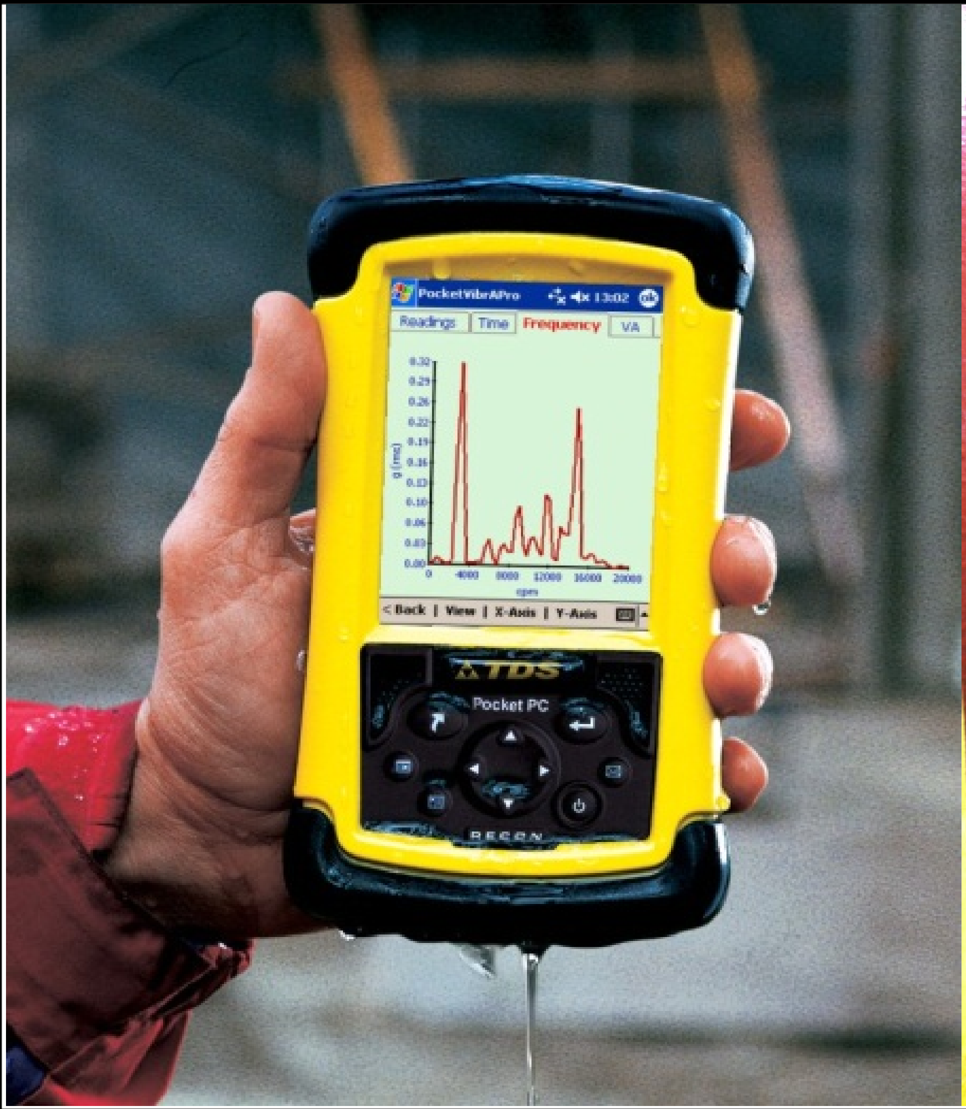
Vibration Analysis and Testing



The Value Leader™

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Plant maintenance techniques:

1. **Breakdown Maintenance** **($15/kW/year*)**
   – what the dinosaurs did!

2. **Planned Maintenance** **($10/kW/year*)**
   – historically what most people have done

3. **Predictive Maintenance** **($7.50/kW/year*)**
   – what the SMART people are doing

4. **Proactive Maintenance** **($4/kW/year*)**
   - closing the loop!

* Estimated figures based on a study carried out by Swedish vibration consultants VT AB

Why do faults appear?

- Regular Day-to-day Wear and tear
- Neglected maintenance
  - lack of or over lubrication
- Corrosion
- Electrical faults
- Excessive mechanical vibration
- Operating conditions
  - e.g. Overload
- Incorrect construction
- Incorrect use

The result of no maintenance work

Avoid big maintenance costs

Can this be prevented?

Yes! An effective maintenance program GUARANTEES that you can reduce or even eliminate breakdowns.

Vibration measurement

- Every mechanical defect causes vibrations in a unique way
- By measuring the levels and the frequencies of these vibrations, different faults can be identified
  - **Unbalance**
  - **Resonance**
  - **Looseness**
  - **Bearing faults etc.**

Vibration frequency

A complex vibration is made up of the sum of several different vibrations, each with a different frequency

