Windrock

Users' Group Conference 2018

Crosshead Monitoring

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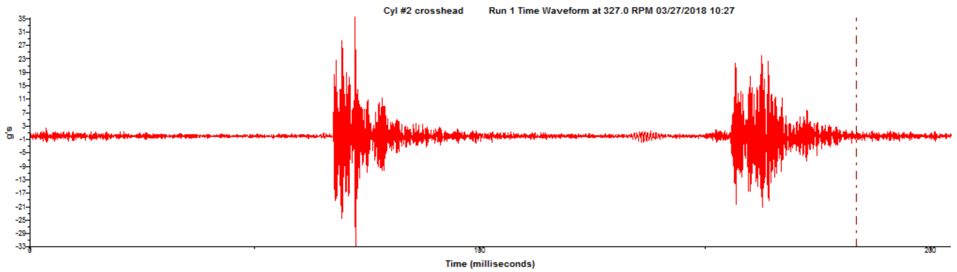
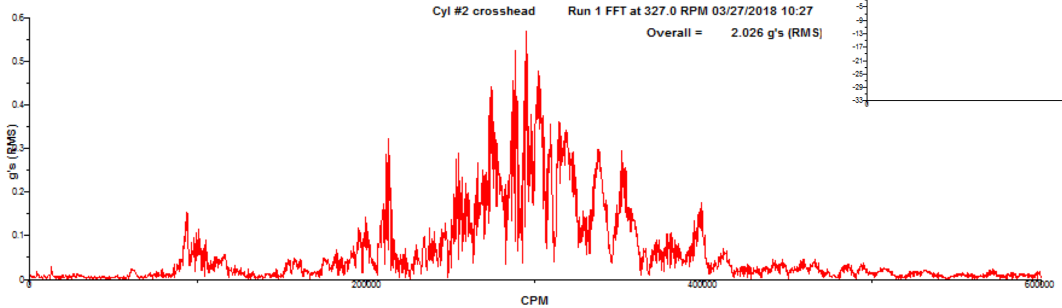
Summary

This is a discussion on using both crank angle data, spectral data and time waveform review to monitor reciprocating machinery crossheads.

It is an expansion of the previously discussed monitoring techniques from Warren Liable. The techniques were applied to main bearings to evaluate their health.

The techniques when applied over time can help to increase an analysts understanding on the crosshead condition, and with careful review make better more informed calls on machinery health.





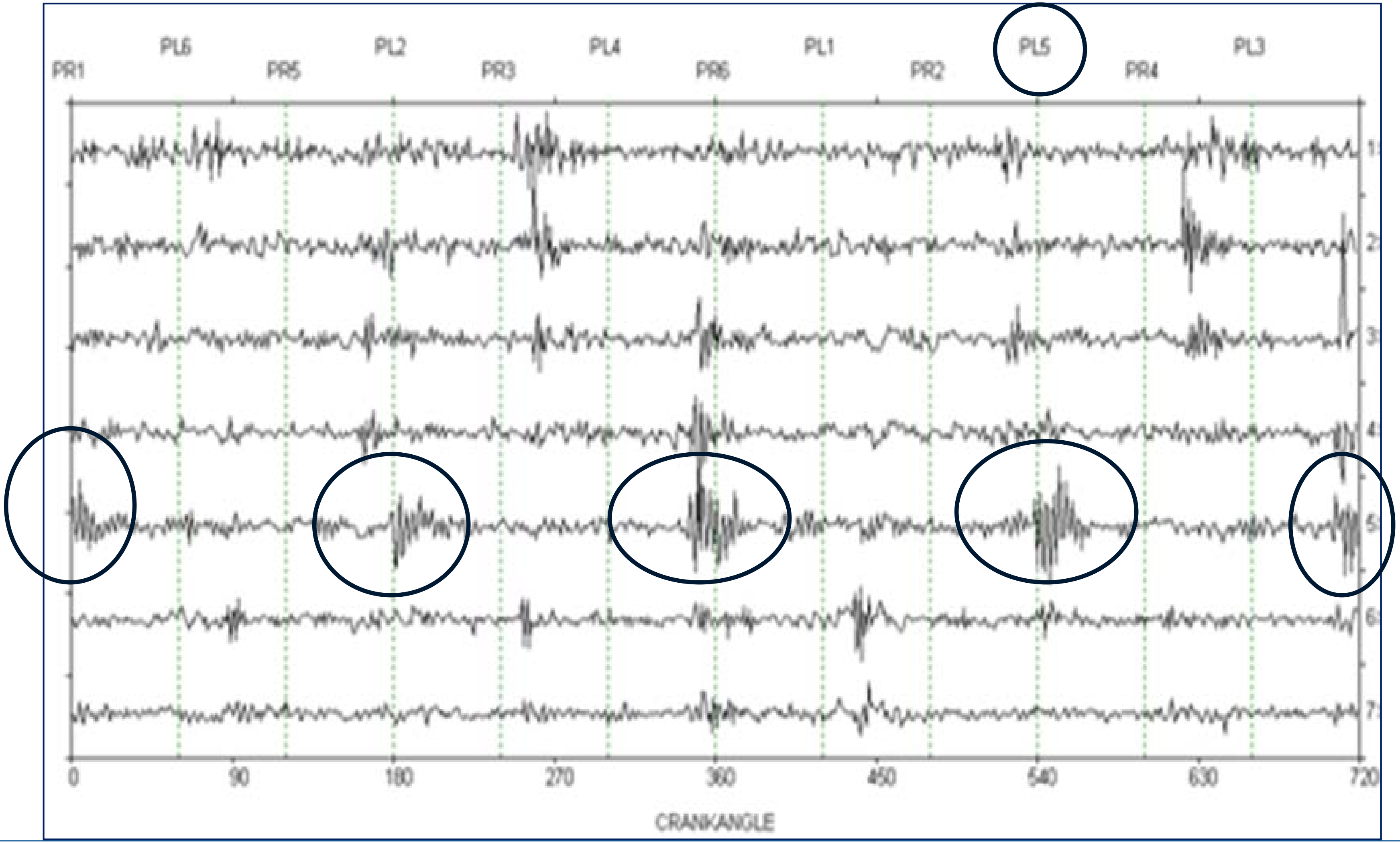
Brief timeline of reciprocating impact analysis

