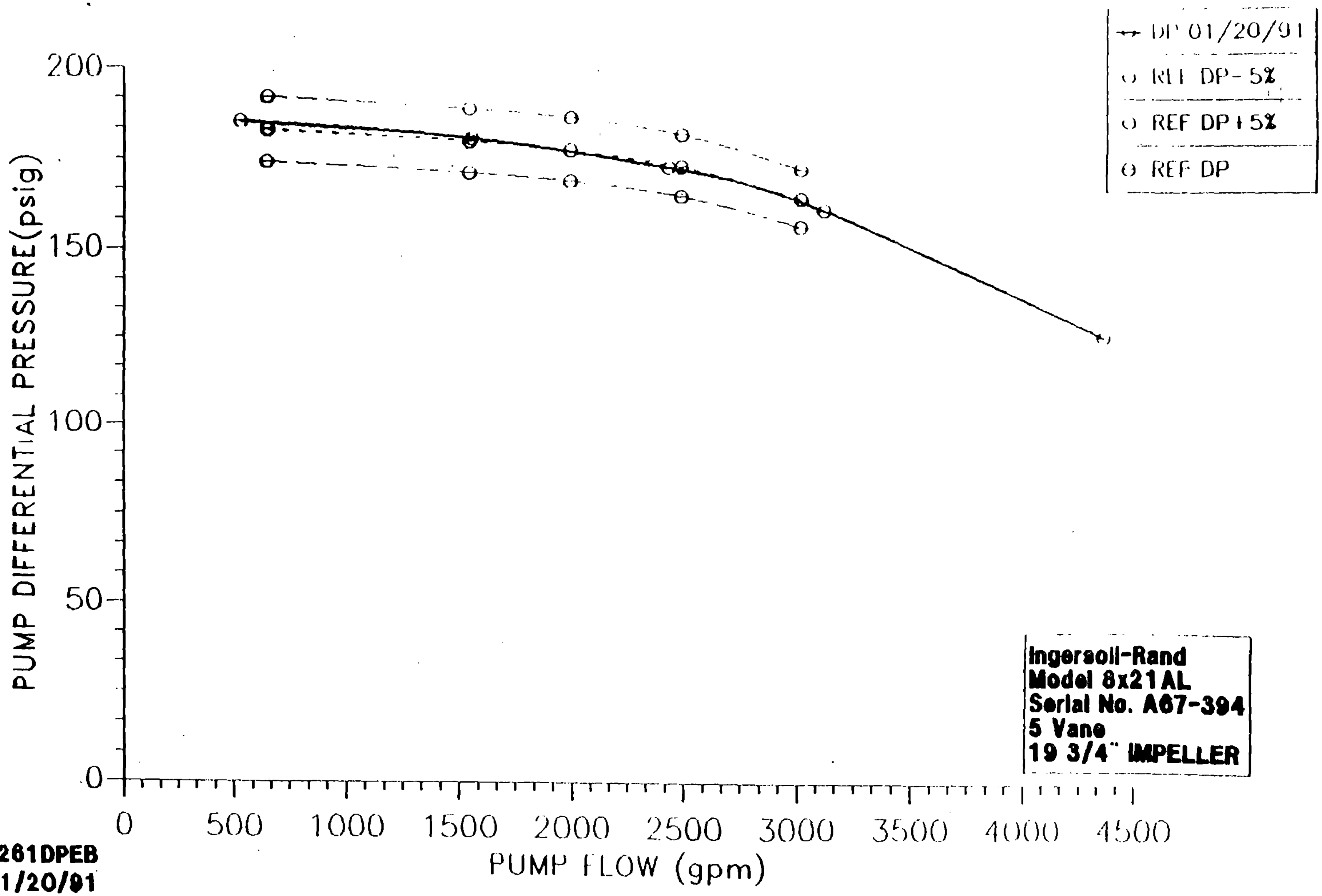
T261EFEA
01/19/91

LPSI PUMP P-67B PERFORMANCE CURVES
DIFFERENTIAL PRESSURE VS FLOW T-261 11/07/88 VS T-261 01/20/91



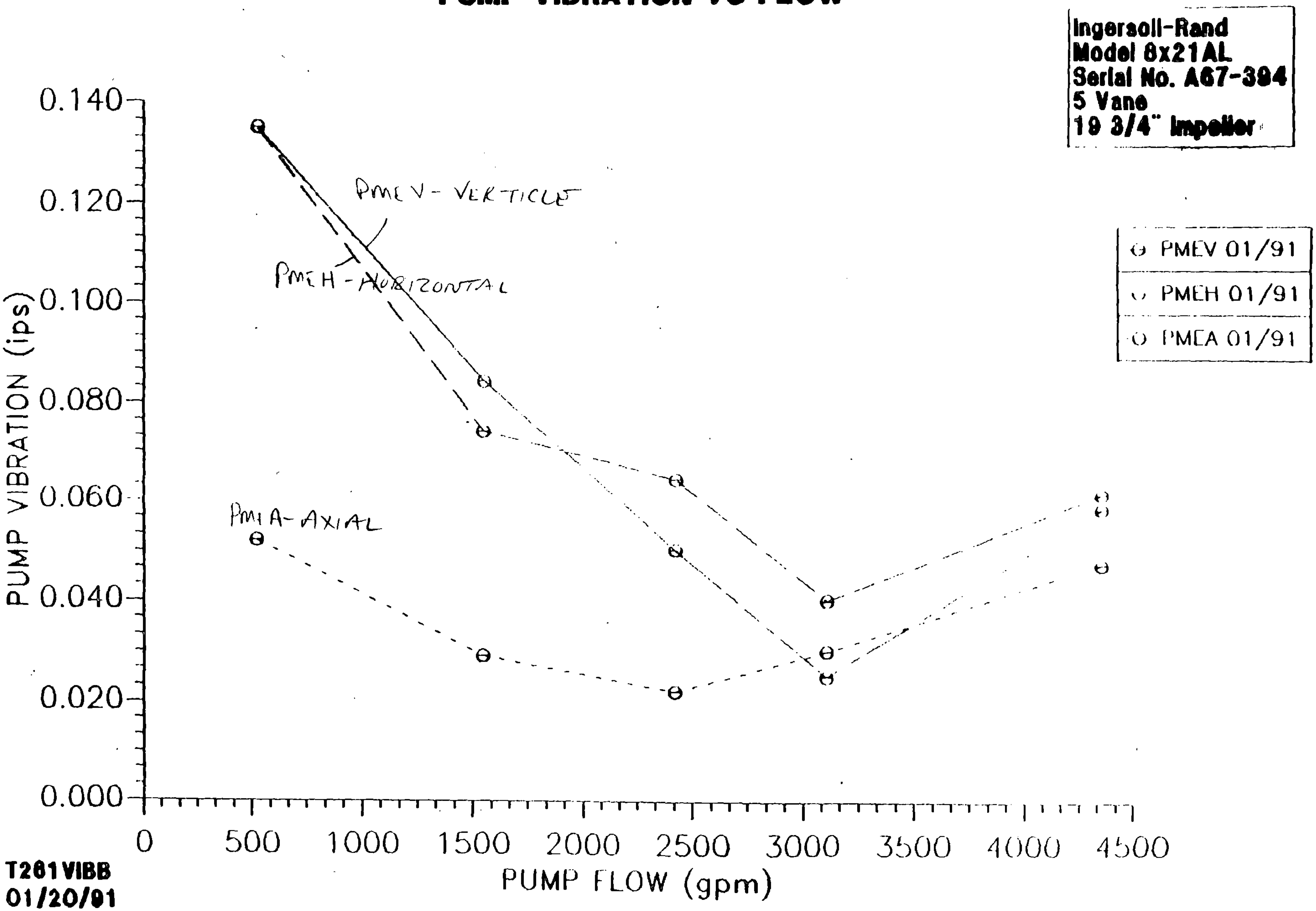
T261DPB
01/20/91

LPSI PUMP P-67B PERFORMANCE CURVES
PUMP DIFFERENTIAL PRESSURE VS REFERENCE DP WITH 5% ERROR BAND



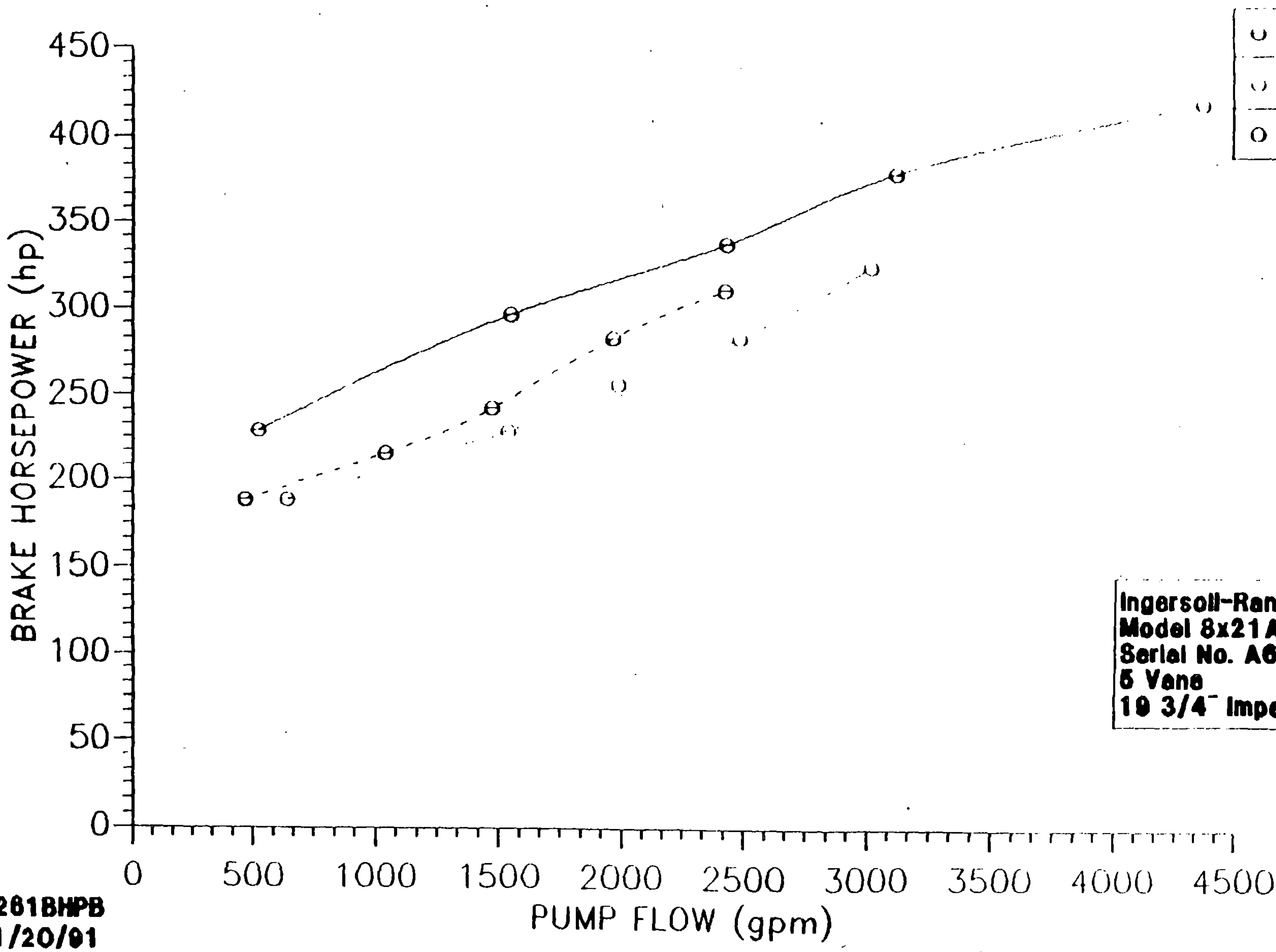
T261DPEB
01/20/91

LPSI PUMP P-67B PERFORMANCE CURVES
PUMP VIBRATION VS FLOW



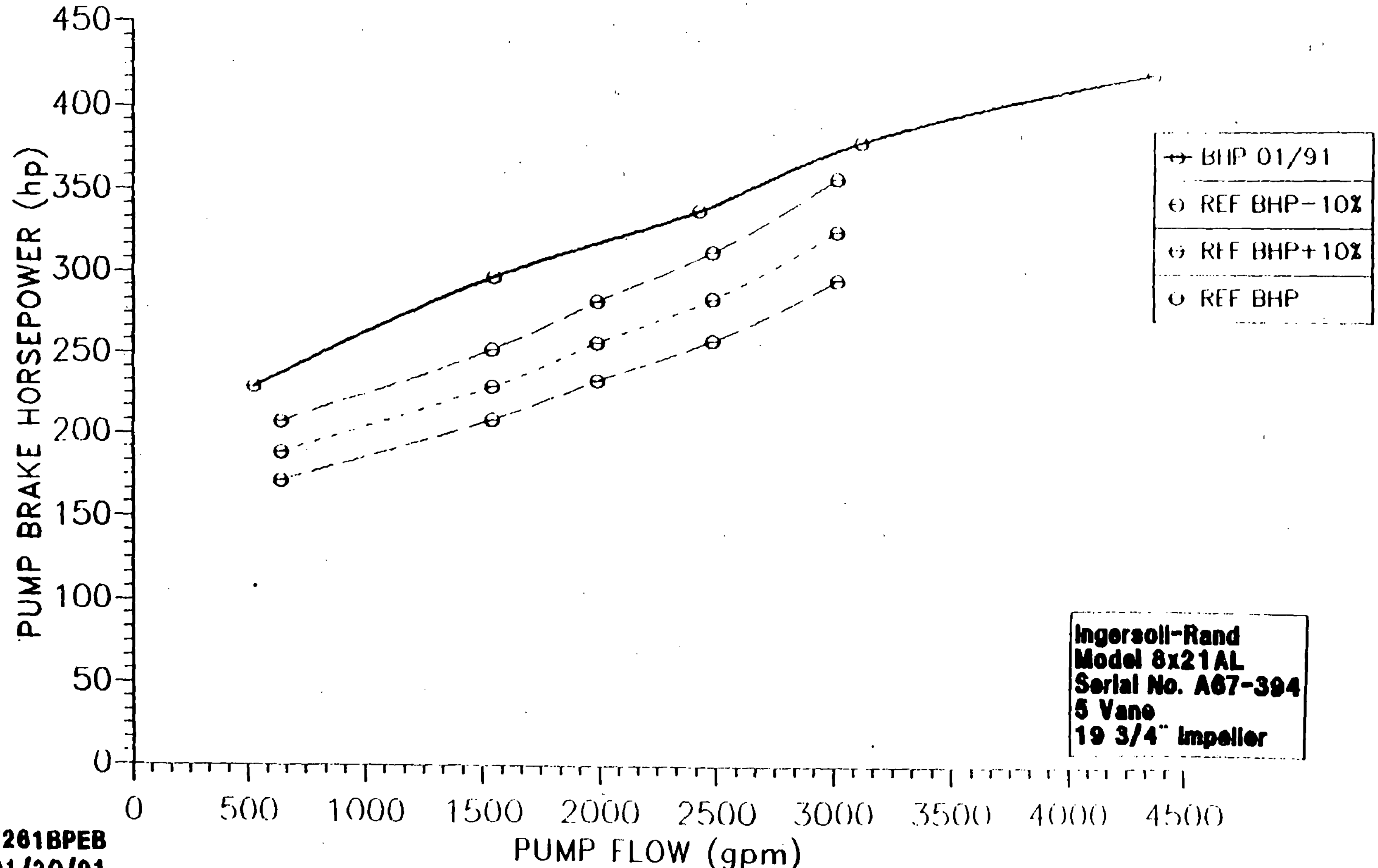
T261VIBB
01/20/91

LPSI PUMP P-67B PERFORMANCE CURVES
BRAKE HORSEPOWER VS T-261 11/07/88 VS T-261 01/20/91



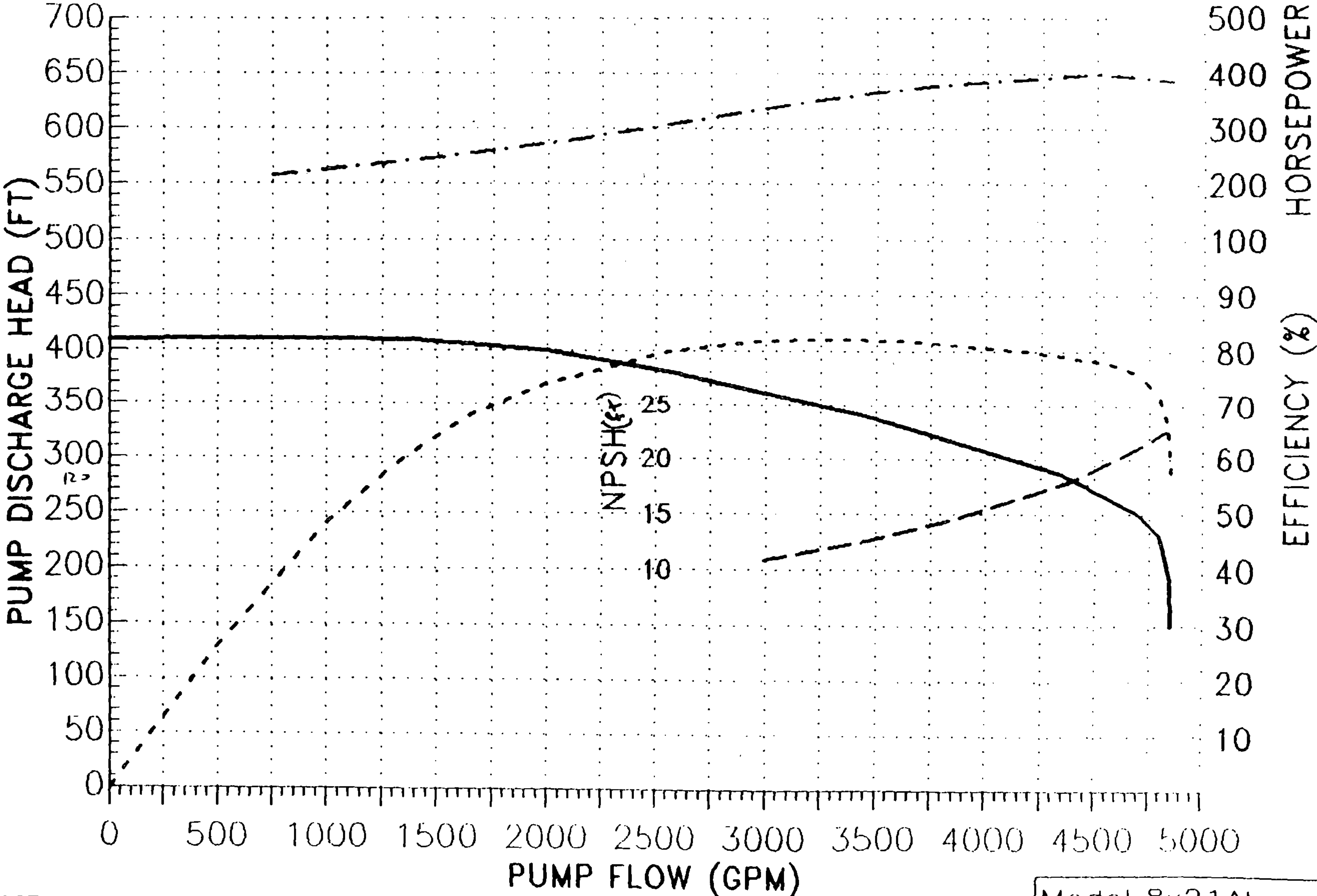
T261BHPB
01/20/91

LPSI PUMP P-67B PERFORMANCE CURVES
PUMP BRAKE HORSEPOWER VS REFERENCE BHP WITH 10% ERROR BAND



T261BPEB
01/20/91

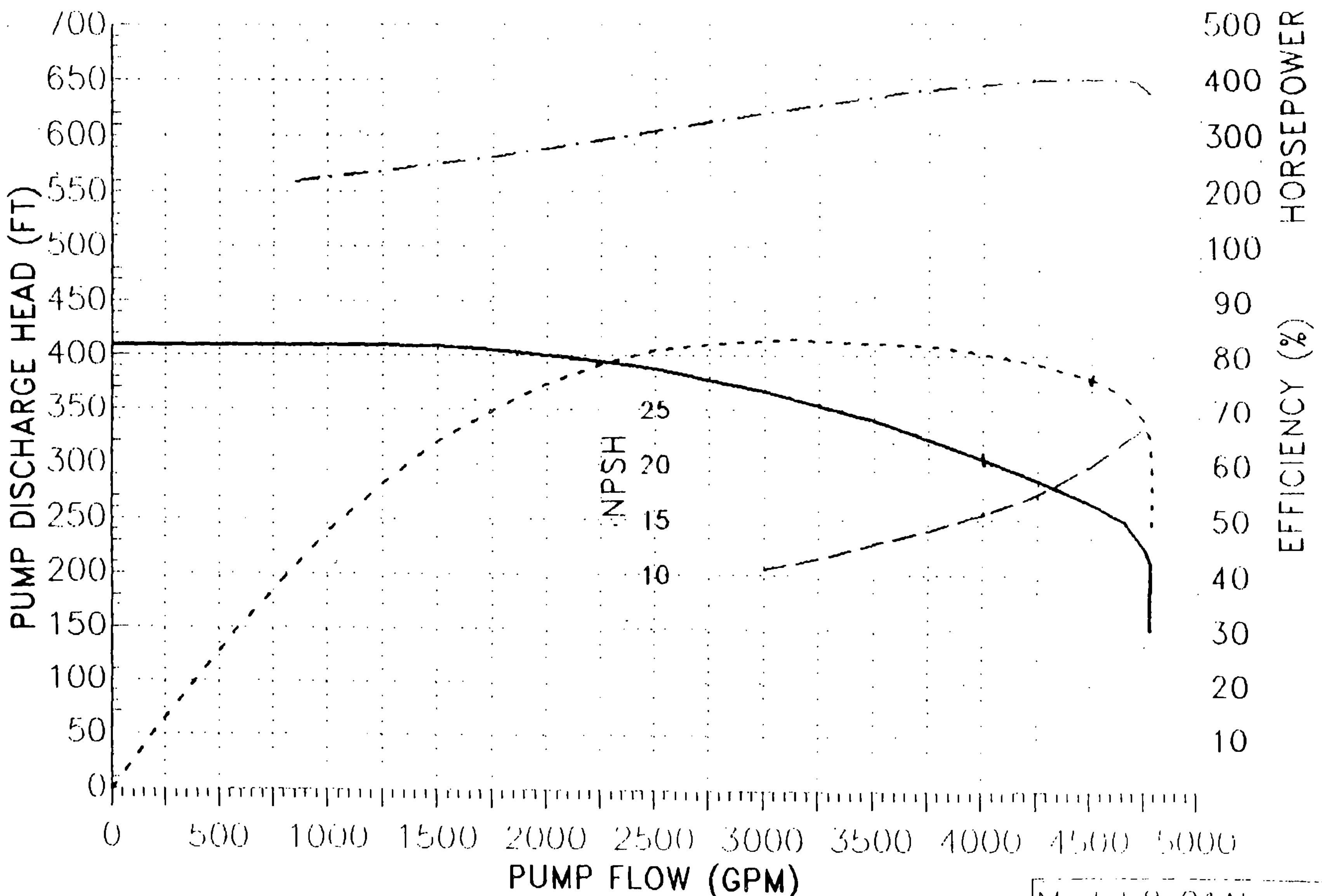
CHARACTERISTIC CURVE, LOW PRESSURE SAFETY INJECTION PUMP P-67B



Ingersoll-Rand Co.

Model 8x21AI
Serial No. A67-394

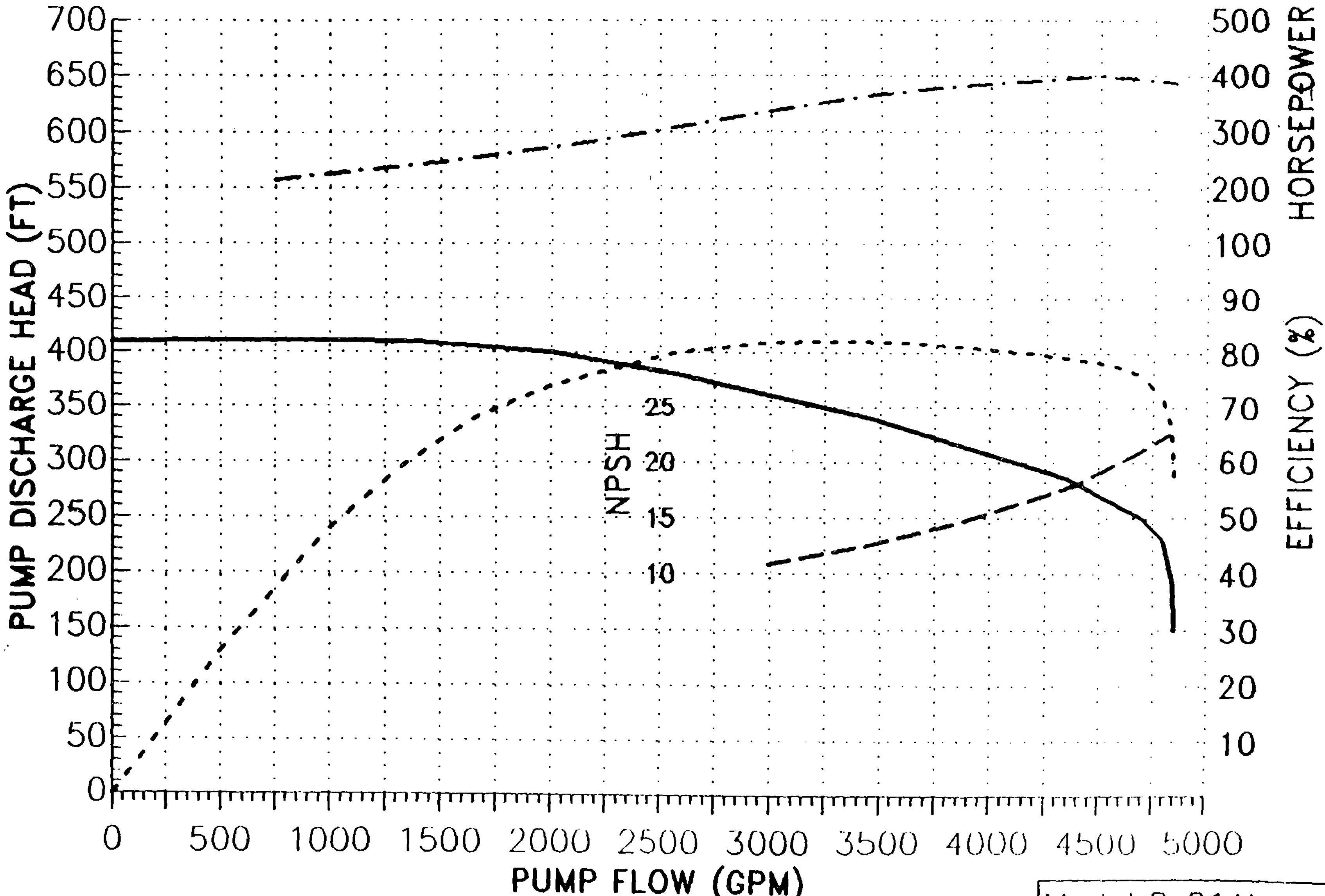
CHARACTERISTIC CURVE, LOW PRESSURE SAFETY INJECTION PUMP P-67A



Ingersoll Rand Co.

Model 8x21AI
Serial No. A67 393

CHARACTERISTIC CURVE, LOW PRESSURE SAFETY INJECTION PUMP P-67B



Ingersoll-Rand Co.

Model 8x21AL
Serial No. A67-394

3.3 Increased motor load –

Based on the nameplate data sheet, G.E. motor model no. 5K 818847A100 full load rating is 92 Amps. (Ref 8)

Selected Result Data from P-67A & P-67B Performance Tests

	P-67A	P-67B (Old Impeller)	P-67B (New Imp)
Date of test	8/18/86	8/14/86	9/10/86
Flow (gpm)	3093	3000	2998.3
Total Head (ft)	362.1	334	376.8
Mtr Current (Amps)	72.9	63.9	72.0
	(Ref 9)	(Ref 10)	(Ref 11)

With the new impeller installed P-67B motor amperage increased from 63.9 to 72 Amps. at full load. Note that P-67B motor current readings compare closely to P-67A for approx same pump flow conditions.

