August 2, 2011

Mr. Ed Newell
Iogen Corporation
300 Hunt Club Rd. East
Ottawa (Ontario) K1V 1C1

Subject: **Vibration analysis of P-17303 Screw Press Feed Tank Pump**
Proaxion WO: 22988 Customer PO: 119657

Dear Mr. Newell,

The following report presents the results of the vibration analysis performed on the hay slurry pump SC-17303.

The data was recorded on July 19th 2011, according to a series of tests to determine causes of previous pump shaft failures.

Hoping that all is to your satisfaction, please feel free to contact us for any questions or comments.

Best Regards,

Janos Pattantyus, M.Eng., P.Eng.
Vibration Group Manager
Vibration specialist IV (# 0305-0069C)

Vibration report

Vibration analysis of P-17303 Screw Press Feed Tk Pump

Janos Pattantyus, M.Eng., P.Eng.
Vibration Group Manager
Vibration specialist IV (# 0305-0069C)

Project: 22988
Customer PO 119657
July 2011

Table of contents

1. EXECUTIVE SUMMARY 4

2. MANDATE 4

3. CONTEXT 4

4. METHODOLOGY..4

5 TECHNICAL DATA..7

6 RESULTS AND ANALYSIS..8

6.1 Speed variations 8

6.2 Vibration Analysis..12

7 CONCLUSIONS..22

8 RECOMMENDATIONS..22

Vibration analysis of P-17303
Screw Press Feed Tk Pump

1. Executive summary

The pump suffered several shaft failures since installation. In order to understand and prevent future occurrences, vibrations were recorded in different operating conditions.

The results show that the pump is subject to excessive speed fluctuations as the variable speed controller reacts to discharge pressure. Agitation in the supply tank also amplifies this effect.

The pump is also subject to impacting, the likely cause being cavitation. It cannot be confirmed if this is detrimental to shaft reliability but remains undesirable.

The corrective action plan is to eliminate the sudden speed variations and study the pump parameters to understand and find ways to reduce or eliminate the pump cavitation.

2. Mandate

The mandate is to record the vibration with the pump empty, with water only, with hay slurry and various levels of agitation.

The results are analyzed for information that can prevent future pump shaft failures.

3. Context

The plant is a demonstration facility where the Ethanol production process is fine-tuned.

A disc pump was installed in April and has since suffered 2 shaft breakages near the impeller, the first at 62 hours and the second after 271 hours of operation.

4. Methodology

4.1 Vibration measurements were recorded using a CSI 4500T (multi channel data collector), connected to portable accelerometers and speed detector.

4.2 Vibration signatures were measured on the equipment casing using magnet mounted accelerometers, having a 100 mV/g sensitivity.

The measurement point locations and identifications of the accelerometers probes are indicated in Figures 1 and 2 below.

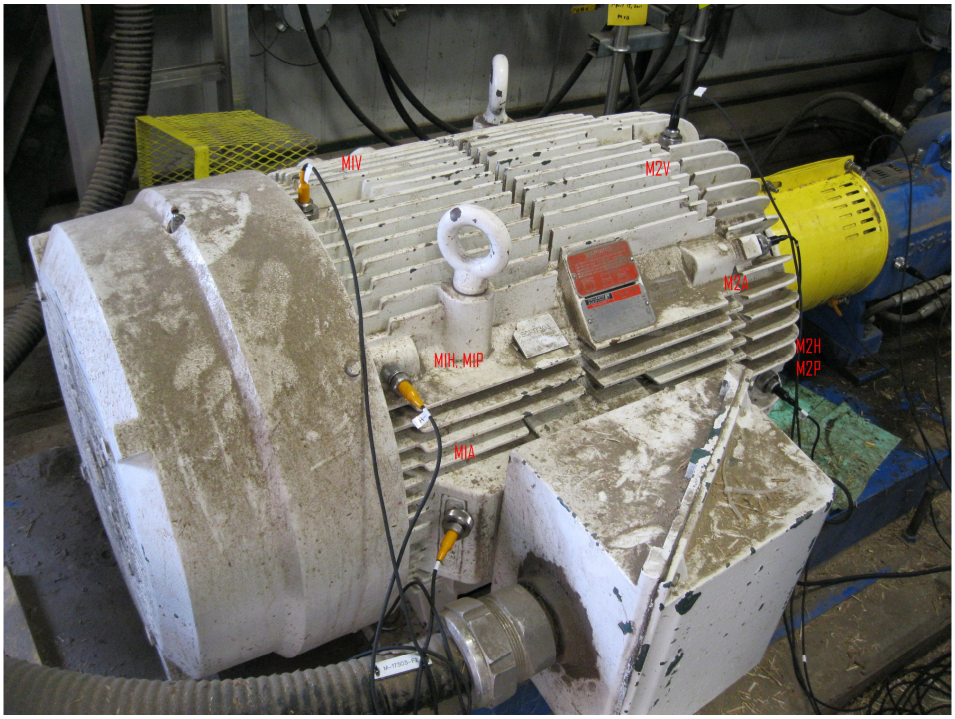


Figure 1 – Motor Point identification & location for casing measurements.

Figure 2 – Pump Point identification & location for casing measurements.

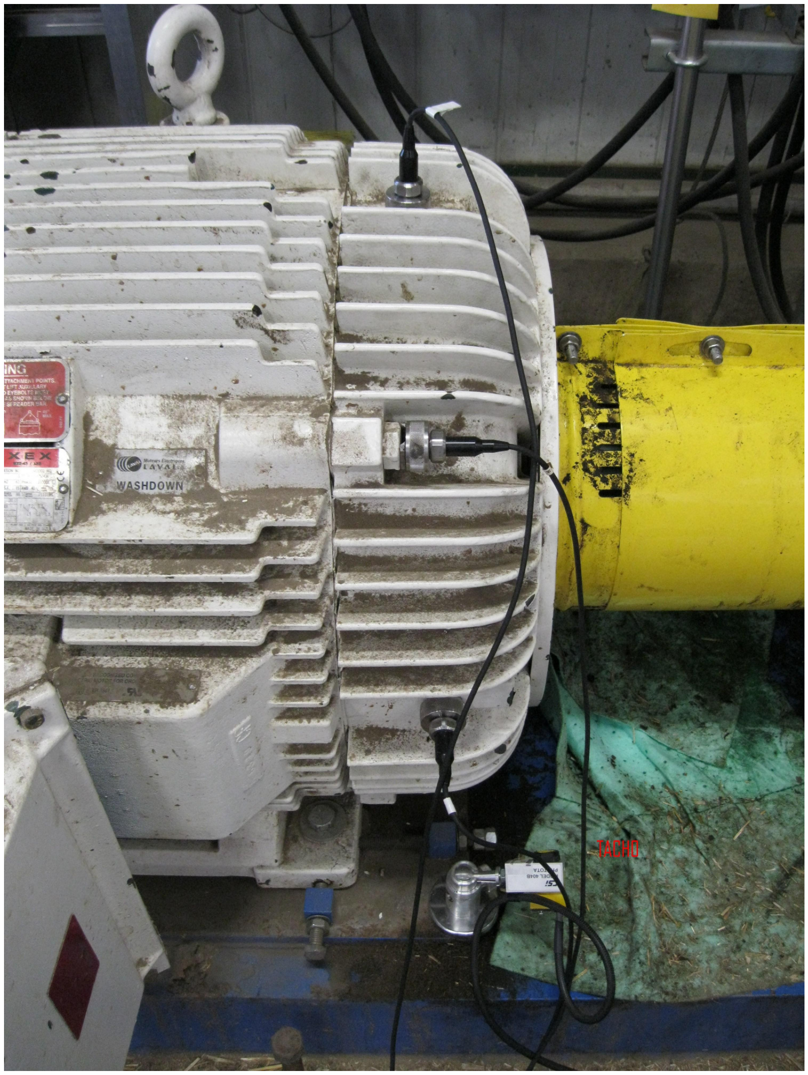


Figure 3 – Speed Point identification & location.