- Previous paper written by Warren Laible

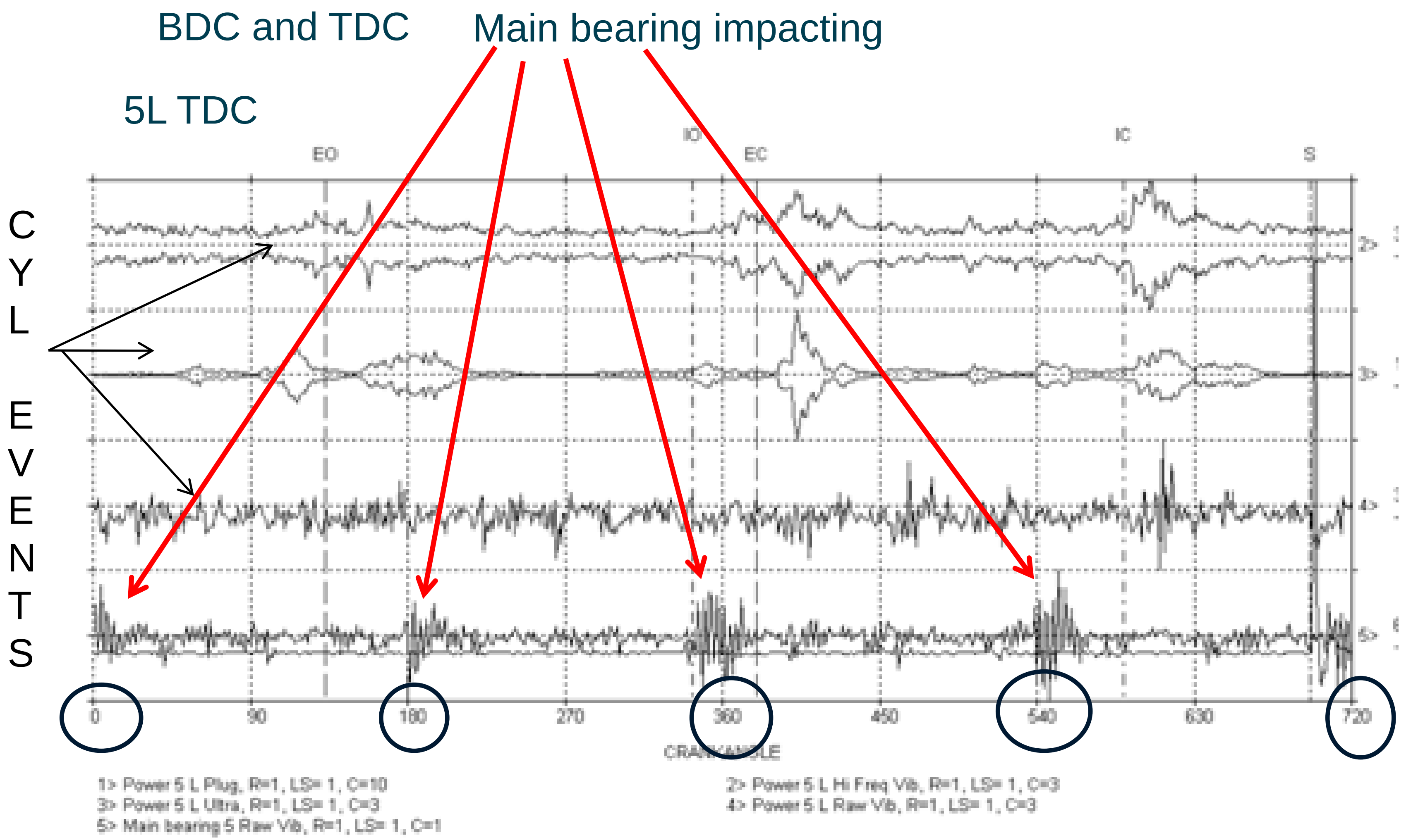
  "*Early Detection of Connecting Rod Bearing Impact Vibrations in High Speed Industrial Gas Engines" – 2011 GMRC & WRI Users group*
- When the bearing material and the crankshaft crankpin journal come in contact with each other in the absence of an effective oil cushion, an impact occurs which generates a resonant ringing of the impacted parts.
- When rod bearings knock, the impact event frequency is 2 times RPM (CPM).
- The "ringing" frequency is usually in the 2.5 KHz to 5 KHz range (150,000 to 300,000 RPM (CPM).
- Use acceleration measurements for early detection and trending of the impacts.
- When velocity amplitudes increase because of a rod bearing knock, severe damage is occurring.
- Oil analysis may help determine the extent of damage and the components that are affected (bearing or bushing).

