

# **Advantages and disadvantages with different types of transducers measuring valve vibration**

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[www.qringtech.com](http://www.qringtech.com)

Pipes/valves rarely has sinusoidal vibrations they are stochastic

Forced sinusoidal vibrations can come from rotating machinery in the system

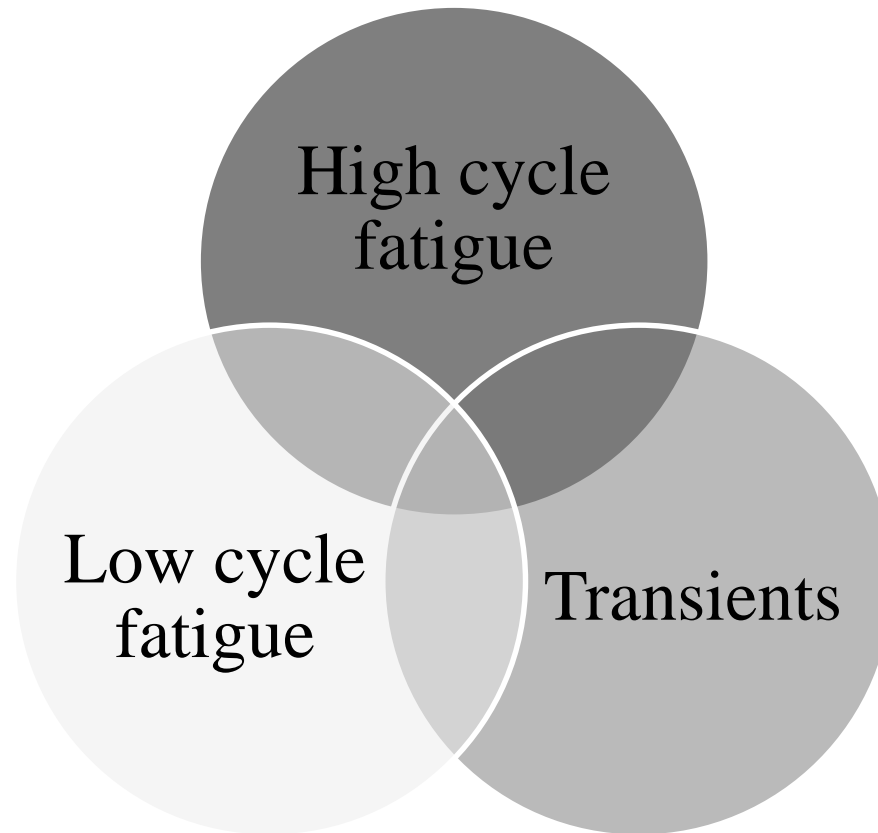
We were issued to look on vibrations on big valves and pipes.

Big pipes can give infra sound witch gives low frequency vibrations

Flow turbulence can induce high frequency vibrations

What phenomena is causing the damage?

What stress factors or stress situations cause damage?



# Transducer choice

- Transducer choice
  - The usual one, i.e. .
  - A planned one
  - A choice based on a discussion with other specialist.
  - A choice based on the damage seen on site

# An example

Tests done on big  
high pressure  
valves

The electric-  
hydraulic control  
valve has broken.

There have  
been more than  
one failure



Consequences  
for production;  
several days  
reduced effect

One of the possible  
causes was vibrations.  
Another was  
pulsations

How did we face the problem?

The damage seems to be of transient  
behaviour

## 1<sup>st</sup> Step

- Fast - improvisation;
  - Use equipment present on-site
    - 4x 10 mV/g PCB 356B21 Triaxial accelerometers
      - These had been used on another system the past year.
      - Mini 4-pole contacts on these accelerometers with limited life.
  - High ambient radiation
    - Allowed mounting time to be < 15 min.
    - 4x accelerometers and ~50 m cabling.
- Produced data with strange spikes in it.
  - Cabling glitches were suspected.
  - [Transducers and cabling later checked out OK on calibration table. ]



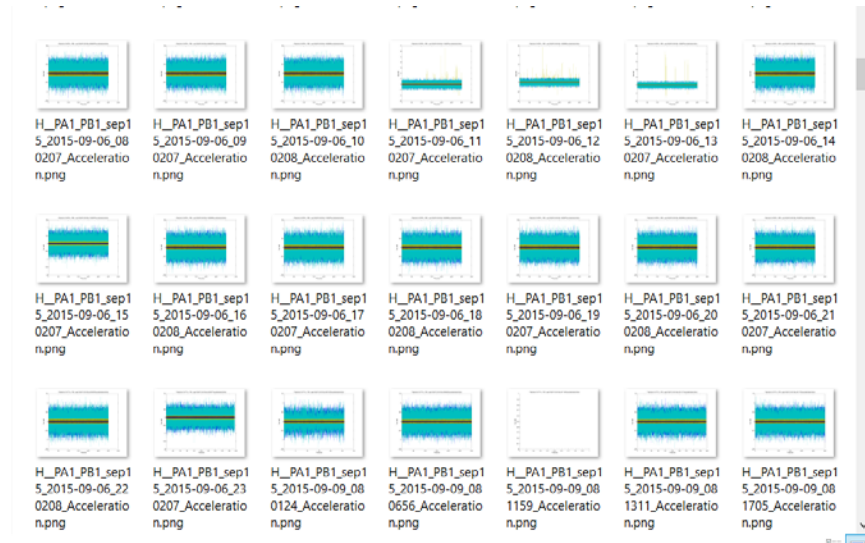
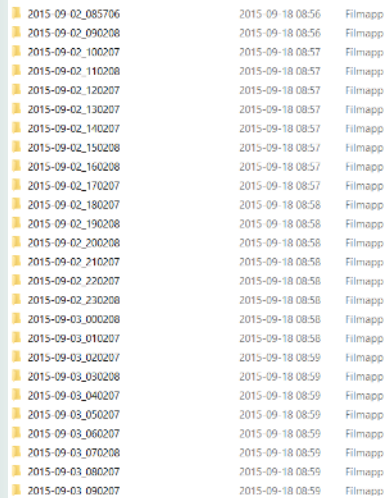


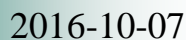
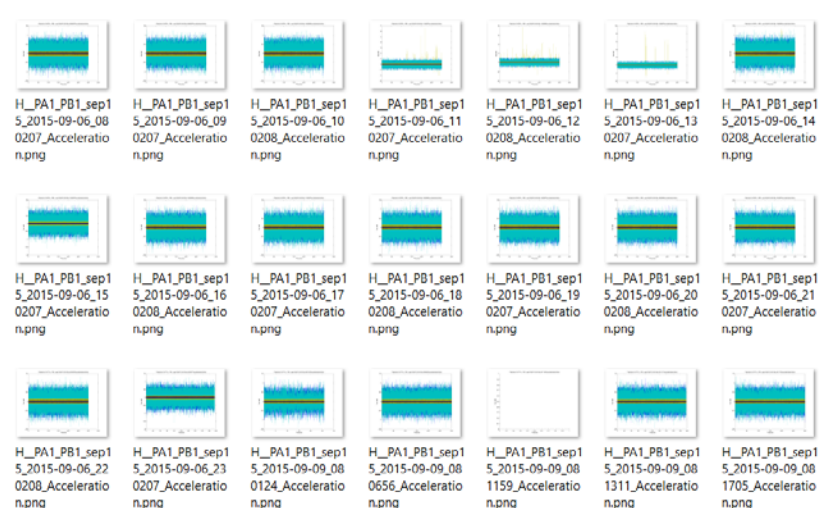
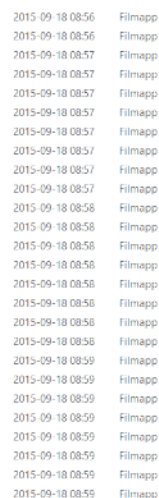