4.5 The data were saved in a database named «Iogen Discflo Pump 2.rbm» for future reference, and can be consulted using the CSI AMSSuite™ software.

4.6 A photo tachometer and reflective tape were used to get a reference mark, also called a « keyphasor® » signal, shown in figure 3 above.

The « keyphasor® » is a 1x/revolution event needed for advanced diagnosis (filtered signals).

4.7 Excel® spreadsheets were created in order to follow the chain of events step-by-step (run-up/coast-down, load variation, etc.).

5 Technical data

The following information's were obtained from the operating personnel of the plant as well as the equipment name plate.

5.1 Motor: Reliance Electric

- AC Induction, 250HP
- Rated speed : 3 570 rpm
- 575 Volts, 220 Amps, 60 Hz, 3-phase, 40 C
- Model P44G5243A, frame: 447TS
- Brgs: 65BC03J30X

Pump: Discflo

- Type : 603-17
- Model : 2HHDL-CD3

Coupling: Similar to Lovejoy S-flex elastomeric – see figure 4

Variable Speed Drive: Not known

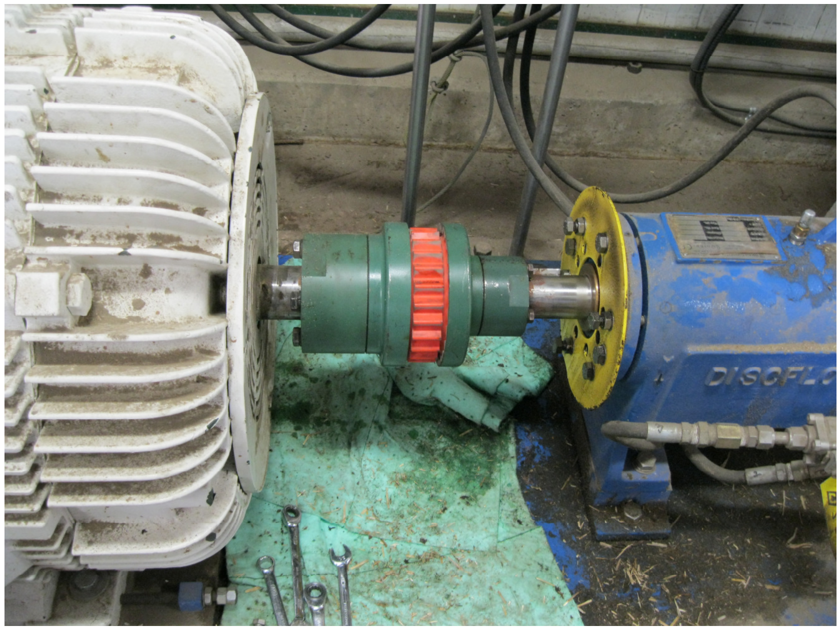


Figure 4 – Coupling

6 Results and analysis

The following section presents relevant data extracted from the pump vibration recording.

The test plan included the following:

-run pump on empty
-run pump with water no agitation
-run pump with water and agitation
-run pump with straw slurry – different agitation levels

6.1 Speed variations

It was noticed that the speed signal (tacho) fluctuated at different times. Figure 5 shows fluctuations while pumping water and with agitation.

Figure 6 shows a comparison while pumping straw slurry, the speed fluctuations are 47 rpm peak-peak while agitating and 10-20 rpm while not agitating or agitating less than 100%, see figures 7 and 8 for the process data.

Since the speed variations are happening within a few seconds, this is likely to cause severe torque variations at the pump shaft. Figure 9 shows the discharge pressure causing a direct effect on the motor pump speed set-point.