Vibration vs. Crank-angle Display

Overview

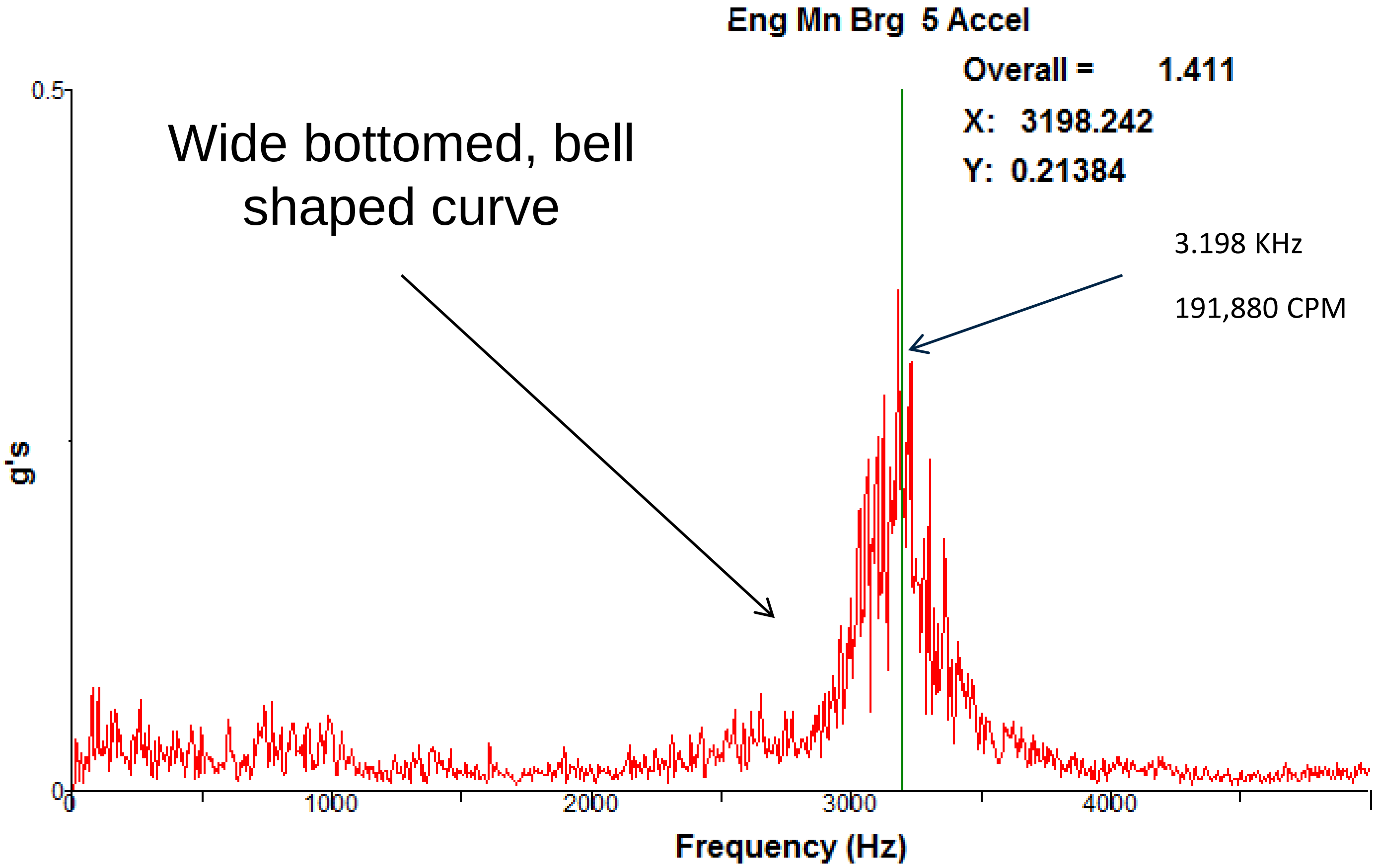


Crank Phased Data With Cylinder Mechanical Events



FFT – Acceleration data

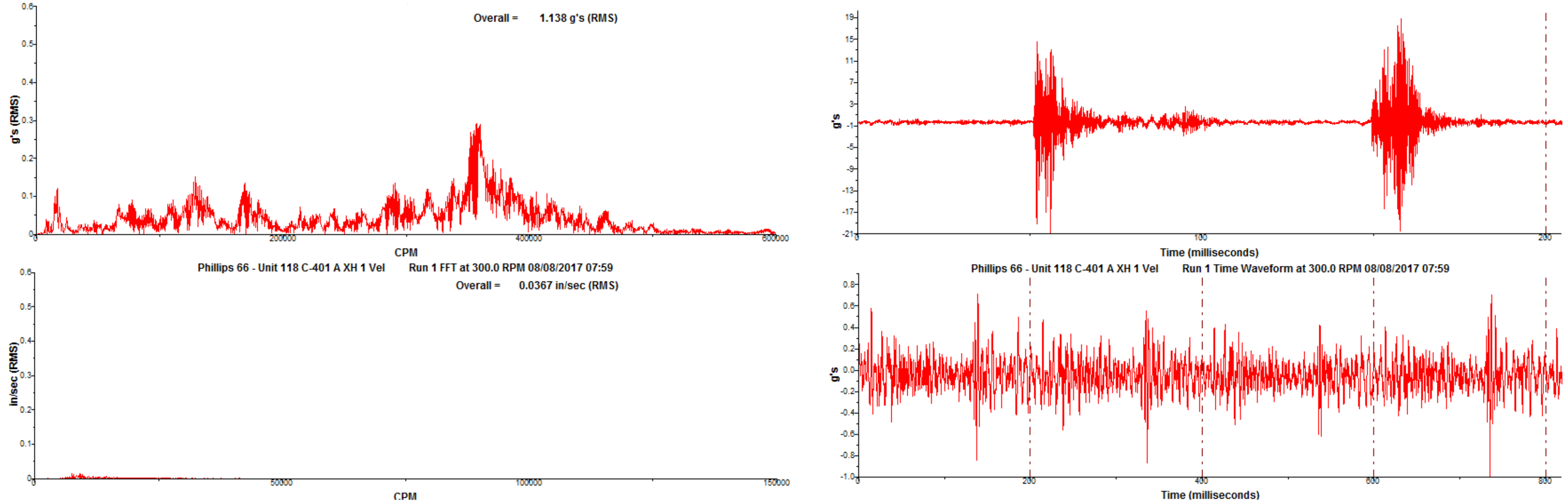
Identification of impacting in FFT spectrum



The long and short of it

Why do I need 4 points at the same location.

- Its important to be able to think about the data your collecting in many ways
  - 2 crank angle data points (Raw and High filters)
  - Time: What do I want to see in my time waveform
    - ips data, Low Fmax, long time waveform, multiple crankshaft revolutions.
  - Frequency: What do I want to see in my spectrum
    - G’s data, High Fmax, short time waveform



Time waveform length

How long does my waveform need to be?

- Try to see between 5 to 10 revolutions of the data in the waveform.

  Example:
  - Lines of resolution = 3200
  - Fmax = 10,000 Hz (600,000 CPM)

  # of samples = 2.56 x 3200 lines = <u>8192 samples</u>

  T = 1/(2x 10,000Hz)) x 8192 = <u>0.4096 seconds</u> or 409.6ms

- If our RPM is 900 then

  900 RPM / 60 = 15 crankshaft revolutions per second

So with a timewaveform of **<u>0.4096 seconds</u>** we will see **<u>6.144 crankshaft revolutions</u>** in our time waveform with a 900 RPM machine.

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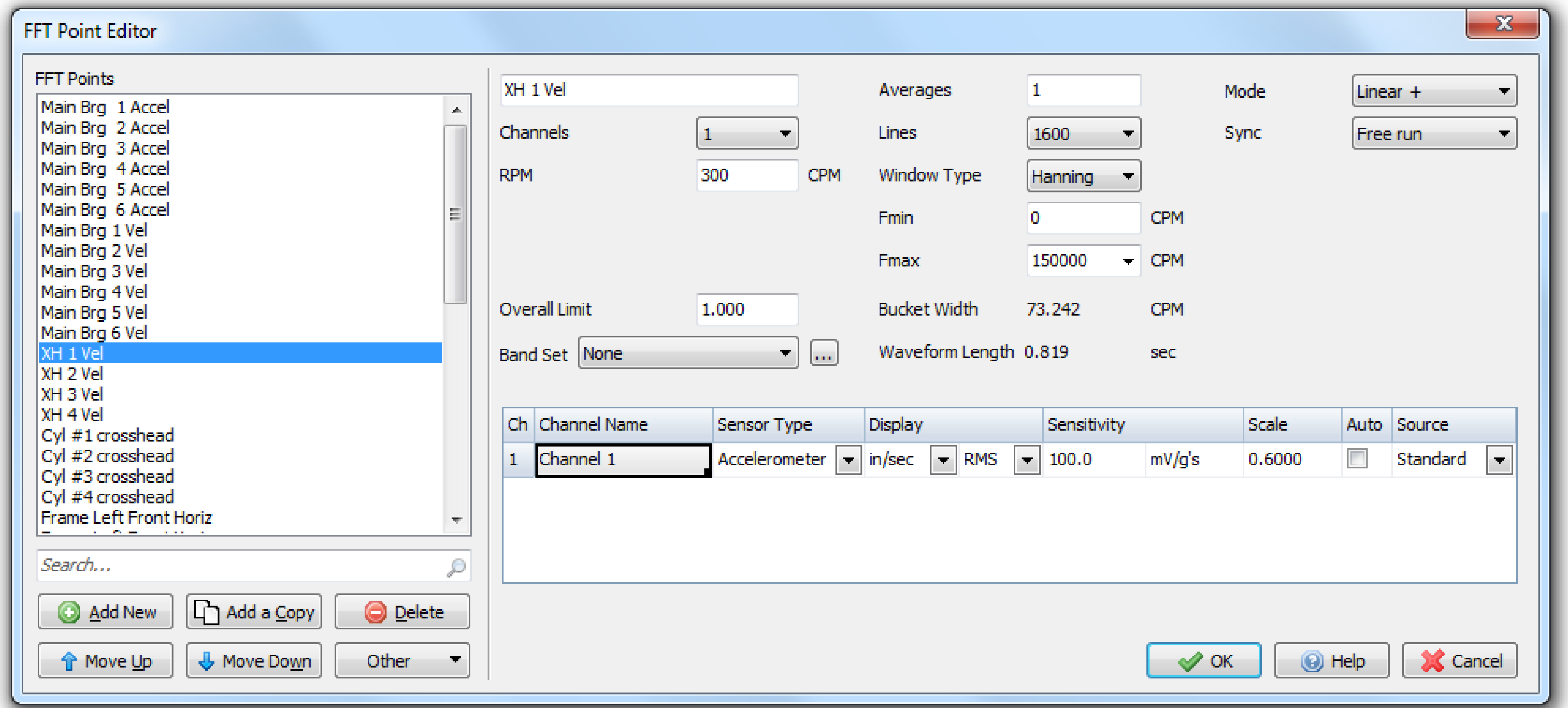
Velocity setup for crosshead