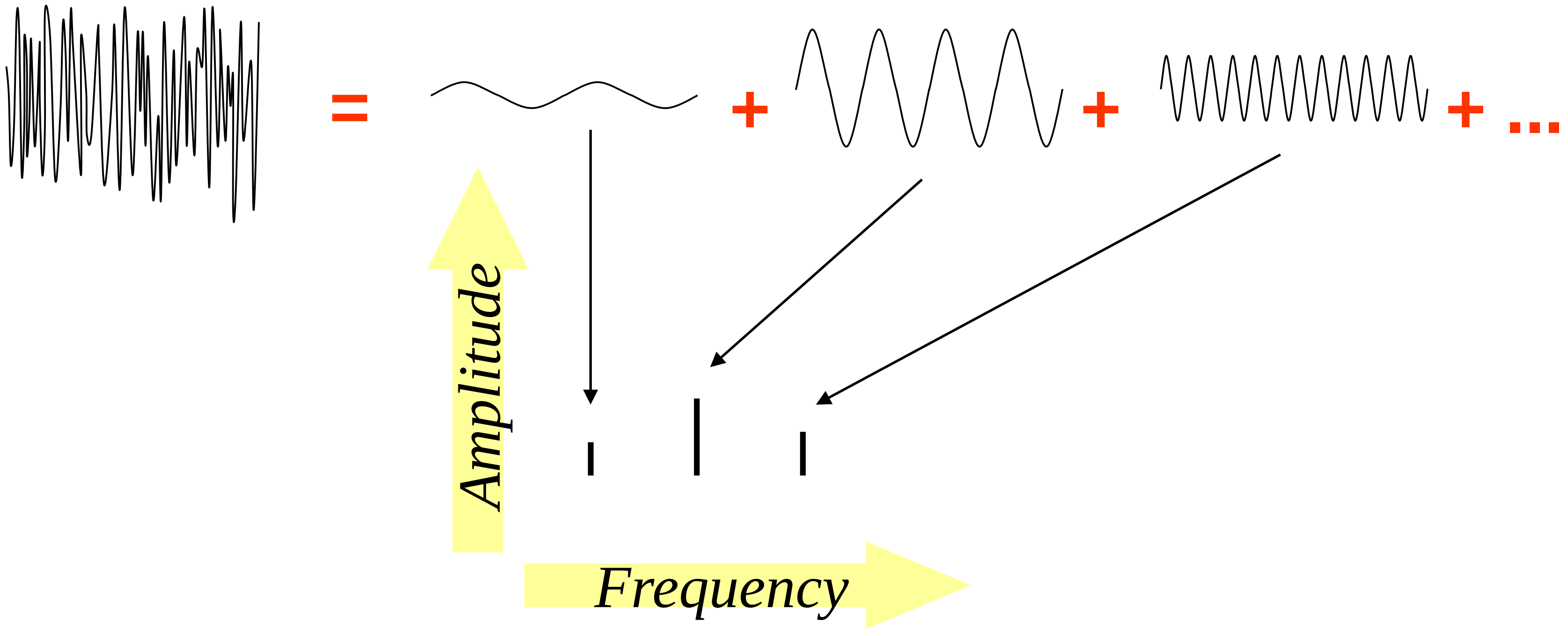
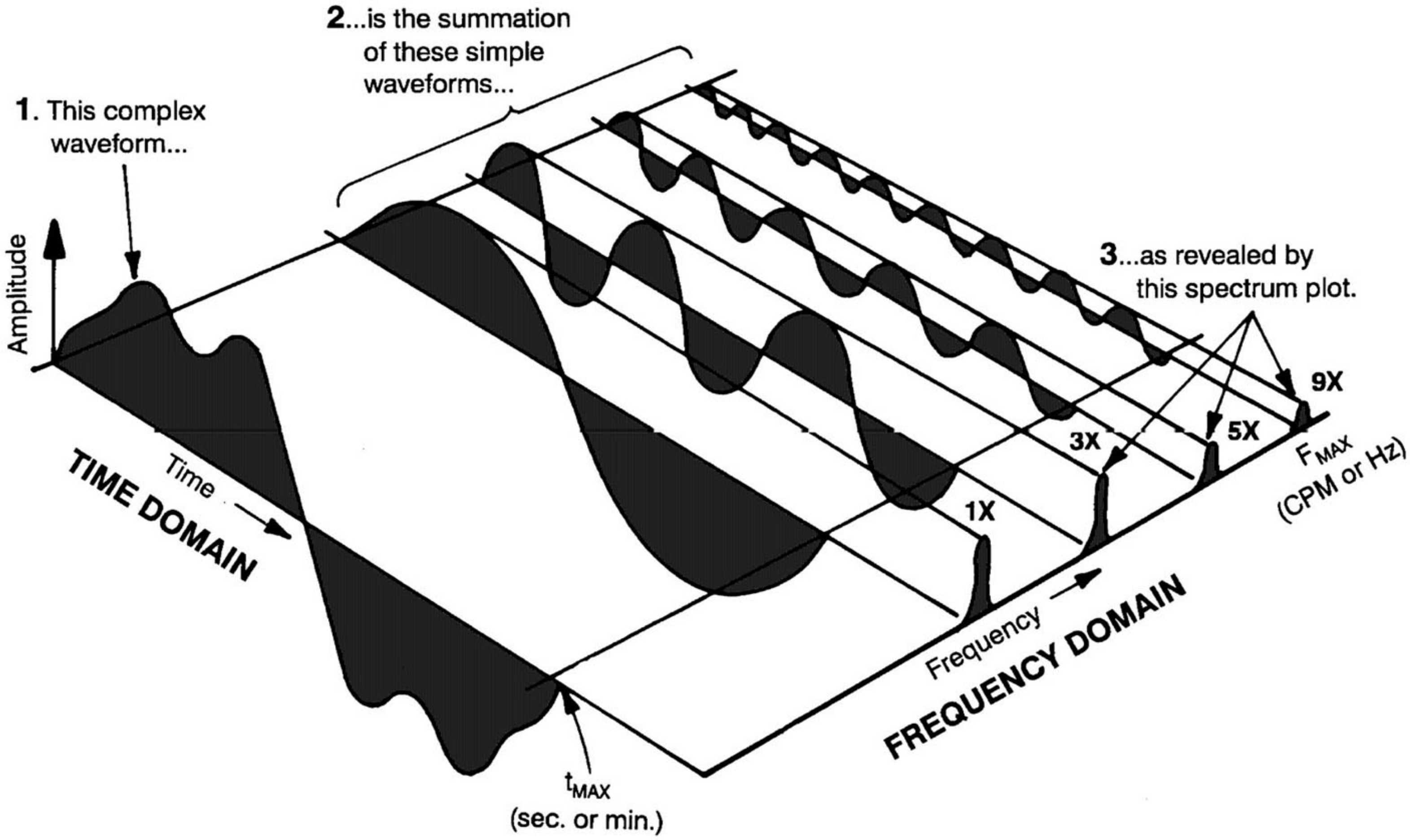
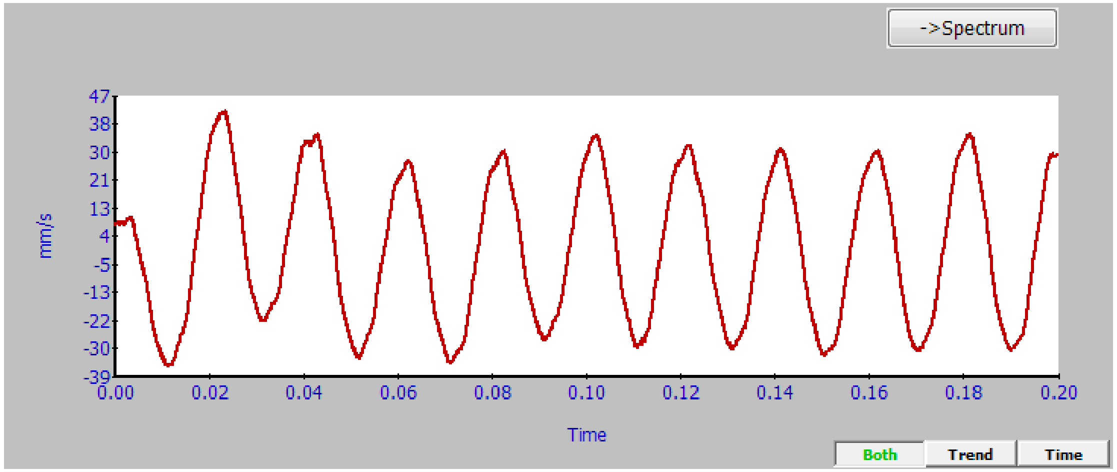