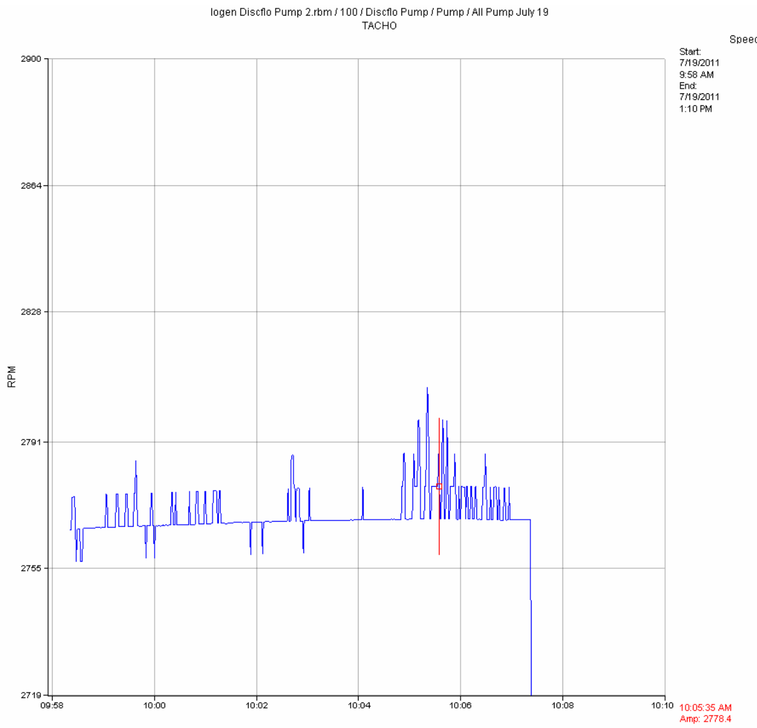


Figure 5 – Speed fluctuations water with agitations – 47 rpm peak-peak

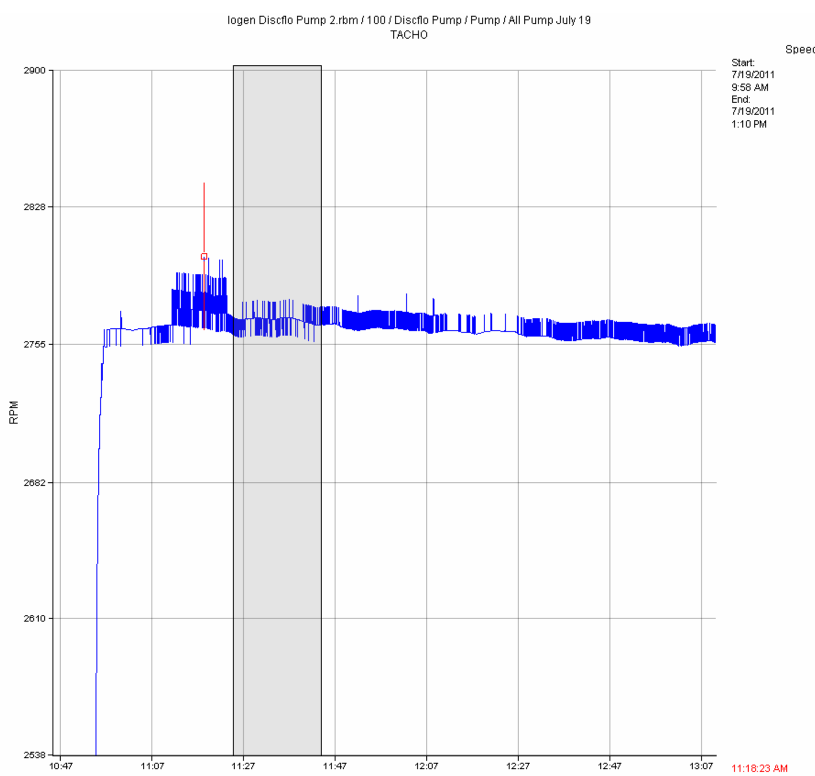
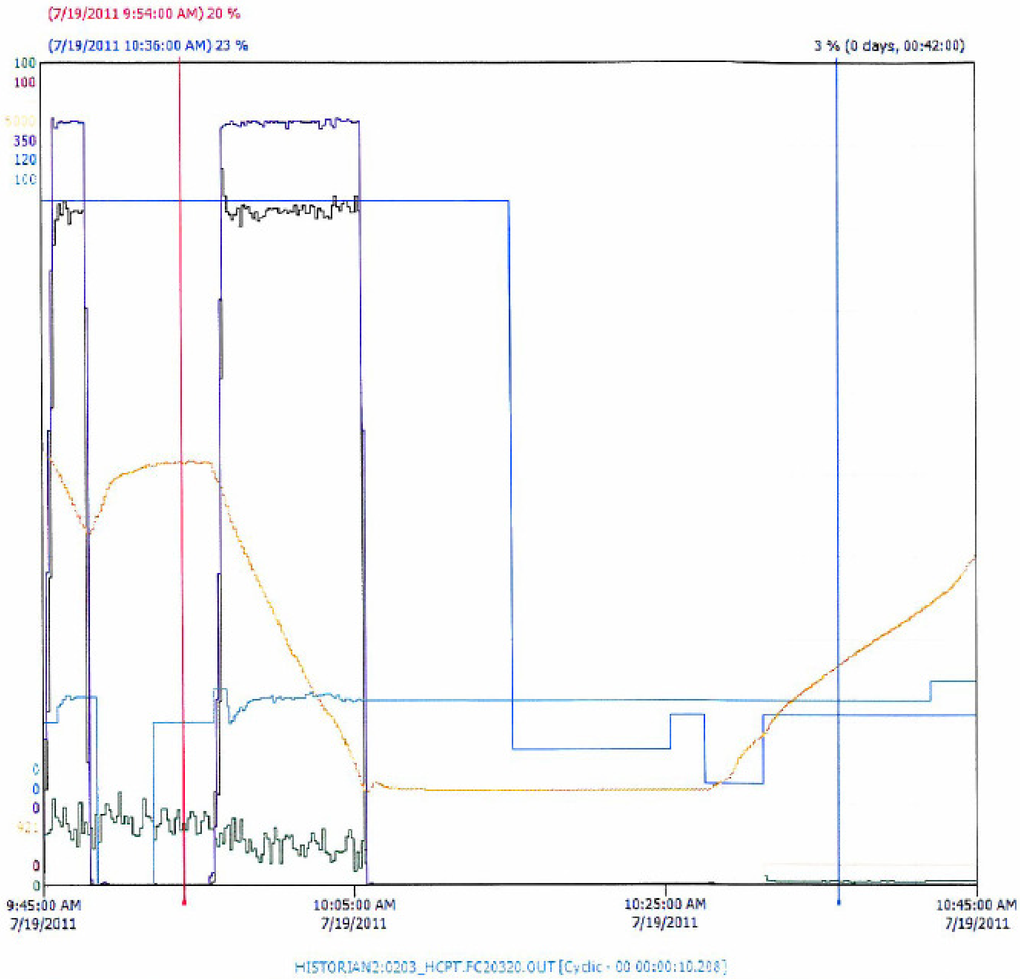
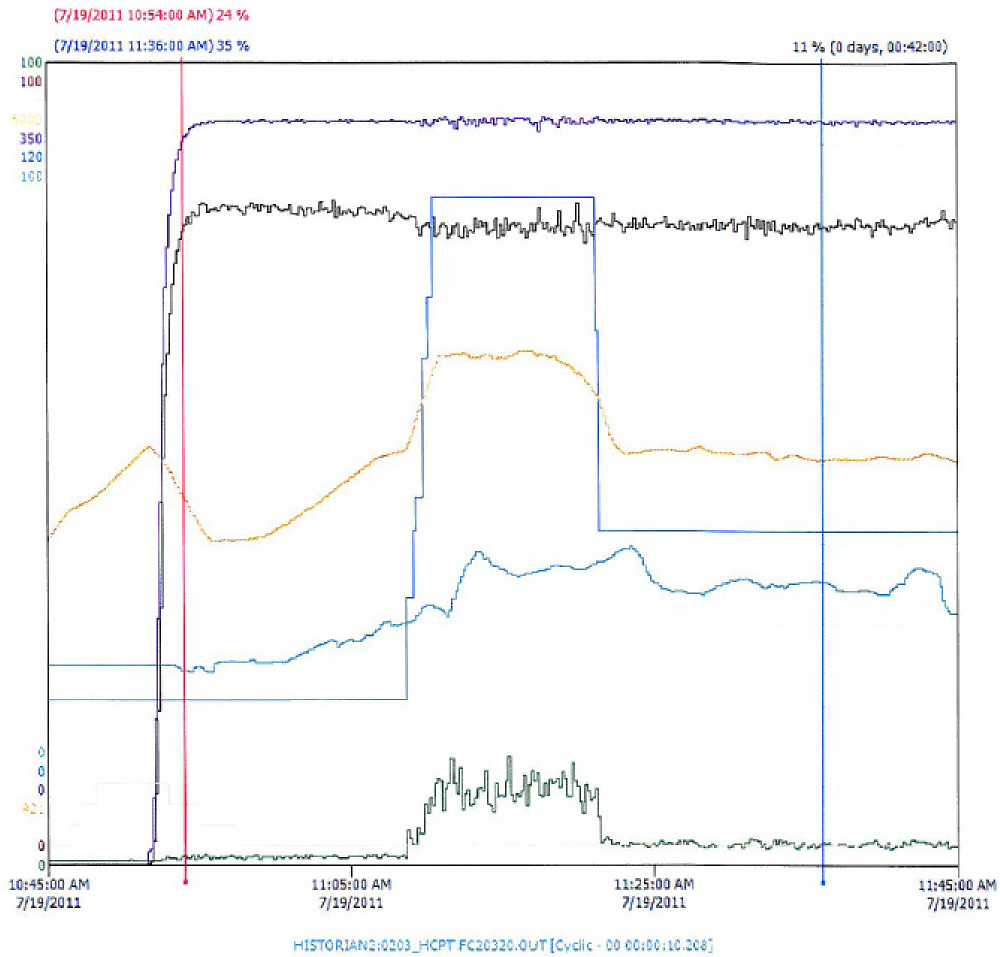


Figure 6 – Speed fluctuations while pumping slurry – peaks at 11:20 approx. to 11:23 approx. are during agitation : 47 rpm peak-peak



	Tag Name	Description	Server	Color	Units	Minimum	Maximum	IO Address
☑	0173_ACID_SK.PC17326.MEAS	STANDPIPE PUMP DISCH PRESS	HISTORI...		PSIG	0	350	\\HISTORIAN2\In:
☐	0173_ACID_SK.PC17326.MEAS	STANDPIPE PUMP DISCH PRESS	HISTORI...		PSIG	319	332	\\HISTORIAN2\In:
☑	0173_ACID_SK.SC17302.MEAS	SCREW PRS FD TK AGIT SP	HISTORI...		%	0	120	\\HISTORIAN2\In:
☐	0173_ACID_SK.SC17303.MEAS	SCREW PRS FD TK PMP VFD SP	HISTORI...		%	76	79	\\HISTORIAN2\In:
☑	0203_HCPT.FC20320.OUT	SLURRY FLOW TO SCREW PRESS	HISTORI...		%	0	100	\\HISTORIAN2\In:

Figure 7 – Process data during tests part 1



Tag Name	Description	Server	Color	Units	Minimum	Maximum	IO Address
☑ 0173_ACID_SK.PC17326.MEAS	STANDPIPE PUMP DISCH PRESS	HISTORI...		PSIG	0	350	\\HISTORIAN2\In!
☐ 0173_ACID_SK.PC17326.MEAS	STANDPIPE PUMP DISCH PRESS	HISTORI...		PSIG	319	332	\\HISTORIAN2\In!
☑ 0173_ACID_SK.SC17302.MEAS	SCREW PRS FD TK AGIT SP	HISTORI...		%	0	120	\\HISTORIAN2\In!
☐ 0173_ACID_SK.SC17303.MEAS	SCREW PRS FD TK PMP VFD SP	HISTORI...		%	76	79	\\HISTORIAN2\In!
☑ 0203_HCPT.FC20320.OUT	SLURRY FLOW TO SCREW PRESS	HISTORI...		%	0	100	\\HISTORIAN2\In!

