VibCloud™ - Knowledge sharing

Analysing bearing condition of an Aurizon locomotive alternator

Case study

Prepare to take measurements

2.Using the mobile app

- Person taking data need to Log in on the app and synchronise
- Route appears on mobile device
- They are ready to take measurements

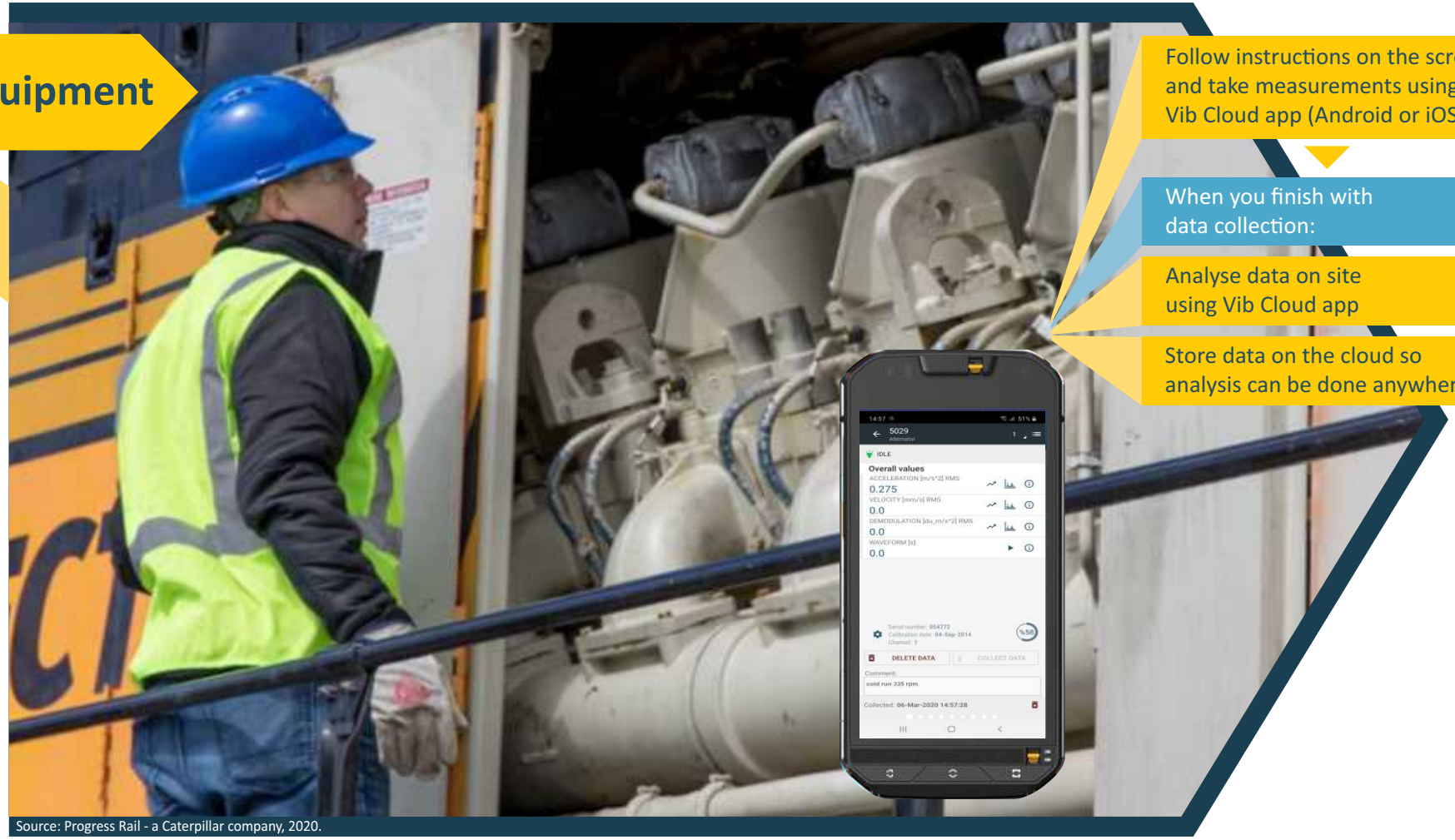
1. Using the Web app

- Database is setup with equipment and route
- Assign route to a person collecting data

Case study

Take measurements

At the equipment



Source: Progress Rail - a Caterpillar company, 2020.