- 1600 Lines
- 150,000 CPM Fmax
- 1 Average
- In/sec RMS



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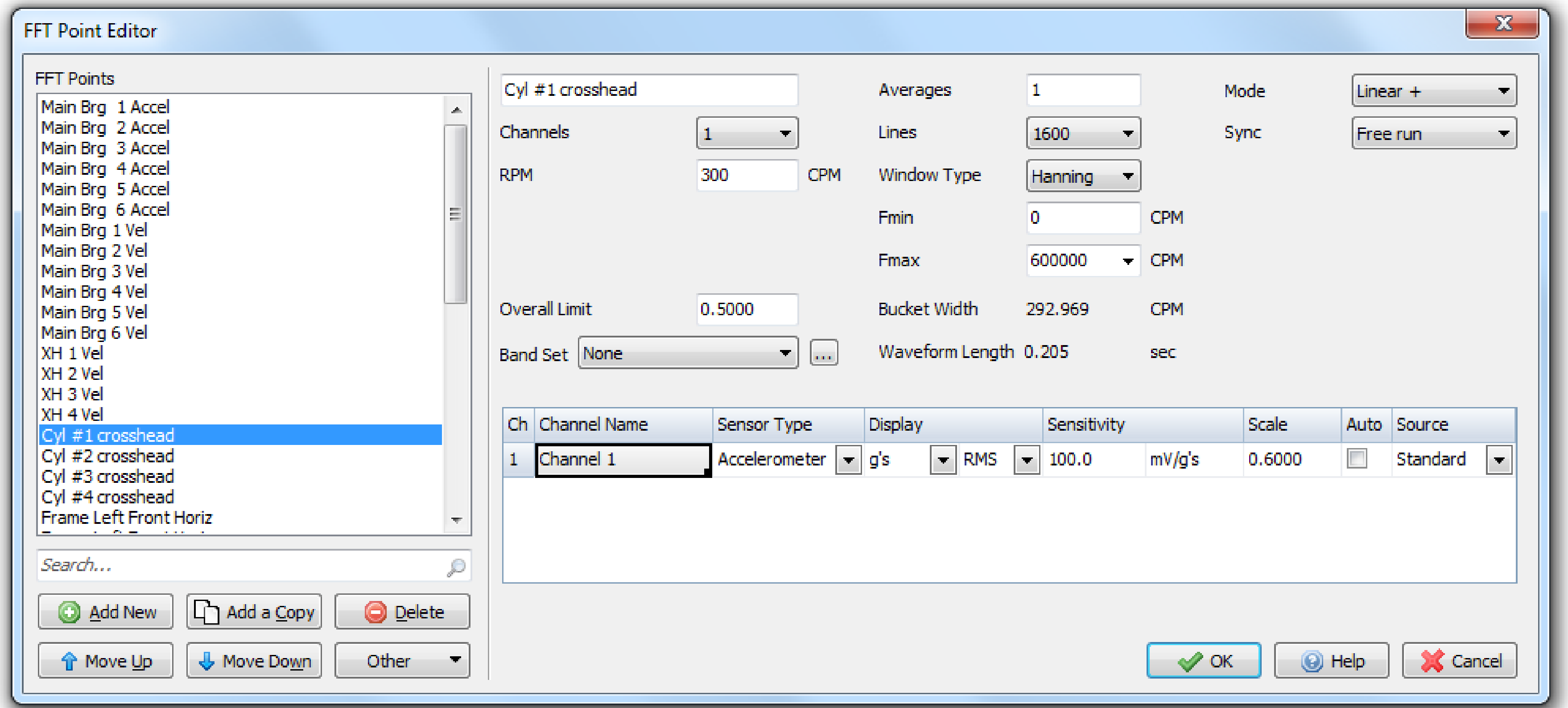
Acceleration setup for crosshead

- 1600 Lines (can be 3200)
- 600,000 CPM Fmax
- 1 Average
- G's RMS



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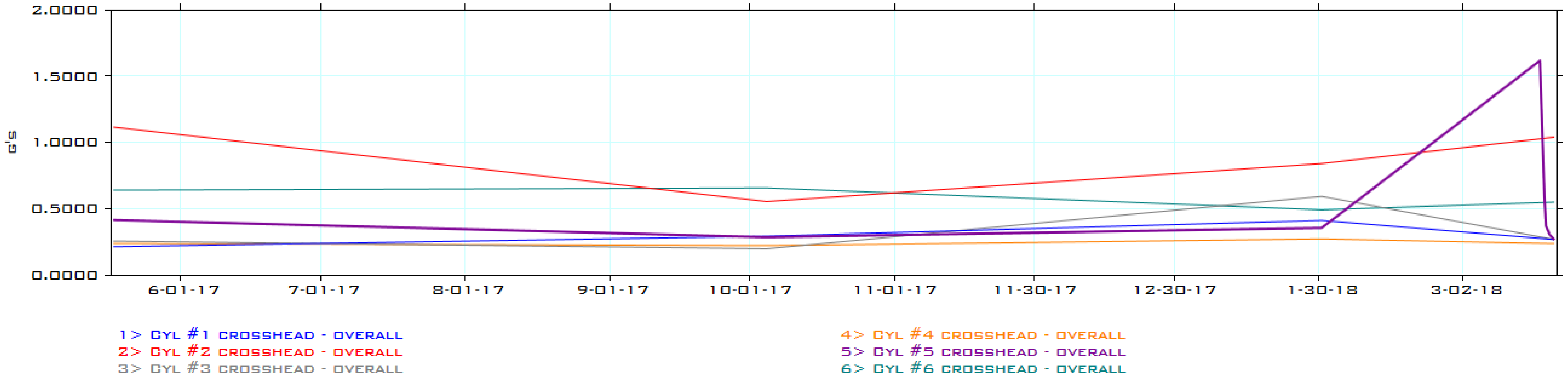
RMS or Pk?