# The Qring Way

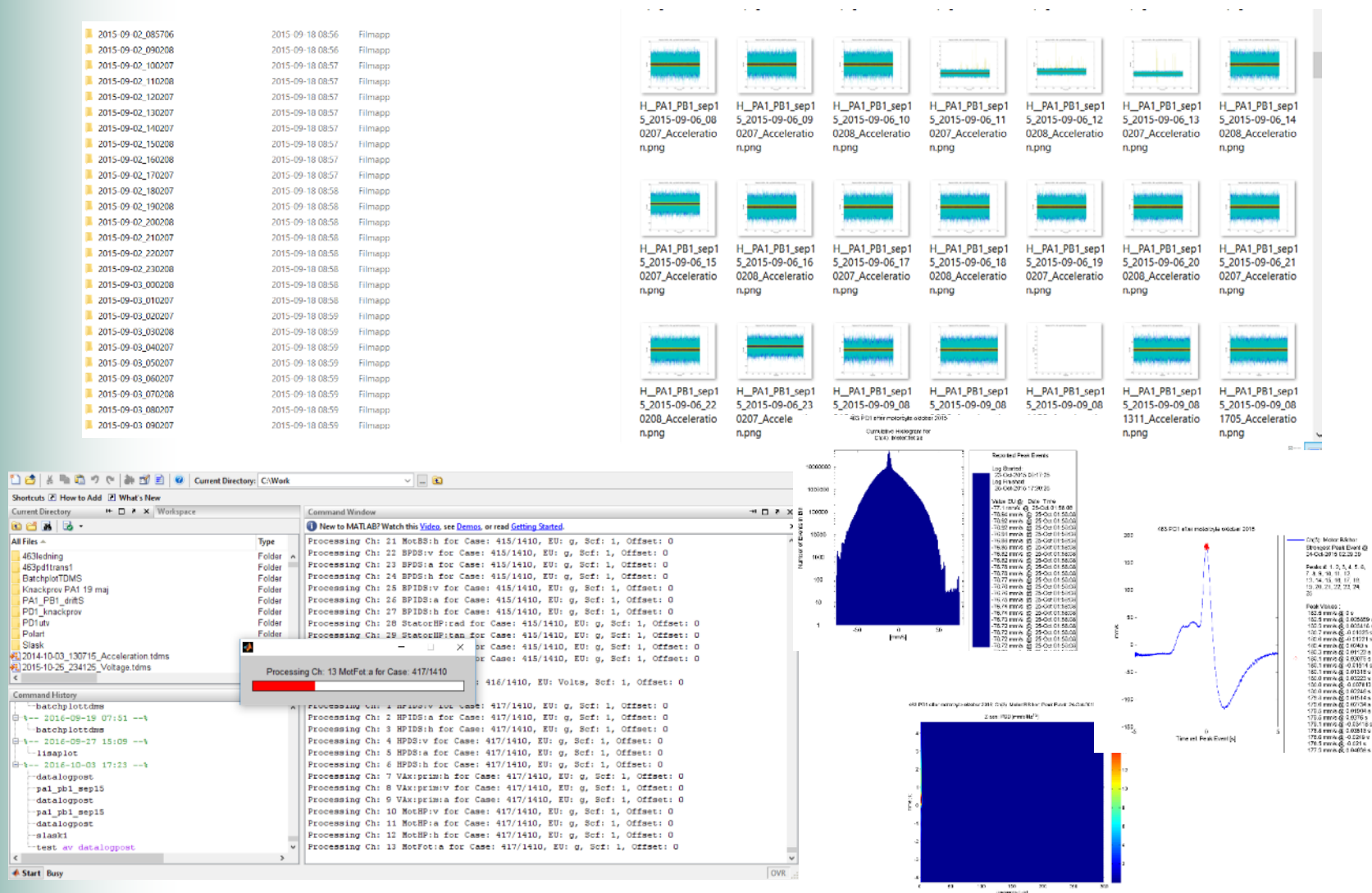
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# The Qring Way

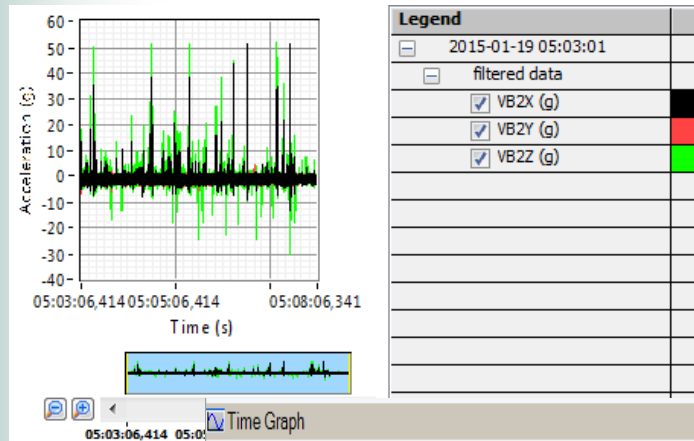




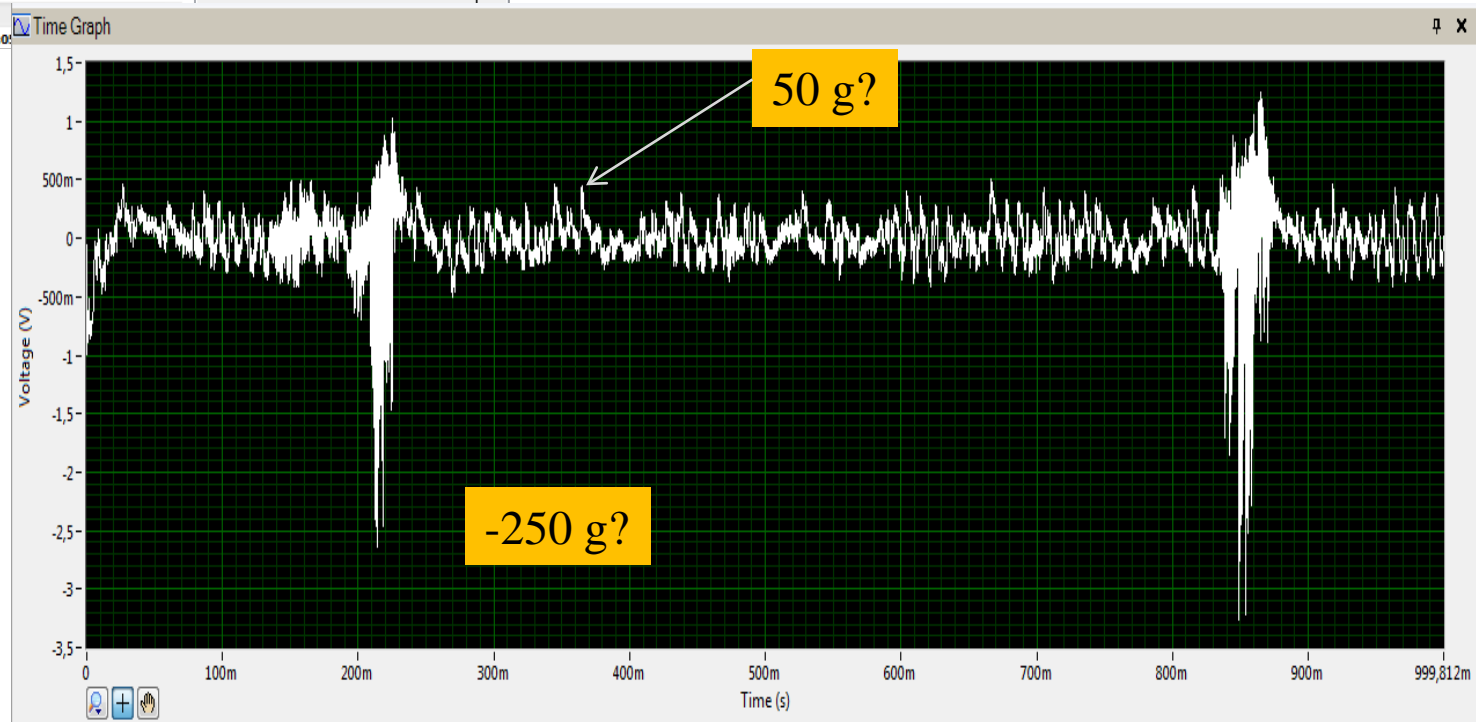
## The Qring Way



## Example Time Signal



10 mV/g



# An example

Tests done on big high pressure valves

The electric-hydraulic control valve has broken.

There have been more than one failure



Consequences for production; several days reduced effect

One of the possible causes was vibrations. Another was pulsations

## 2nd Step

- Change transducers & place in optimal positions



- Accelerometers

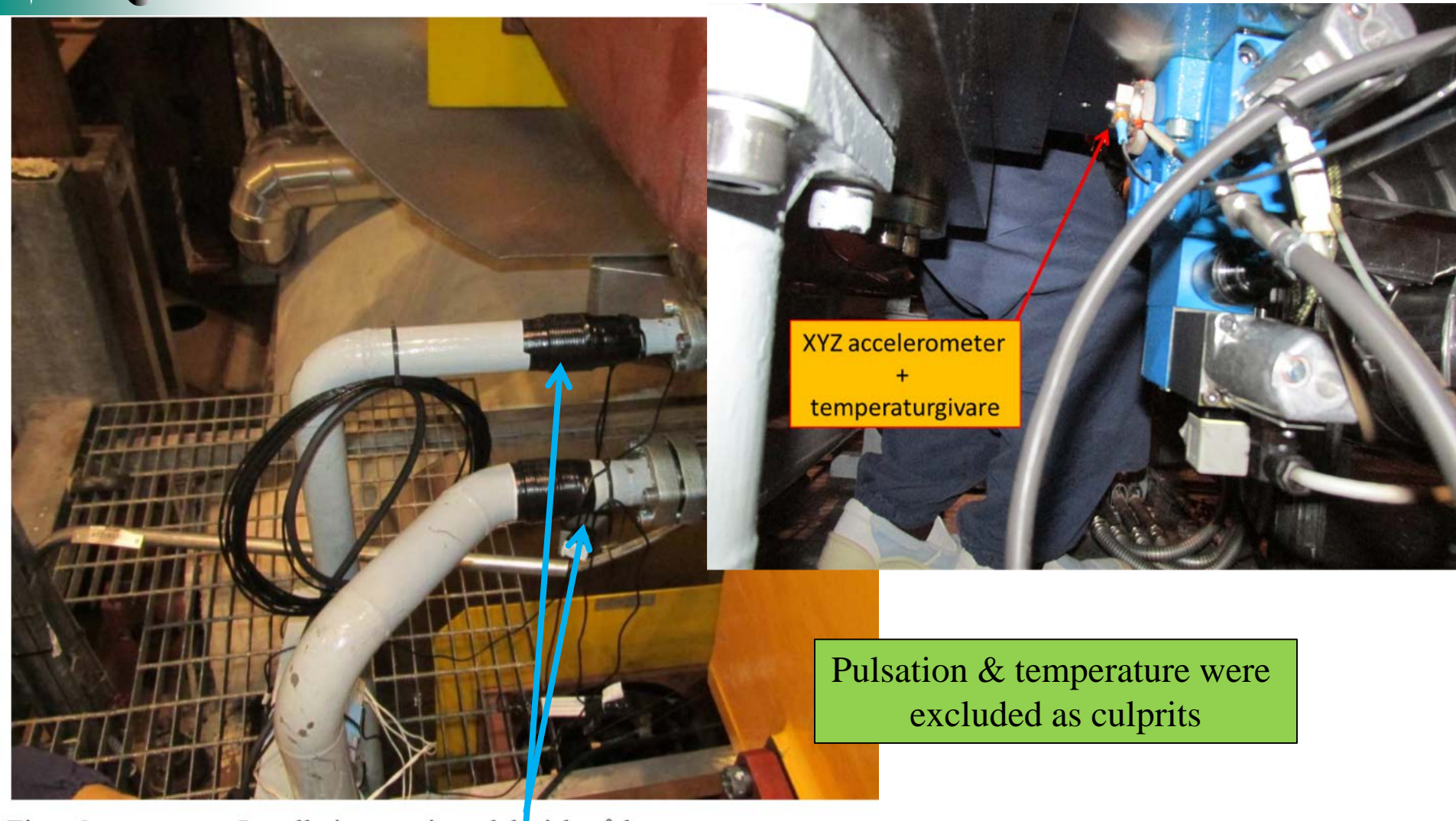
- Brand new 100 mV/g industrial 3143D Dytran transducers with brand new cabling.
- +/- 50 g, 0.5 – 3 000 Hz frequency range ( $\pm 5\%$ ) & isolated chassis.
- Intended for general purpose use
- 25 kHz > internal resonance frequency