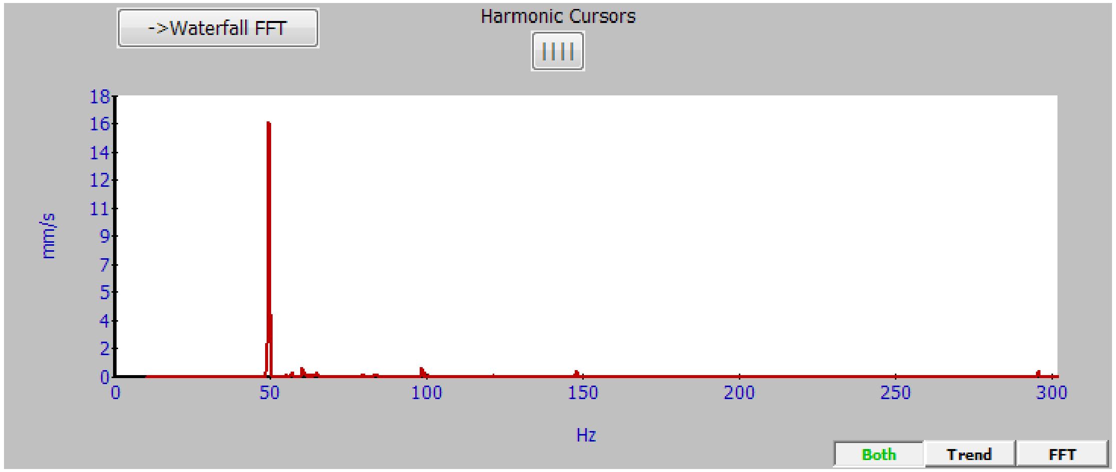
Diagram - time & frequency



Time/frequency domains

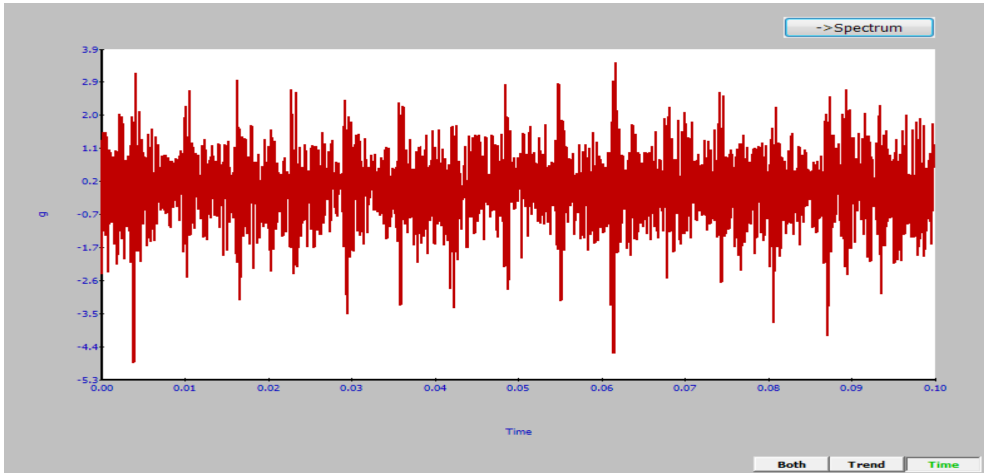


Sinusoidal waveform vibration in the time domain

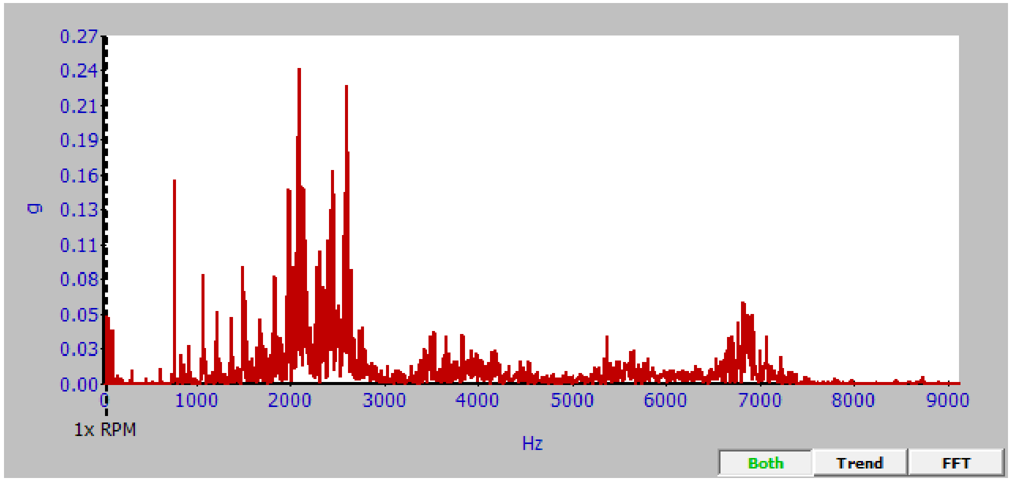


One peak in the frequency domain

Bearing noise in the time and frequency domains

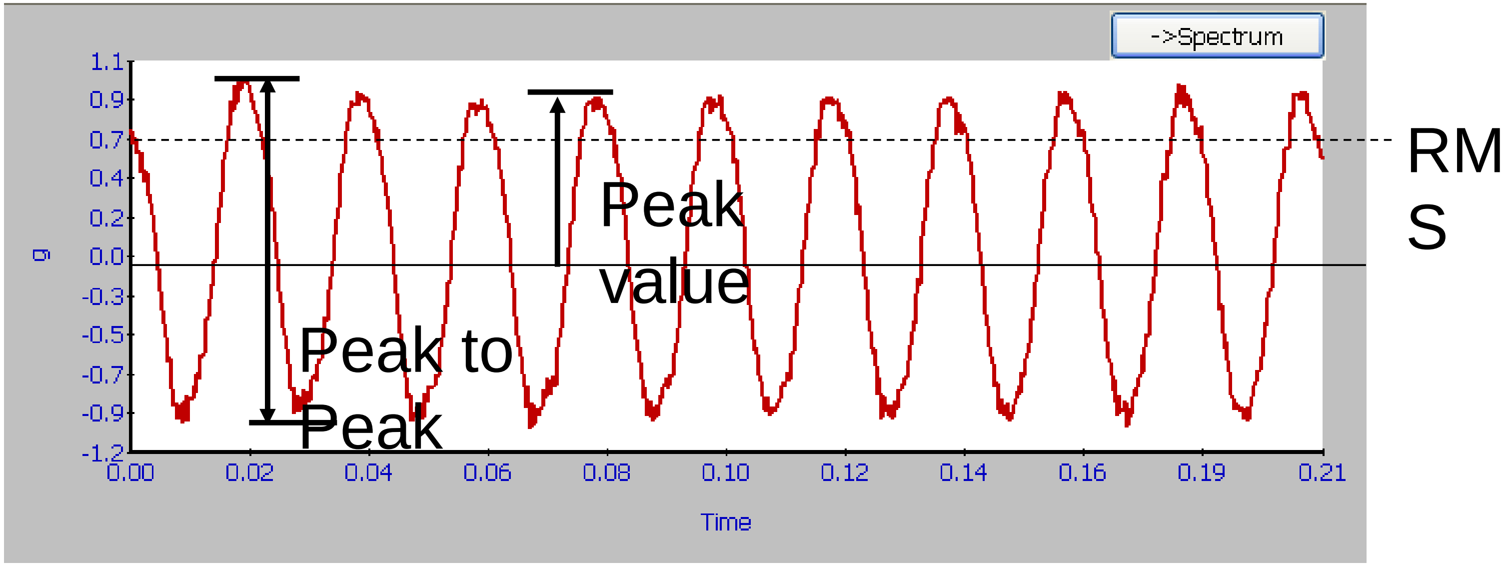


Bearing noise in the time domain



Multiple peaks in the frequency domain

Time waveform



Peak to peak value = max value of the signal, from upper to lower limit

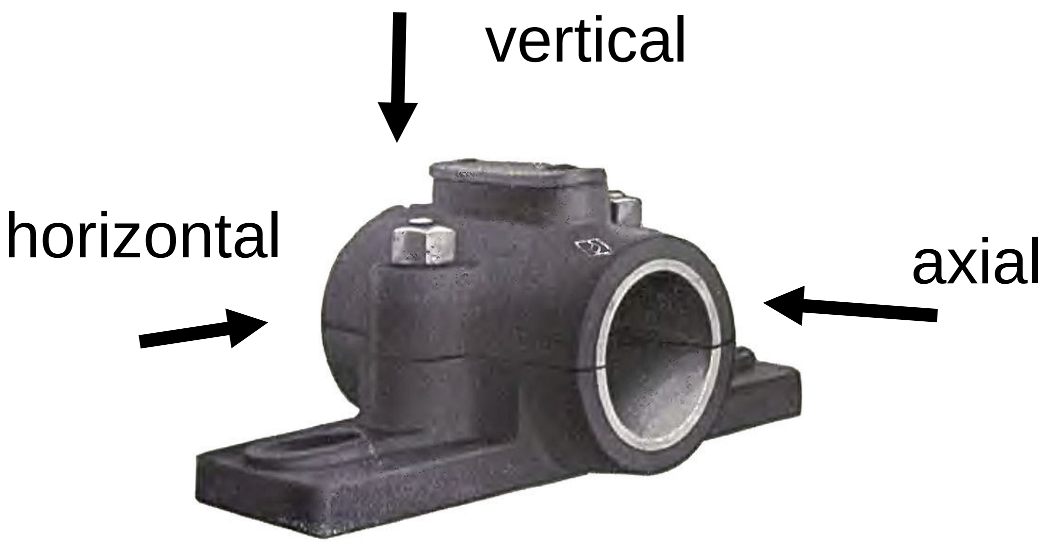
RMS = root mean squared value

For **sinusoidal** waveforms RMS = 0.707 * peak value

