SONOTEC

Preventive Maintenance

NEW BROADBAND SENSOR APPROACH FOR CONDITION MONITORING

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- Broadband Ultrasound Sensors
- SONAPHONE Device and Software
- Application Example: Machine Model
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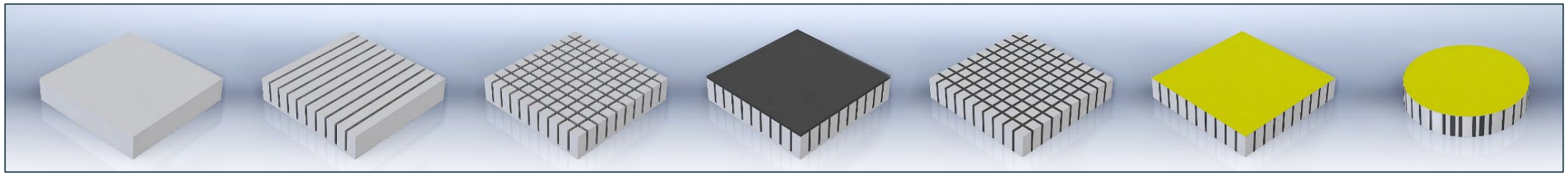
Piezocomposites (I)

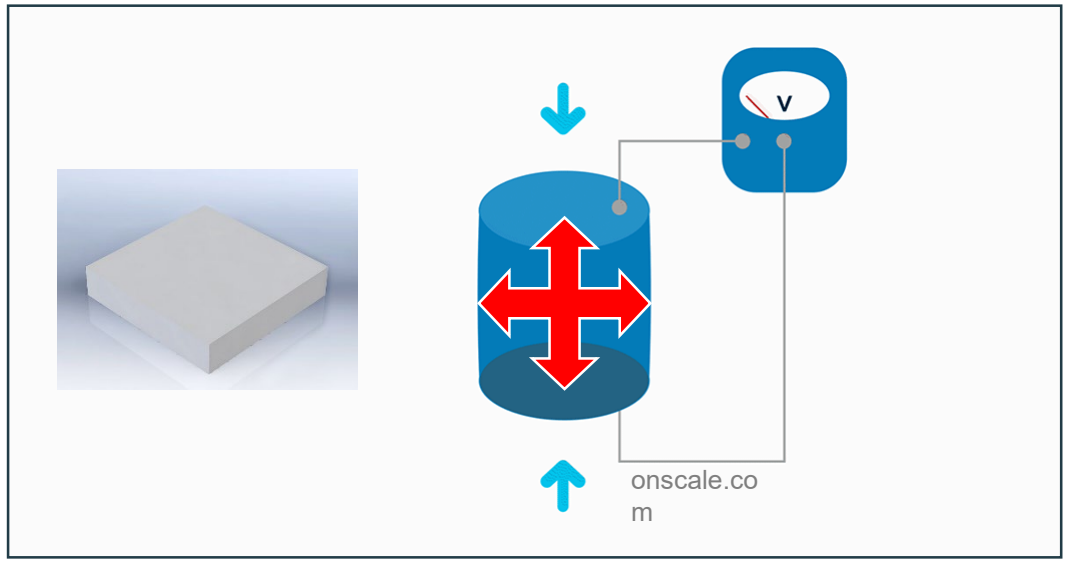
- → Piezocomposite material as a key to broadband structure-borne sound sensors
- → 15 years of experience in the production of high-quality piezocomposite material
- → Own manufacturing line for all necessary steps has been established at the SONOTEC HQ in Halle / Germany



Piezocomposites (II)