- Pulsation measured using Piezocable

- Temperature measured using PT100



# 2nd Installation

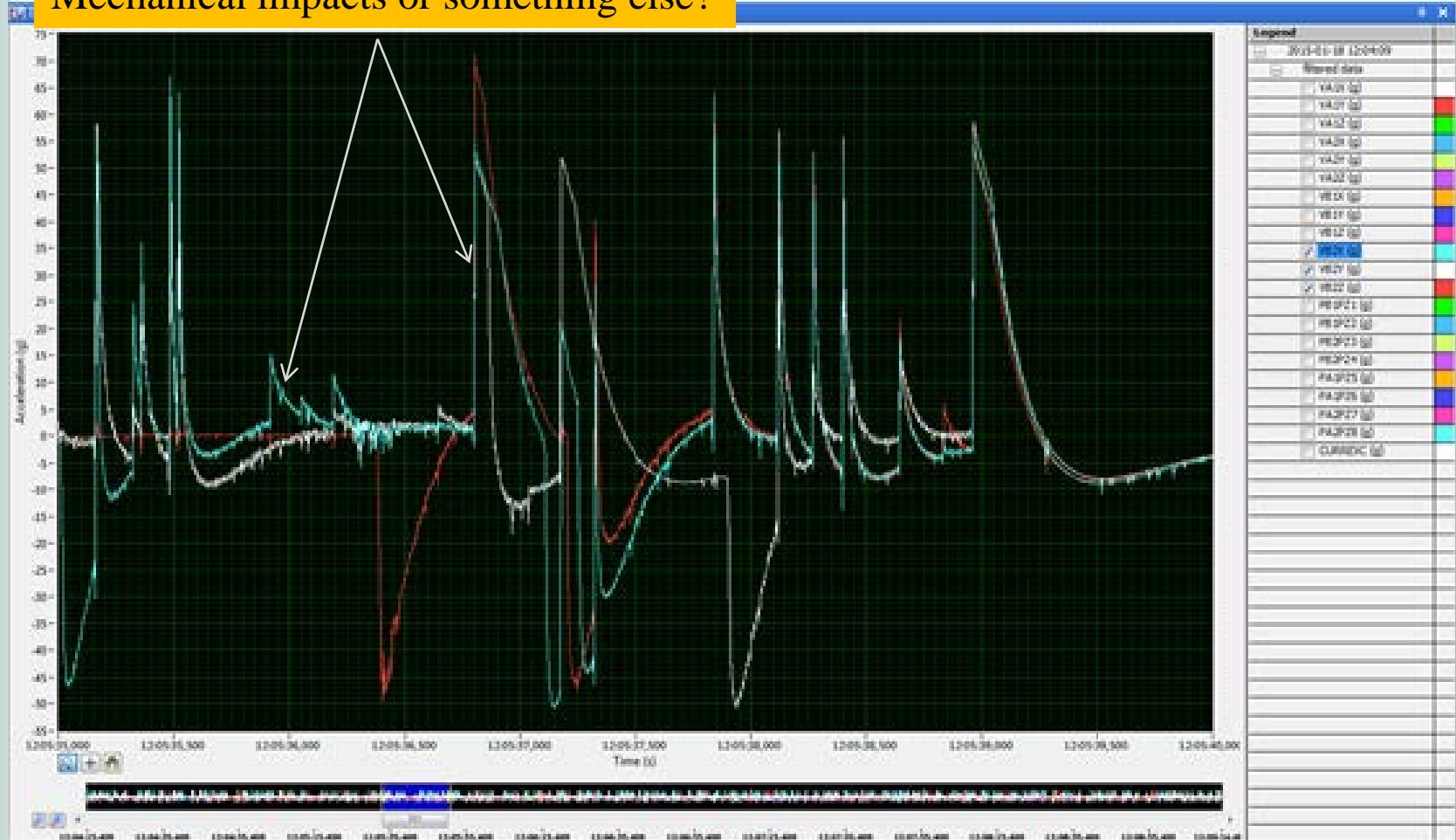


Figur 2 Installation av piezoelektrisk tråd.



## Example Time Signals

Mechanical impacts or something else?





# Debugging showed

- DC-offset
  - The measurement frontend was placed on metal bench that was in contact with (not connected) cable shield.
  - This was found to cause DC offset on input amplifier which could explain why a 50g accelerometer clips at 20g.
  - DC offset comes and goes without 50 Hz hum
- Spikes
  - There were still strange spikes present in the signal that sometimes clipped and sometimes did not clip.

3D Time Graph

Acceleration (g)

Time (s)

+/- 50 g range for transducer & frontend

Legend

- VIA01 (g)
- VIA02 (g)
- VIA03 (g)
- VIA04 (g)
- VIA05 (g)
- VIA06 (g)
- VIA07 (g)
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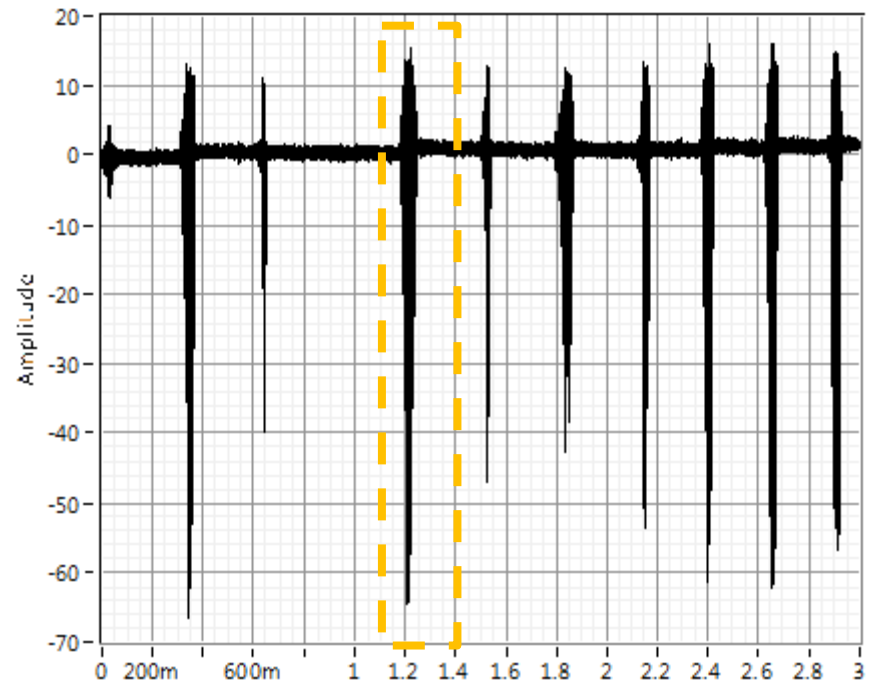
# Why would a transducer clip at 10% of its amplitude range?

- Short duration mechanical shocks can excite up to very high frequency, i.e 100+ kHz?
- Overloaded piezosensors are shocked with a DC shift that remains for a long time (many minutes)
- Literature shows that shock accelerometers have
  - 80+ kHz resonance frequency & built in mechanical filters to avoid saturating accelerometer amplifier when driving sensor at resonance.
- Such excitation only exists very close to the mechanical impact.
  - (Not explained by valve closing)