Since relay protection is based on name plate rating, or 92 Amps, there is plenty of reserve margin.

The diesel generator emergency load for large motors is based on actual calculated load instead of nameplate load. From "Summary of Loads During Emergency Conditions" table, the LPSI pump load is 289.27 kW. (Ref 17)

$$\text{LPSI Pump Emer Load} = \frac{289{,}270\ \text{kW}}{\sqrt{3}} \times \frac{1}{2300\text{V}} = 72.6\ \text{Amps}$$

Thus P-67B pump motor under normal max. load is within the actual emergency load.

3.6 Acceptance Criteria

The table below compares the performance of P-67B pump against the FSAR requirements and system design limits. Results of recent tests of P-67B with old impeller and P-67A are included for information only.

	System Design Reqmt/Limit	P-67B (New Imp)	P-67B (Old Imp)	P-67A
Disch Press (psig)	500 (max)	486	N/A	N/A
FSAR rqd head (ft) @ 3000 gpm	350	377	334	362
Mtr Current (Amp)	92 (max) 72.6 max(analysis)	72	63.9	72.9*

*Note: The amp reading for P-67A of 72.9 is extracted from test data and is uncorrected. If corrected for max flow amp reading is less than 72.6

4.0 Conclusion:

The P-67B pump with new, larger, machined impeller is capable of meeting FSAR requirements while operating safely within system design limits. The performance characteristics of P-67B now are about the same as for P-67A. Recent tests demonstrated that the old P-67B impeller was not capable of delivering required pump capacity. Improved performance is attributed to the new machined impeller. The effect of the physical differences of the new impeller have been addressed in this analysis. It is concluded that there is no adverse impact on the pump or discharge portion of the LPSI system as a result of installing the new impeller.