- You can decide to collect the g’s and ips in either RMS or peak.
- The Peak number will be higher than the RMS.
- The RMS will be lower even with some impacting in the waveform.
- Over years of testing I take the values in RMS unless directed to be a customer.
  - The RMS overall is not as affected by the small changes as the peak number.
  - When the crosshead is in good condition the RMS numbers stay low until clear impacting is detected.
  - The peak numbers will be higher and vary more over time.
  - Trending of the RMS overall number is steadier than trending with the Pk number.
- This is a general guide only from the feel I have with this data.
- Every analyst will have to decide to use either RMS or Pk.

Trend the acceleration

G's get trended and used as the severity guideline.

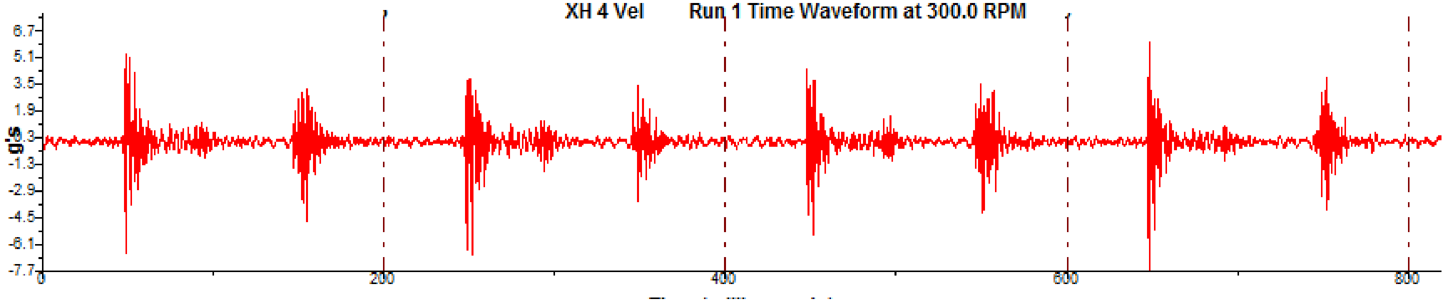
- Use the g's Raw overall as a guide into severity.
- This can be trended over time to evaluate the condition of the crosshead.
- A general rule is that no crosshead should be double what the others are.
- 2.0 to 2.5g's overall is a good starting point for a warning level.



Velocity data review

Ips - Look at the timewaveform impacting

- The spectrum if set up correctly will help in diagnosing the fault and severity, but….
- The time waveform is the true representation of the analog to digital conversion of the signal from the sensor
- It will show the unfiltered representation of what is actually happening.
- Make sure to create a sensor point that you will use to only look at the timewaveform
- Look for:
  - Modulation over time
  - Impacts per revolution
  - All the data that is missing out of your FFT
  - Yes, your going to have to actually look at the data you collected to make your calls…



Don’t get confused

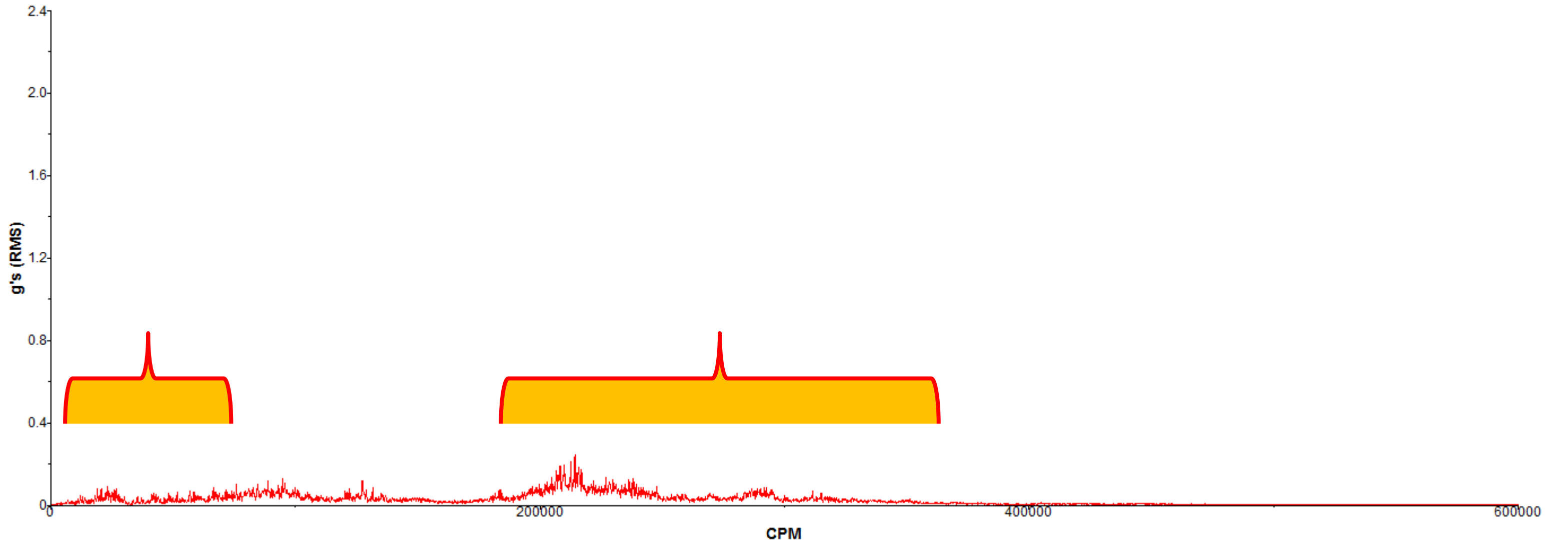
- Impacting in the crosshead can be caused by many issues.
  - Loose reciprocating masses
    - Loose piston / cracked piston / piston lost crush.
    - Loose piston nut / crosshead nut.
  - Clearance in the pin / bushing area.
  - Clearance in the crosshead shoes.
  - Valve impacting.
  - Cracked valve chair.

To name a few of the most common.

When there is some impacting in the crosshead it does not always have to be a crosshead issue. Be careful to study all of the possible data to evaluate and diagnose the problem.

Reading the acceleration spectrum

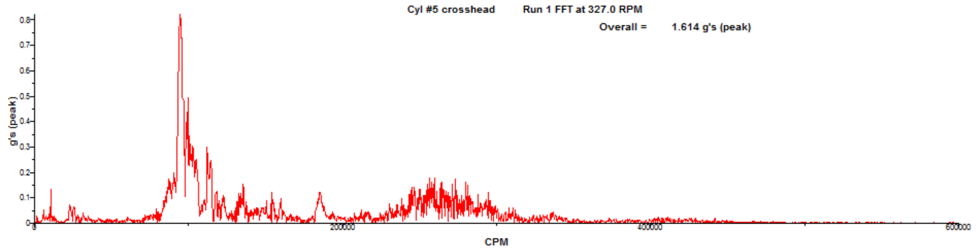
- A rule of thumb for the spectrum is
  - High frequency haystacks = crosshead / main bearing issues.
  - Low frequency haystacks = valve and piston related.

