VIBRATION MONITORING IP/LP FEED WATER PUMP REPORT

Report by : Nguyen Quang Thuy – Maintenance & Reliability Engineer
Date : . Sep 30 th , 2013

PV POWER SERVICES
REPORT

VIBRATION MONITORING REPORT
Reliability Surveys

PETRO VIETNAM POWER CO., LTD.
NHON TRACH 1 THERMAL POWER PLANT

Reported By: Nguyen Quang Thuy – Maintenance & Reliability Engineer

PetroVietNam Power Service Joint Stock Company
HCM Branches: 25-27 Dang Dung, Wards Tan Dinh, Dist.1, HCMC
TABLE OF CONTENTS

1. BACKGROUND & SCOPE OF WORK
2. INSTRUMENTS & TECHNIQUE
3. MACHINERY LIST
4. VIBRATION & TEMPERATURE MEASUREMENT LOCATIONS & DIRECTIONS
5. LAST MESUREMENT REPORT
6. APPENDIX
   APPENDIX I : OVERALL VIBRATION REFERENCE – ISO 10816-1
   APPENDIX II : OVERALL VIBRATION REFERENCE – CRITERIA FOR OVERALL CONDITION RATING – TECHNICAL ASSOCIATES OF CHARLOTTE, P.C
VIBRATION REPORT

1. BACKGROUND & SCOPE OF WORK

Predictive Maintenance Program or PdM is a maintenance program that makes use of condition monitoring technology to prevent costly avoidable machine breakdown. PdM program can be executed by monitoring established machine parameters on a periodic basis. The most commonly used machine parameter is its vibration. Monitoring and analyzing vibration can give us an indication if a machine is experiencing a problem. These abnormalities could be due to unbalance, misalignment, bent shaft, mechanical looseness, bearing defects, gear problems, and resonance.

2. INSTRUMENTS & TECHNIQUE

<table>
<thead>
<tr>
<th>INSTRUMENTS</th>
<th>TRANSDUCERS</th>
<th>DDT CASE TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruments</td>
<td>Transducers Needed</td>
<td>Component</td>
</tr>
<tr>
<td>Microlog CMX A 70</td>
<td>1</td>
<td>SKF CM 2200 Freq. Accel. (100mV/g)</td>
</tr>
<tr>
<td>Machine Analyst - Data Management &amp; Analysis Software</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DATA BASE SETUPS AND TECHNIQUES USED

- Vibration FFT Analysis
- Velocity Vibration FFT’s
- Acceleration Envelope FFT’s

PROJECT DESCRIPTION, SERVICES DATES & RESPONSIBLE ANALYST

ANALYST: Nguyen Quang Thuy – Maintenance & Reliability Engineer
Email: thuy01vnn2003@yahoo.com
Handphoned: 084-0935385226

ON-SITE SERVICE DATE(S) FROM: 4/11/2013 TO: 12/24/2013

3. NAME MACHINERY: IP/LP FEED WATER PUMP

18LAC30AP001 & 18LAC20AP001

4. VIBRATION MEASUREMENT LOCATIONS & DIRECTIONS

Measurement point naming convention:

V : Vertical direction (for vertical pumps: rectangular direction with discharge piping)
H : Horizontal direction (for vertical pumps: parallel direction with discharge piping)
Vibration Report

A : Axial direction
VEL : Velocity vibration, unit : mm/s (RMS)
ACC : Acceleration vibration, unit : g (peak)
E3 : Enveloped Acceleration, filter 3 (500 Hz – 10 KHz), unit : gE (p-p)
E2 : Enveloped Acceleration, filter 2 (50 Hz – 1kH), unit : gE (p-p)
E1 : Enveloped Acceleration, filter 1 (5 Hz – 100 Hz), unit : gE (p-p)

Numbers are used to identify measurement positions (1,2,3,4,…). Measurement positions should be closed to bearing housings if possible.

For machine trains that consist of single shafts or rotors, the consecutive numbering shall be in the direction of power flow.

For machine trains that consist of multi shafts or rotors, the consecutive numbering shall be in the direction of process flow.

5. LAST MESUREMENT REPORT

5.1 OVERALL CONDITION

PV POWER SERVICES
An overall condition of each machine covered under the VIBRATION BASE LINE PROGRAM is provided for quick reference. This overall condition rating is determined by rigorous review of Reliability Survey vibration data including overall levels, analysis of vibration spectra.

Next, an assessment is made of the severity of any problems detected during the latest Reliability Survey. Both the problem found and the recommended solutions are included in the "Vibration Analysis Report". On this section, the severity of each problem and when it should be resolved is listed in order of highest to lowest problem severity.