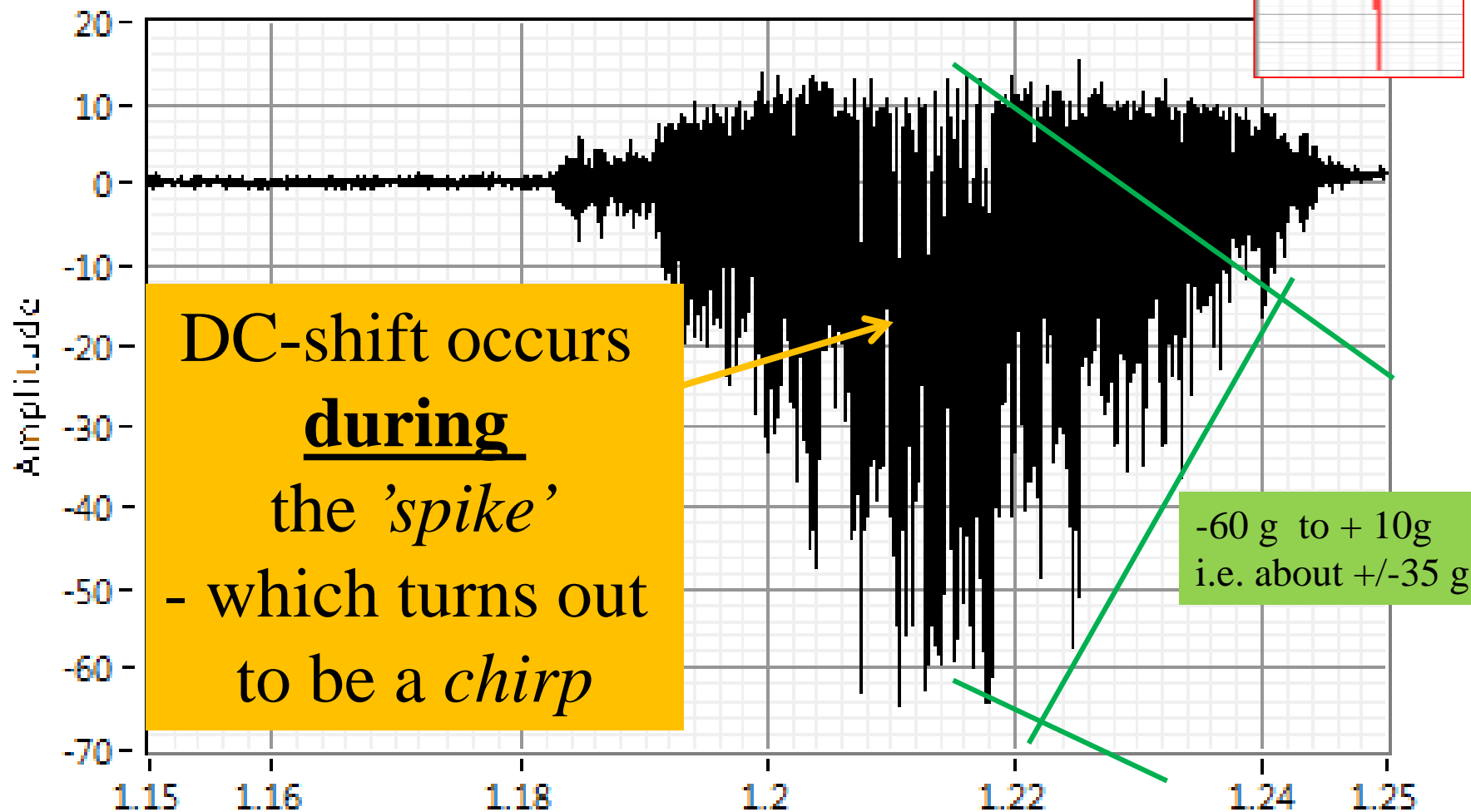
## Extra Measurement

- 1 MS/s (390 kHz) frontend
- 10 V input range
- Battery operated ICP amplifier
- Measurement PC operated from battery
- 1ch at a time

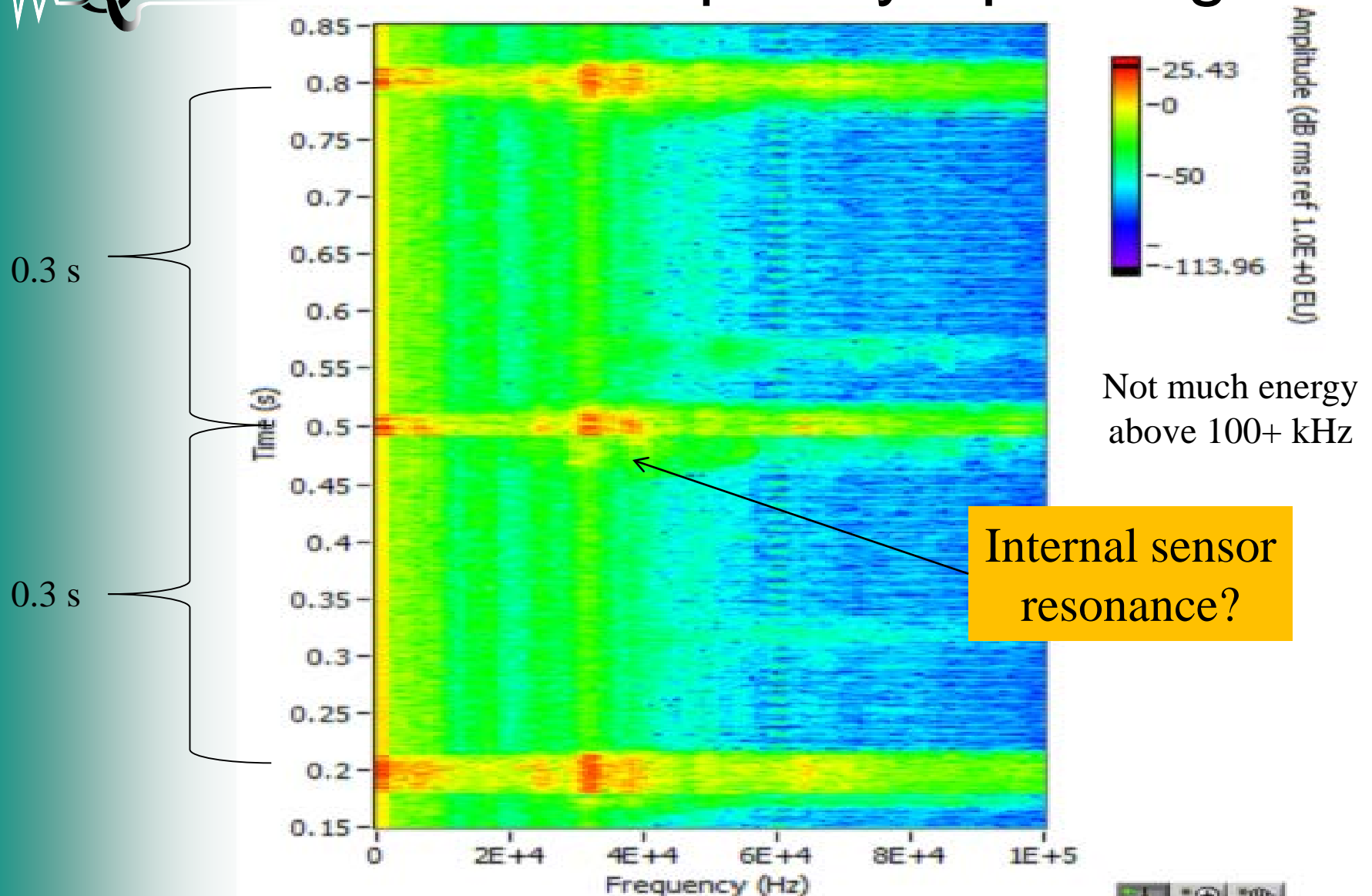
Why are spikes  
asymmetric ?



## Zoom In on Single 'Spike' sampled at 1 MS/s



## Time-Frequency Spectrogram





# Observations

- DC shift in sensor electronics when sensor is loaded at 25+ kHz resonance.
- Not '*Spikes*' - *Chirps*
  - *Transmission* of chirps may be explained by things like
    - Compression modes in mechanical components, e.g. a compression wave propagates at 5000 m/s in steel, a length of 2 m  $\Rightarrow \lambda/2$  @ 1250 Hz.
    - The compression/shear wavelength at 25 kHz is 0.2 m/0.1 m which is small enough for resonance in the breast plate height direction, etc.
  - What is driving these chirps?
  - Is it a problem for the EHS?

A second opinion was called in

In this case there were 2 measurement  
systems on the same transducers

## 3rd Step.

# Investigations why we got different & these strange results?

Goals were to

- Figure out what is the correct vibration level?
- Why do we get these strange spikes?
- Are they harmful?

## 4th setup

- Vibration transducers of varying type, and make
  - Dytran 3143D, 100 mV/g
  - Wilcoxon 100 mV/g compression type
  - PCB 356B21 10mV/g
  - B&K 4381V/4382V with charge amplifiers 1 mV/pc to 0.01 mV/pC
  - Velocity transducer VT1613 with linearization amplifier
- Piezostain gauges on linkage to estimate valve loads.
- NI cDaq frontend switched to VXI frontend
  - 20 V input range
  - 30V ICP feed to maximize transducer range.
  - OKG Multicabling & dSUB25 based cabling.