7640 0268

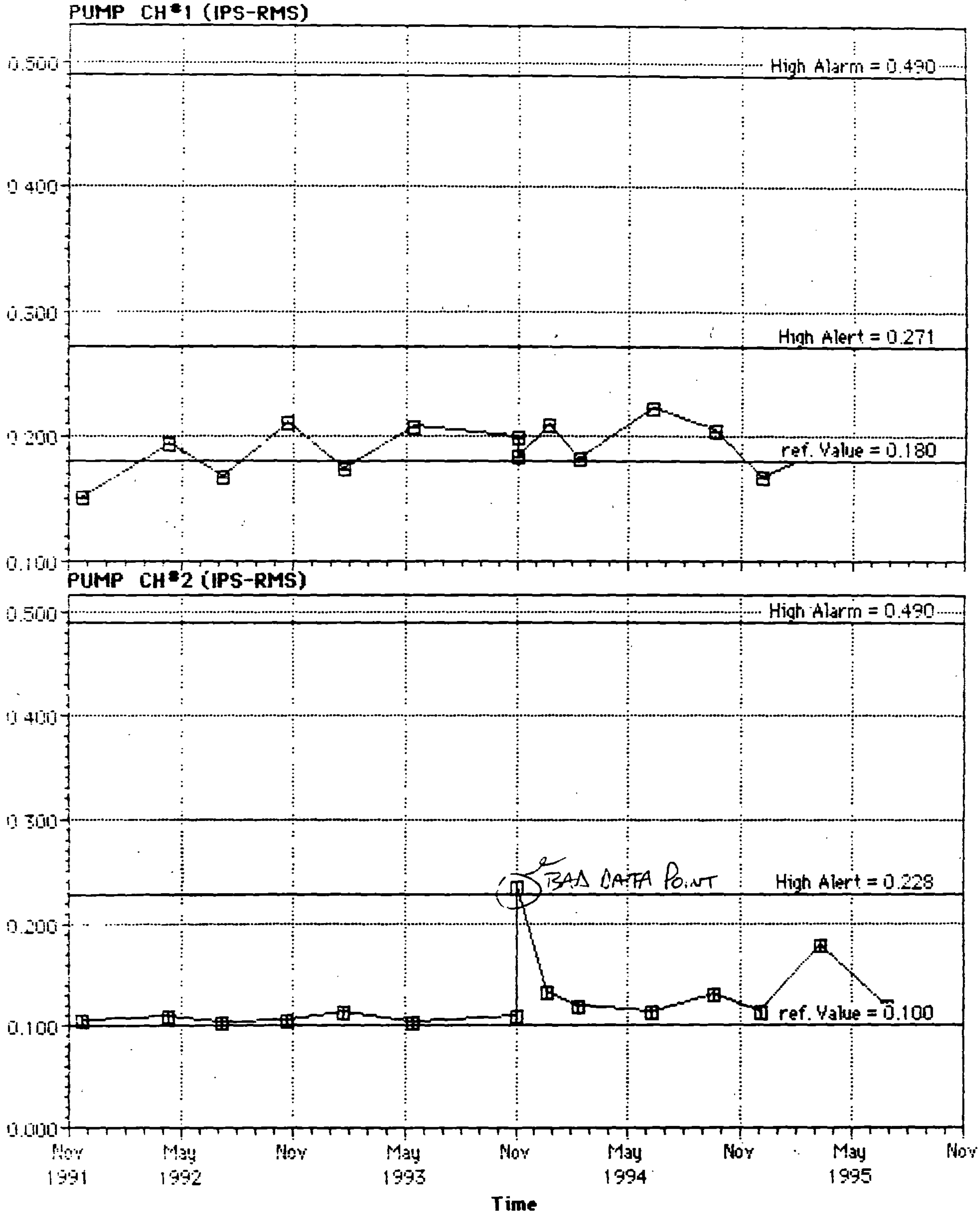
ATTACHMENT 6

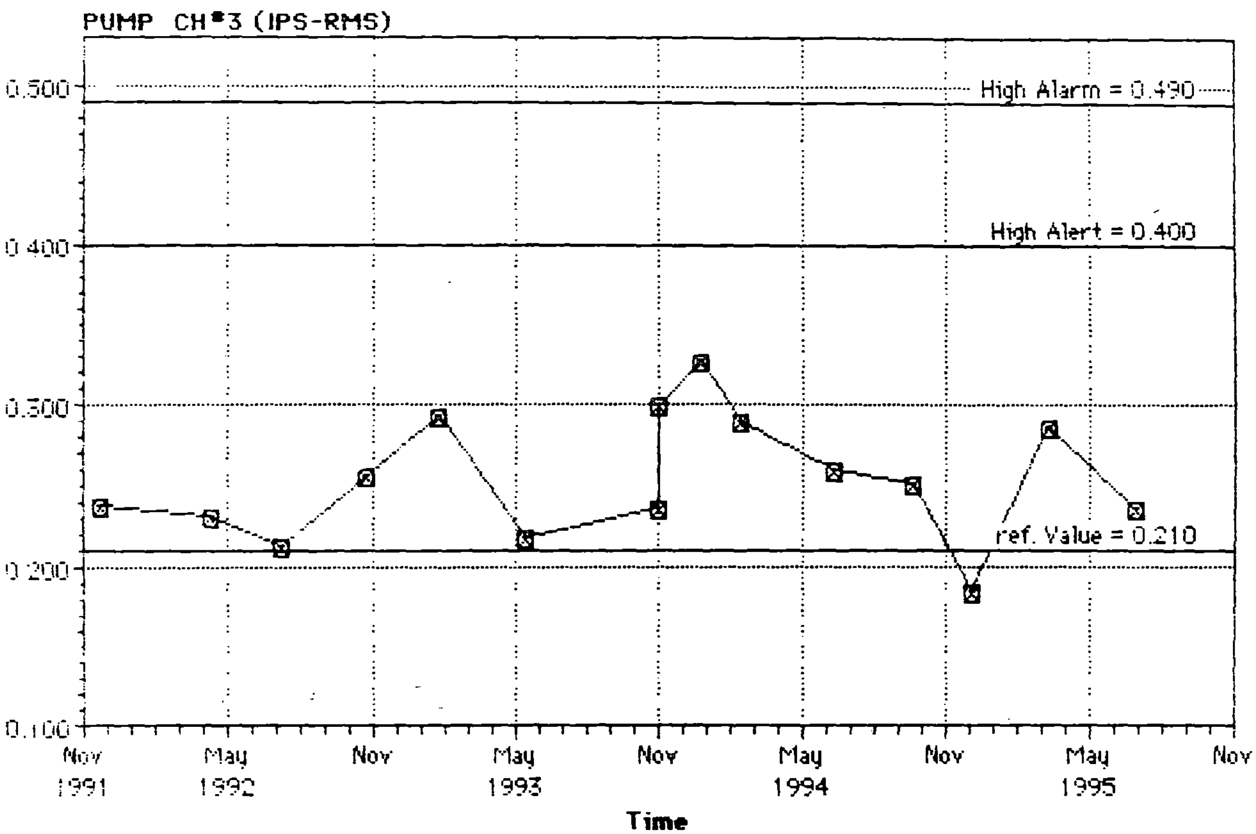
CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

LOW PRESSURE SAFETY INJECTION PUMPS

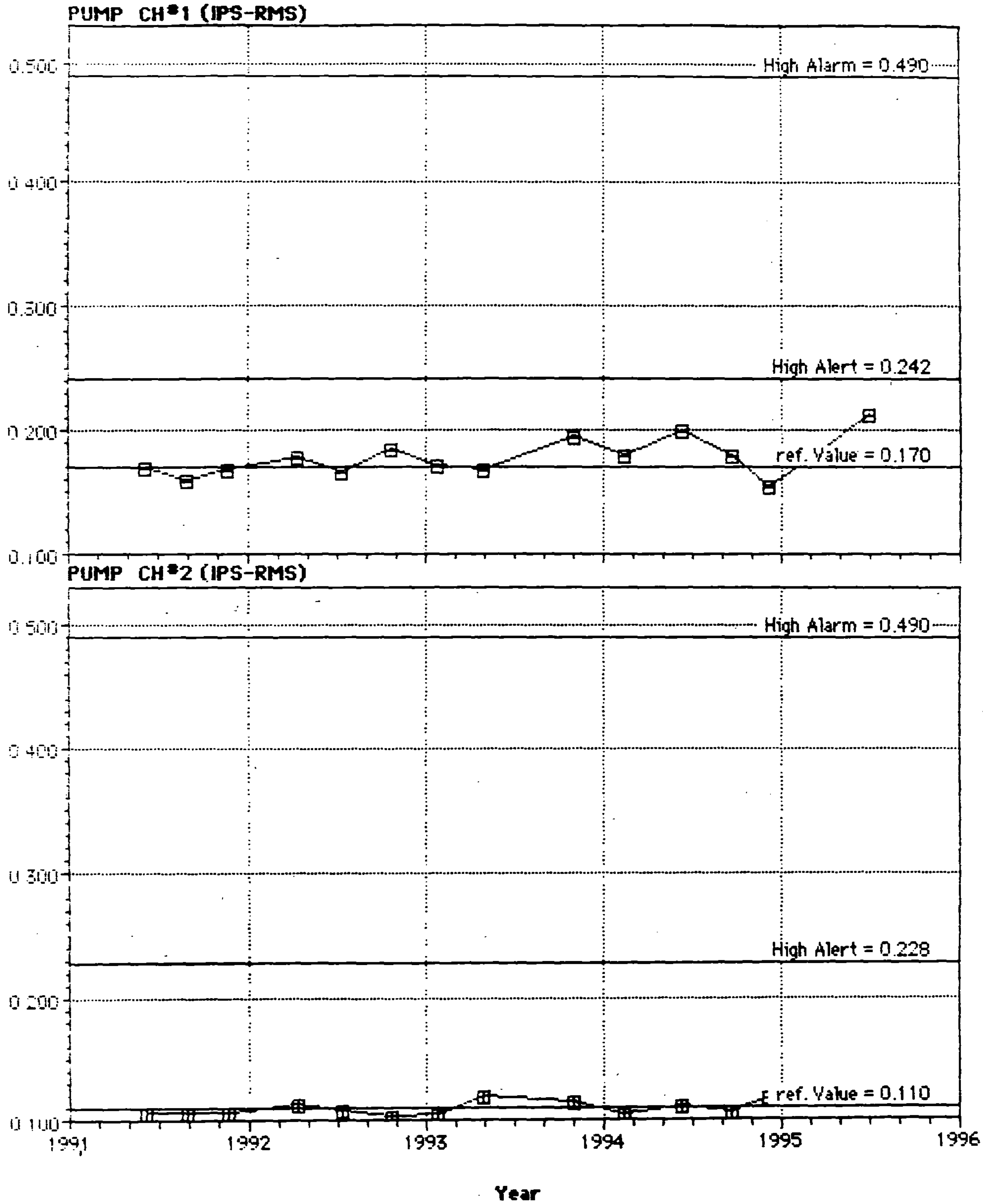
DERIVATION OF VIBRATION ACCEPTANCE LIMITS

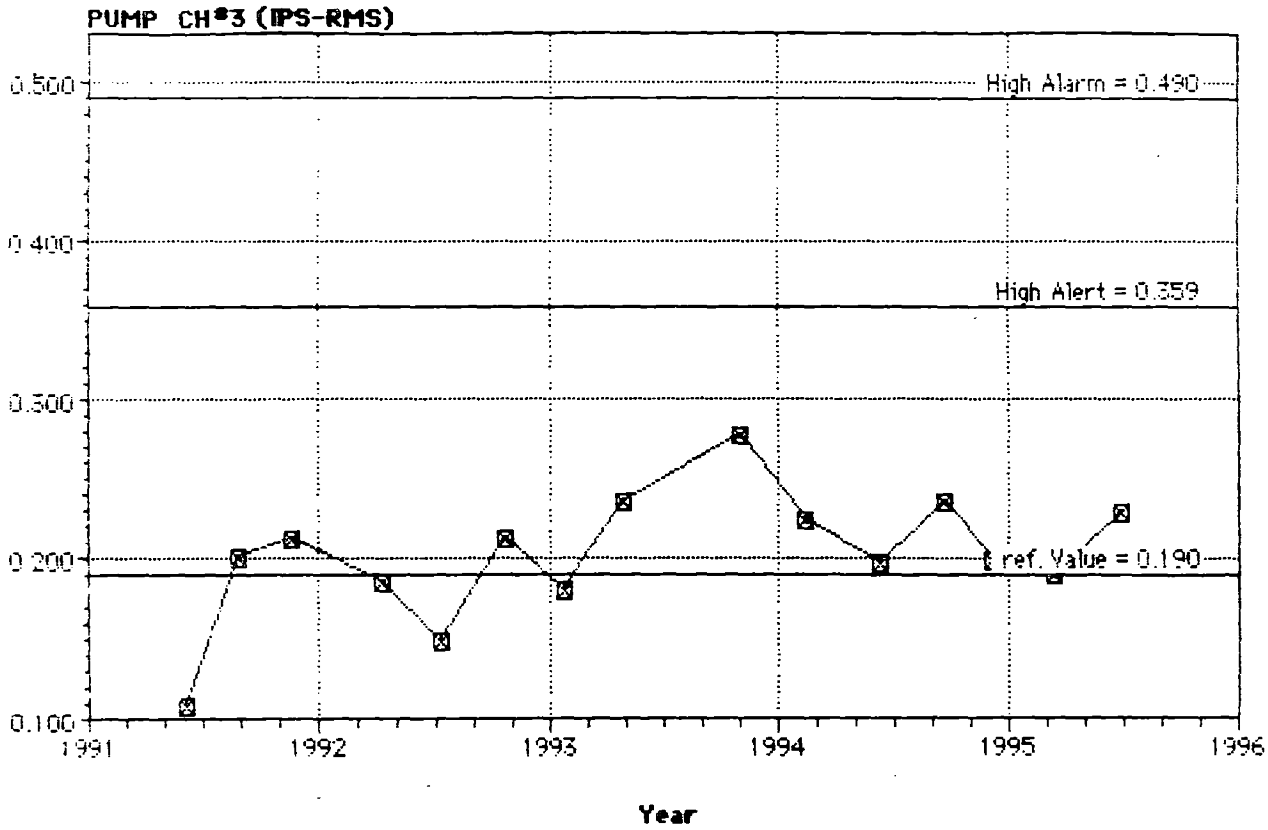
ID: P-67A / QO-20 (PROPOSED)
Location: Aux Bldg, East Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 8:54 AM




PUMP CH#3 (IPS-RMS)
High Alarm = 0.490
High Alert = 0.400
ref. Value = 0.210
0.500
0.400
0.300
0.200
0.100
Nov 1991
May 1992
Nov
May 1993
Nov
May 1994
Nov
May 1995
Nov
Time

ID: P-67B / 00-20 (PROPOSED)
Location: Aux Bldg, West Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 9:05 AM




PUMP CH#3 (IPS-RMS)
High Alarm = 0.490
High Alert = 0.359
ref. Value = 0.190
0.500
0.400
0.300
0.200
0.100
1991
1992
1993
1994
1995
1996
Year

ATTACHMENT 7

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

CONTAINMENT SPRAY PUMPS

PUMP TEST DATA

ID: P-54A / QO-16
Location: Aux Bldg, East Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 9:26 AM

Parameter Statistics

start: '91 May 23
end : '95 Aug 29

Par	Name	Units	No. of Meas. Total Average	Maximum Minimum Range	Stand. Dev. Variance Median
5	PUMP CH#1	IPS-RMS	15 3.495 0.233	0.296 0.200 0.096	0.026 6.986e-4 0.226
6	PUMP CH#2	IPS-RMS	15 1.950 0.130	0.177 0.113 0.064	0.019 3.501e-4 0.124
7	PUMP CH#3	IPS-RMS	15 3.678 0.245	0.284 0.219 0.065	0.020 4.131e-4 0.240

ID: P-54B / QO-16
Location: Aux Bldg, West Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 9:28 AM

Parameter Statistics

start: '91 May 23
end : '95 Aug 29

Par	Name	Units	No. of Meas. Total Average	Maximum Minimum Range	Stand. Dev. Variance Median
5	PUMP CH#1	IPS-RMS	15 3.765 0.251	0.301 0.229 0.072	0.020 4.142e-4 0.247
6	PUMP CH#2	IPS-RMS	15 2.878 0.192	0.271 0.149 0.122	0.028 7.740e-4 0.190
7	PUMP CH#3	IPS-RMS	15 4.498 0.300	0.340 0.253 0.087	0.029 8.342e-4 0.304

H_

ID: P-54C / QO-16
Location: Aux Bldg, West Engineering Safeguards, 570'
Date: Thursday, September 7, 1995 @ 3:48 PM

Parameter Statistics

start: '91 May 23
end : '95 Aug 29

Par	Name	Units	No. of Meas. Total Average	Maximum Minimum Range	Stand. Dev. Variance Median
5	PUMP CH#1	IPS-RMS	15 2.996 0.200	0.233 0.181 0.051	0.014 2.036e-4 0.201
6	PUMP CH#2	IPS-RMS	15 2.164 0.144	0.160 0.105 0.055	0.015 2.167e-4 0.148
7	PUMP CH#3	IPS-RMS	15 3.847 0.256	0.301 0.208 0.093	0.024 5.828e-4 0.268

P-54A / 00-16

Date: '95 Sep 11, 09:21

Location: Aux Bldg, East Engineering Safeguards, 570'

Description: INSERVICE TEST PROCEDURE - CONTAINMENT SPRAY PUMPS

Measurement Values

Meas. No.	Parameter No.	5	6	7
	Name	PUMP CH*1 V	PUMP CH*2 A	PUMP CH*3 H
	Units / Time	IPS-RMS	IPS-RMS	IPS-RMS
1	May 23, 1991	0.226	0.127	0.253
2	Aug 12, 1991	0.213	0.113	0.226
3	Nov 12, 1991	0.213	0.113	0.240
4	Jan 22, 1992	0.211	0.135	0.219
5	Jul 08, 1992	0.265	0.122	0.280
6	Oct 21, 1992	0.200	0.113	0.233
7	Jan 26, 1993	0.231	0.132	0.250
8	Apr 12, 1993	0.204	0.118	0.270
9	Oct 31, 1993	0.245	0.124	0.255
10	Jun 10, 1994	0.218	0.132	0.222
11	Sep 21, 1994	0.257	0.114	0.235
12	Dec 20, 1994	0.296	0.177	0.284
13	Mar 01, 1995	0.221	0.152	0.249
14	Jun 30, 1995	0.241	0.157	0.232
15	Aug 29, 1995	0.253	0.121	0.230

-546 / 00-16 **Date**: '95 Sep 11, 09:24

Location: Aux Bldg, West Engineering Safeguards, 570'