Each of these five levels of recommended action are then repeated in this "Vibration Analysis Report" with headings of "NORMAL CONDITION (Good to Fair)", "TREND PROBLEM ONLY", "PERFORM RECOMMENDED ACTIONS"; "SCHEDULE REPAIRS AT CONVENIENCE"; "MAINTENANCE REQUIRED ASAP". Nothing needs to be done by plant maintenance at this time for those machines listed under "Trend Problem Only". Simply refer to the problem detected and watch for any deterioration of this problem in future Reliability Surveys.

It is strongly recommended that maintenance action be taken at the earliest possible moment for those machines listed under the column "Maintenance Required ASAP". These machines have been found to have serious problems, which might cause catastrophic failure in the near future. Recommended actions are listed in the aforementioned results and recommendations chart.

Maintenance should be scheduled when possible for those machine listed under "Schedule Repair at Convenience". In general, these machines have less serious problems at the time of the Reliability Survey, but still mandate close attention for any possible deterioration. Again, recommended actions are listed in the results and recommendations summary chart.

In general, it is recommended that neither scheduled nor unscheduled repairs be performed on machinery indicated to be in good operating condition by the PMP program. This will tend to waste expensive maintenance dollars and reduce efficiency both of the program and of the Maintenance staff. However, normal repairs such as periodic lubrication, filter changes, cleaning, fastener tightening, etc. should be continued.

The measured condition and its diagnosis are the machineries’ current condition at the time of measurement. Routine measurements (PdM program) should be followed to trend the machine conditions.

### 5.2 OVERALL VIBRATION REPORT

<table>
<thead>
<tr>
<th>Machine Name &amp; Point Name</th>
<th>Unit</th>
<th>18LAC30 AP001</th>
<th>18LAC20AP001</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTOR</td>
<td></td>
<td>Previous Measurement</td>
<td>Last Measurement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4/11/2013</td>
<td>13/12/2013</td>
</tr>
<tr>
<td>V01 VEL</td>
<td>mm/s</td>
<td>0.580</td>
<td>0.771</td>
</tr>
<tr>
<td>H01 VEL</td>
<td>mm/s</td>
<td>0.797</td>
<td>0.803</td>
</tr>
<tr>
<td>H01 ACC</td>
<td>g</td>
<td>0.373</td>
<td>0.230</td>
</tr>
<tr>
<td>H01 E3</td>
<td>gE</td>
<td>1.187</td>
<td>1.032</td>
</tr>
<tr>
<td>H01 E2</td>
<td>gE</td>
<td>0.721</td>
<td>0.604</td>
</tr>
<tr>
<td>V02 VEL</td>
<td>mm/s</td>
<td>0.448</td>
<td>0.401</td>
</tr>
<tr>
<td>H02 VEL</td>
<td>mm/s</td>
<td>0.646</td>
<td>0.576</td>
</tr>
<tr>
<td>H02 ACC</td>
<td>g</td>
<td>0.172</td>
<td>0.150</td>
</tr>
<tr>
<td>H02 E3</td>
<td>gE</td>
<td>3.090</td>
<td>2.244</td>
</tr>
<tr>
<td>H02 E2</td>
<td>gE</td>
<td>0.432</td>
<td>0.443</td>
</tr>
<tr>
<td>A02</td>
<td>mm/s</td>
<td>0.545</td>
<td>0.454</td>
</tr>
</tbody>
</table>

PV POWER SERVICES
### Vibration Analysis Report

<table>
<thead>
<tr>
<th></th>
<th>V03 VEL</th>
<th>H03 VEL</th>
<th>H03 ACC</th>
<th>H03 E3</th>
<th>H03 E2</th>
<th>A03</th>
<th>V04 VEL</th>
<th>H04 VEL</th>
<th>H04 ACC</th>
<th>H04 E3</th>
<th>H04 E2</th>
<th>A04</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm/s</td>
<td>mm/s</td>
<td>g</td>
<td>gE</td>
<td>gE</td>
<td>mm/s</td>
<td>mm/s</td>
<td>mm/s</td>
<td>g</td>
<td>gE</td>
<td>gE</td>
<td>mm/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4.575</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.241</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 5.3 Vibration Analysis Report

**Name convention:**
- One time running speed frequency: 1X
- Line frequency (50Hz): Fl
- Bearing Defect Frequency: BDF
- Rotor Bar Pass Frequency: RBPF
- Vane/Blade Pass Frequency: BPF

**Description of Severity:**
- 0 = Normal condition (Good to Fair)
- 4 = Trend problem only
- 3 = Perform recommended actions
- 2 = Schedule checks/repairs at convenience
- 1 = Maintenance required ASAP