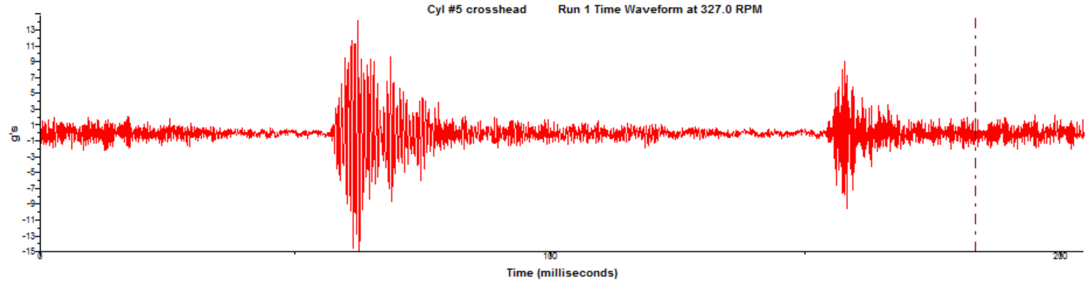


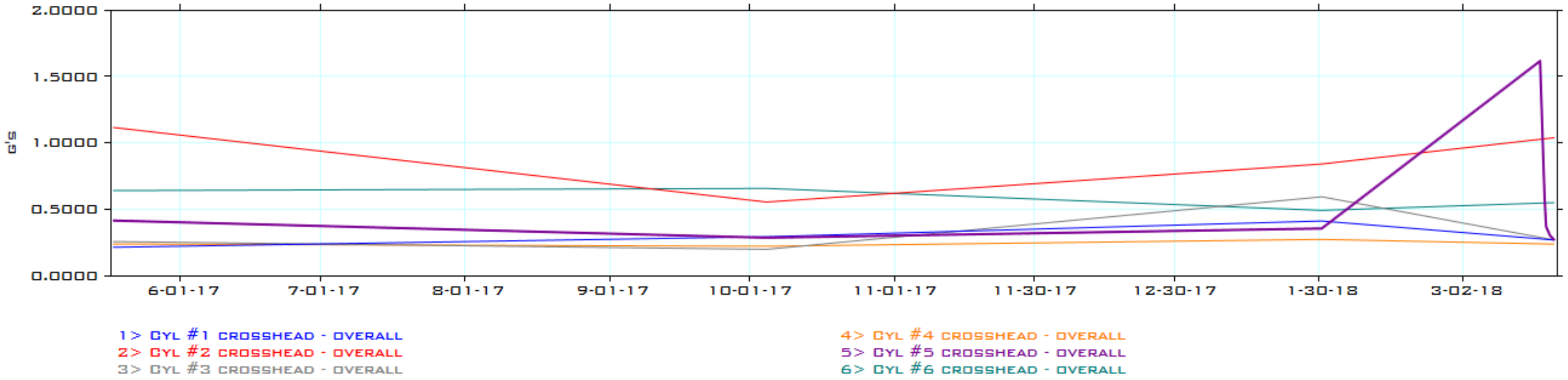
Example #1

High crosshead impacting recorded

- Operations thinks crosshead is knocking.
- Data shows elevated crosshead impacting.
- Clear double impacts in timewaveform.
- Trending of energy showed increase.



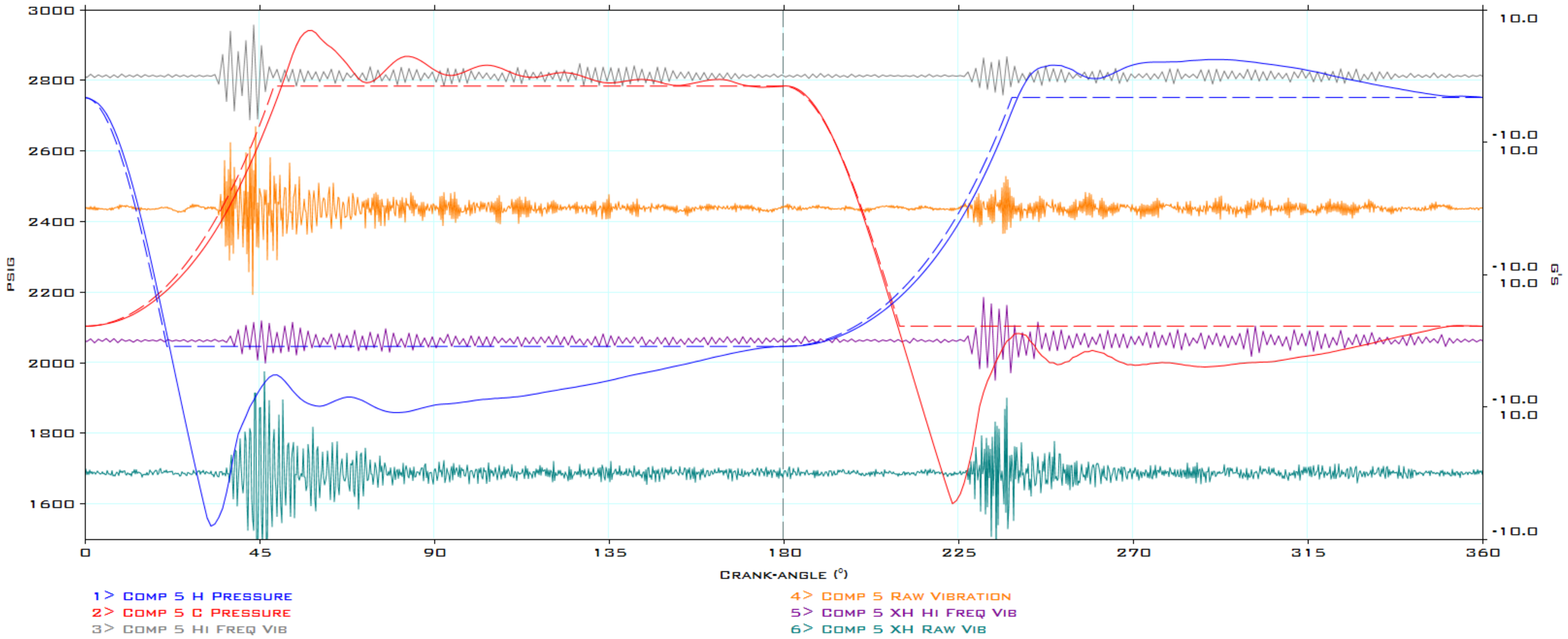




Example #1

Crankangle data review

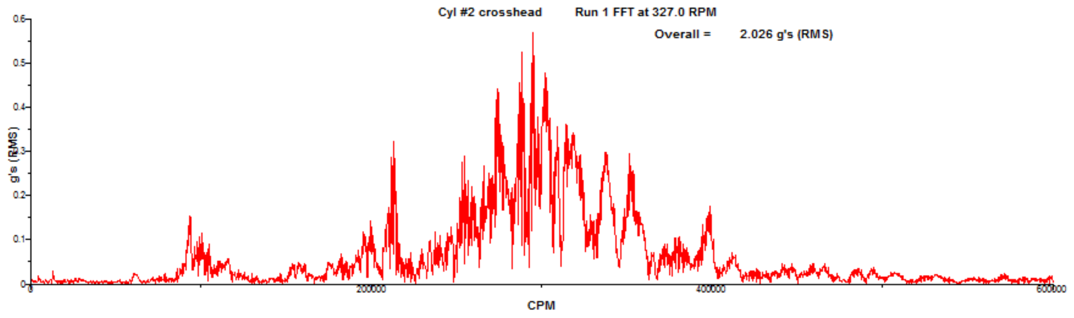
- Impacting caused by suction valve issues.