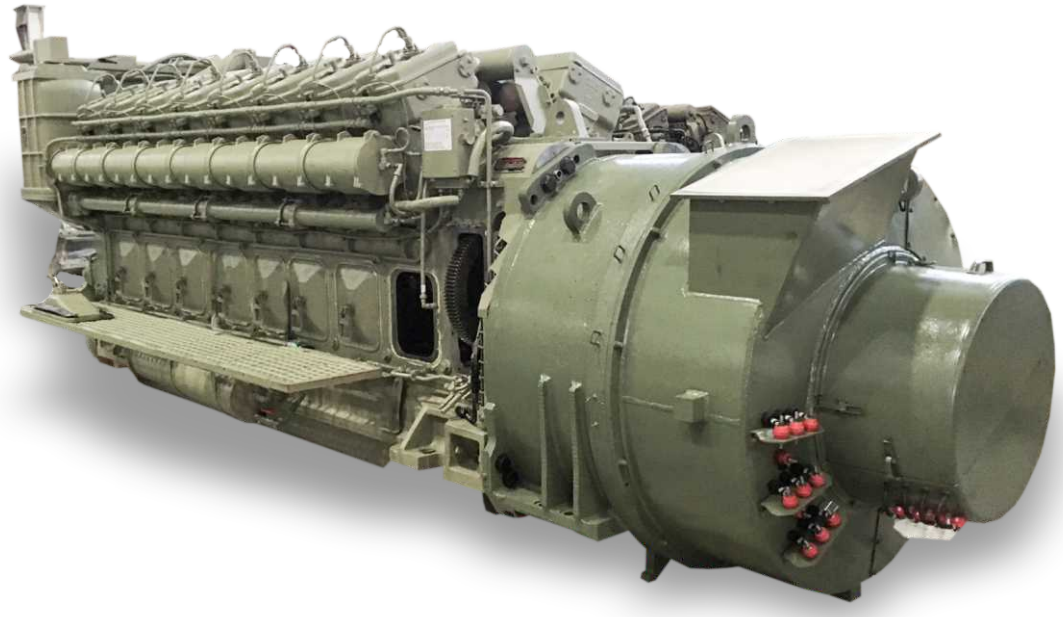
Follow instructions on the screen and take measurements using Vib Cloud app (Android or iOS)

When you finish with data collection:

Analyse data on site using Vib Cloud app

Store data on the cloud so analysis can be done anywhere

Analyse – Alternator vibration



Machine operating speed:

1xFreq	
Hz	rpm
7.38502	443.1012

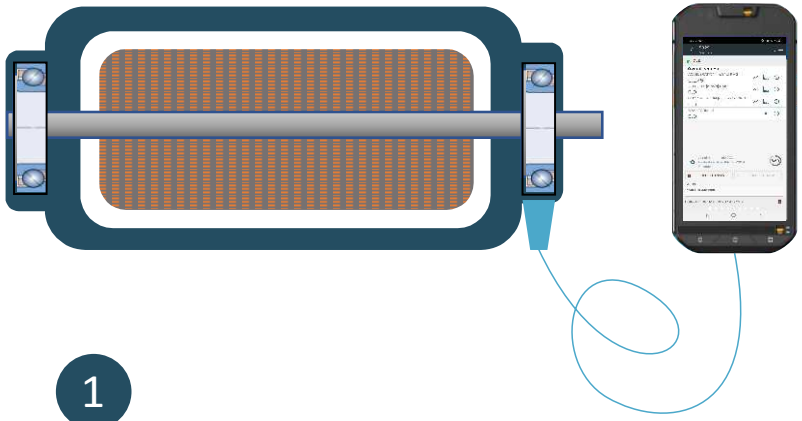
Understanding vibration:	All signal processing and calculation shown on next pages is done by Vib Cloud app when collecting data.

Case study

What acceleration signal is telling – impacts detected

Machine operating speed:

1xFreq	
Hz	rpm
7.38502	443.1012

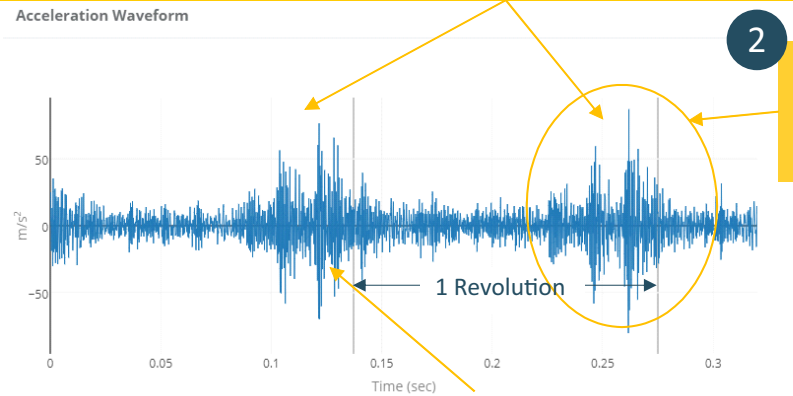


1

Vib Cloud allows to captured raw wav file and you can play back this file in the field or in the office. In our case, we can clearly hear the rumbling noise