#### 3/ IP/LP Feed Water Pumps

Rolling Bearing designations:

- Motor: 6319 C4 (DE) – NU219M (NDE)
- Pump: NU314 EMC (SKF) Before new bearing change
- NU314 EMC (NSK) After new bearing change

- Number of vanes/ blades: Unknown
- Number of stage: Unknown

PV POWER SERVICES
### I. IP/LP FEED WATER PUMP (18LAC30AP001)

<table>
<thead>
<tr>
<th>Component</th>
<th>Severity levels</th>
<th>Diagnostic and Recommendation</th>
<th>Value highest</th>
<th>See plot no</th>
</tr>
</thead>
</table>
| Motor     |                 | - Overall enveloped vertical reading still normal condition very field by low vibration amplitude and normal signature in FFT spectrum.  
- Do not see bearing defect frequencies problem of both position DE & NDE of Motor.  
- Routine monitor for trending. **No immediate action required** | 0.771 mm/s | 1  
0.401 mm/s | 2  
3  
4 |
| Pump      |                 | - Overall enveloped vertical readings at position input shaft (DE) of Pump still high (V03 VEL = 5.340 mm/s, H03 VEL = 5.931 mm/s). Before change new bearing on 4/11/2012 see bearing defect (BPFO) at peak 8X of pump running speed 2980 rpm. After change new bearing on 13/12/2013 peak 8X reduce running speed 2980 rpm. Peak 7X pump rpm increased with high amplitude and FFT spectrum showing harmonic peaks of 1X pump rpm which is typical spectrum for journal bearing. Appearing FFT spectrum showing harmonic peaks of 5X pump rpm.  
- After change new bearing value overall enveloped acceleration reading (gE) still high and FFT spectrum showing harmonic peaks of 1X Motor rpm and dominated peaks at 7xpump rpm, 10xpump rpm at both position of axial  
- It is recommended that should schedule to check wear/clearance problem of journal bearing at both position DE and NDE of pump.  
- At both position sort foot DE of pump (M5,M6) and NDE of pump (M7, M8) high dominated peak 7X & 10X and FFT spectrum showing harmonic peaks of 1xmotor rpm.  
- At both position input section and output section of piping system of pump. Dominated peak 10X and FFT spectrum showing harmonic peaks of 1xmotor rpm  
- It is recommended that should schedule to check piping system of pump at both position input section and output.  
- At both position A03 and A04 axial FFT spectrum showing harmonic peaks of 5X pump rpm | 5.340 mm/s | 5  
5.931 mm/s | 6  
14.34 gE | 7  
11.85 gE | 8  
3.897 mm/s | 9  
3.883 mm/s | 10  
11.64 gE | 11  
7.320 gE | 12  
3.897 mm/s | 13  
3.883 mm/s | 14  
11.64 gE | 15  
7.320 gE | 16  
3.897 mm/s | 17  
3.883 mm/s | 18  
11.64 gE | 19  
7.320 gE | 20  
3.897 mm/s | 21  
3.883 mm/s | 22  
11.64 gE | 23  
7.320 gE | 24  
3.897 mm/s | 25  
3.883 mm/s | 26  
11.64 gE | 27  
7.320 gE | 28 |

Plot 1 : V01 VEL
Vibration Report

Plot 2 : V01 VEL

Plot 3 : V02 VEL
Plot 4: V02 VEL

Plot 5: V03 VEL  Trend spectrum before change new bearing on 4/11/2013
### Vibration Report

#### Plot 6: V03 VEL Trend spectrum after change new bearing on 13/12/2013

- **7X rpm**
- **8X rpm**
- **10X rpm**
- **2X rpm**

#### Plot 7: V03 VEL Trend spectrum after change new bearing on 13/12/2013

- **7X rpm**
- **10X rpm**
- **2X rpm**
- **8X rpm**
Plot 8: V03 VEL Trend spectrum after change new bearing on 13/12/2013

Plot 9: H03 VEL Trend spectrum before change new bearing on 4/11/2013
Vibration Report

Plot 10: H03 VEL Trend spectrum after change new bearing on 13/12/2013

Plot 11: A03
Plot 12: H03 E3 Trend spectrum before change new bearing on 4/11/2013

Plot 13: H03 E3 Trend spectrum after change new bearing on 13/12/2013

Appearing raise noise floor indication wear of bearing
Plot 14 : H03 E2 Trend spectrum before change new bearing on 4/11/2013

Plot 15 : H03 E2 Trend spectrum after change new bearing on 13/12/2013

Appearing bearing defect of bearing
Plot 16: H04 VEL before change new bearing on 4/11/2013