We added more transducers to figure out what was the problem

100 mV/g Dytran 3143D

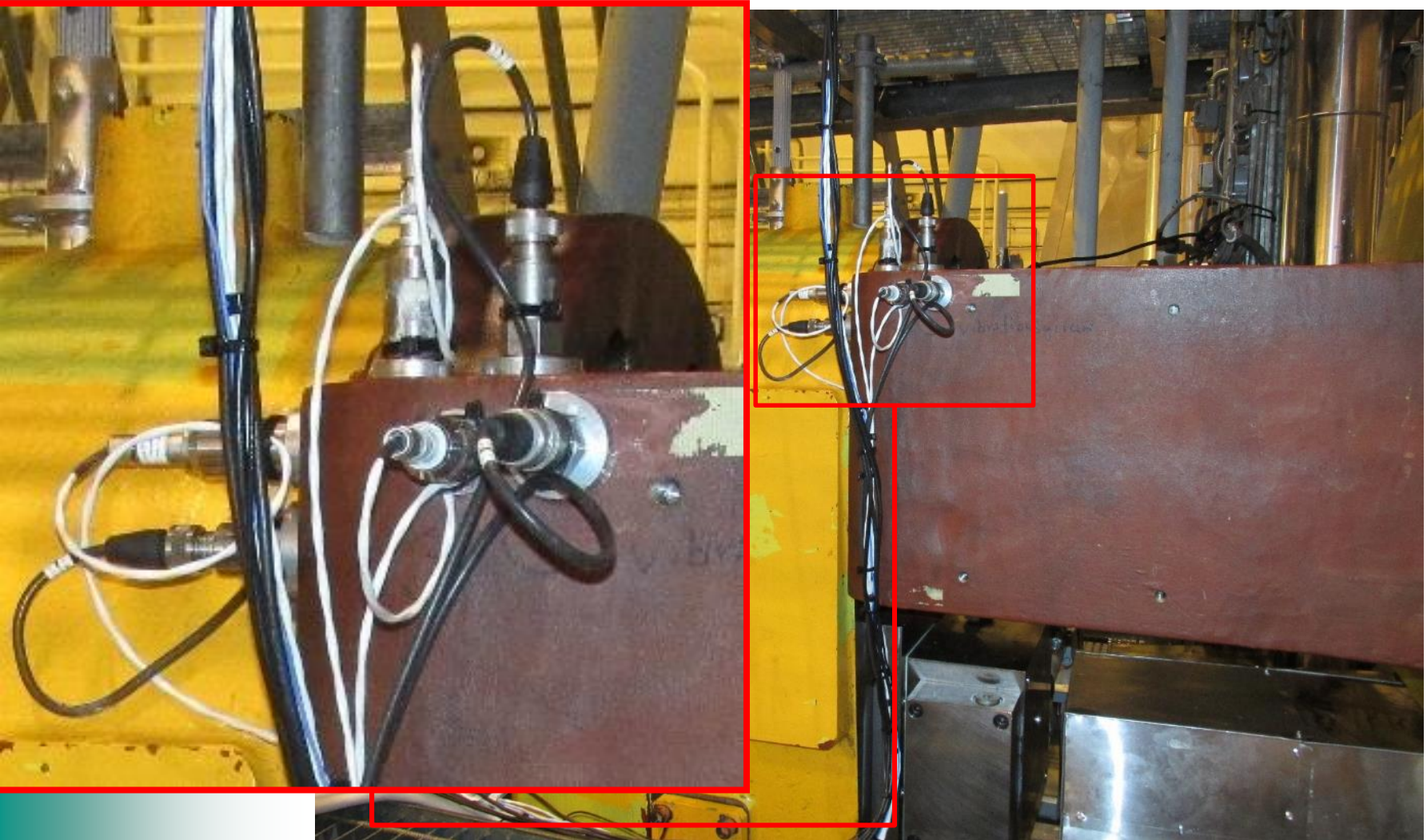
10 mV/g PCB 356B21

10 mV/g PCB 356B21  
+ mechanical LP-filter

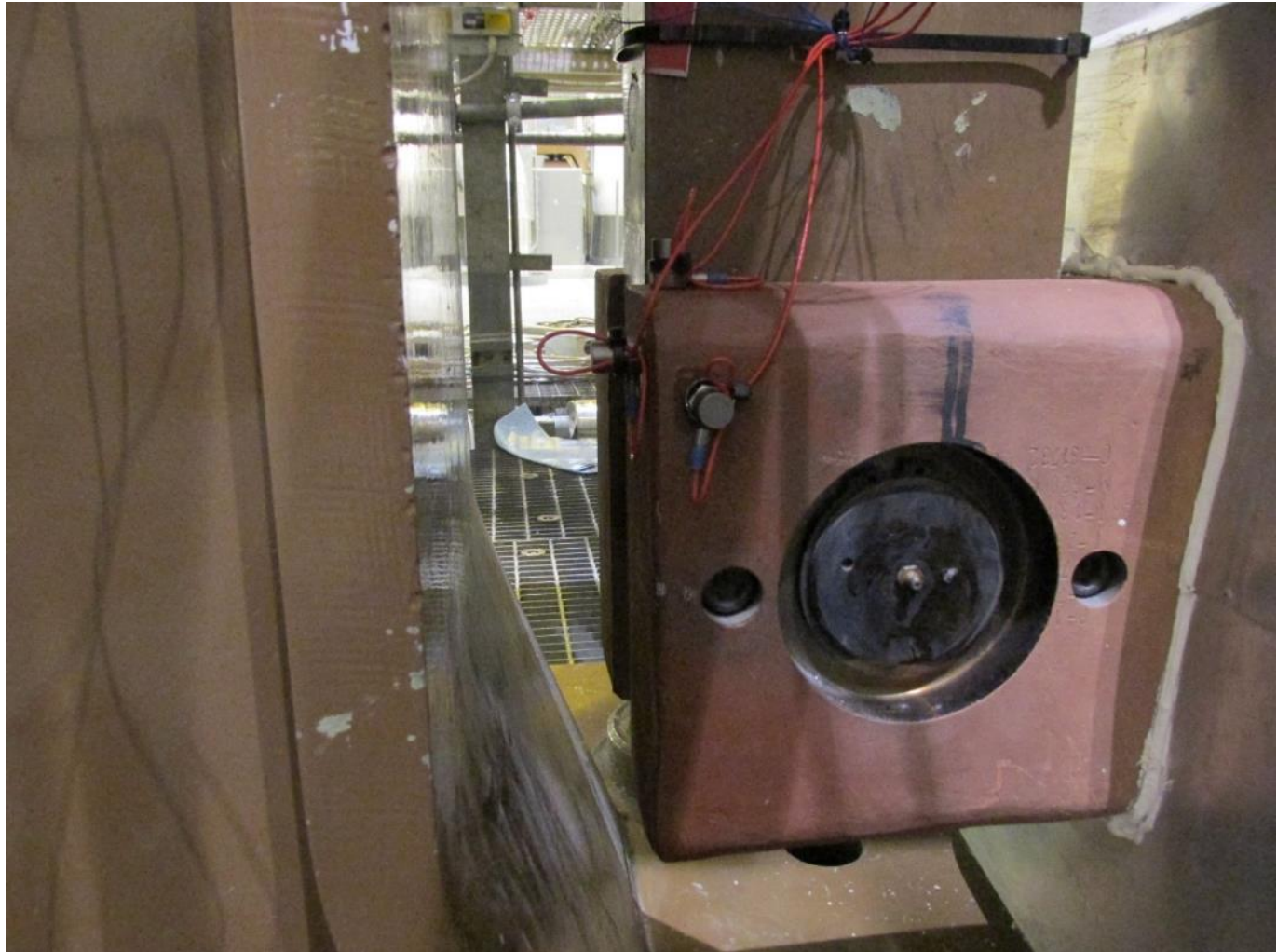
Mechanical LP filter  
(a felt pad)  
w. resonance at  $\sim 3+$  kHz



# Industrial Accelerometer 100 mV/g & Velocity transducer



# B&K 4381V/4382V 35 pC/g High Temperature Accelerometer on Steam Valve



# Piezo electric strain transducers showed low vibration





## Comparison

Dytran  
3143D  
100 mV/g

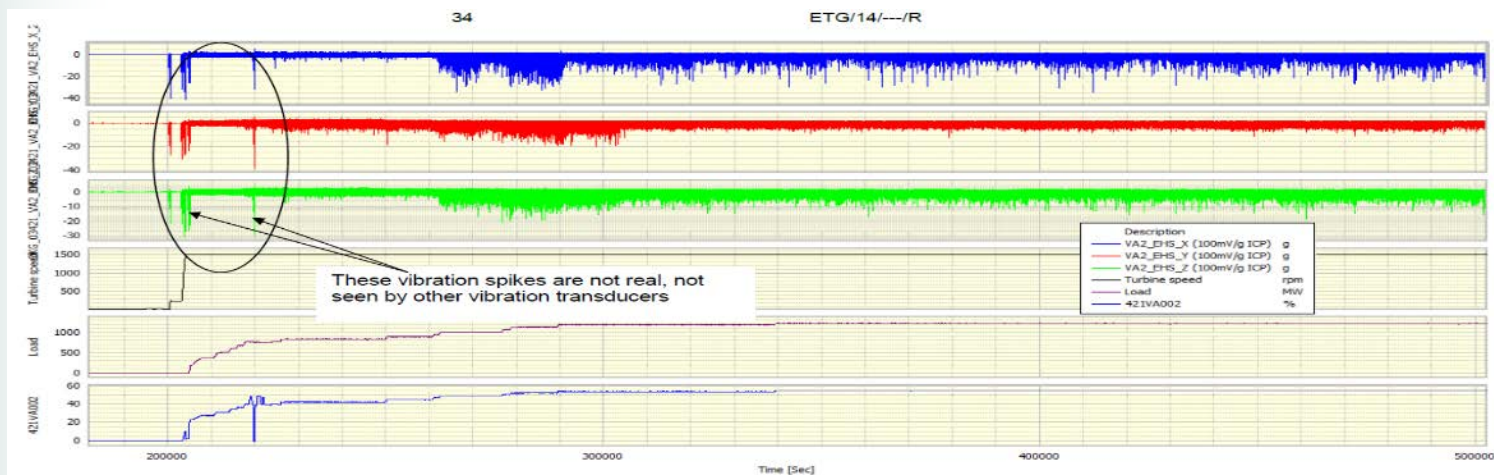


Figure 32 OKG 03: VA2: EHS Dytran 314D1 triaxial accelerometer (100 mV/g) vibration transducers X, Y, Z: Trend plot during load-up to 1200 MW 29<sup>th</sup> June 2015 to 2<sup>nd</sup> July 2015