Double click on the icon above to listen to the bearing noise

Knocking is clearly visible in acceleration time waveform

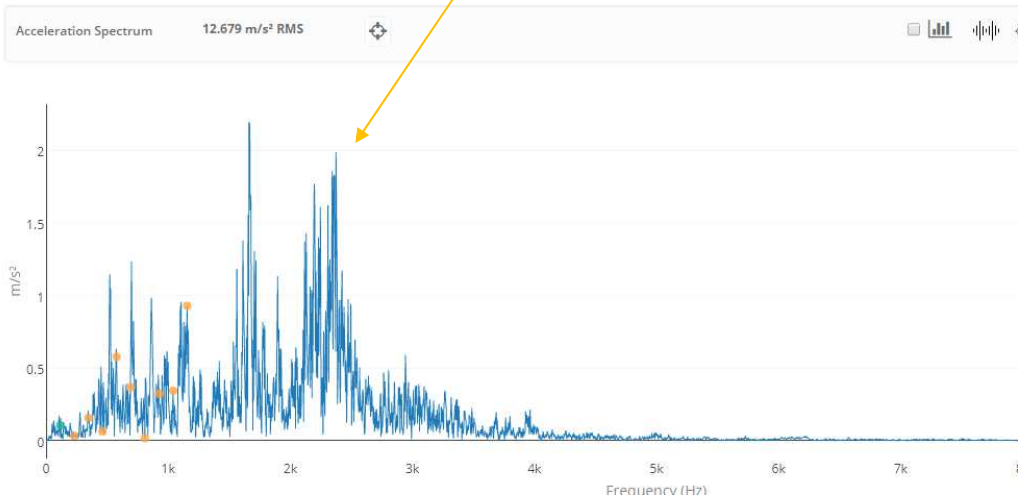


2

Looks like there are 3 stronger impacts and several smaller impacts distributed evenly

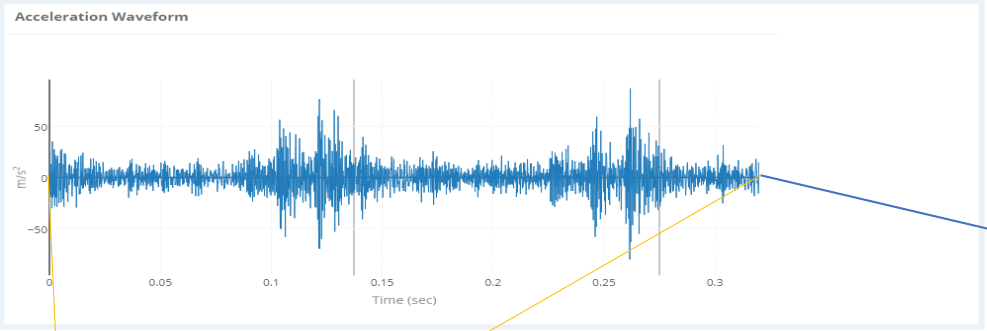
Knocking – we suspect that metal to metal contact is causing bearing race ringing (noise we can hear) 3

The resulting ringing after impact is visible in acceleration spectra as a hump at high frequency 4



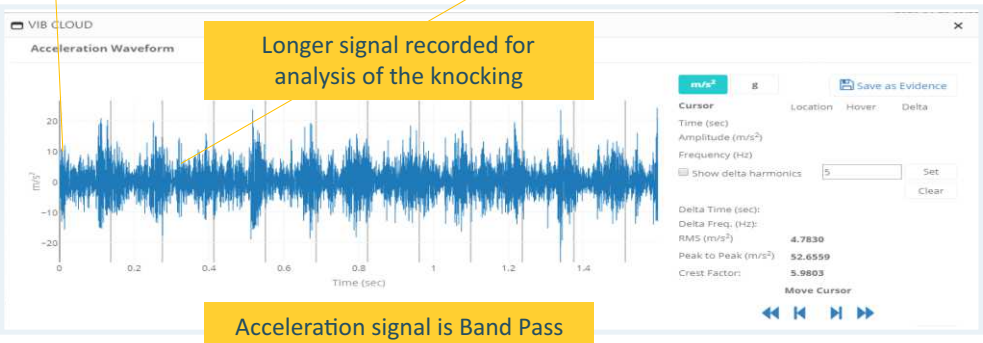
Case study

Use demodulation to determine the rate of knocking



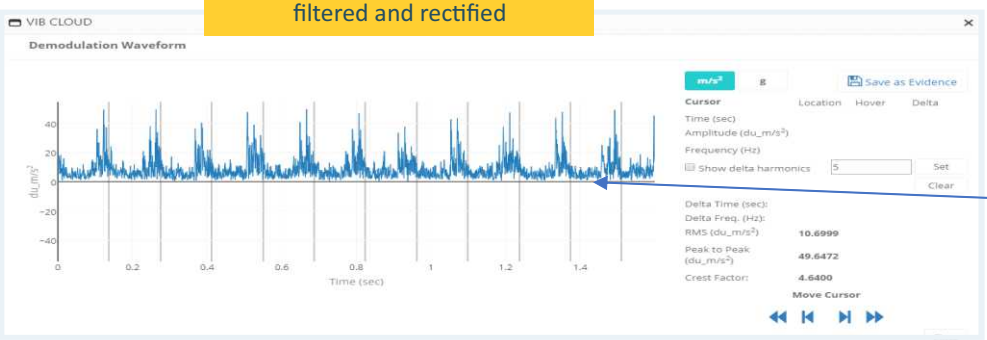
Demodulation will help us to better understand the impact rate so we can determine what may be casing this impacts. It is calculated from acceleration signal with some data processing shown below.