Measuring vibrations

Practical aspects

- Choosing measurement points
- Orientation of the transducer



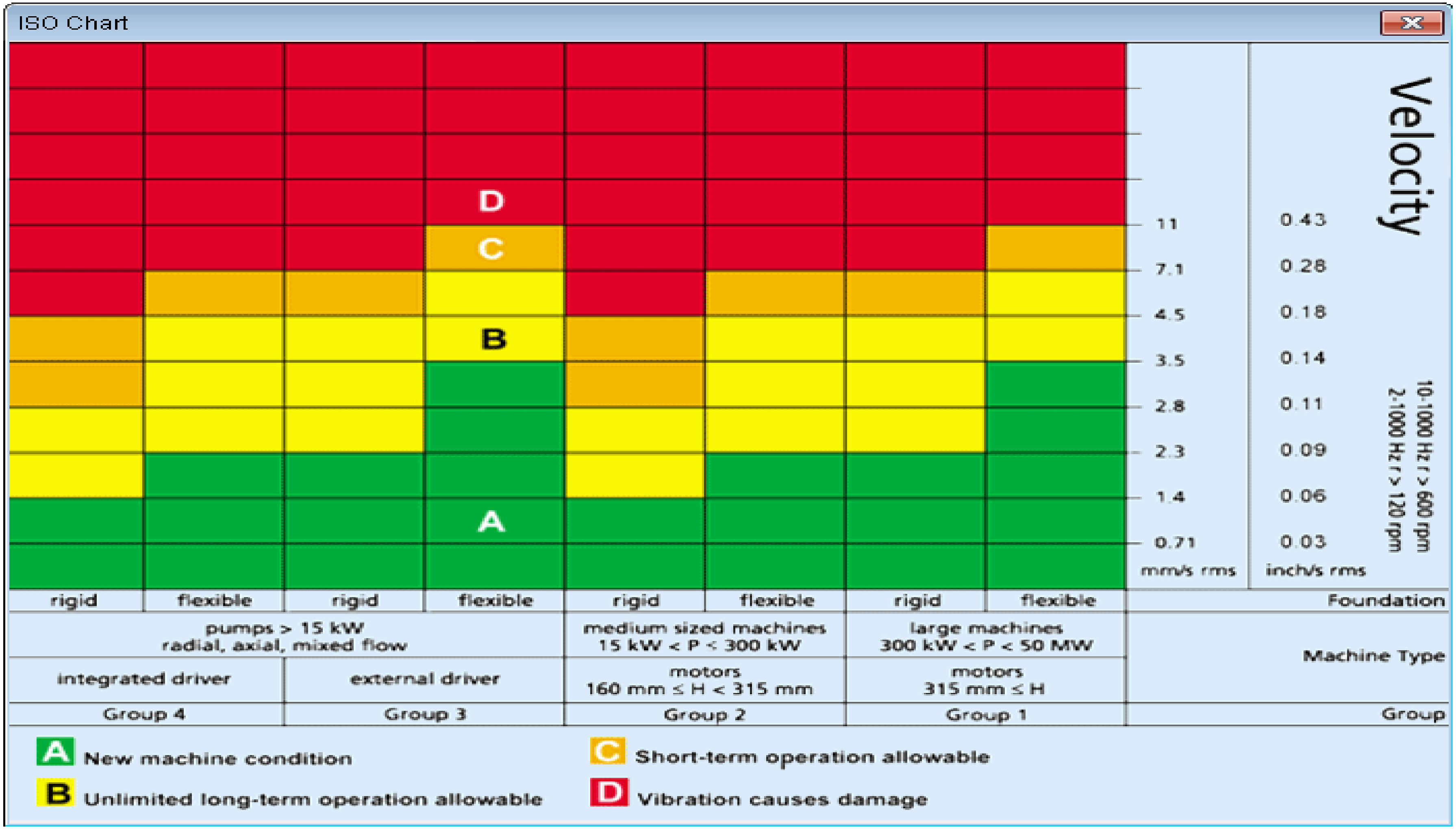
ISO vibration levels

The International Standards Organisation specifies acceptable vibration levels for rotating machines of varying power levels

The specified levels are **only** valid for vibration **velocities** within the frequency range 10Hz to 1kHz

N.B. this range does **not** cover all possible fault frequencies (e.g. bearings)

ISO chart



ISO Chart
D
C
B
A
11
7.1
4.5
3.5
2.8
2.3
1.4
0.71
mm/s rms
0.43
0.28
0.18
0.14
0.11
0.09
0.06
0.03
inch/s rms
Velocity