Figure 8 – Process data during tests part 2

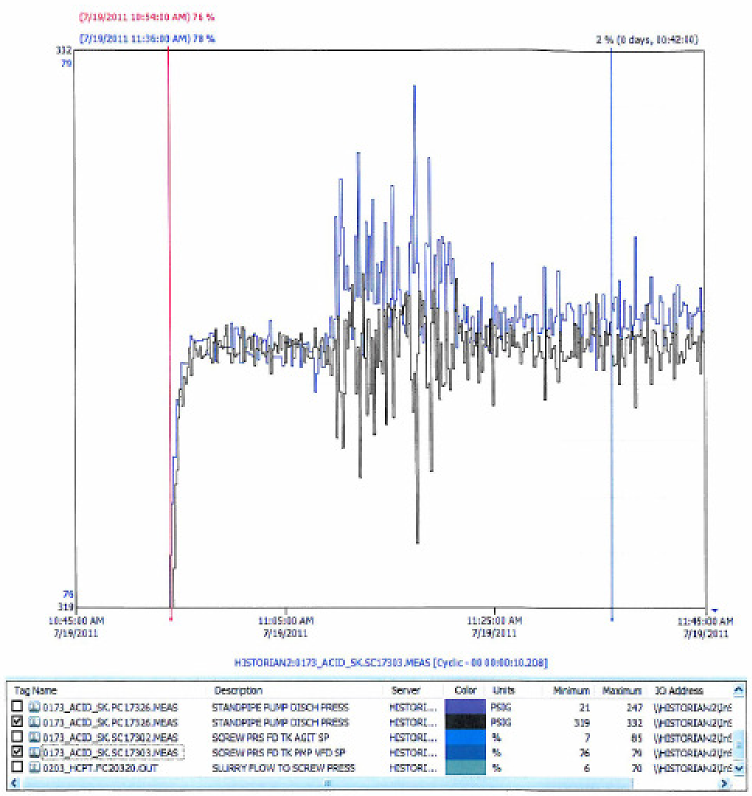


Figure 9 – Discharge pressure versus pump motor set point

6.2 Vibration Analysis

6.2.1 Overall levels

Overall velocity vibration amplitudes are highest at the pump, and generally at point P2V (pump outboard vertical), as can be seen from figures 10 and 11.

In terms of high frequencies with PeakVue detection, the motor inboard (M2) location is the highest, see figure 11. The high amplitudes on the motor are likely from electrical source, the frequency is 2.012 orders (figure 13) and we can see these sidebands around 78xrpm (figure 14), where rotor bar/stator slot frequencies typically are present. Otherwise, the high frequencies in PeakVue due to impacting are highest at the pump outboard (P2).

The overall vibration levels, 1xrpm levels and and impacting levels don't seem to be particularly process sensitive, see figures 15 and 16 as examples. We rather get some random amplitude variation due to the short duration of the measurements, which may catch a higher or lower peak.