Description: INSERVICE TEST PROCEDURE - CONTAINMENT SPRAY PUMPS

Measurement Values

Parameter No.		5	6	7
Name		PUMP CH#1 V	PUMP CH#2 A	PUMP CH#3 H
Meas. No.	Units / Time	IPS-RMS	IPS-RMS	IPS-RMS
1	May 23, 1991	0.301	0.201	0.338
2	Aug 12, 1991	0.268	0.190	0.338
3	Nov 13, 1991	0.250	0.200	0.340
4	Jan 22, 1992	0.233	0.199	0.304
5	Jul 08, 1992	0.242	0.179	0.253
6	Oct 21, 1992	0.255	0.149	0.253
7	Jan 18, 1993	0.247	0.164	0.280
8	Apr 13, 1993	0.267	0.174	0.290
9	Oct 31, 1993	0.230	0.165	0.286
10	Jun 10, 1994	0.229	0.184	0.307
11	Sep 21, 1994	0.239	0.190	0.289
12	Dec 20, 1994	0.235	0.201	0.275
13	Mar 02, 1995	0.267	0.200	0.308
14	Jun 30, 1995	0.270	0.271	0.334
15	Aug 29, 1995	0.232	0.211	0.304

[illegible]-54C / Q0-16 **Date:** '95 Sep 11,09:27

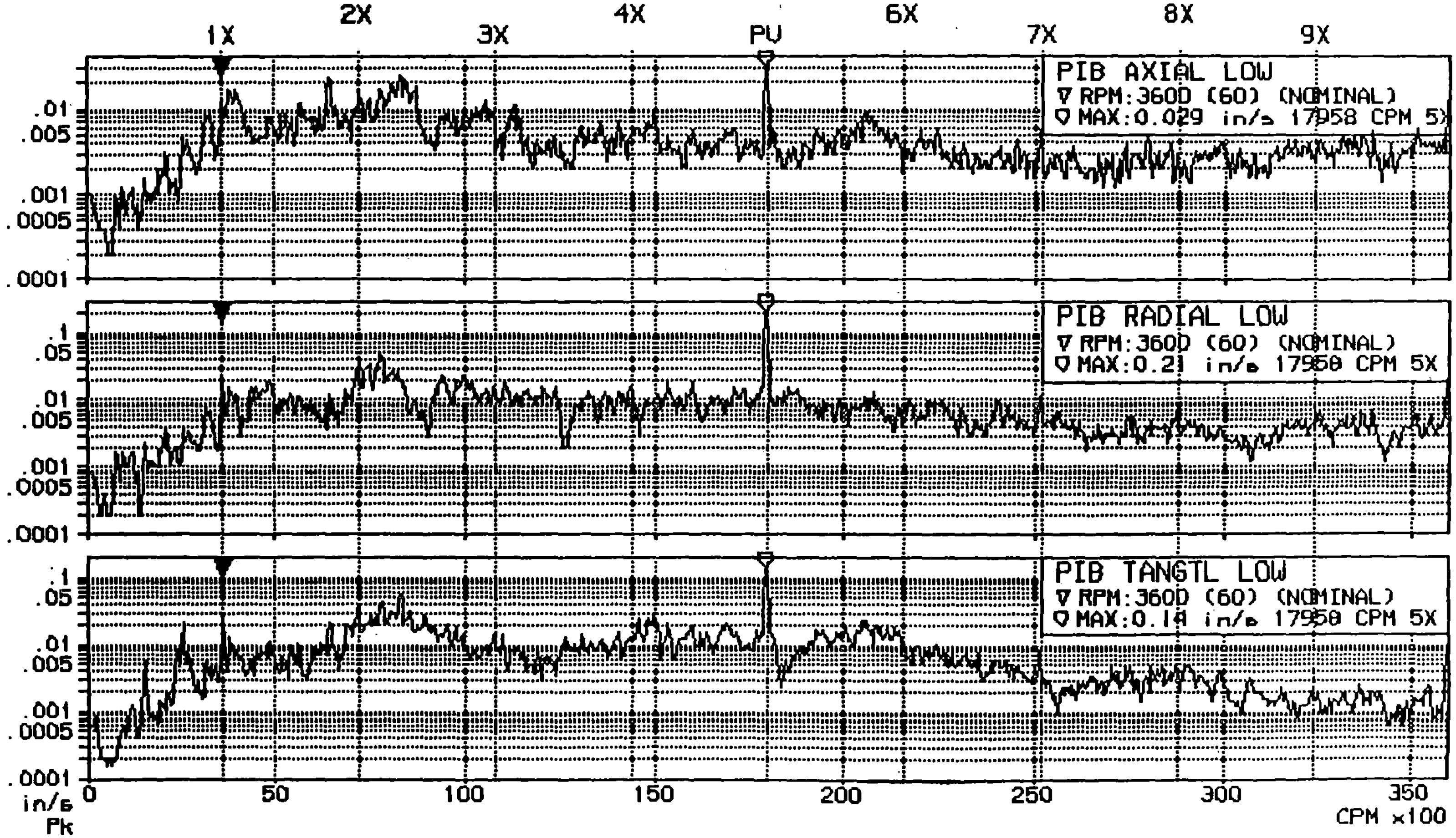
Location: Aux Bldg, West Engineering Safeguards, 570'

Description: INSERVICE TEST PROCEDURE - CONTAINMENT SPRAY PUMPS

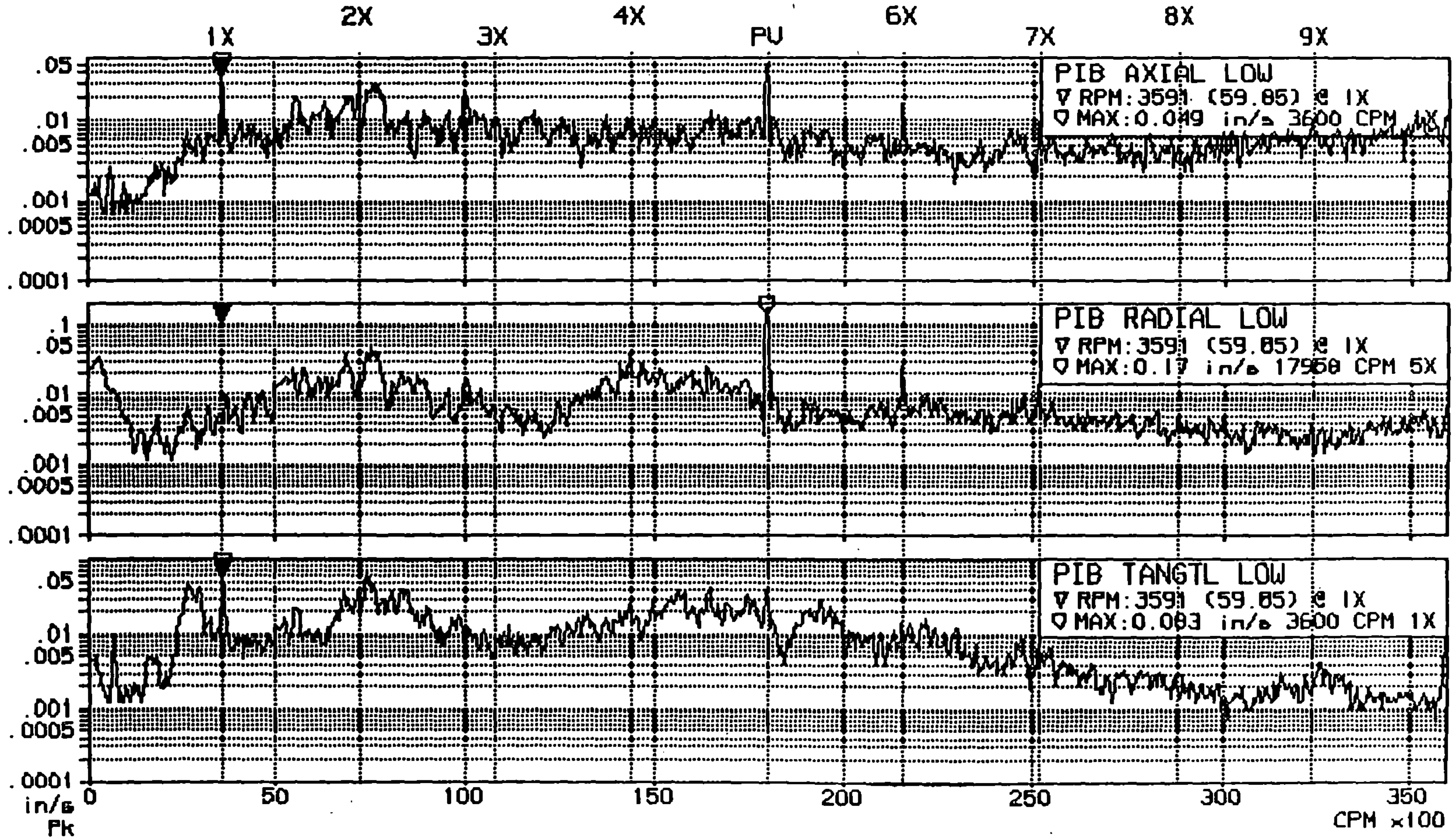
Measurement Values

Parameter No.		5	6	7
Name		PUMP CH#1 V	PUMP CH#2 A	PUMP CH#3 H
Meas No.	Units / Time	IPS-RMS	IPS-RMS	IPS-RMS
1	May 23, 1991	0.190	0.160	0.301
2	Aug 12, 1991	0.213	0.135	0.268
3	Nov 14, 1991	0.190	0.160	0.268
4	Jan 22, 1992	0.217	0.157	0.245
5	Jul 09, 1992	0.205	0.147	0.270
6	Oct 21, 1992	0.191	0.136	0.264
7	Jan 19, 1993	0.201	0.135	0.252
8	Apr 14, 1993	0.188	0.151	0.277
9	Oct 31, 1993	0.181	0.131	0.268
10	Jun 10, 1994	0.233	0.154	0.269
11	Sep 21, 1994	0.185	0.137	0.269
12	Dec 21, 1994	0.208	0.148	0.221
13	Mar 05, 1995	0.206	0.150	0.208
14	Jun 30, 1995	0.186	0.105	0.236
15	Aug 29, 1995	0.203	0.158	0.231

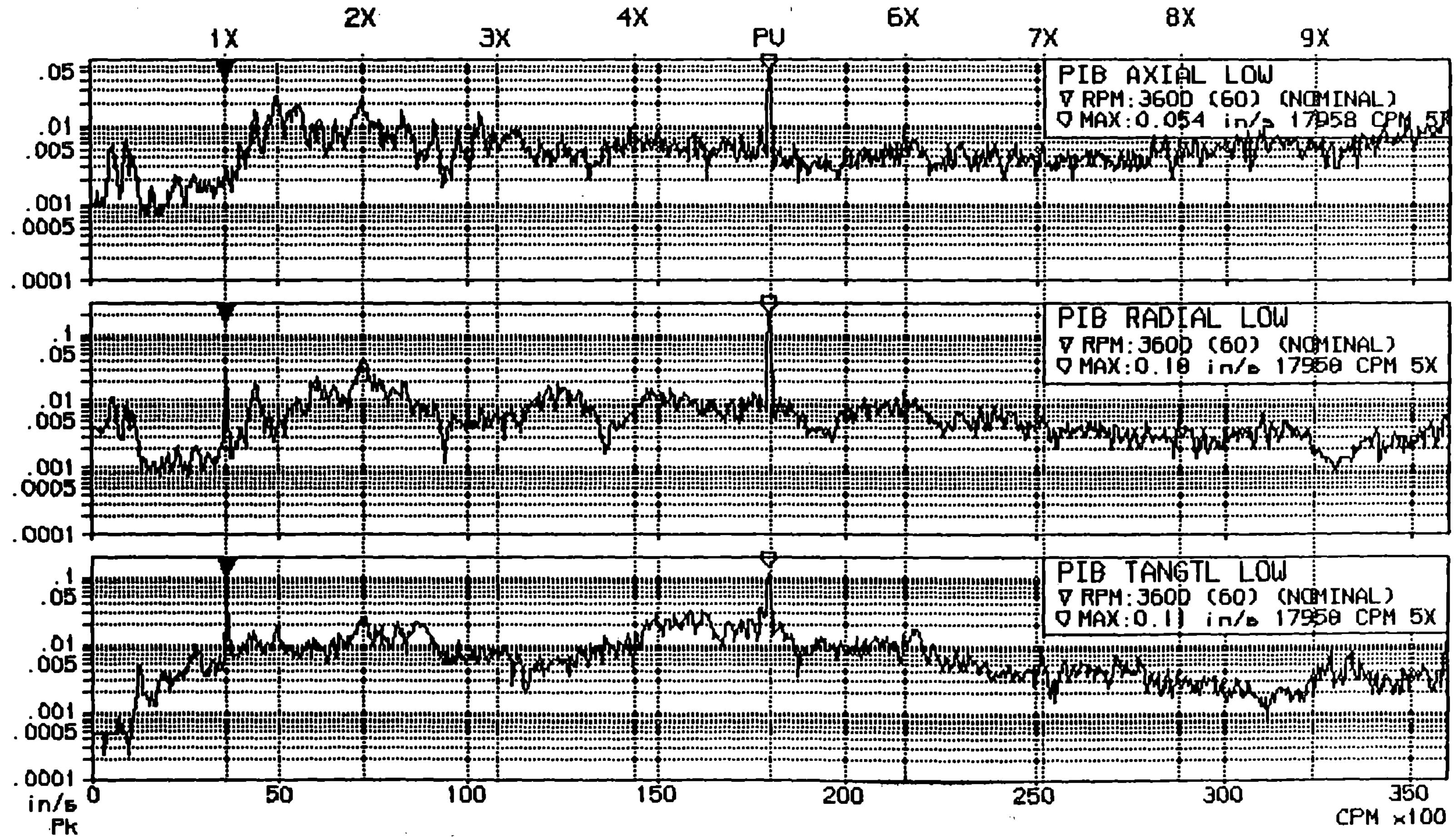
PLANT: CONSUMERS POWER - PAL   AREA: PLANT NOT INCLUDING COOLING TOWERS 30Aug95
MACHINE: P-54A CONTAINMENT SPRAY PUMP [OK]   MID: 44
LOCATION: PUMP INBOARD [3AL]   DATE: 1 Mar 1995/19:35:09 RPM: 3600
LEGEND: 1 Mar 1995
FREQ: 3600 CPM   ORDER: 1 X   LEVEL: .0131 in/s



PLANT: CONSUMERS POWER - PAL   AREA: PLANT NOT INCLUDING COOLING TOWERS   30Aug95
MACHINE: P-54B CONTAINMENT SPRAY PUMP [OK]   MID: 44
LOCATION: PUMP INBOARD [3AL]   DATE: 2 Mar 1995/13:35:33   RPM: 3600
LEGEND: 2 Mar 1995
FREQ: 3600 CPM   ORDER: 1 X   LEVEL: .0495 in/s



PLANT: CONSUMERS POWER - PAL AREA: PLANT NOT INCLUDING COOLING TOWERS 30Aug95
MACHINE: P-54C CONTAINMENT SPRAY PUMP [MOD] MID: 44
LOCATION: PUMP INBOARD [3AL] DATE: 18 Jul 1995/02:23:29 RPM: 3600
LEGEND: 18 Jul 1995
FREQ: 3600 CPM ORDER: 1 X LEVEL: .00311 in/s



ID: P-54A QO-10 **Date:** '95 Aug 29,15:41
Location:
Description: CONTAINMENT SPRAY AND LPSI CHECK VALVE TEST

Measurement Values

Parameter No.		6	12	13	14
Name		TEST FLOW	PMP CH#1	PMP CH#2	PMP CH#3
Meas. No.	Units / Time	RATE GPM	IPS-RMS V	IPS-RMS A	IPS-RMS H
4	Feb 11, 1991	1007	0.160	0.067	0.179
5	Apr 07, 1992	1007	0.131	0.062	0.155

ID: P-54A QO-10 **Date:** '95 Aug 29,15:44
Location:
Description: CONTAINMENT SPRAY AND LPSI CHECK VALVE TEST