This was short acceleration time waveform (about 2 rev of the shaft. For demodulation we need longer time waveform.



Longer signal recorded for analysis of the knocking

So, we take longer time waveform. Here we can see more revolutions of the shaft and, we can see how impacting has repeatable pattern.



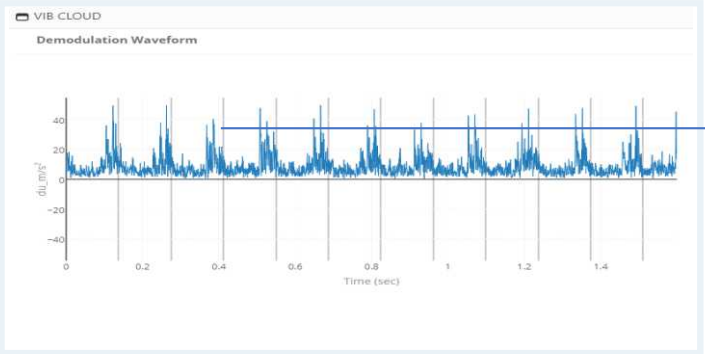
Acceleration signal is Band Pass filtered and rectified

Now we continue processing the signal. First, we band pass the signal to only analyse hump we suspect to be related to the ringing noise. In this case that is the region above 2kHz. We can go lower, but it may introduce additional sources not necessarily related to the ringing we observed.

After band passed filtering, we rectified the signal, so it is all positive witch helps to further highlight the impacts. This is shown on the left.

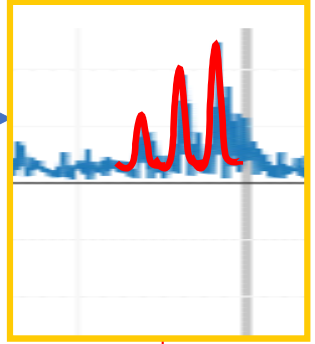
Case study

Use demodulation to determine the rate of knocking



Apply Low pass filter = smoothening the signal

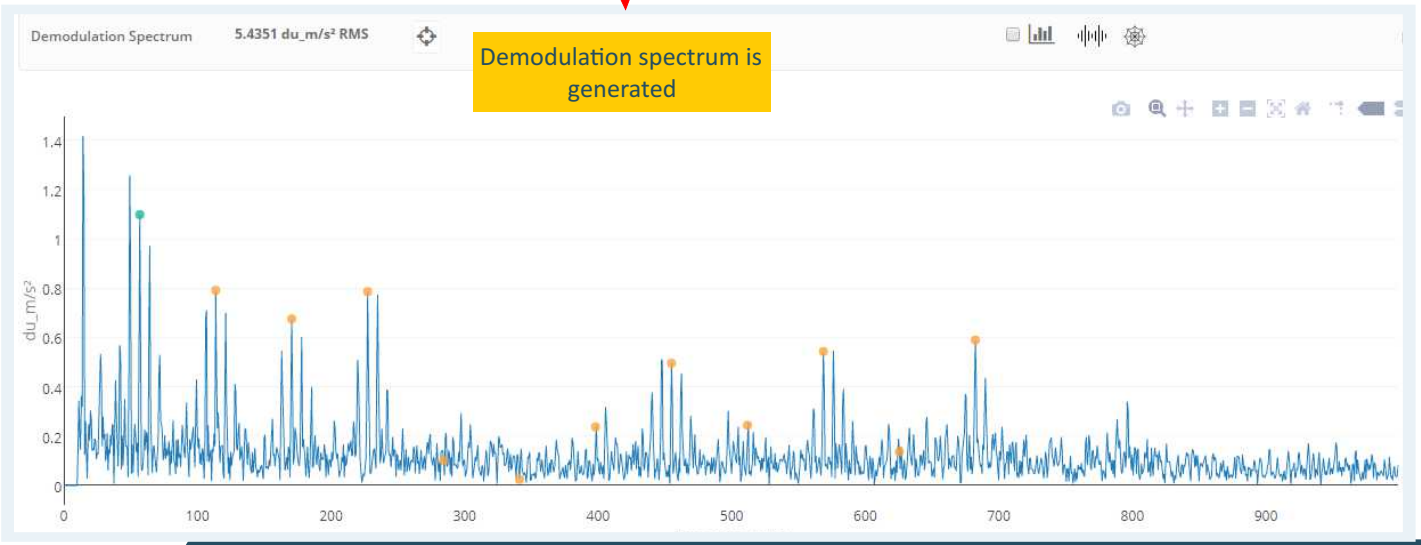
Low pass filter is applied



After we rectified the signal, we pass that signal through a Low pass filter. This step act as an envelope, basically smoothens all peaks.
The amplitude and shape of this new time waveform follows the contours of the rectified acceleration signal. Now we can see the impacts more clearly.