10-1000 Hz r > 600 rpm
2-1000 Hz r > 120 rpm
rigid
flexible
rigid
flexible
rigid
flexible
rigid
flexible
Foundation
pumps > 15 kW
radial, axial, mixed flow
medium sized machines
15 kW < P < 300 kW
large machines
300 kW < P < 50 MW
Machine Type
integrated driver
external driver
motors
160 mm ≤ H < 315 mm
motors
315 mm ≤ H
Group 4
Group 3
Group 2
Group 1
Group
A New machine condition
B Unlimited long-term operation allowable
C Short-term operation allowable
D Vibration causes damage

Bearing Condition

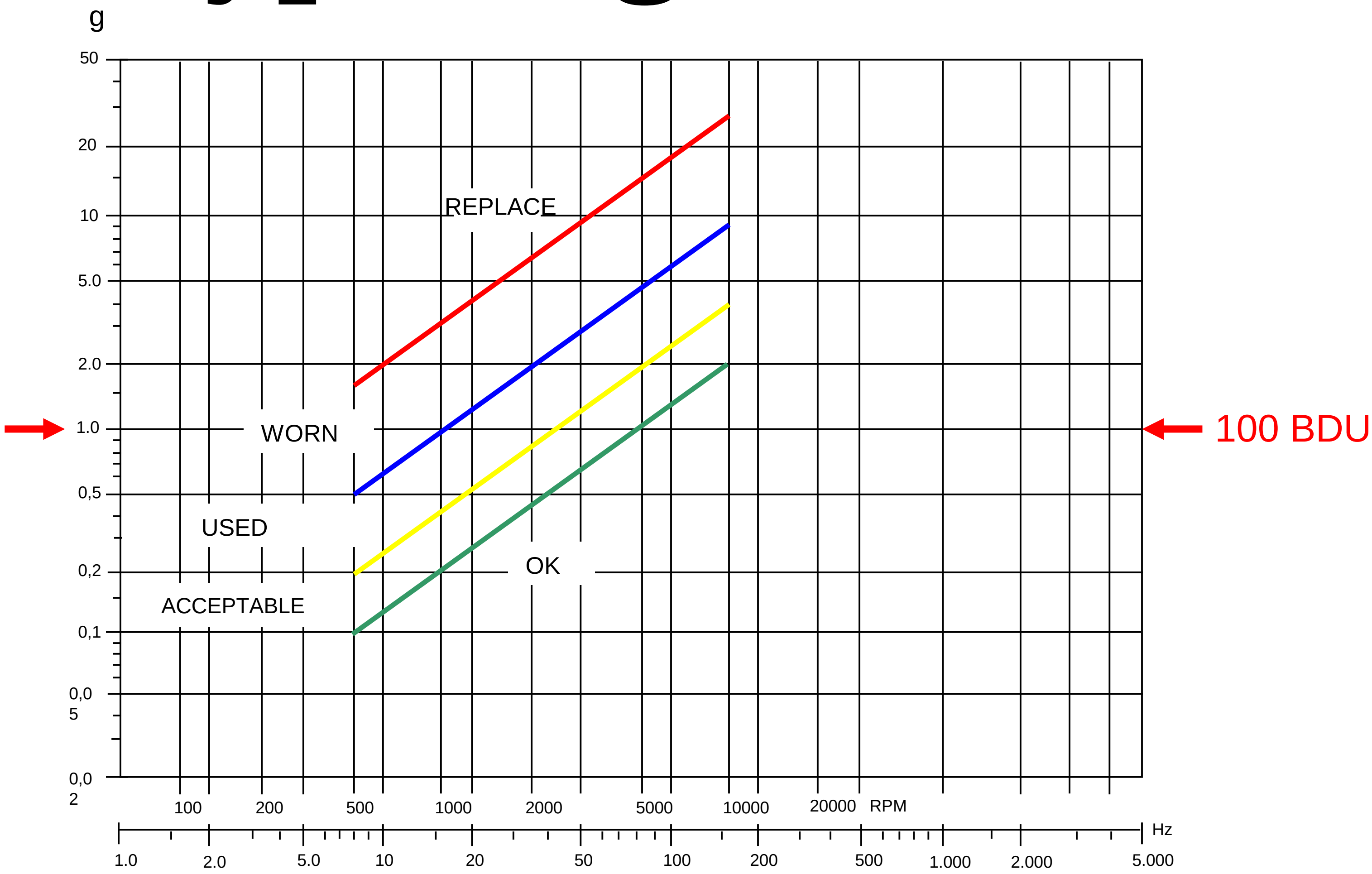
Measured in bearing damage units (BDU*) = mean sum of all high frequency vibrations