PCB  
356B21  
10 mV/g  
glued

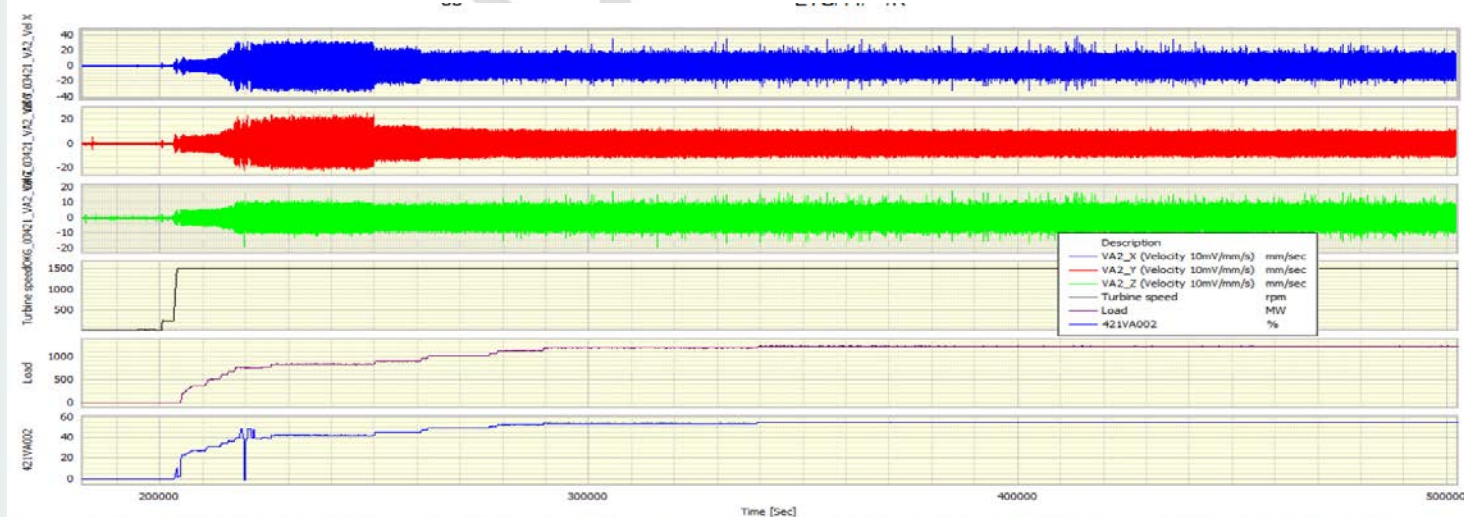
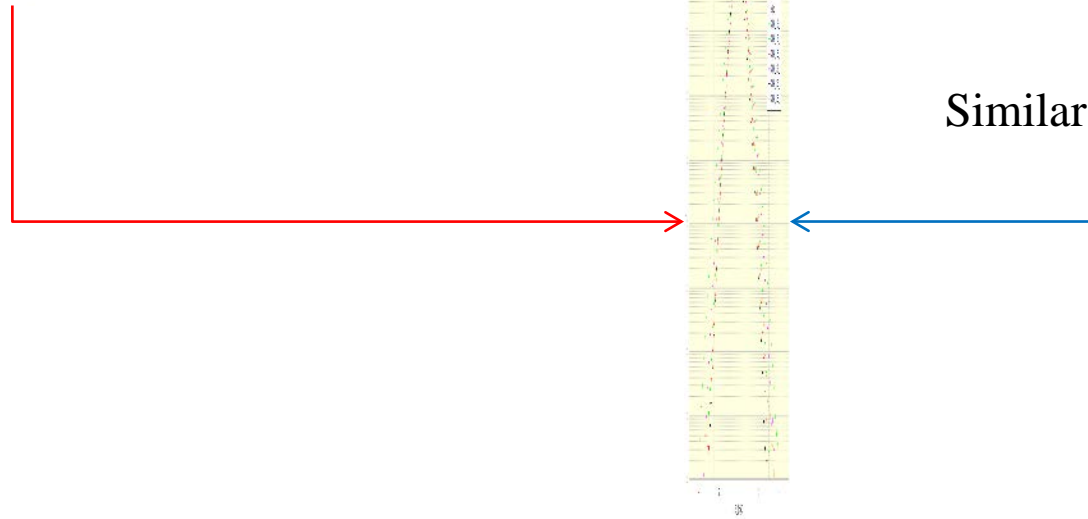
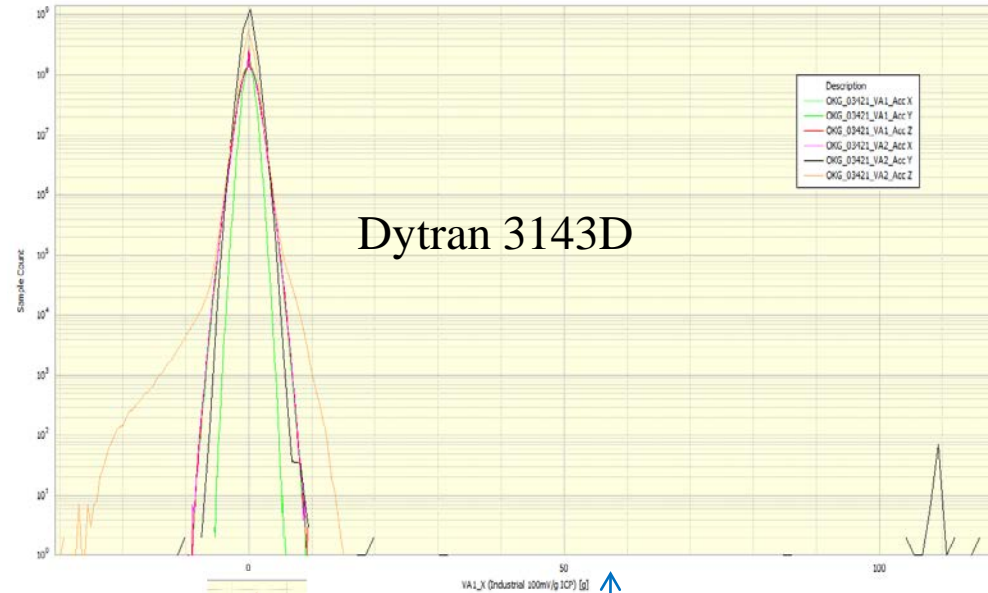
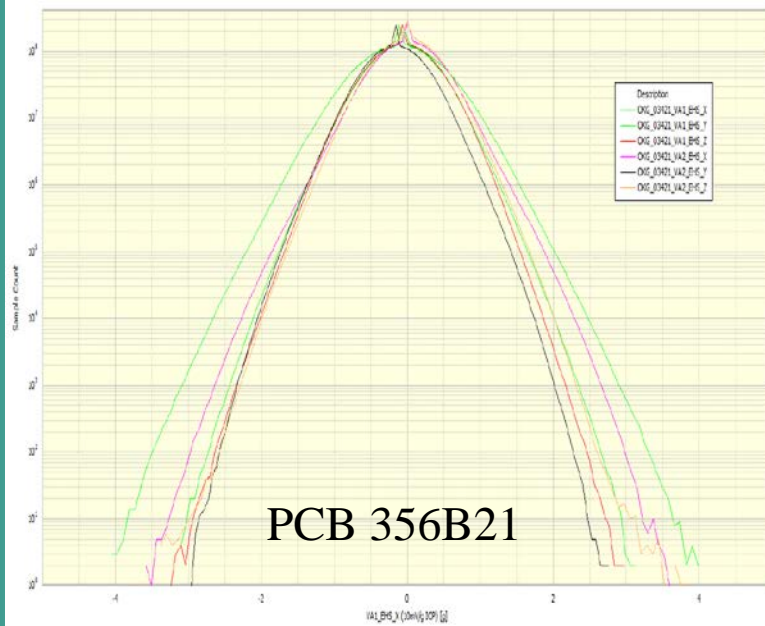
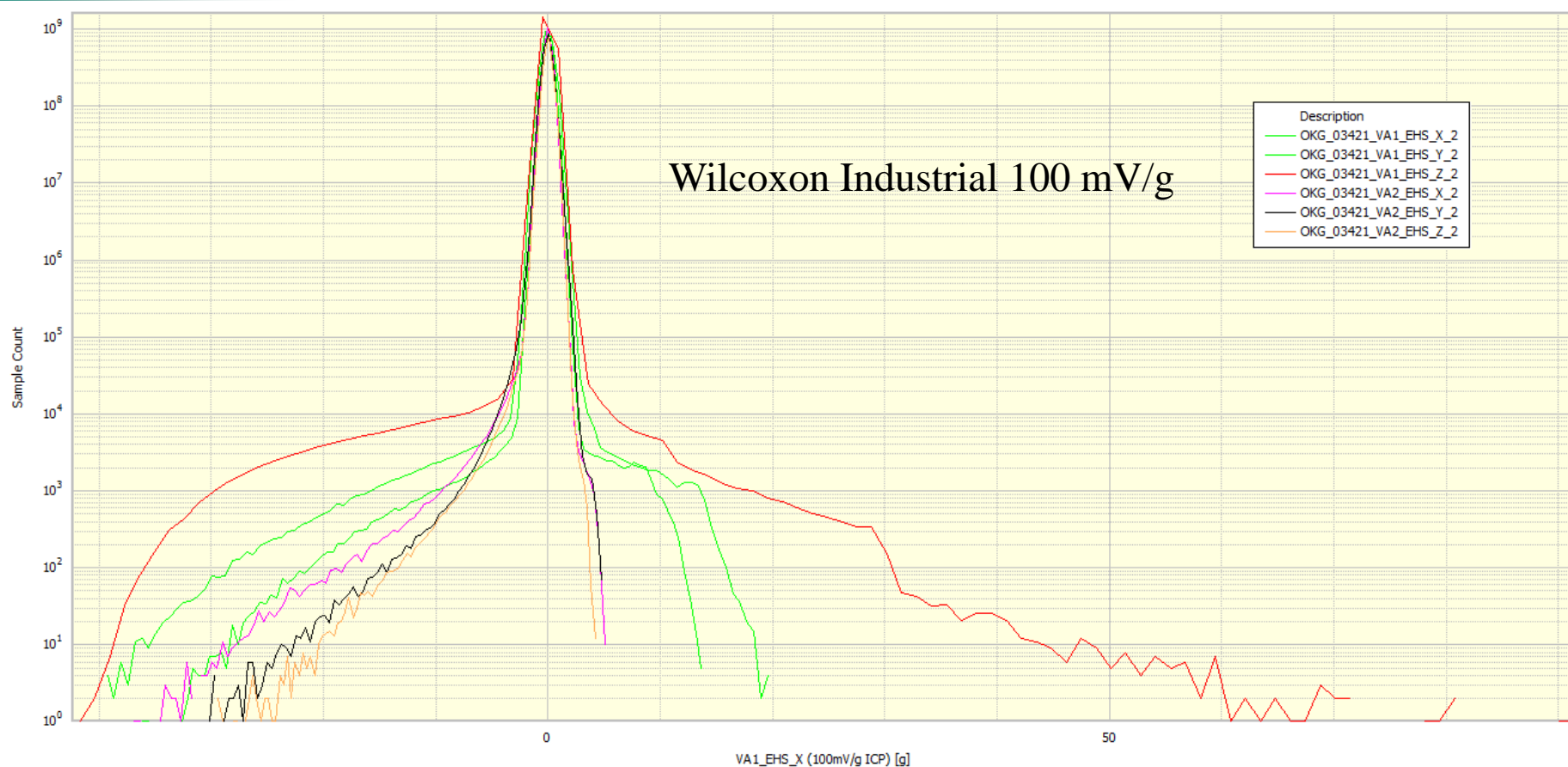