Generate spectrum from this smoothen time waveform

Demodulation spectrum is generated

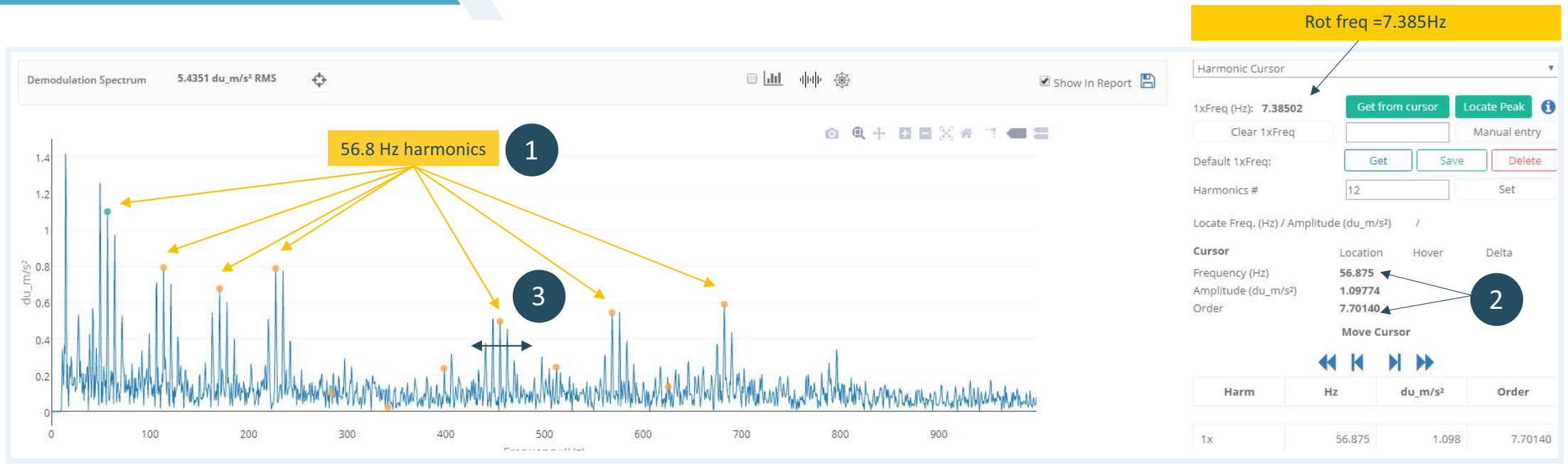


The process of rectification and low pass filtering is very similar to what is known in AM radio communication as amplitude demodulation. That why we call this simple **demodulation spectrum**.

All this processing and calculations are done by VibCloud app when collecting data.

Case study

Analyse Demodulation Spectrum



1. We can see some regular pattern in the demodulation spectrum. Using harmonic cursor we can see this pattern has 56.8 Hz harmonics → Impact is at 56.8 Hz

2. We know the rotational frequency is 7.385Hz, so we look for order of our peak of interest (divide frequency of interest with rotational frequency). Multiplier is 7.7x → Impact happens 7.7 times per revolution (7.7th order)

3. We also observe sidebands around each of the harmonics. Using sidebands courser in Vib Cloud, we can determine what is the spacing between the harmonic and its sidebands. This reviled that the spacing is related to rotational frequency (7.385Hz spacing). → 7.7 order peaks have rotational speed sidebands (7.385Hz)

With this information we can conclude with high degree of confidence that there is a **strong possibility of bearing deterioration casing this impacts**.