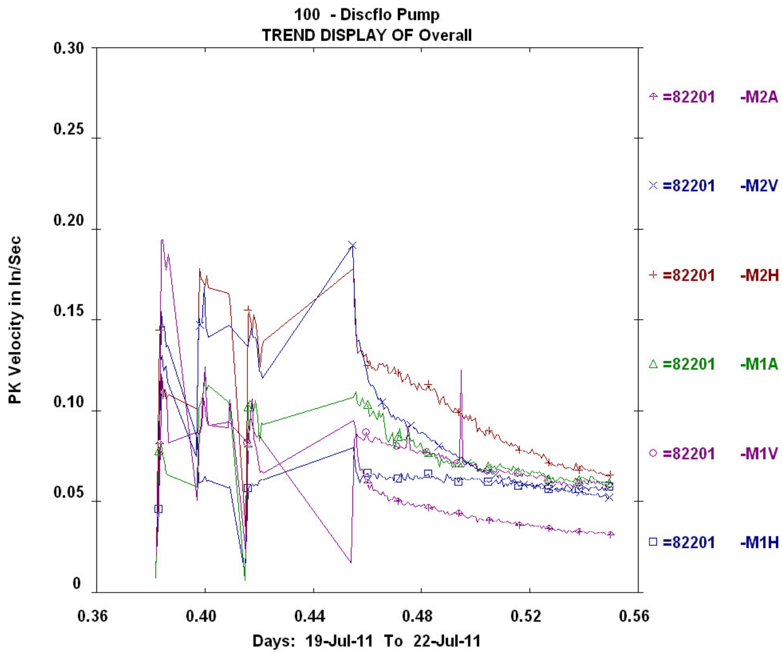


Figure 10 – Overall velocity vibration levels during measurements at the motor

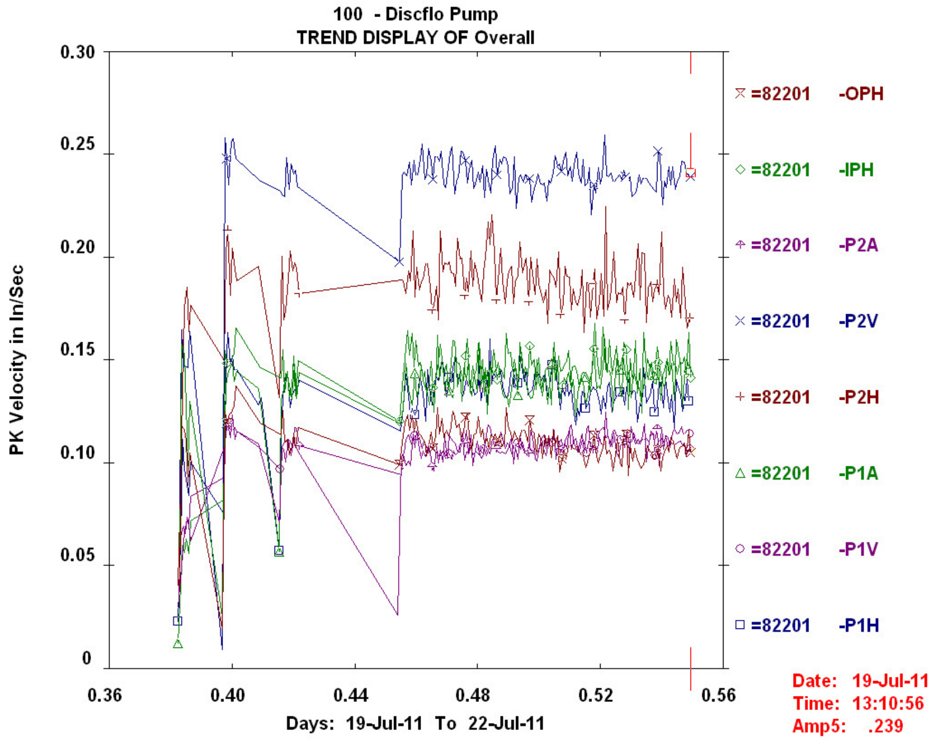


Figure 11 – Overall velocity vibration levels during measurements at the pump

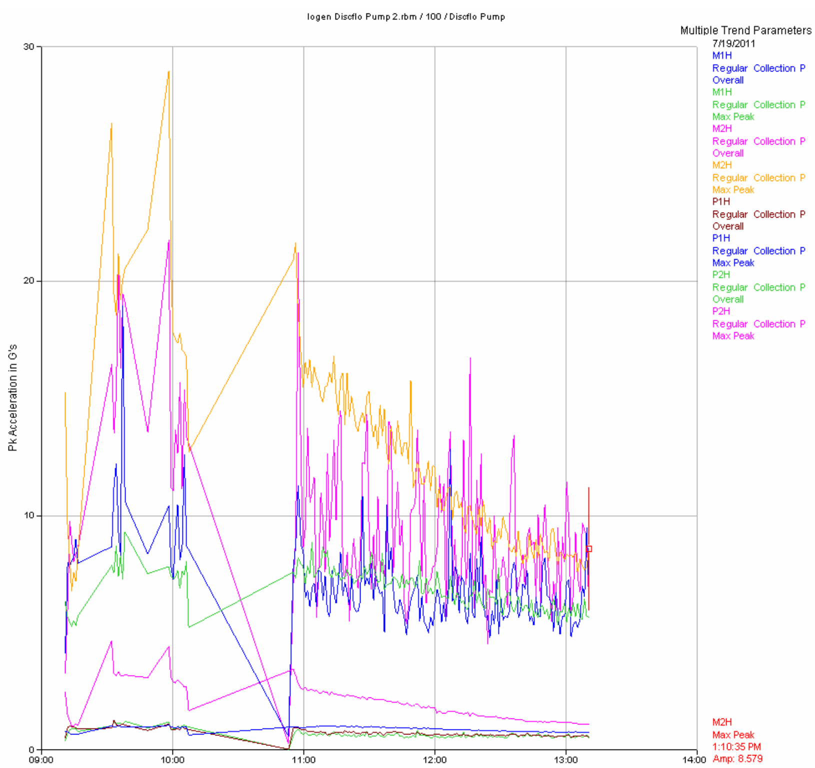


Figure 12 – Overall and Max Peak PeakVue (impact detection) levels during measurements at the motor and pump