Measurement Values

Parameter No.		15	16	17	18	19	20
Name		MTR CH #1 V	MTR CH#2 A	MTR CH#3 H	MTR CH#1 V	MTR CH#2 A	MTR CH#3 H
Meas. No.	Units / Time	P-IPS-~~RMS~~ (IN BOARD) →	P-IPS-RMS	P-IPS-RMS	M-IPS-RMS (OUT BOARD) →	M-IPS-RMS	M-IPS-RMS
4	Feb 11, 1991	0.054	0.060	0.101	0.043	0.067	0.101
5	Apr 07, 1992	0.045	0.047	0.090	0.042	0.041	0.110

ID: P-54B Q0-10 **Date:** '95 Aug 29,15:50

Location:

Description: CONTAINMENT SPRAY AND LPSI CHECK VALVE TEST

Measurement Values

Parameter No.		6	12	13	14
Name		TEST FLOW	PMP CH#1 V	PMP CH #2 A	PMP CH#3 H
Meas. No.	Units / Time	RATE GPM	IPS-RMS	IPS-RMS	IPS-RMS
4	Feb 11, 1991	992	0.160	0.101	0.213
5	Apr 07, 1992	1005	0.140	0.100	0.180

ID: P-54B Q0-10 **Date:** '95 Aug 29,15:52

Location:

Description: CONTAINMENT SPRAY AND LPSI CHECK VALVE TEST

Measurement Values

Parameter No.		15	16	17	18	19	20
Name		MTR CH#1 (INBOARD)	MTR CH#2	MTR CH#3 →	MTR CH#1 (OUTBOARD)	MTR CH#2	MTR CH#3 →
Meas. No.	Units / Time	V P-IPS-RMS	A P-IPS-RMS	H P-IPS-RMS	V M-IPS-RMS	A M-IPS-RMS	H M-IPS-RMS
4	Feb 11, 1991	0.028	0.076	0.041	0.036	0.071	0.038
5	Apr 07, 1992	0.028	0.076	0.036	0.037	0.072	0.038

ID: P-54C Q0-10

Date: '95 Aug 29,15:55

Location:

Description: CONTAINMENT SPRAY AND LPSI CHECK VALVE TEST

Measurement Values

Parameter No.		6	12	13	14
Name		TEST FLOW	PMP CH*1 V	PMP CH*2 A	PMP CH*3 H
Meas. No.	Units / Time	RATE GPM	IPS-RMS	IPS-RMS	IPS-RMS
4	Feb 11, 1991	1010	0.127	0.090	0.160
5	Apr 07, 1992	999	0.118	0.072	0.142

ID: P-54C Q0-10

Date: '95 Aug 29,15:57

Location:

Description: CONTAINMENT SPRAY AND LPSI CHECK VALVE TEST

Measurement Values

Parameter No.		15	16	17	18	19	20
Name		MTR CH*1 V	MTR CH*2 A	MTR CH*3 H	MTR CH*1 V	MTR CH*2 A	MTR CH*3 H
Meas. No.	Units / Time	P-IPS-RMS (INBOARD) →	P-IPS-RMS	P-IPS-RMS	M-IPS-RMS (OUTBOARD) →	M-IPS-RMS	M-IPS-RMS
4	Feb 11, 1991	0.113	0.151	0.134	0.054	0.151	0.107
5	Apr 07, 1992	0.099	0.207	0.123	0.060	0.184	0.111

ATTACHMENT 8

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

CONTAINMENT SPRAY PUMPS

PERFORMANCE TEST QO-10 RESULTS AND EVALUATION OF FEBRUARY 1991

To:	KV Cedarquist	CONSUMERS POWER COMPANY
From:	AA Alatalo	
Date:	**March 11, 1991**	Internal Correspondence
Subject:	P-54's Vibration Status	
CC:	RP Margol TC Saarela	AAA 91*012

The latest set of QO-10 Surveillance Testing on P-54's taken on February 11, showed four vibration measurements in the surveillance's alert category. Two were on the pump horizontal and vertical of P-54A, and two were on the motor inboard and outboard axial of P-54C. There are several potential causes for the values being in alert status. First, this was the initial set of data obtained using the new DLI Watchman vibration data collector system. With a different instrument and accelerometers some variation is likely. Second, this was the first set of data taken in velocity RMS readings. Previous limits had been set in mils based on use of a TK-80 vibration meter. These limits were revised based on a theoretical conversion of mils to velocity, assuming a simple vibration signal. If there are significant amplitudes at frequencies other than running speed, a complex signal results, causing some inaccuracies in this conversion. A third potential cause for some of the changes could have been the change in location of the readings. This occurred as a result of the use of a single point triaxial accelerometer in the DLI system. Finally, maintenance was performed on P-54A and P-54C since the last QO-10. On P-54A, a new impeller, shaft, and bearings were installed and the unit was realigned. P-54C was also realigned. Any of the above changes could cause normal variations in vibration level. With all of these combined occurring, there was a high probability of variations.

Even though vibration values were in the surveillance alert range, data gathered on February 11 during QO-10 Surveillance testing, indicates that the P-54's appear to be mechanically sound. The largest overall velocity reading was .21 inches per second rms (.3 ips peak) on P-54B (See Attachment 1). This is an acceptable valuable per industry standards. The vibration signatures on P-54A (See Attachment 2) indicate primarily a normal impeller vane pass frequency. Vibration values on P-54C motor (See Attachment 1) are somewhat higher than the other two motors, as was the case in previous QO- 16 tests. A small amount of motor looseness was indicated by signatures (See Attachment 2). This was also seen in previous QO-16 tests and when the motor was tested uncoupled on 12-14-90. This does not appear to be a serious nor escalating problem at this time.

Based on the above, it is recommended that a new vibration baseline be established for P-54's for QO-10 using the February 11 data. In addition a new baseline should also be established for the next QO-16 test using the rms velocity readings taken during the next test. No need is seen for increased surveillance testing of these pumps at this time.

ATTACHMENT 1

VIBRATION MEASUREMENTS FOR QO-10

ON FEBRUARY 11, 1991

(VELOCITY -IPS RMS)

	P-54A	P-54B	P-54C
Pump Horizontal	.16	.16	.13
Pump Axial	.07	.10	.09
Pump Vertical	.18	.21	.16
Motor Inboard Horizontal	.05	.03	.11
Motor Inboard Axial	.06	.08	.15
Motor Inboard Vertical	.10	.04	.13
Motor Outboard Horizontal	.04	.04	.05
Motor Outboard Axial	.07	.07	.15
Motor Outboard Vertical	.10	.04	.11

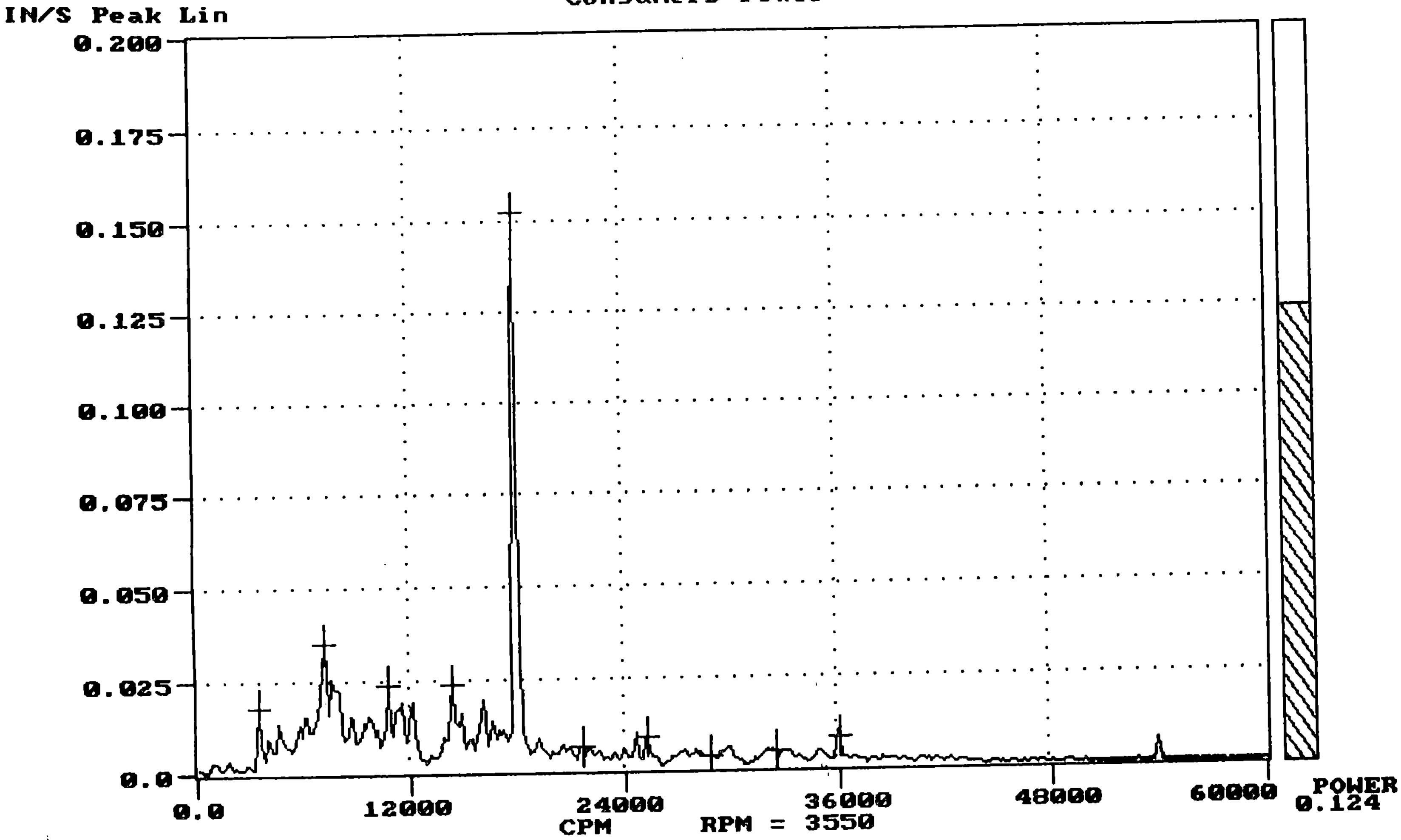
ATTACHMENT 2

P-54'S VIBRATION SIGNATURES

FEBRUARY 11, 1991

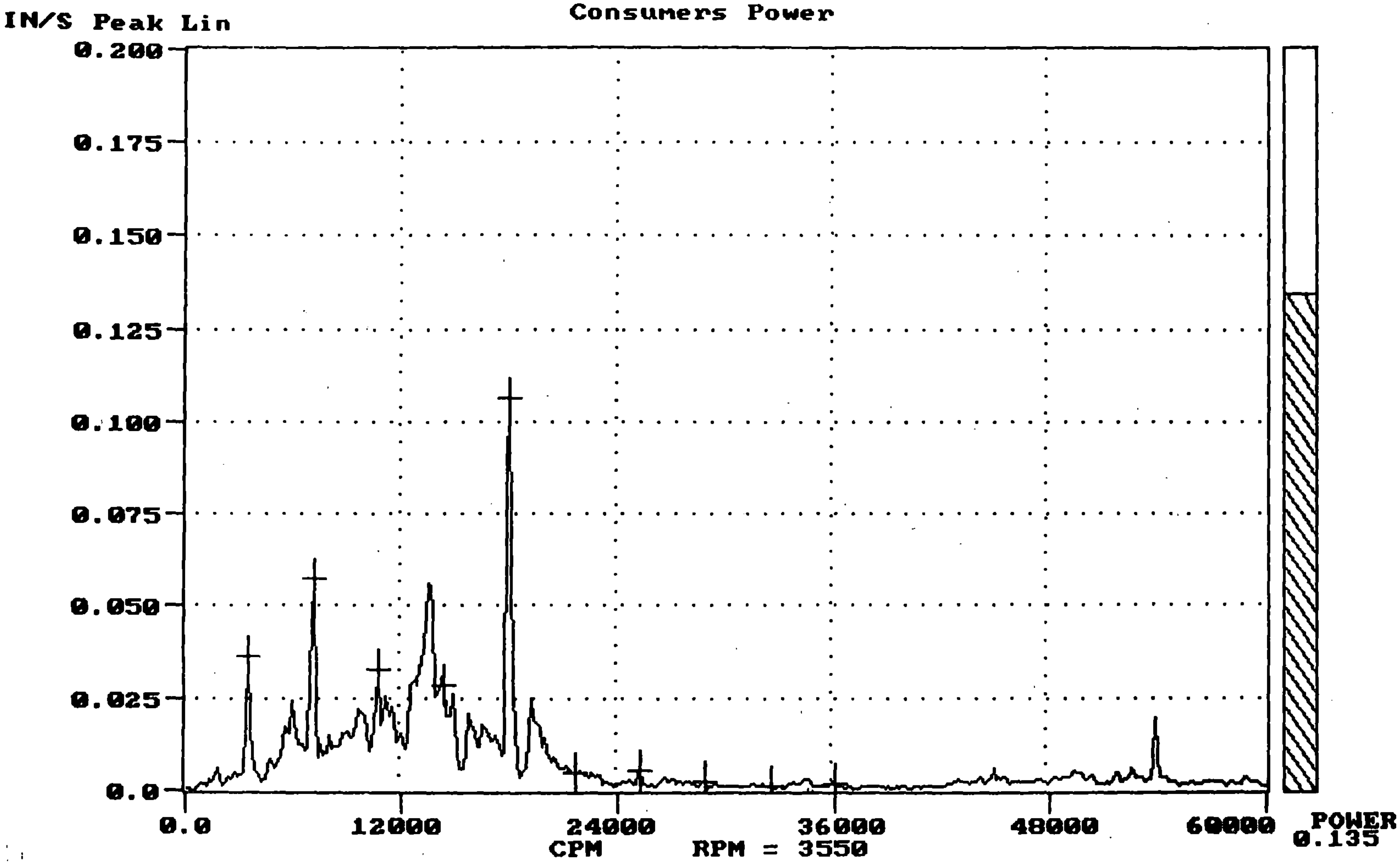
PALISADES NUCLEAR PLANT
02/11/91 8:47:47 AM
Consumers Power

X value: 3600
Y value: 0.018

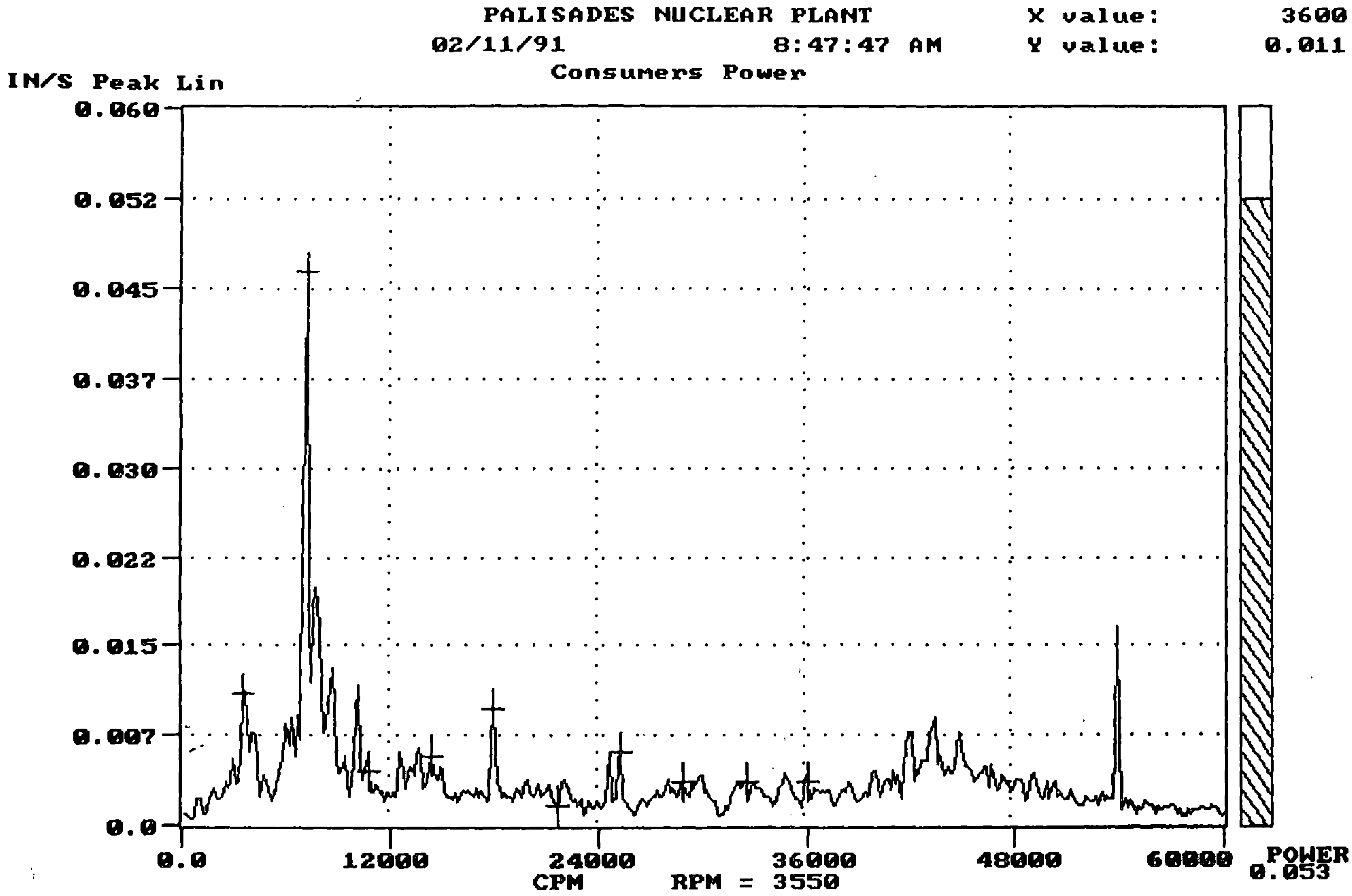


Description: P-54A CONTAINMENT SPRAY PUMP
MACHINE: PUMP
POINT ID: PIBV
TRAIN: P-54A
Point: 00067