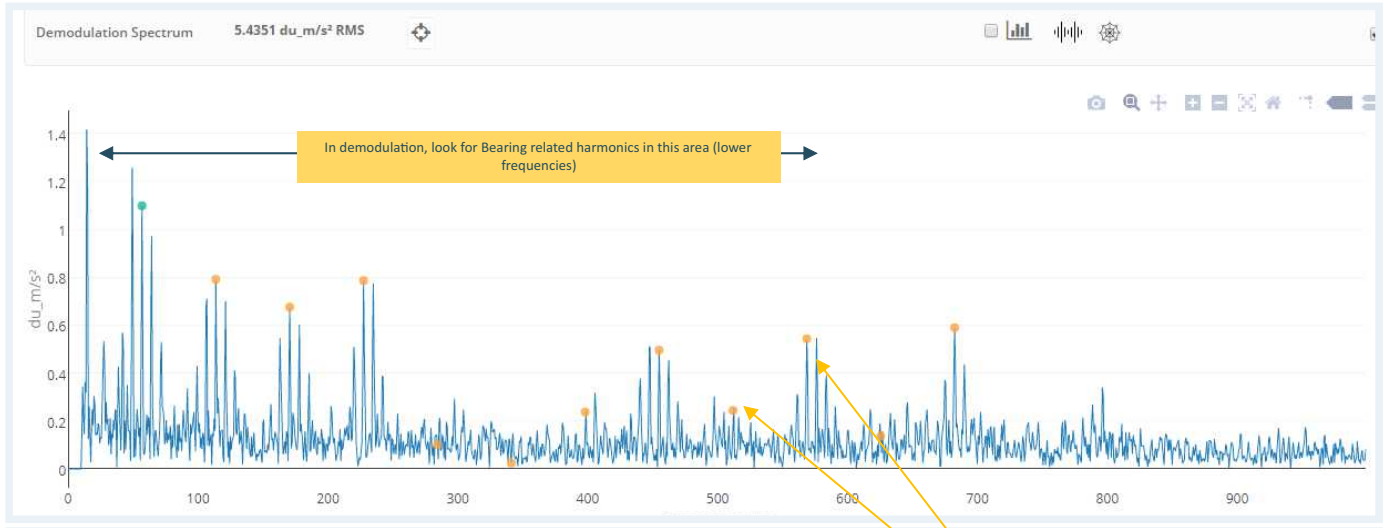
In addition, having sidebands around each harmonic indicates further modulation of the impact once per shaft revolution. This can be **caused by the inner race part of the bearing** - (as inner race rotates, per revolution the actual damage on the race gets closer to our accelerometer (stronger peaks)

Conclusion: **there is strong indication of an inner race damage of the bearing. Bearing needs to be replaced to ensure equipment reliability.**