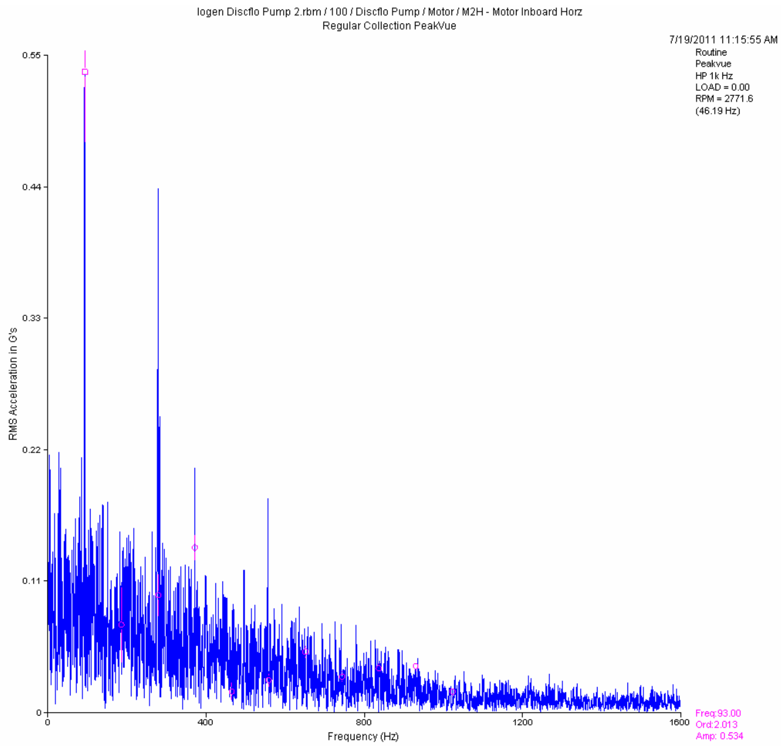


Figure 13 – Motor inboard PeakVue spectrum

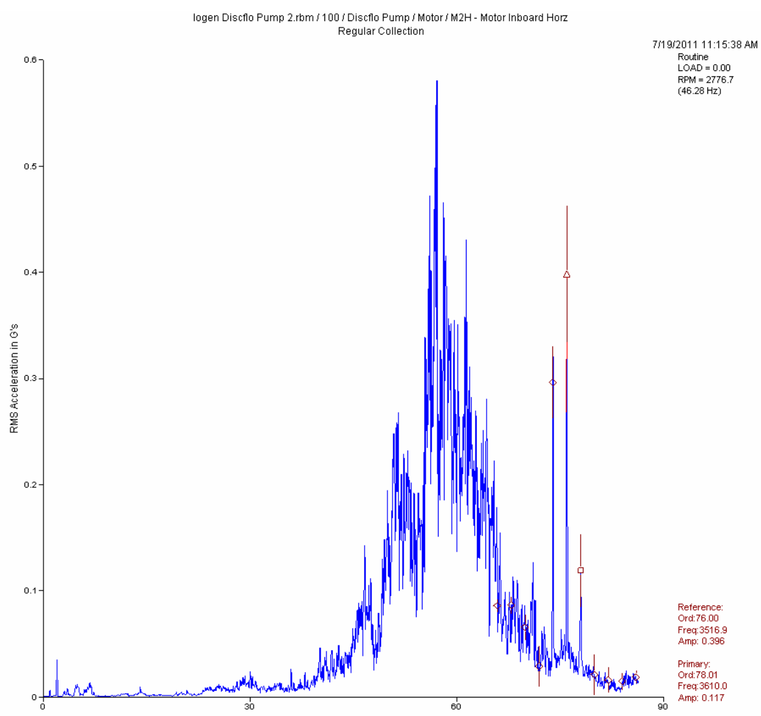


Figure 14 – Motor inboard acceleration spectrum

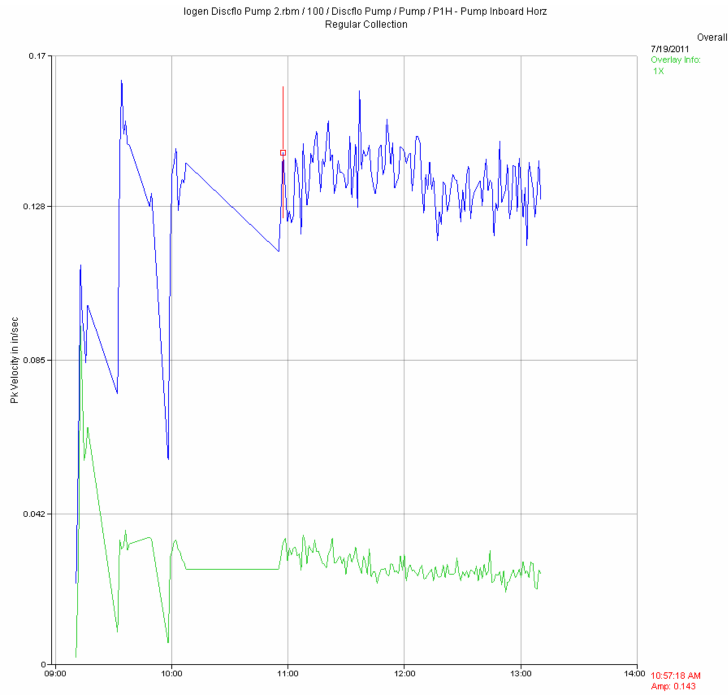


Figure 15 – Pump inboard overall and 1xrpm trends

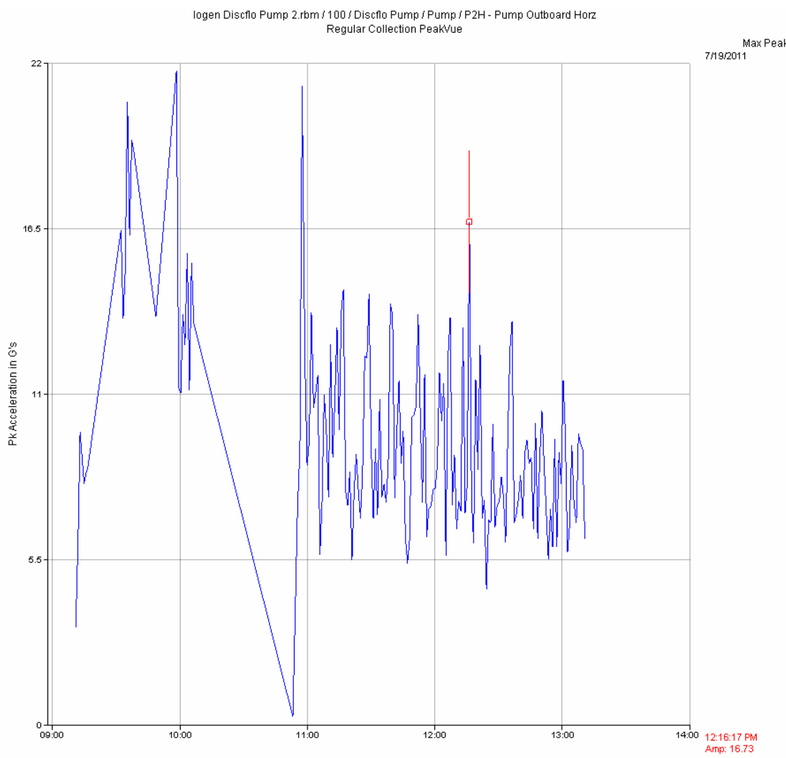


Figure 16 – Pump outboard horizontal PeakVue max peak capture trend

6.2.2 Impacting

The impacting present on the pump can be characterized as severe, and appears as soon as fluid is being pumped and the speed of 1000 rpms are exceeded on speed-up and when the speed is above 675 rpm on machine stop, see figures 17 and 18.

Figures 19, 20 and 21 show the impacting, which, depending on the measurement method, reached 22 Gs peak on the pump. The repetition is random, as demonstrated by the lack of autocorrelation peaks.

The source of the impacting is likely to be some form of cavitation. Whether the cavitation is causing fatigue on the shaft cannot be confirmed with the current data. Normally cavitation will cause erosion of the impeller and volute surfaces.

Since the flow is low with the output valve choked, a centrifugal pump would be subject to a force from the change in output fluid velocity. It is not clear if this effect would also apply to a disc pump, which operates on a different pumping principle.