PALISADES NUCLEAR PLANT X value: 3600
02/11/91 8:47:47 AM Y value: 0.036
Consumers Power



Description: P-54A CONTAINMENT SPRAY PUMP
MACHINE: PUMP TRAIN: P-54A
POINT ID: PIBH Point: 00069



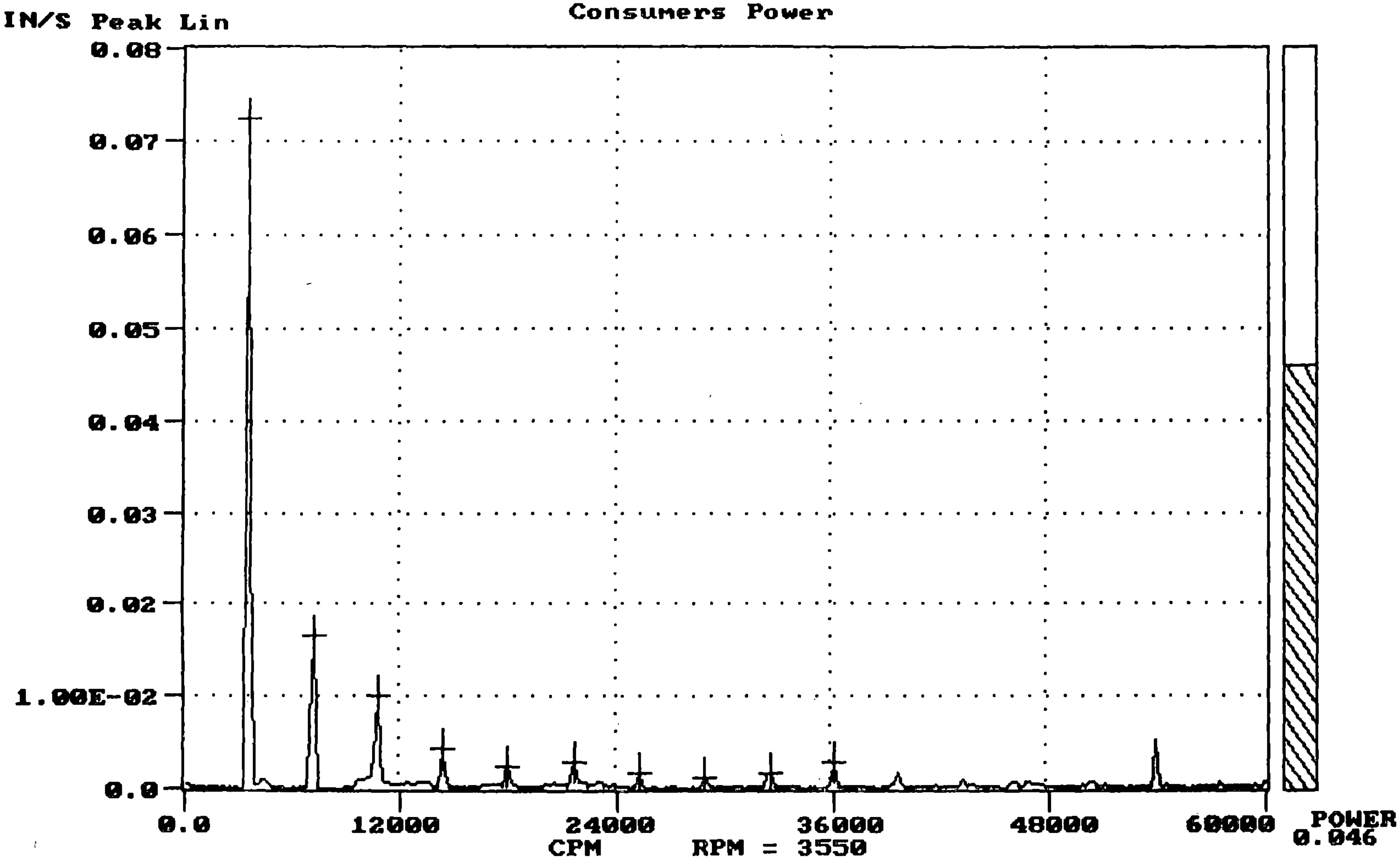
Description: P-54A CONTAINMENT SPRAY PUMP