The movement of the rolling elements causes broadband noise and vibration.

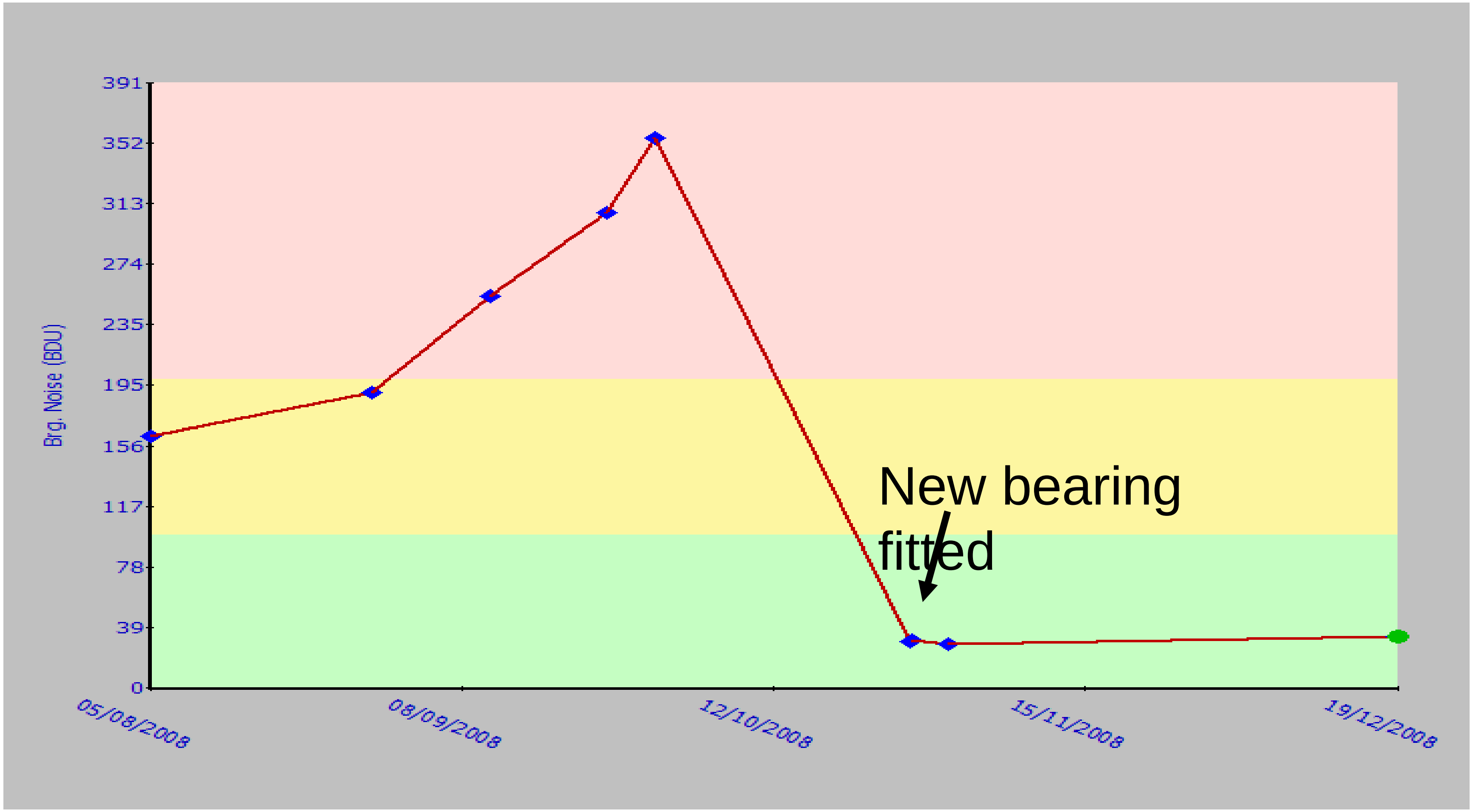
These vibrations increase when the bearing is poorly greased or damaged.