Figure 31 OKG 03: VA2: Velocity 10mV/mm/s vibration transducers X, Y, Z: Trend plot during load-up to 1200 MW 29<sup>th</sup> June 2015 to 2<sup>nd</sup> July 2015

# QRING Comparison: Amplitude Histograms





# Velocity transducer VT1613



# Observations

- Dytran & Wilcoxon general purpose 100 mV/g industrial accelerometers did not provide usable signals.
- Velocity transducer VT1613 provides slightly asymmetric histogram.
- 356B21 (glued) 10 mV/g shows symmetric histogram.
- 356B21 w. mech. Filter not measured by 3rd party
- Data up to 60% load.

# Project Stopped

- Root cause for EHS problem was identified not to relate to vibration at all.

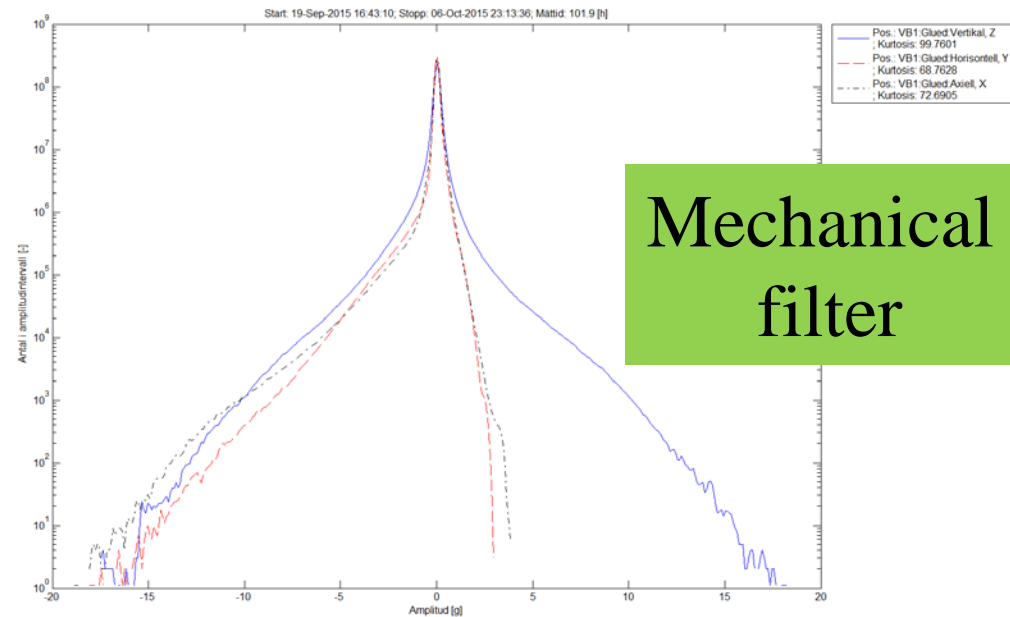
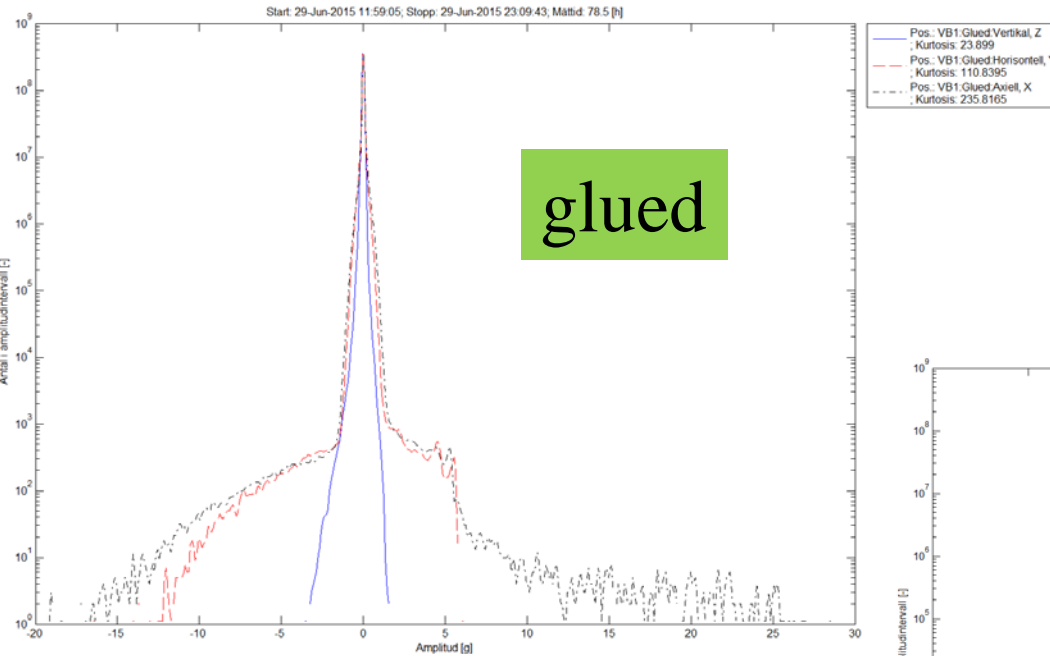
## Comparison to 3rd part

- He had 24 channels – we had 96 channels.
- He measured to 60% load – we measured 5 month continuous.
- He could not take transducers of every configuration

## Was 4th round measurement data used?

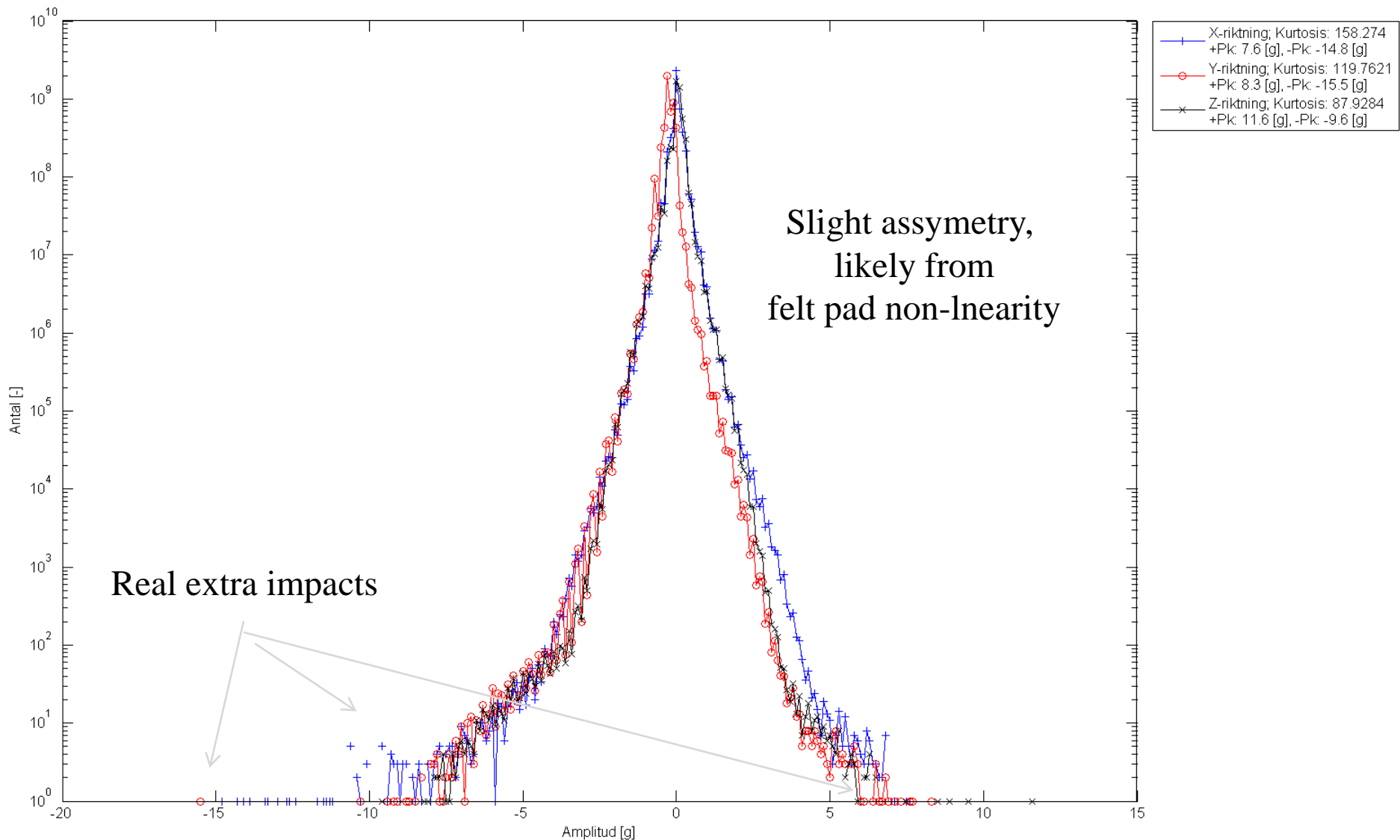
- Yes, we used it for accelerated testing of the new EHS.
- The transducer evaluation had to continue to do this.