MACHINE: PUMP TRAIN: P-54A

POINT ID: PIBA Point: 00068

PALISADES NUCLEAR PLANT
02/11/91 10:58:39 AM
Consumers Power

X value: 3600
Y value: 0.072



Description: P-54C CONTAINMENT SPRAY PUMP

MACHINE: MOTOR TRAIN: P-54C

POINT ID: MOBV Point: 00079

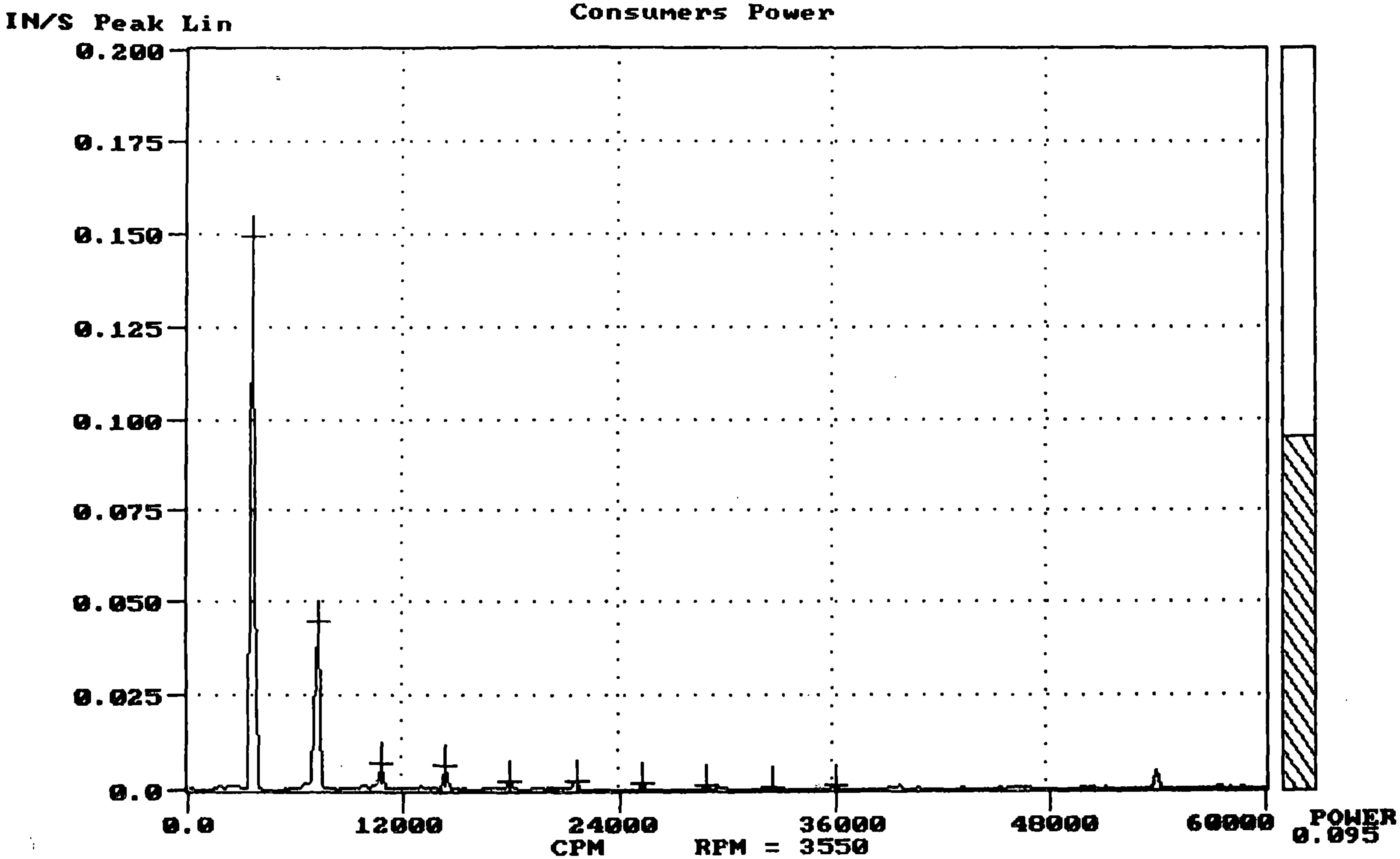
PALISADES NUCLEAR PLANT

02/11/91 10:58:39 AM

Consumers Power

X value: 3600

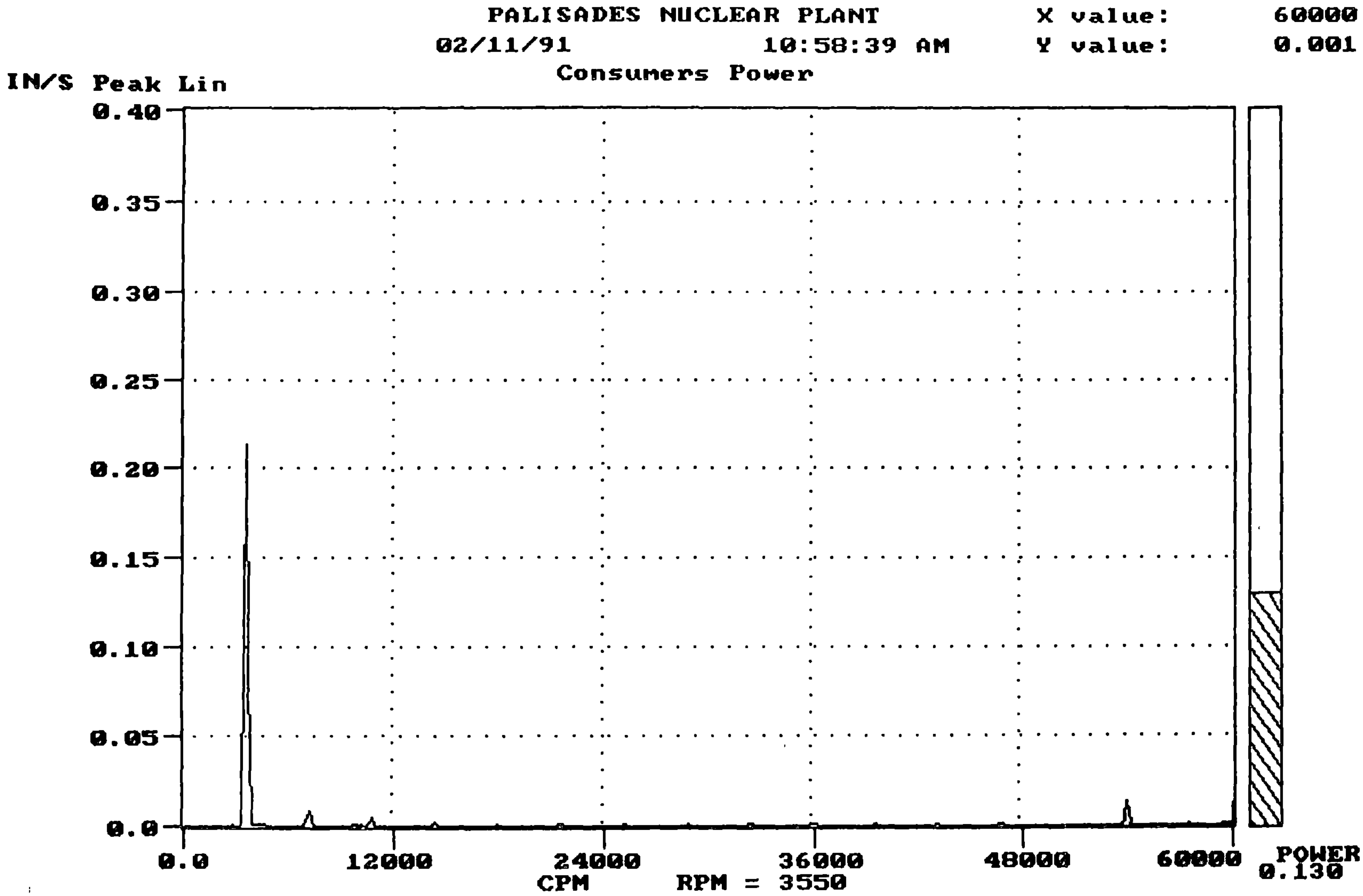
Y value: 0.149



Description: P-54C CONTAINMENT SPRAY PUMP

MACHINE: MOTOR TRAIN: P-54C

POINT ID: MOBH Point: 00081



Description: P-54C CONTAINMENT SPRAY PUMP

MACHINE: MOTOR TRAIN: P-54C

POINT ID: MOBA Point: 00080

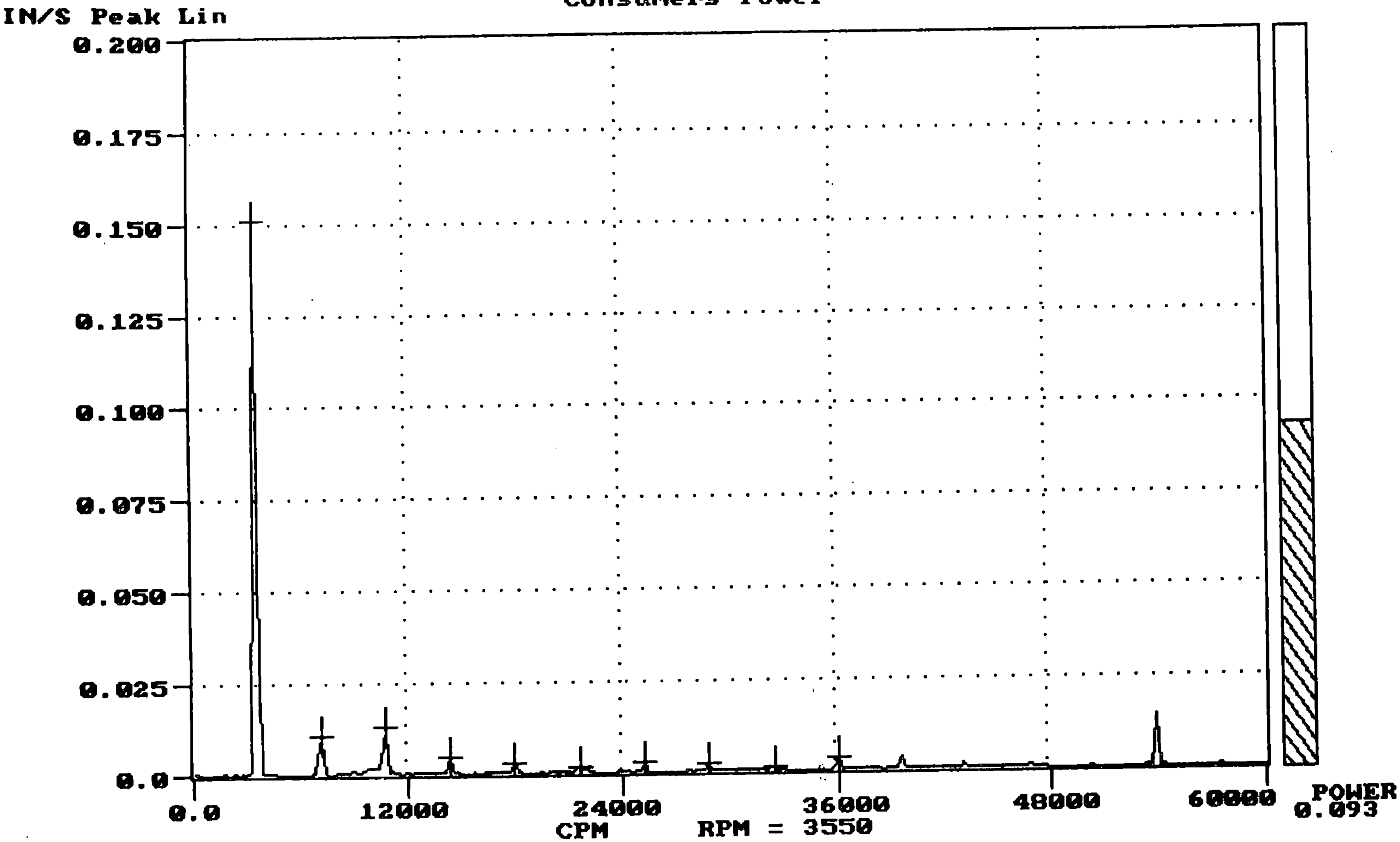
PALISADES NUCLEAR PLANT

02/11/91 10:56:00 AM

Consumers Power

X value: 3600

Y value: 0.151

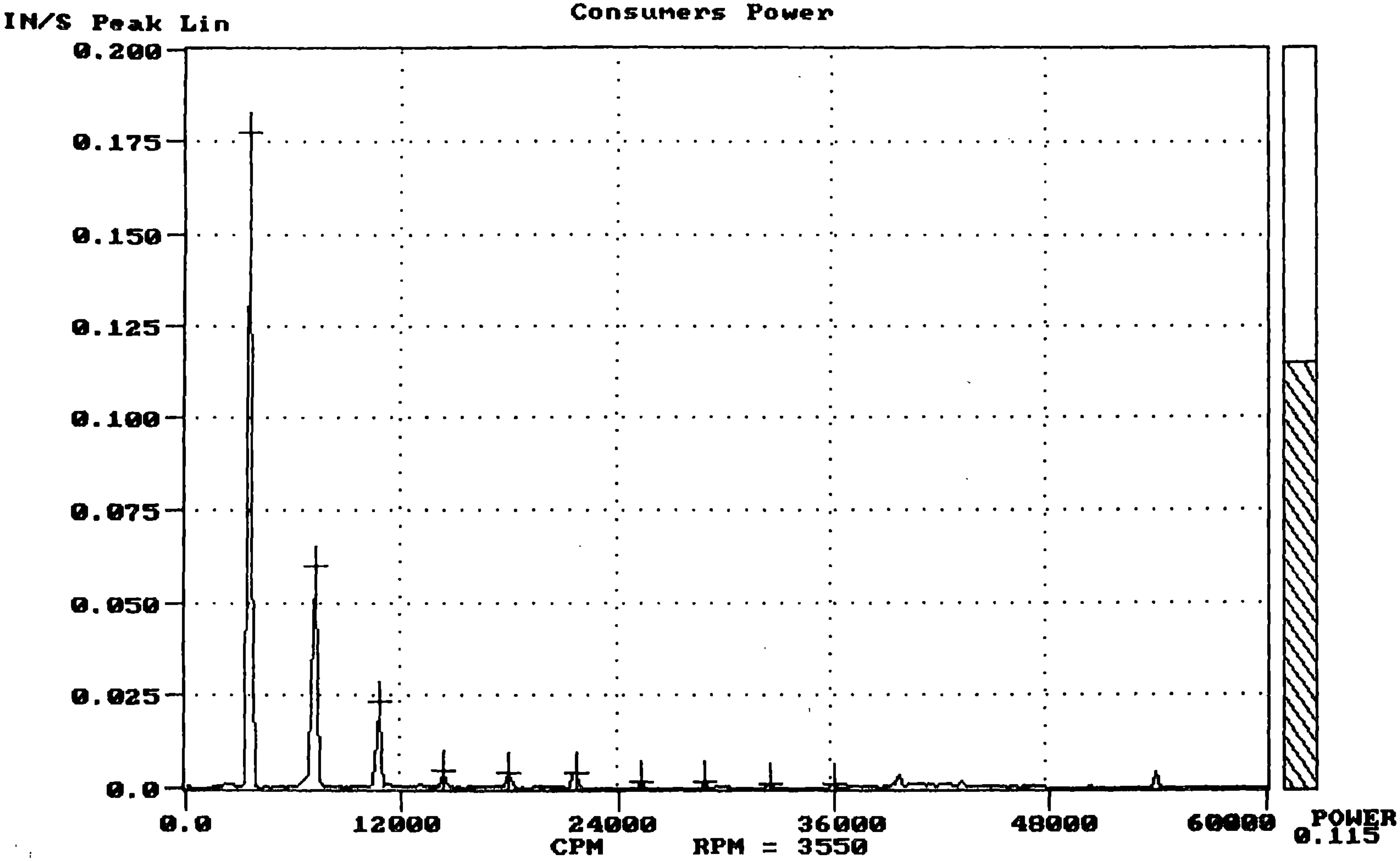


Description: P-54C CONTAINMENT SPRAY PUMP

MACHINE: MOTOR TRAIN: P-54C

POINT ID: MIBV Point: 00082

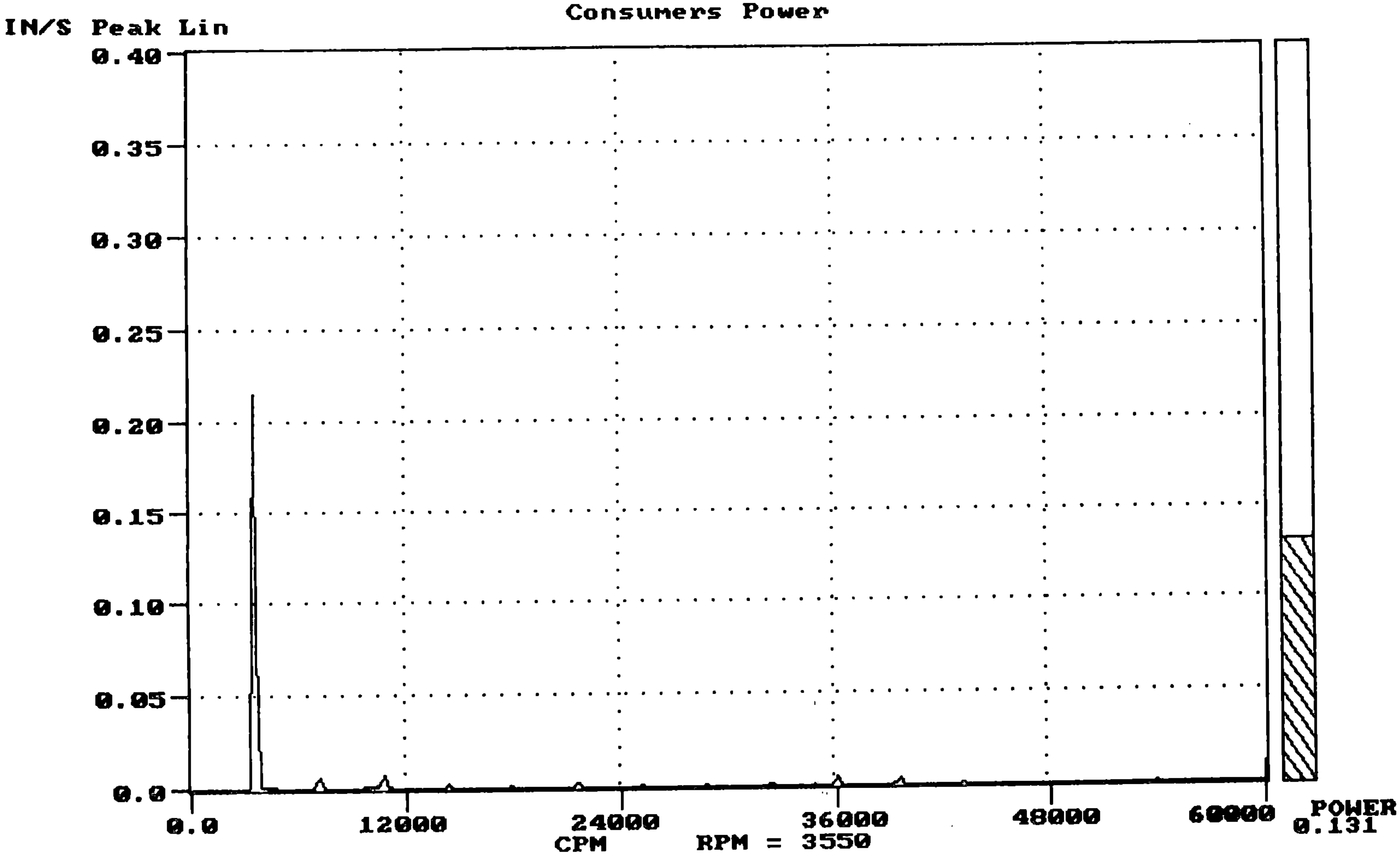
PALISADES NUCLEAR PLANT　　X value: 3600
02/11/91　　10:56:00 AM　　Y value: 0.177
Consumers Power



Description: P-54C CONTAINMENT SPRAY PUMP
MACHINE: MOTOR　　TRAIN: P-54C
POINT ID: MIBH　　Point: 00084