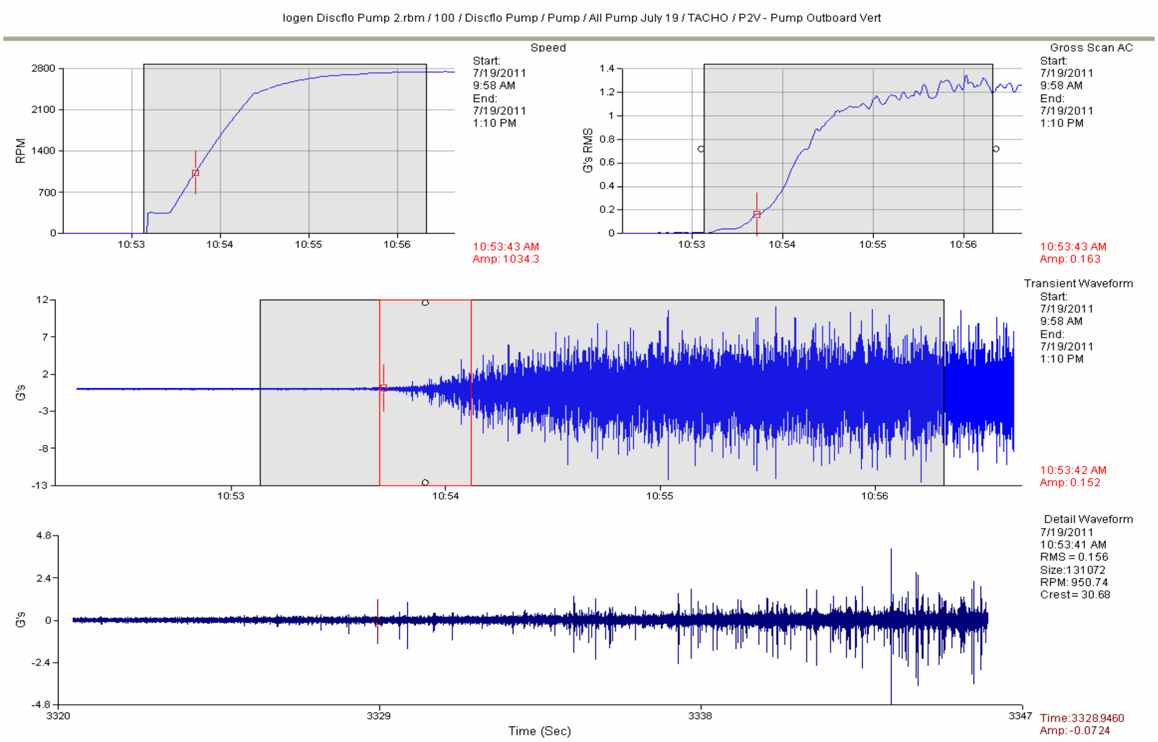


Figure 17 – Impact energy begins above 1000 rpm at speed-up

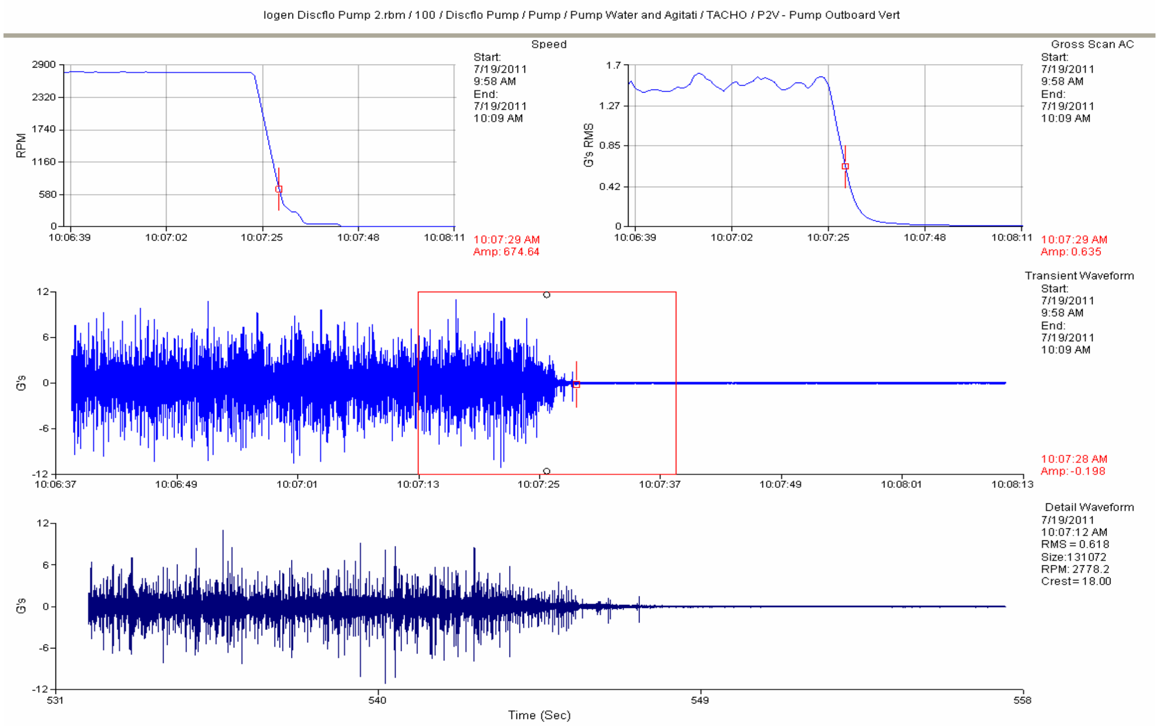


Figure 18 – On coast-down, impacts cease at 675 rpm

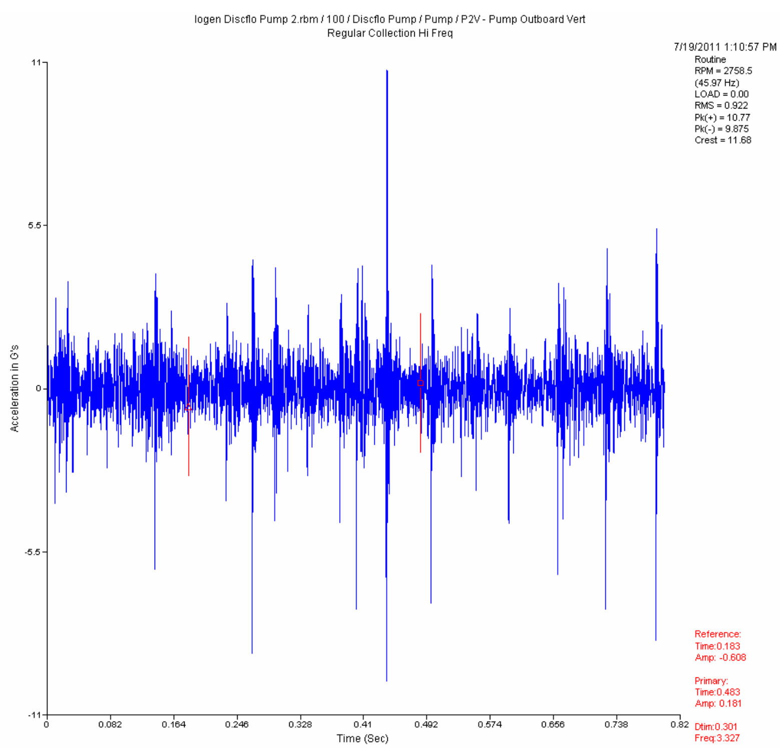


Figure 19 – Typical impacts

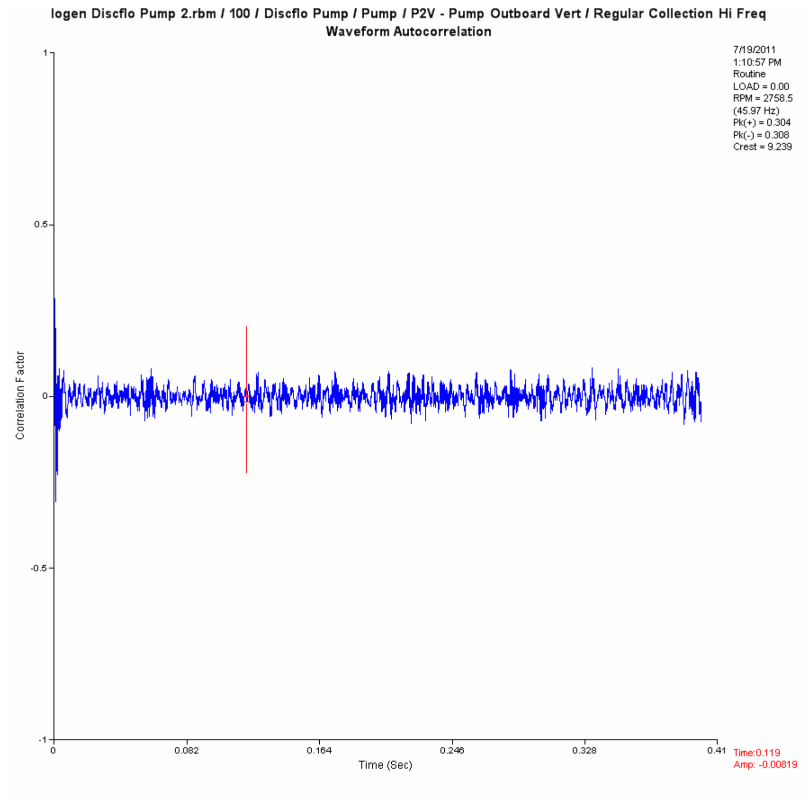


Figure 20 – Autocorrelation shows no repetition

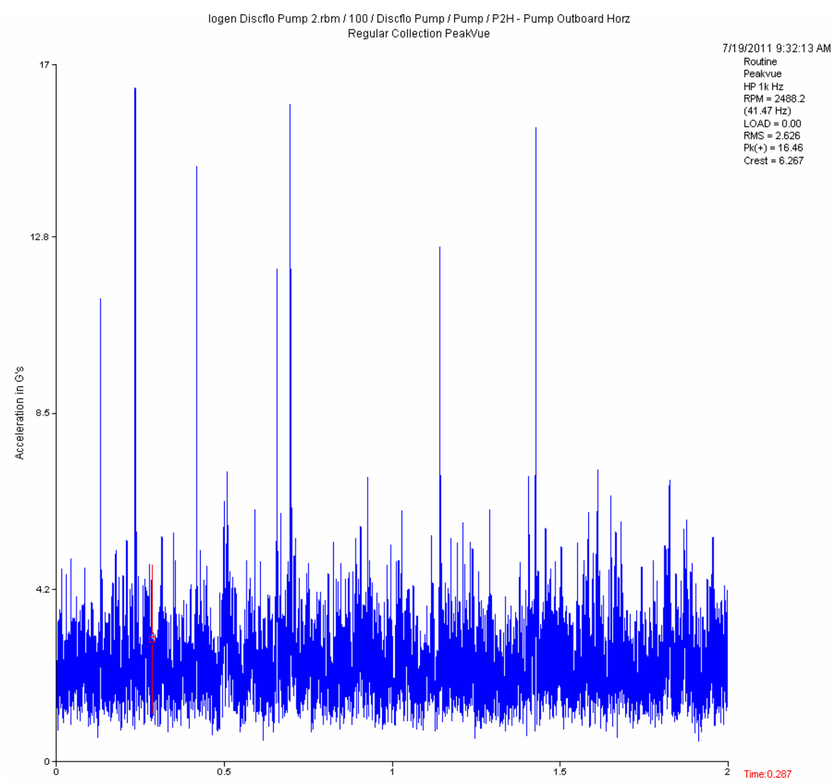


Figure 21 – Example of impacts measured with PeakVue (waveform)

6.2.3 Velocity vibration

On a typical velocity spectrum we observe 1x, 4x and 8x vibration frequencies, as shown in figure 22. These levels can be judged normal for a typical pump. We can also note that the noise floor is showing the pump resonances, and this is a result of the impacting.

Figures 23 and 24 show the behavior of the 1x vibration that establishes itself at 2700 rpm and remains stable. This can be seen as normal, resulting from residual unbalance.