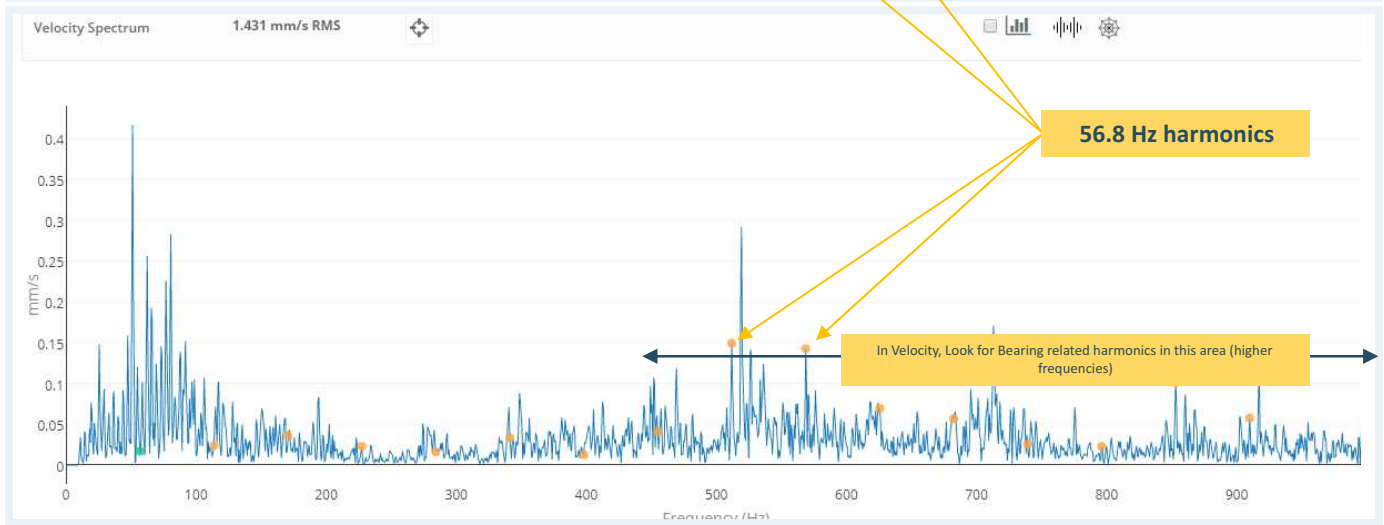
Case study

Analyse Velocity Spectrum

Demodulation Spectrum



Velocity Spectrum



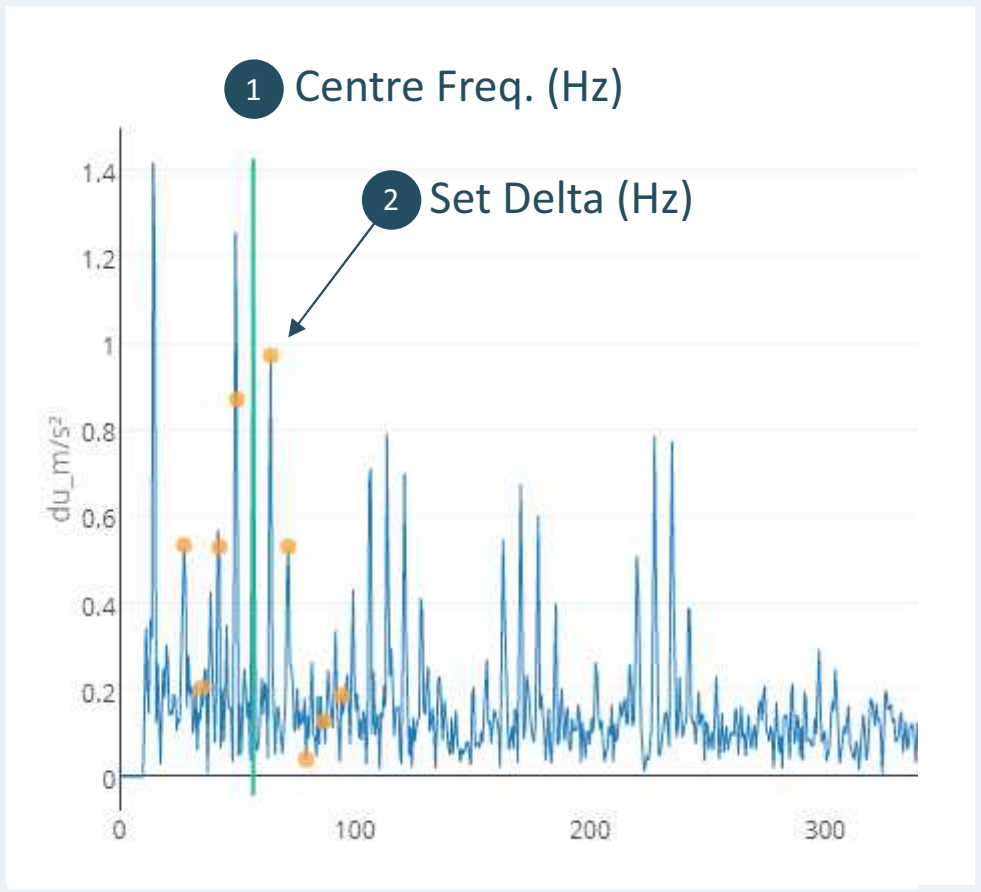
1. In this case, from acceleration and demodulation analysis, we conceded that there is a strong possibility of bearing inner race deterioration.

2. Velocity spectrum can be used to further understand the severity of the problem. In most cases, if we can see the harmonics of the bearing inner race fault related peak in velocity spectrum, it means the damage is more serios and advanced.

   The top graph is demodulation spectrum and bottom is velocity spectrum. Using harmonic cursor, we can see if there is presents of harmonics of the observed bearing fault frequencies.

   We can see that **bearing inner race defect frequency is visible in velocity** indicating **that damage more advanced**. This confirms our diagnosis and also helps to make final conclusion **– change the bearing if you want reliable operation.**

How to use sideband cursor



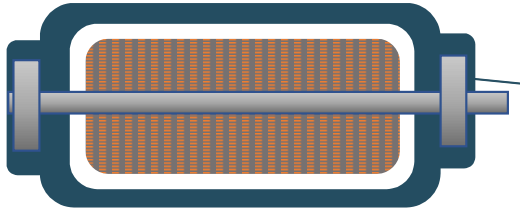
We mention use of sideband cursor to determine which race may be responsible for the observed harmonic. To do that we use sideband cursor.

1. First, we select the frequency of interest (in this case 58.875Hz peak) as a Centre freq.

2. Second, we place sideband cursor on one of the surrounding peaks and mark this as “set delta” in Vib Cloud. We can move this delta cursor until we find good match of sideband harmonics with as many as possible surrounding peaks. Wed can now compare this delta frequency with say rotational frequency. In this example, delta frequency is equal to the rotational frequency, which helps us to suspect inner race defect

Case study

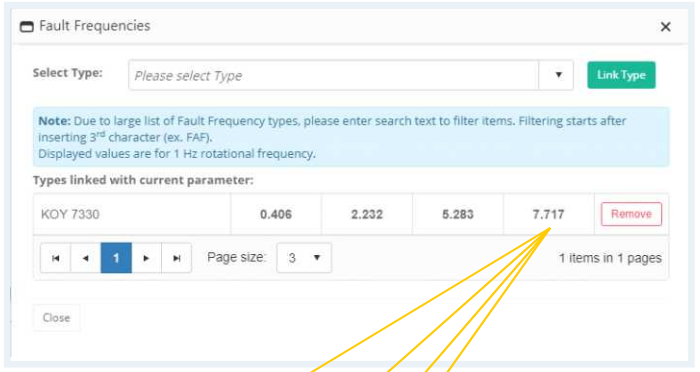
How to use library of bearings fault frequencies



Find bearing designation
Example: Koy 7330

If we know bearing designation or bearing dimensions including the number of balls / rollers, we can calculate expected bearing fault frequencies.