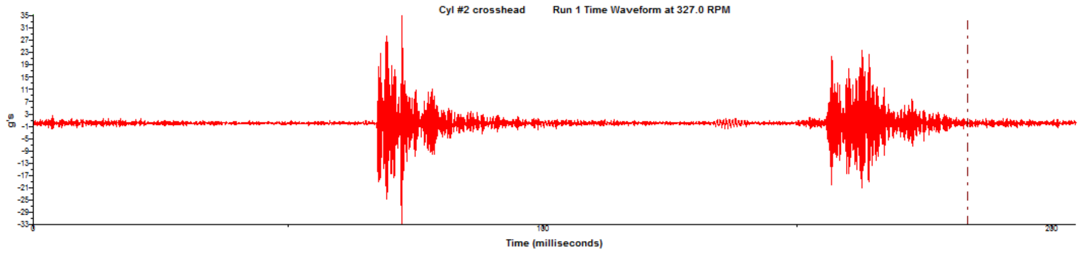


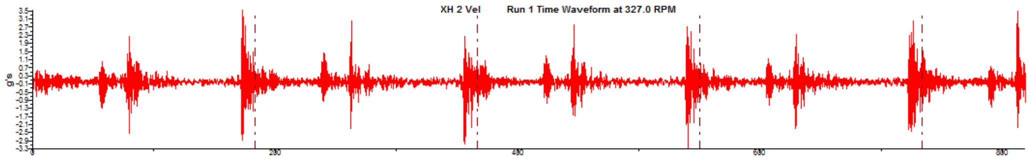
Example #2

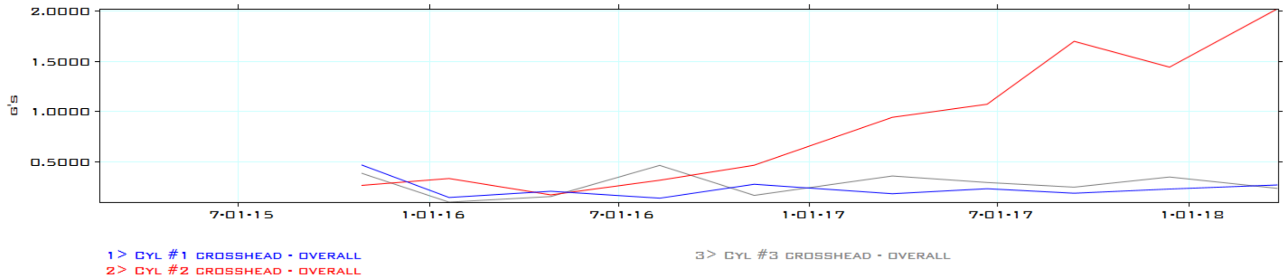
Acoustic impact by cylinder

- Maintenance wants to know cause of knocking.
- Data shows elevated crosshead impacting.
- Clear double impacts in timewaveform.
- Trending of energy showed increase.





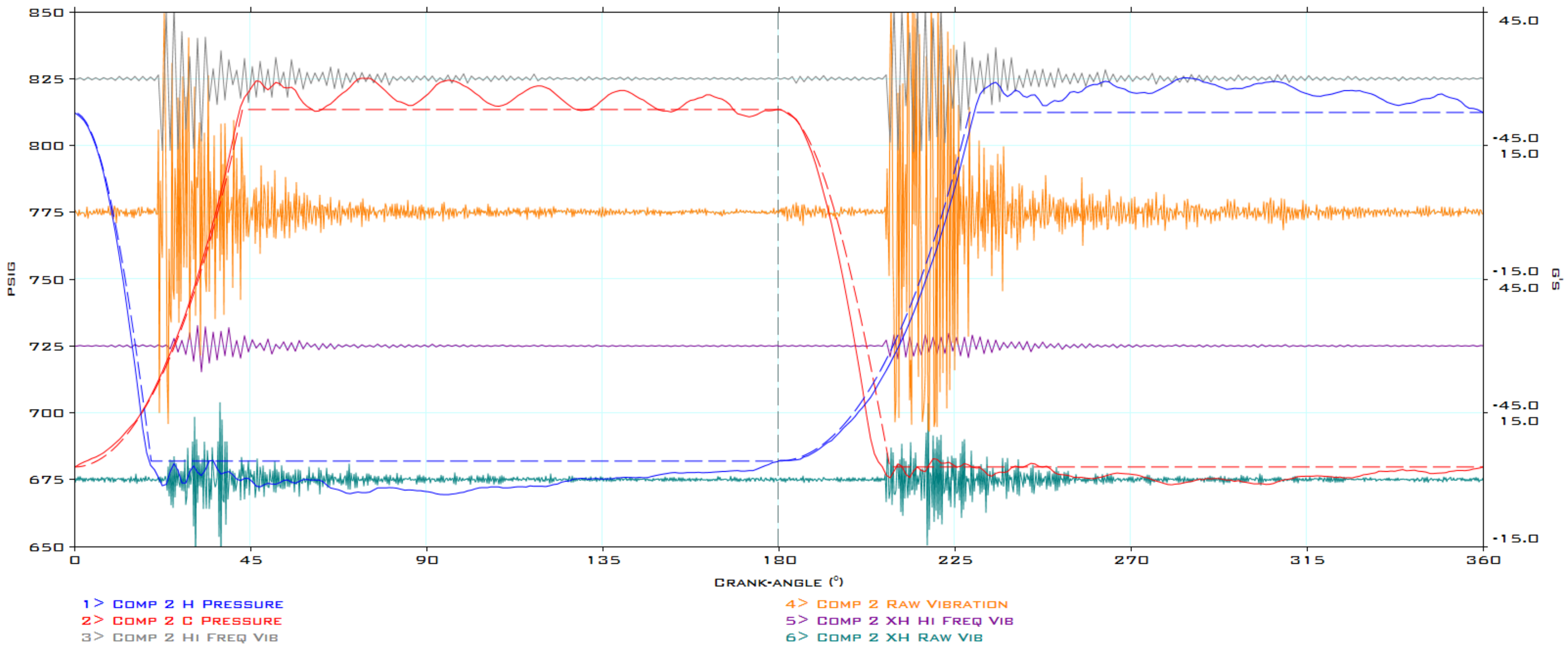




Example #2

Crank angle data review

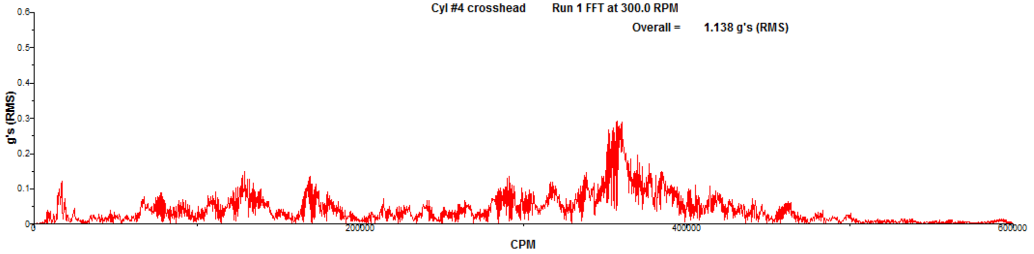
- Impacting caused by suction valve issues.