Also 356B21 misbehaved when glued

# QRING Data used for Accelerated Testing



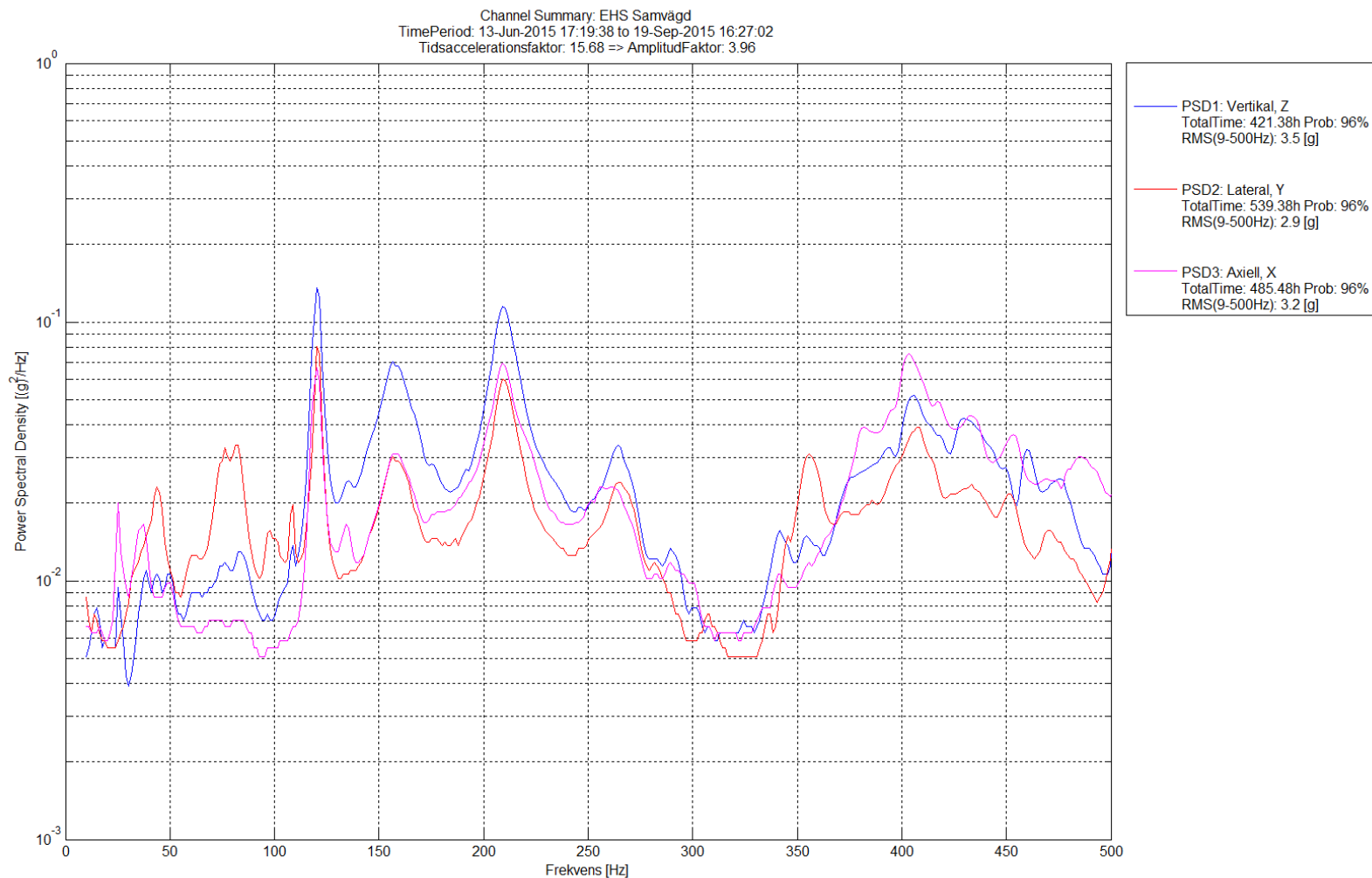
# Lesson Learned

- All glued accelerometers were affected by internal sensor resonance and zero shifted because of this.
- Accelerometer with mechanical filter & Velocity transducers worked best because they did not pick up high frequency vibration.
- 4x triaxials with filters were input.
  - 2x fell off after a while
  - 2x worked through the while measurement .

# End Results

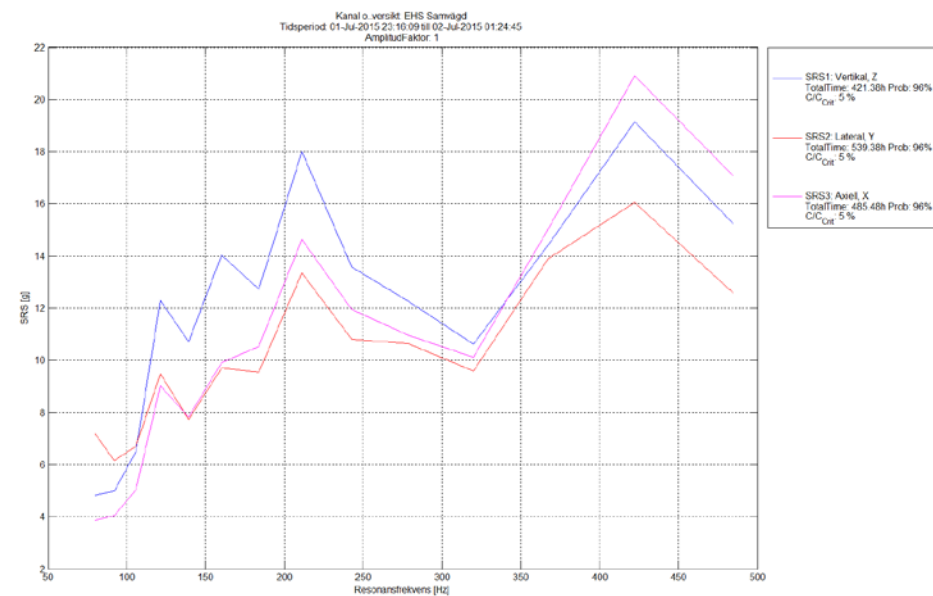
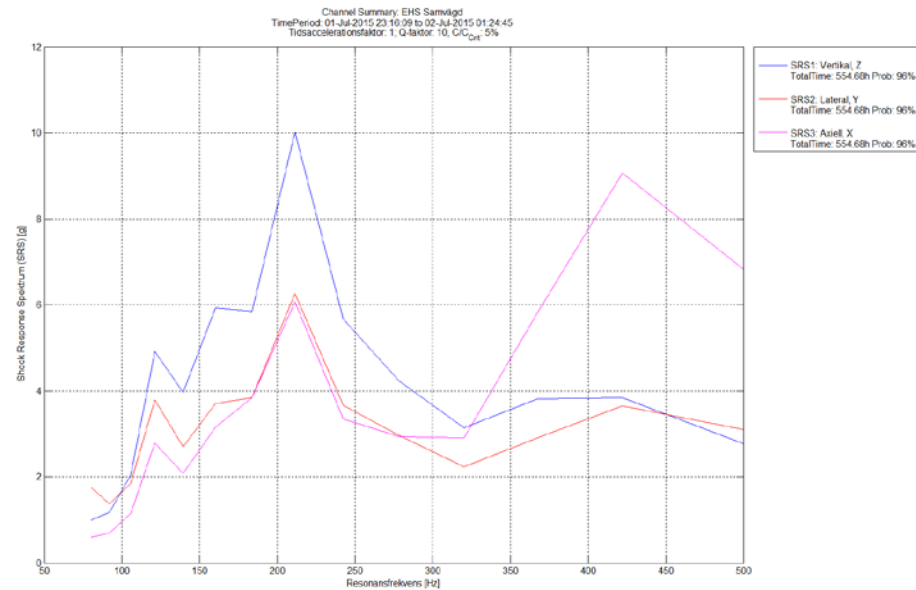
## Accelerated Testing

# 96% Probable PSD



# Shock Response Spectrum

## *Direct (time) & Indirect (spectral)*



SRS shows the outlier peaks to be covered  
by the noise excitation variability