PALISADES NUCLEAR PLANT
02/11/91 10:56:00 AM
Consumers Power

X value: 60000
Y value: 0.00000



Description: P-54C CONTAINMENT SPRAY PUMP

MACHINE: MOTOR

TRAIN: P-54C

POINT ID: MIBA

Point: 00083

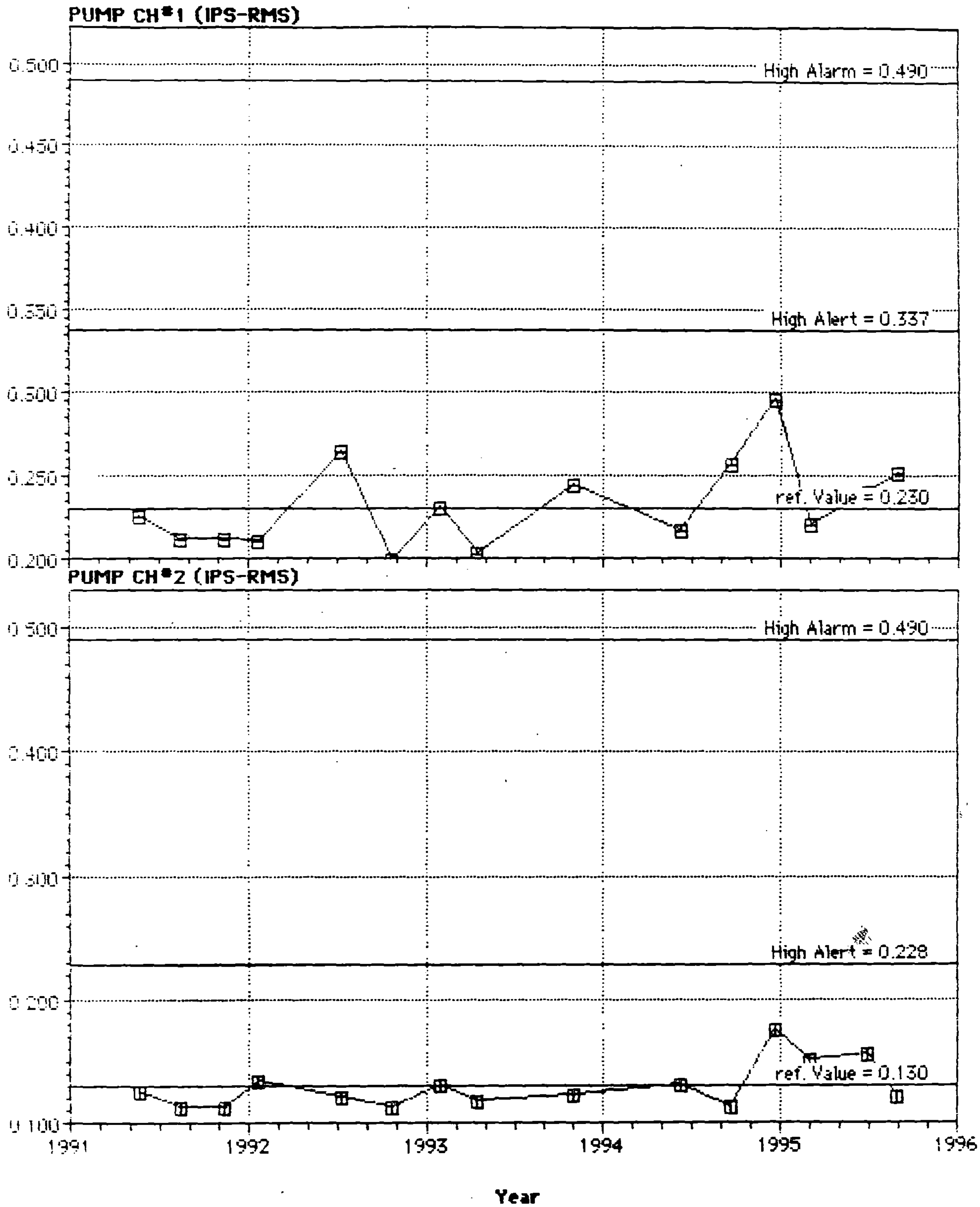
ATTACHMENT 9

CONSUMERS POWER COMPANY
PALISADES PLANT
DOCKET 50-255

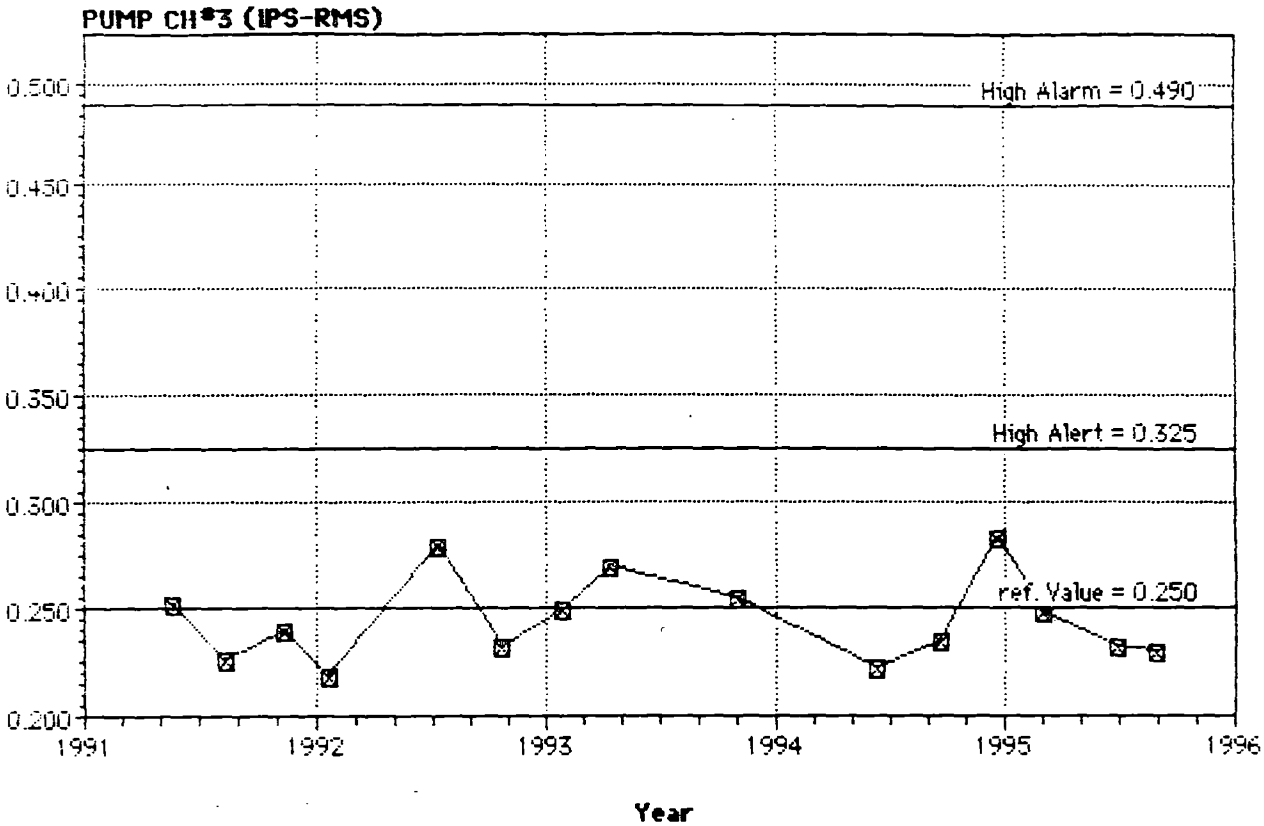
CONTAINMENT SPRAY PUMPS

DERIVATION OF VIBRATION ACCEPTANCE LIMITS

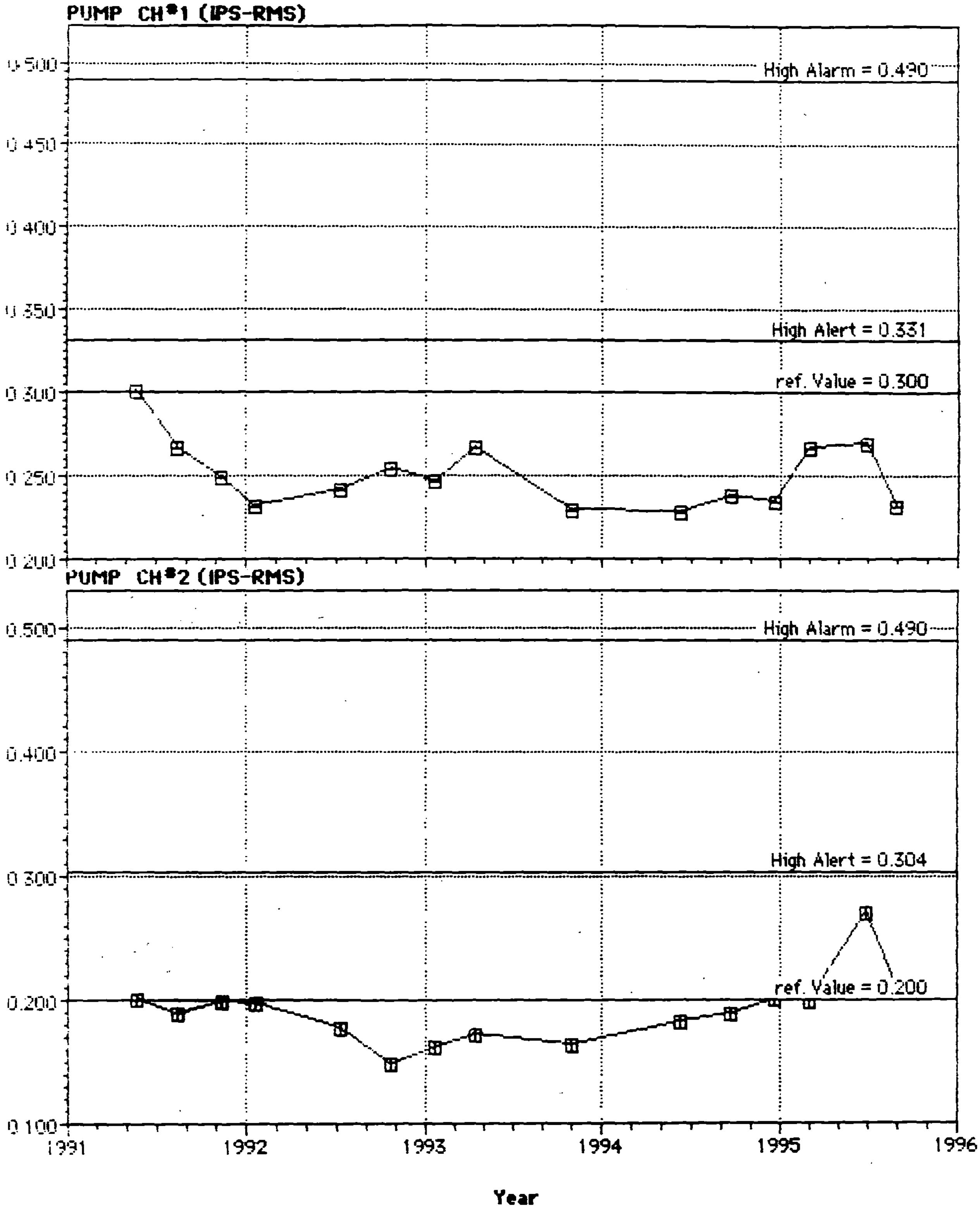
ID: P-54A / QQ-16 (PROPOSED)
Location: Aux Bldg, East Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 9:33 AM



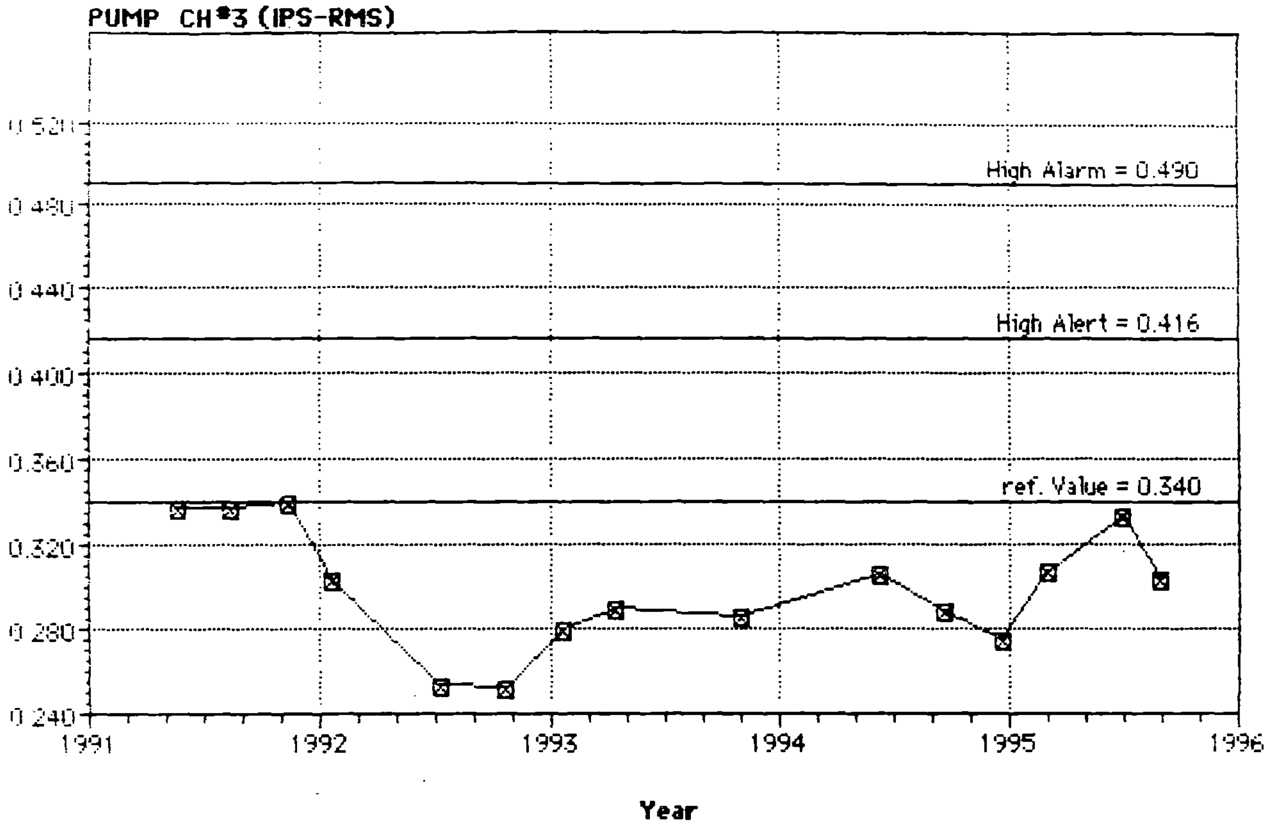
H_


PUMP CH#3 (IPS-RMS)
High Alarm = 0.490
High Alert = 0.325
ref. Value = 0.250
0.500
0.450
0.400
0.350
0.300
0.250
0.200
1991
1992
1993
1994
1995
1996
Year

ID: P-54B / QO-16 (PROPOSED)
Location: Aux Bldg, West Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 9:52 AM

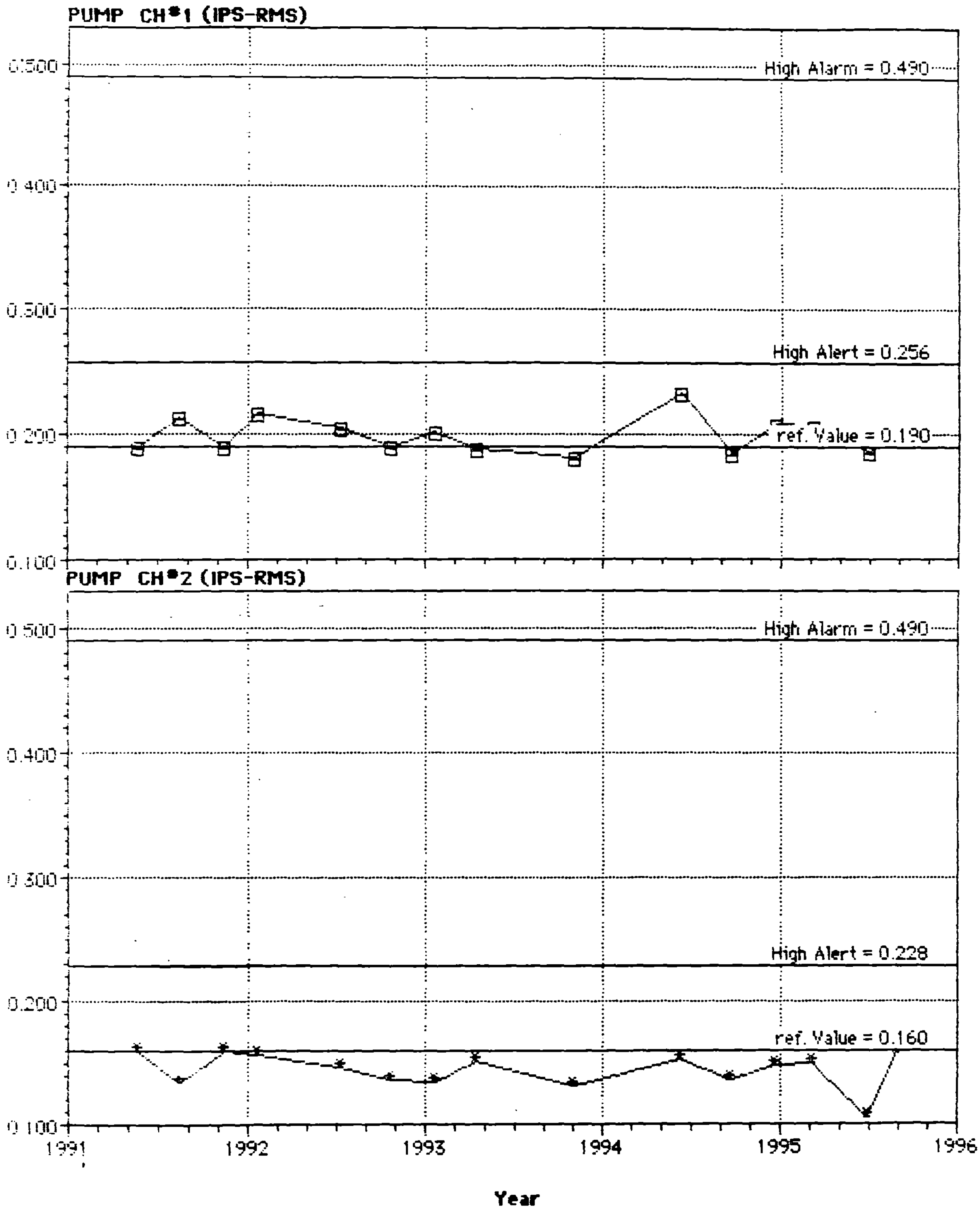


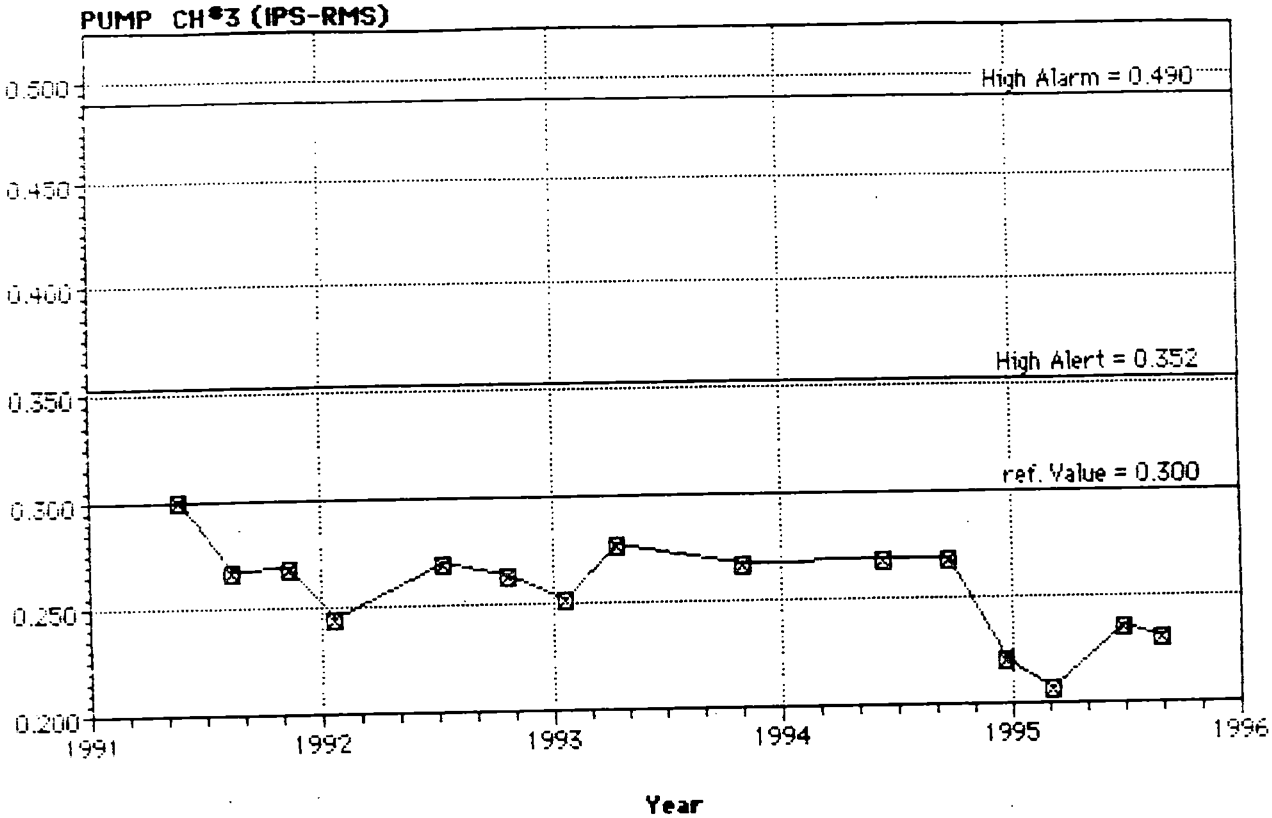
H.



PUMP CH#3 (IPS-RMS)
0.520
0.480
0.440
0.400
0.360
0.320
0.280
0.240
High Alarm = 0.490
High Alert = 0.416
ref. Value = 0.340
1991
1992
1993
1994
1995
1996
Year

ID: P-54C-/ QO-16 (PROPOSED)
Location: Aux Bldg, West Engineering Safeguards, 570'
Date: Tuesday, September 12, 1995 @ 10:12 AM




PUMP CH#3 (IPS-RMS)
High Alarm = 0.490
High Alert = 0.352
ref. Value = 0.300
0.500
0.450
0.400
0.350
0.300
0.250
0.200
1991
1992
1993
1994
1995
1996
Year