Plot 17: H04 VEL after change new bearing on 13/12/2013

7X rpm
8X rpm
Vibration Report

Plot 18: H04 VEL after change new bearing on 13/12/2013

Plot 19: H04E2 before change new bearing on 4/11/2013

8X rpm
Plot 20: H04E2 after change new bearing on 13/12/2013

After change new bearing on 13/12/2014 peak 3X increase and peak 8X reduce. Appearing harmonic 1X run speed 2980 rpm

Plot 21: H04E2 after change new bearing on 13/12/2013
Vibration Report

Plot 22: A04

Plot 23: M5 Sort foot at position DE of pump
Plot 24: M6 Sort foot at position DE of pump
Vibration Report

Plot 25: M7 Sort foot at position NDE of pump
### Plot 26: MS Sort foot at position NDE of pump

![Image of vibration report](image1)

### Plot 27: Vibration piping system at position input section of pump

![Image of vibration report](image2)
Plot 28: Vibration piping system at position output section of pump
Vibration Report

PV POWER SERVICES
# Vibration Report

## II. IP/LP FEED WATER PUMP (18LAC20AP001)

<table>
<thead>
<tr>
<th>Component</th>
<th>Severity levels</th>
<th>Diagnostic &amp; Recommendation</th>
<th>Value highest</th>
<th>See plot no</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor</strong></td>
<td></td>
<td>• Overall enveloped vertical reading still normal condition very field by low vibration amplitude and normal signature in FFT spectrum .</td>
<td>0.430 mm/s</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Do not see bearing defect frequencies problem of both position DE &amp; NDE of  Motor .</td>
<td>0.317 mm/s</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Routine monitor for trending. No immediate action required</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pump</strong></td>
<td></td>
<td>• Overall enveloped vertical readings at position input shaft (DE) of Pump high (V03 VEL = 5.209 mm/s, H03 VEL =4.041 mm/s ) . Peak 7X pump rpm increased with high amplitude and FFT spectrum showing harmonic peaks of 1X pump rpm which is typical spectrum for journal bearing. Peak 2X high compare with pump 18LAC30AP001. It is misalignment between Motor And Pump</td>
<td>5.209 mm/s</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• It is recommended that should schedule to check wear/clearance problem of journal bearing at both position DE and NDE of pump.</td>
<td>18.140 gE</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• At position H03 ACC see noise of piping system with about 2119Hz frequencies .</td>
<td>3.777 mm/s</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• At both position sort foot DE of pump ( M5,M6) and NDE of pump (M7, M8) high dominated peak 5X &amp; 10X and FFT spectrum showing harmonic peaks of 1Xmotor rpm.</td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• At both position input section and output section of piping system of pump. Dominated peak 5X and FFT spectrum showing harmonic peaks of 1Xmotor rpm</td>
<td>6.241 gE</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• It is recommended that should schedule to check piping system of pump at both position input section and output.</td>
<td></td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• At both position A03 and A04 axial FFT spectrum showing harmonic peaks of 1X rpm of pump</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Do not see bearing defect frequencies problem of both position DE &amp; NDE of  Motor .</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Plot 2.1 : V01 VEL**
Vibration Report

Plot 2.2 : V02 VEL

Plot 2.3 : V03 VEL
Vibration Report

Plot 2.4: H03 VEL

Plot 2.5: H03 ACC

Peak highest at 7X, 8X & 10X

2X
Vibration Report

Plot 2.6 : H03 E3

Noise at 2119Hz frequencies

Plot 2.7 : A03

Noise wear of bearing Nu 314
Vibration Report

Plot 2.8: V04 VEL

Plot 2.9: H04 ACC
Vibration Report

Plot 2.10 : H04 E2

Appearing harmonic and noise of floor

Plot 2.11 : A04

Appearing noise of floor of bearing
Plot 2.12: M5 Sort foot at position DE of pump

Appearing harmonic 1X and peak highest at 7X
**Vibration Report**

**Plot 2.13**  
M6  
Sort foot at position DE of pump

**Plot 2.14**  
M7  
Sort foot at position NDE of pump
Plot 2.15  M8  Sort foot at position NDE of pump
Plot 2.16  Vibration piping system at position input section of pump
Plot 2.17  Vibration piping system at position output section of pump
6. APPENDIX