*100 BDU = 1g RMS high frequency vibration

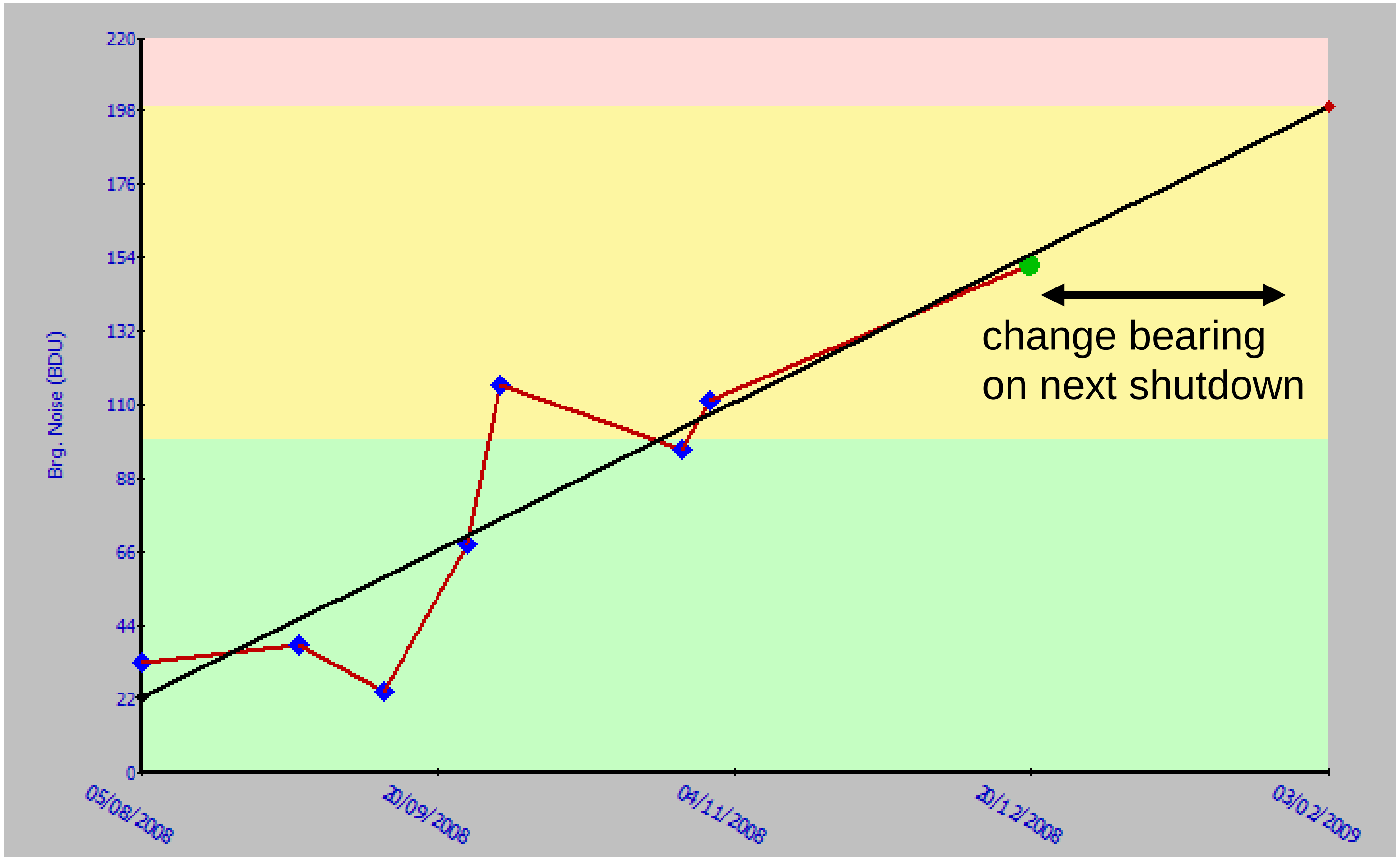
Typical g-values



Bearing noise trending



Bearing noise trending



Vibration analysis

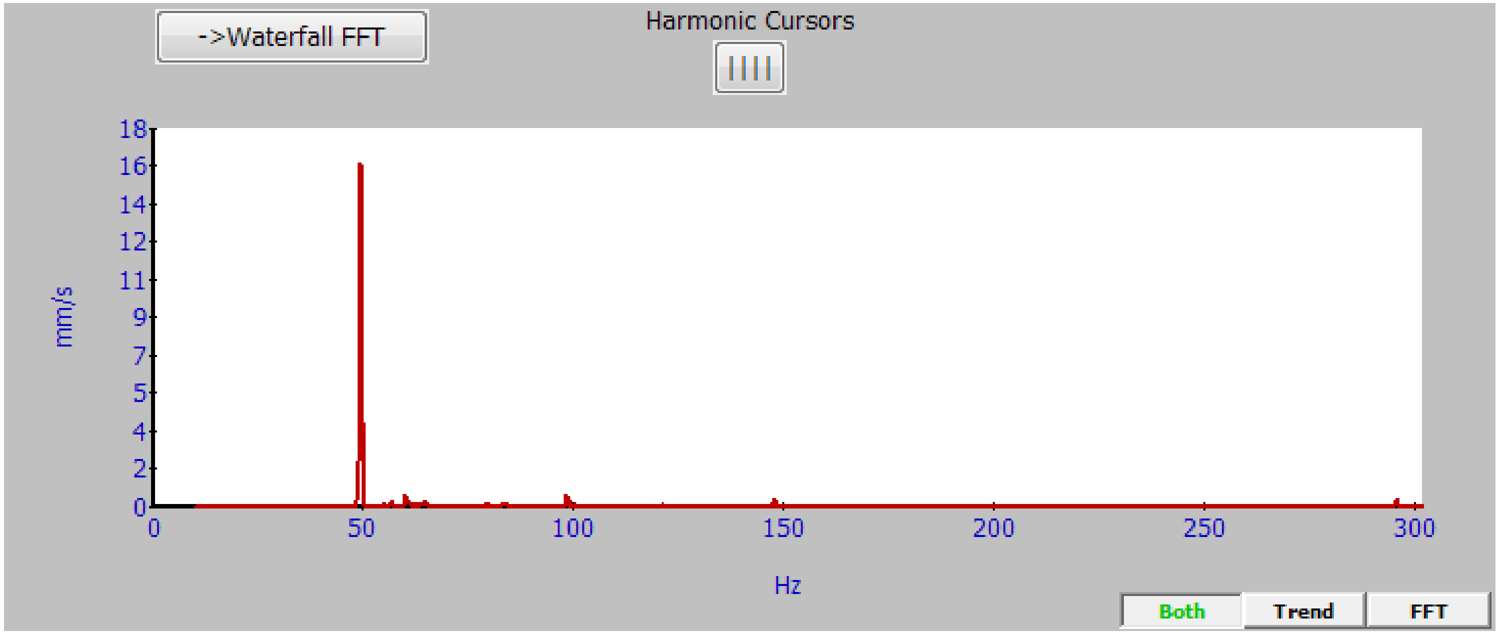
Different faults generate vibrations with different frequencies and amplitudes

For example **high vibration** at:

- Running speed = out of balance
- Twice running speed = misalignment
- Three times running speed = looseness

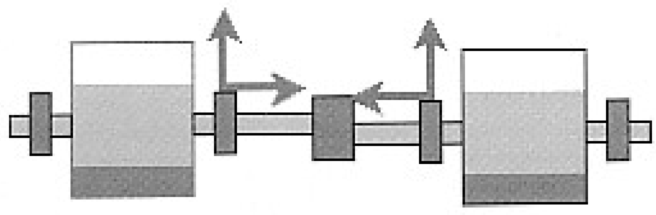
Unbalance

Unbalance generates an **unusually large** vibration component at the speed of rotation

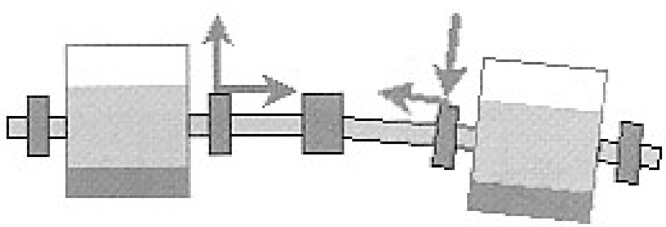


Misalignment

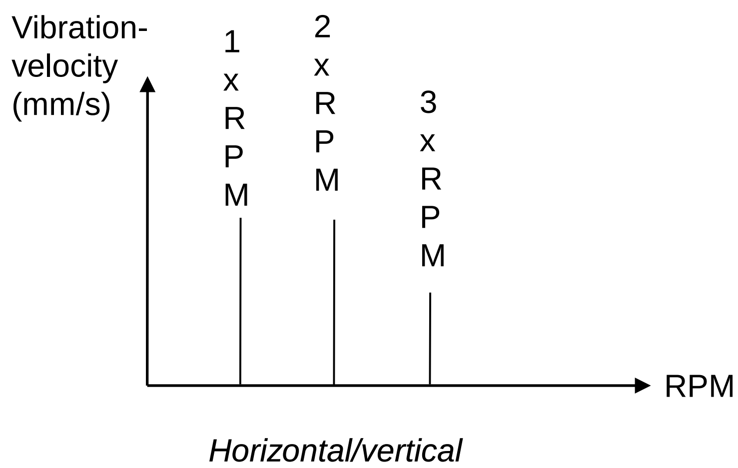
Occurs when the shaft centrelines of two directly mating components meet at angles and/or are offset from one another



Offset misalignment



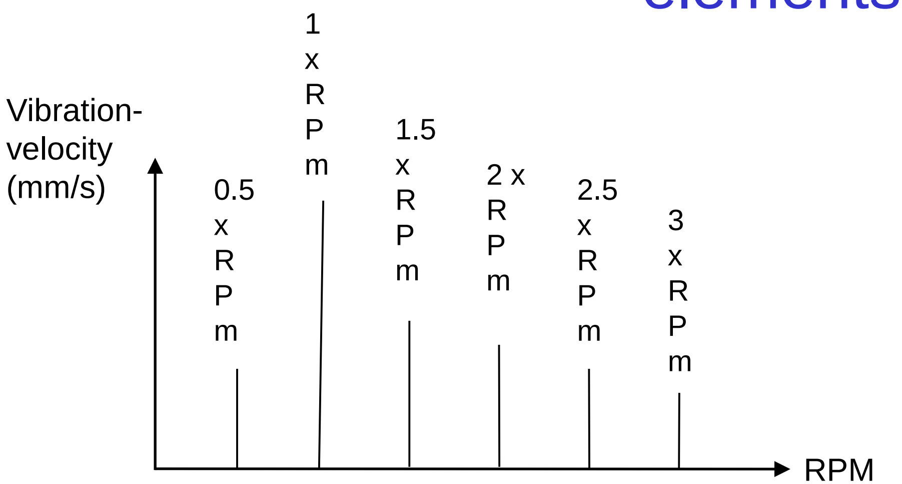
Angular misalignment



Mechanical looseness

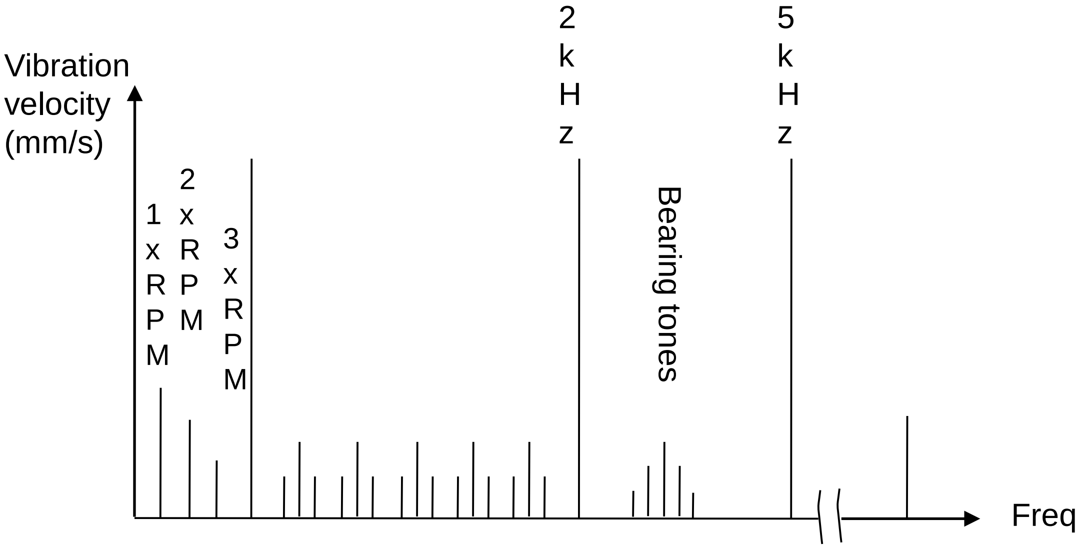
Rotating looseness - Too large a distance between rotating and stationary elements

Non-rotating looseness - Too large a distance between two stationary elements



Rolling element bearing problems

The frequencies generated by bearings are called bearing tones. These start to appear at high frequency and then move to lower frequencies as bearing damage progresses.



Vibration Testing

Vibration measurement