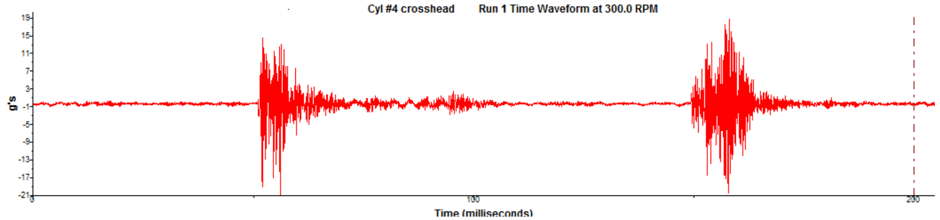


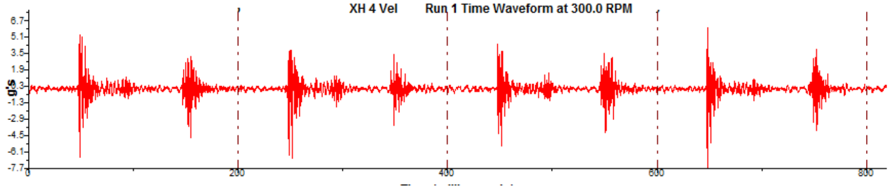
Example #3

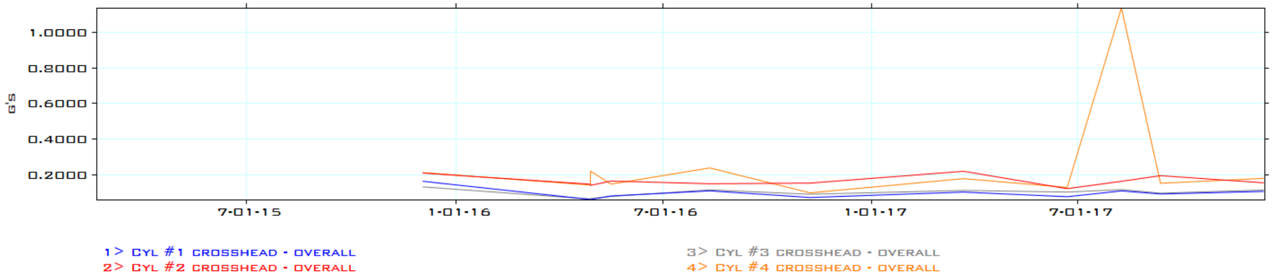
Acoustic impact by cylinder

- Operations wants to know cause of knocking.
- Data shows elevated crosshead impacting.
- Clear double impacts in timewaveform.
- Trending of energy showed increase.





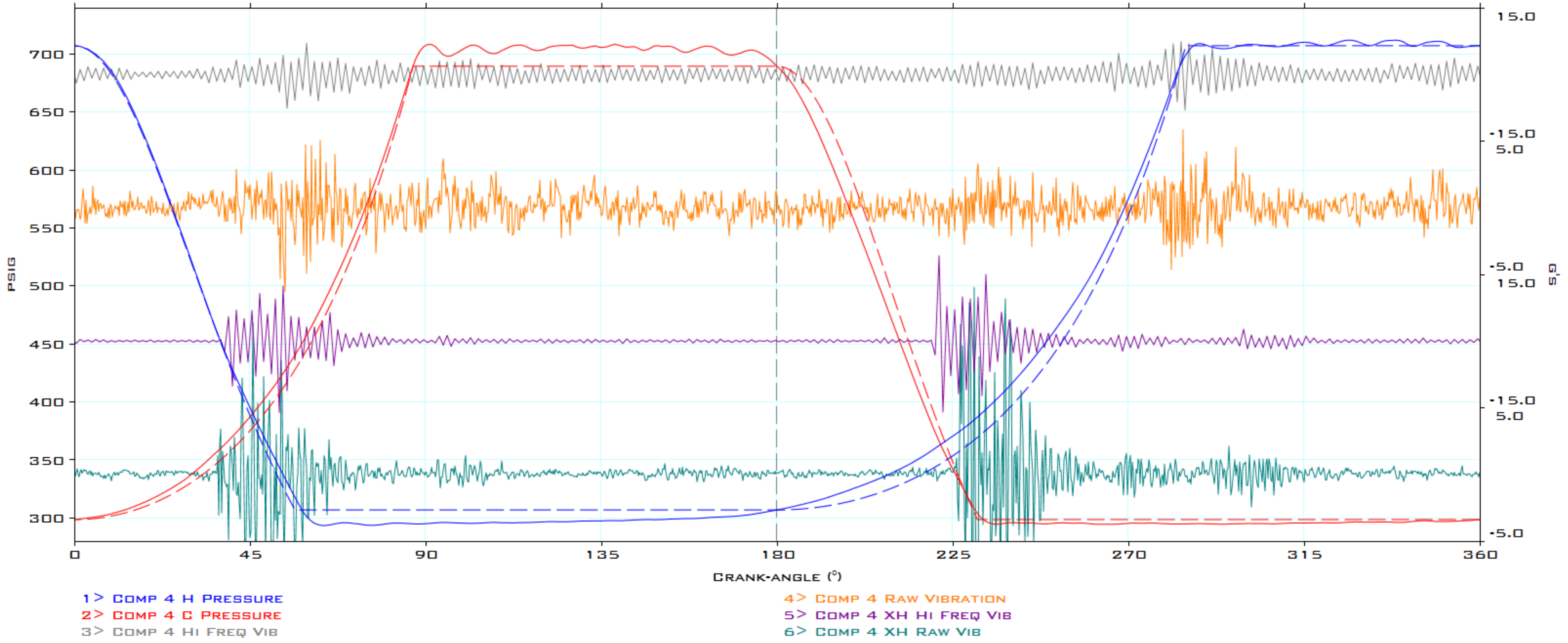




Example #3

Crankangle data review

- Impacting clearly caused by loose reciprocating mass (piston)



Closing Summary

- 4 datapoints at each crosshead will give a complete view of any impacting.
- Use acceleration data for fault severity.
- Use velocity data for time waveform review.
- When there is some impacting in the crosshead it does not always have to be a crosshead issue. Be careful to study all of the possible data to evaluate and diagnose the problem.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Thank you for listening
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