6.1 Appendix I:

Overall Vibration References
ISO 10816-1 Vibration Severity Chart

<table>
<thead>
<tr>
<th>Velocity Severity</th>
<th>Velocity Range Limits and Machine Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ISO Std. 10816-1</td>
</tr>
<tr>
<td>mm/s RMS</td>
<td>in/s peak</td>
</tr>
<tr>
<td>Class I</td>
<td>Small Machines</td>
</tr>
<tr>
<td></td>
<td>Medium Machines</td>
</tr>
<tr>
<td></td>
<td>Large Machines</td>
</tr>
<tr>
<td></td>
<td>Rigid Supports</td>
</tr>
<tr>
<td></td>
<td>Flexible Supports</td>
</tr>
<tr>
<td>.36</td>
<td>0.02</td>
</tr>
<tr>
<td>.54</td>
<td>0.03</td>
</tr>
<tr>
<td>.72</td>
<td>0.04</td>
</tr>
<tr>
<td>1.08</td>
<td>0.06</td>
</tr>
<tr>
<td>1.80</td>
<td>0.10</td>
</tr>
<tr>
<td>2.87</td>
<td>0.16</td>
</tr>
<tr>
<td>4.50</td>
<td>0.25</td>
</tr>
<tr>
<td>7.18</td>
<td>0.40</td>
</tr>
<tr>
<td>11.14</td>
<td>0.62</td>
</tr>
<tr>
<td>17.96</td>
<td>1.00</td>
</tr>
<tr>
<td>23.00</td>
<td>1.56</td>
</tr>
<tr>
<td>44.90</td>
<td>2.50</td>
</tr>
<tr>
<td>70.94</td>
<td>3.95</td>
</tr>
</tbody>
</table>

**Class I**: Machines may be separated driver and driven, or coupled units comprising operating machinery up to approximately 15Kw (approx 20HP)

**Class II**: Machinery (electrical motors 15Kw (20HP) to 75Kw (100HP), without special foundations, or rigidly mounted engines or machines up to 300Kw (400HP) mounted on special foundations

**Class III**: Machines are large prime movers and other large machinery with large rotating assemblies mounted on rigid and heavy foundations which are reasonably stiff in the direction of vibration.

**Class IV**: includes large prime movers and other large machinery with large rotating assemblies mounted on foundations which are relatively soft in the direction of the measured vibration (i.e, turbine generators and gas turbines greater than 10MW (approx. 13500HP) output.
6.2: Appendix II:
Overall Vibration References

Technical Associates of Charlotte, P.C
Criteria for Overall Condition Rating (RMS overall velocity, mm/s)

<table>
<thead>
<tr>
<th>MACHINE TYPE</th>
<th>GOOD</th>
<th>FAIR</th>
<th>ALARM 1</th>
<th>ALARM 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOTOR/GENERATOR SETS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belt-Driven</td>
<td>0 – 5.0</td>
<td>5.0 – 7.5</td>
<td>7.5</td>
<td>12.0</td>
</tr>
<tr>
<td>Direct Coupled</td>
<td>0 – 3.5</td>
<td>3.5 – 5.5</td>
<td>5.5</td>
<td>8.0</td>
</tr>
<tr>
<td>CENTRIFUGAL PUMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical pump (12’ – 20’ Height) (*)</td>
<td>0 – 6.0</td>
<td>6.0 – 9.0</td>
<td>9.0</td>
<td>13.5</td>
</tr>
<tr>
<td>Vertical pump (8’ – 12’ Height) (*)</td>
<td>0 – 5.0</td>
<td>5.0 – 7.5</td>
<td>7.5</td>
<td>11.5</td>
</tr>
<tr>
<td>Vertical pump (5’ – 8’ Height) (*)</td>
<td>0 – 4.0</td>
<td>4.0 – 6.0</td>
<td>6.0</td>
<td>9.5</td>
</tr>
<tr>
<td>Vertical pump (0’ – 5’ Height) (*)</td>
<td>0 – 3.5</td>
<td>3.5 – 5.5</td>
<td>5.5</td>
<td>8.0</td>
</tr>
<tr>
<td>General purpose Horizontal pump – Direct coupled</td>
<td>0 – 3.5</td>
<td>3.5 – 5.5</td>
<td>5.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Boiller Feed Pumps – Horizontal Orientation</td>
<td>0 – 3.5</td>
<td>3.5 – 5.5</td>
<td>5.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Hydraulic pumps – Horizontal Orientation</td>
<td>0 – 2.0</td>
<td>2.0 – 3.5</td>
<td>3.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

Note: The “ALARM 1” and “ALARM 2” overall levels given above apply only to in-service machinery which has been operating for some time after initial installation and/or overhaul. They do not apply (and are not meant to serve as) Acceptance Criteria for either new or rebuilt machinery.

(*) Height from Grade to Top Motor Bearing.