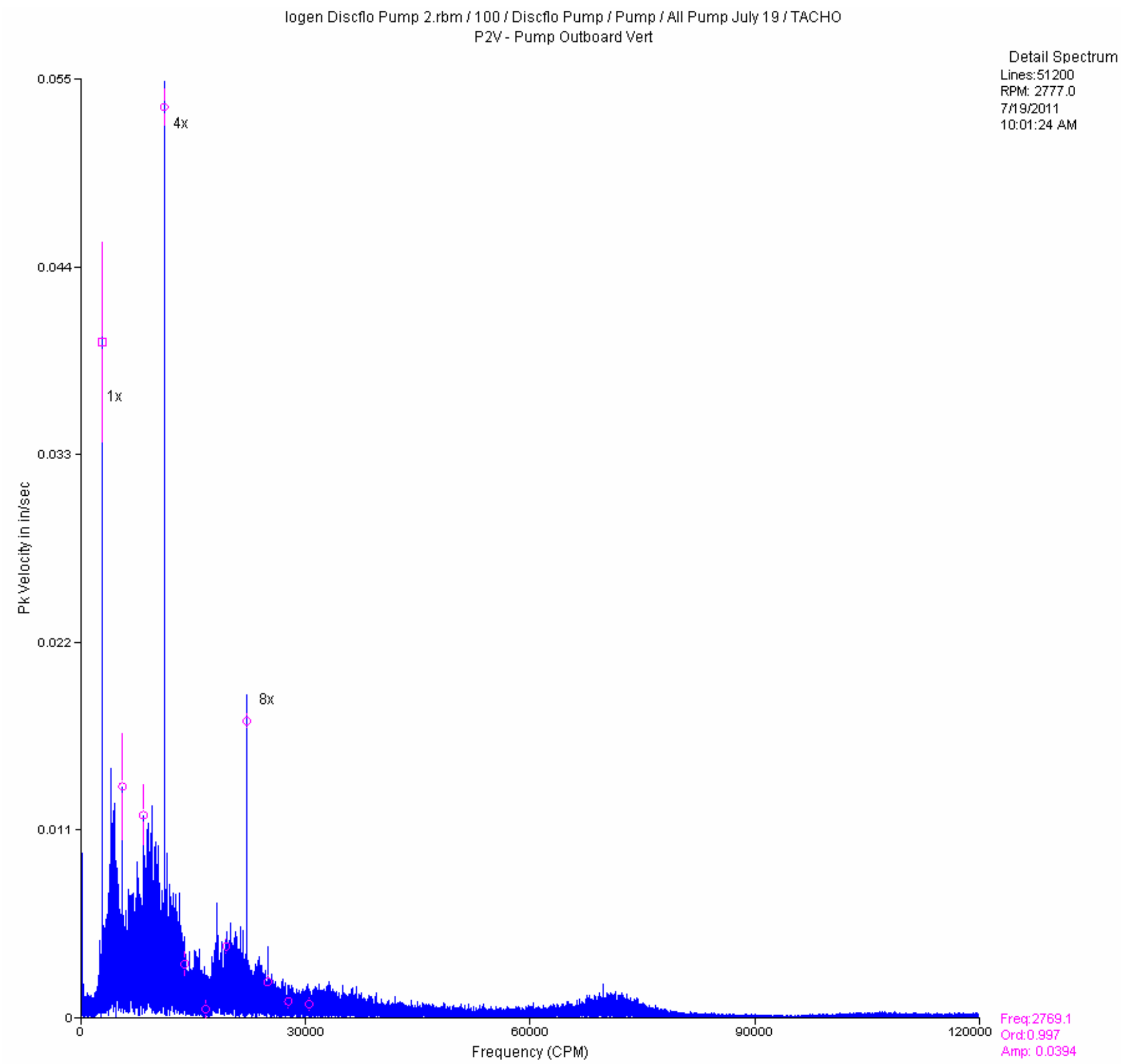


Figure 22 – Vibration spectrum showing 1x energy, as well as 4x and 8x (from the ribs of the impeller), the first resonance peak is located at 70 Hz.

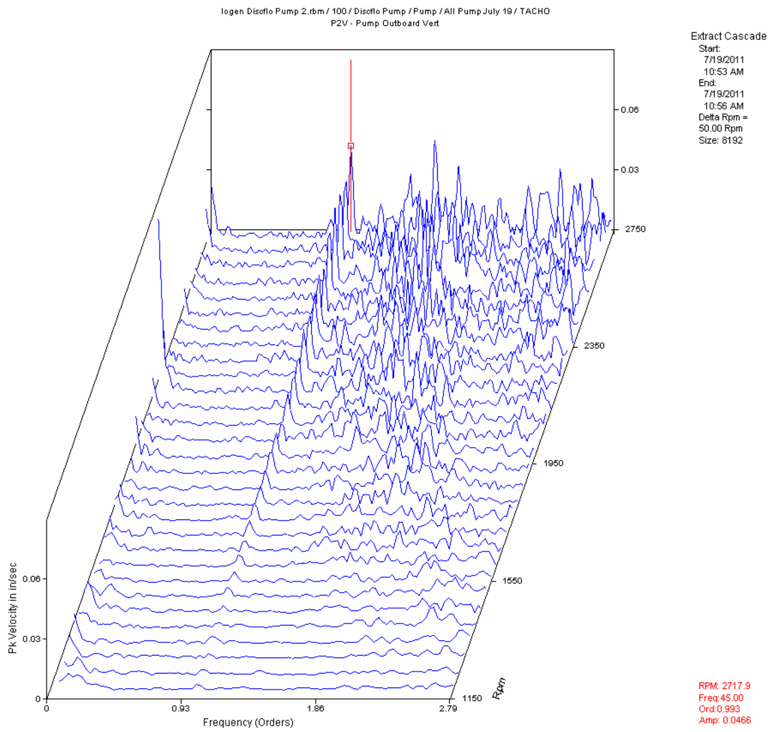


Figure 23 – The 1x energy establishes itself at above 2700 rpm

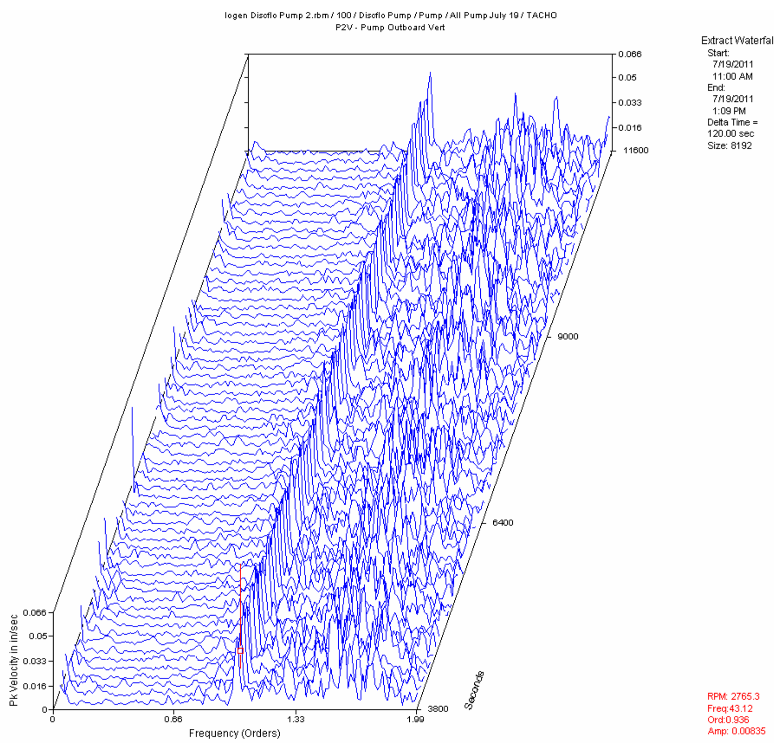


Figure 24 – The 1X energy remains stable at 2700+ rpm

7 Conclusions

7.1 The motor and pump are subject to excessive and rapid speed fluctuations due to the control loop reacting to discharge pressure changes. These fluctuations are the most likely sources of torque variations that can fatigue shafts to the point of failure.

7.2 The pump is subject to severe impacting that is likely the result of cavitation. It is not certain whether the impacting affects the pump shaft reliability, since it is typically associated with surface erosion problems.

8 Recommendations

8.1 Keep agitation to a minimum until changes are made to alter the control loop (or reduce pressure pulses) and vfd parameters to eliminate sudden motor speed changes. If needed, additional tests can be performed to measure speed, torsion and torque variations in better detail.

8.2 Review the pump operating conditions and design application with the manufacturer to see if the cavitation can be better understood and ideally, eliminated.