Vib Cloud has over 20000 bearings with corresponding bearing fault frequencies. This has been collected over time by VibCloud team. Also, there are online libraries by bearing manufacturer that can be used to find fault frequencies.

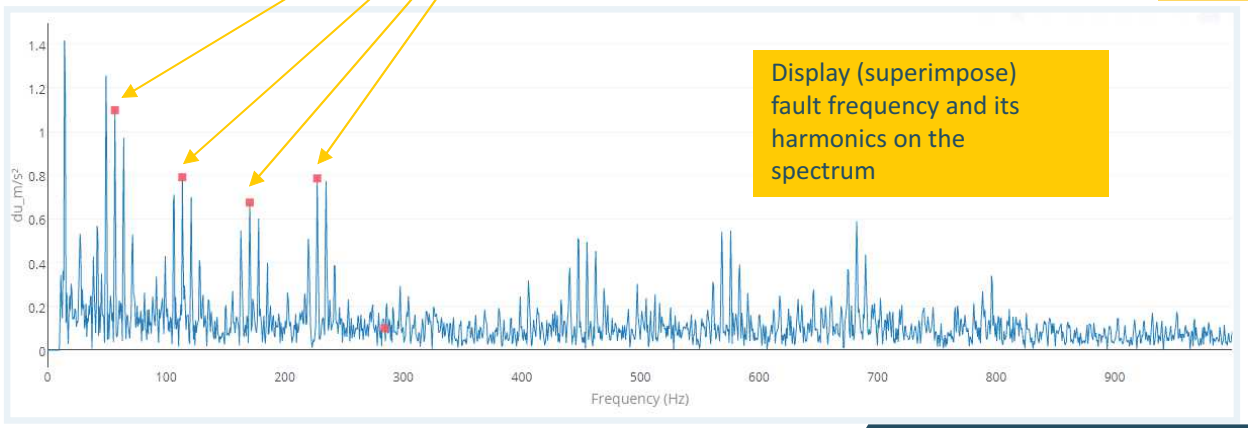


There are 4 typical bearing fault frequencies: FTF, BSF,BPFO and BPFI

FTF – Fundamental train frequency (Cage rotational frequency)
BSF – ball (or rolling element) spin frequency
BPFO –ball (or rolling element) passing Outer race frequency
BPFI - ball (or rolling element) passing Inner race frequency

Find bearing fault frequency

As bearing details were unknown in this case, searching the database reviled one bearing (Koy 7330) to be a match – its bearing inner race fault frequency (multiplier of 7.7x matches observed frequency in demodulation spectra (multiplier of 7.7 times).



Display (superimpose) fault frequency and its harmonics on the spectrum

We can now see a good match between bearing fault frequencies from the Vib Cloud bearing library and measurements taken on this alternator bearing.

Summary

- In this case study, we demonstrated how to analyse vibration in order to determine bearing condition. In spite that we did not know exactly what bearing is being installed, we can confidently say that we have vibration pattern typical of an inner rave bearing problem.
- We use full Vib Cloud capabilities to diagnose this problem by following this steps:
  - We started with listening of the recording acceleration wav file and notice a **rumbling noise**;
  - Then, we observe in the acceleration time waveform **regular impacting** (short sharp spikes);
  - We look at the demodulation spectrum and identified that the **impacts were happening 7.7 times per revolution**. As this is not an integer, it is likely that pattern is **cased by a bearing problem**. We also found sidebands related to shaft rotational frequency which makes us to **suspect bearing inner race defect**;
  - **Velocity spectra also shows higher frequency harmonics** of the suspected impacting frequency. This indicated that the **damage is advanced**;
  - We can now recommend an action to **replace the bearing to ensure reliability and integrity of this unit.**

Important note: Conducting vibration analysis to determining bearing condition should not be done for the purpose of “do I need to replace the bearing immediately” but to assess bearing integrity and ability of the bearing to reliably perform its function. No bearing is designed to produce visible fault frequency if operates normally and is in good condition. So, if bearing shows noise related to the bearing, if there are harmonics of fault frequency in demodulation then bearing is not functioning properly, and its integrity is impacted. Furthermore if bearing fault frequency can be also detected in the velocity, bearing needs to be scheduled for replacement.
If the equipment is part of a regular condition monitoring program, trending of amplitudes at characteristic frequencies and changes in the vibration patterns can be used for the purpose of establishing statistical limits and estimation of remaining life.

VIB CLOUD

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