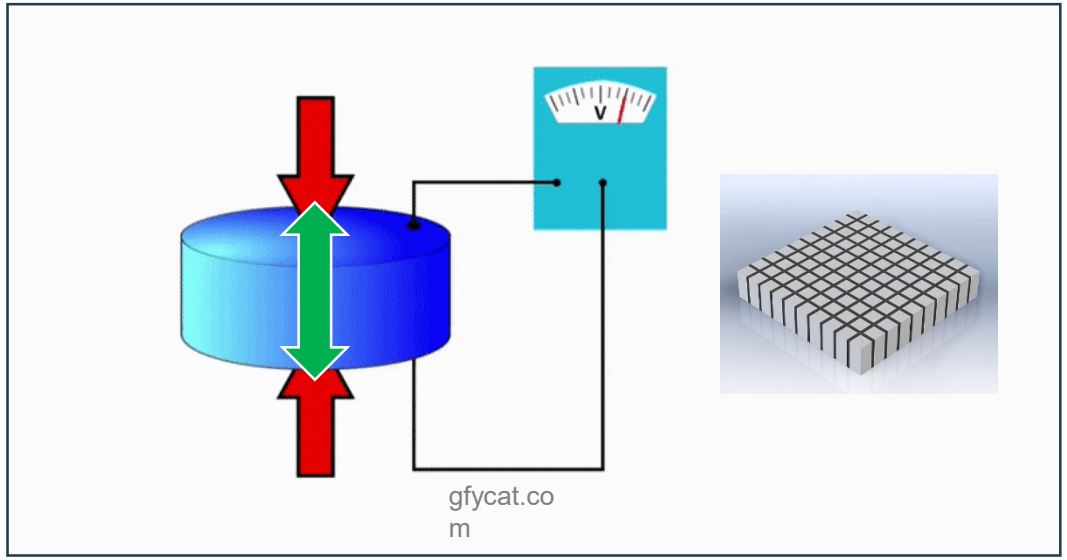
Piezoceramic material

- → Expansion/compression in **all spatial axes**
- → Different vibration modes
- → Several resonances



Piezocomposite material

- → Expansion/compression **only in Z-axis**
- → Mainly one vibration mode
- → Only one high frequency resonance (e.g. > 500 kHz)



Broadband Ultrasound Sensors (I)

Analog transducer:
temporary or permanent monitoring

Digital sensor:
used with SONAPHONE for
route-based measurements

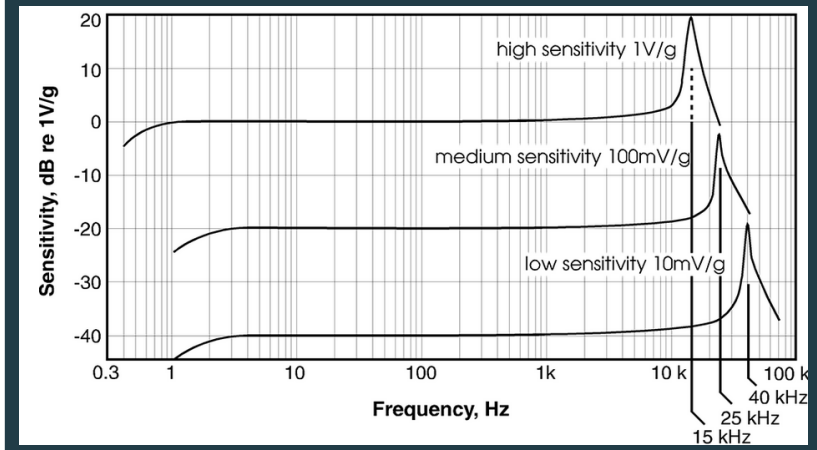
T10

T20

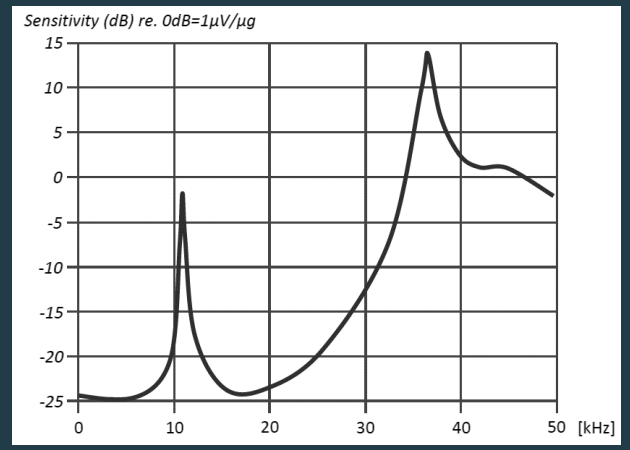
BS40

Broadband Ultrasound Sensors (II)

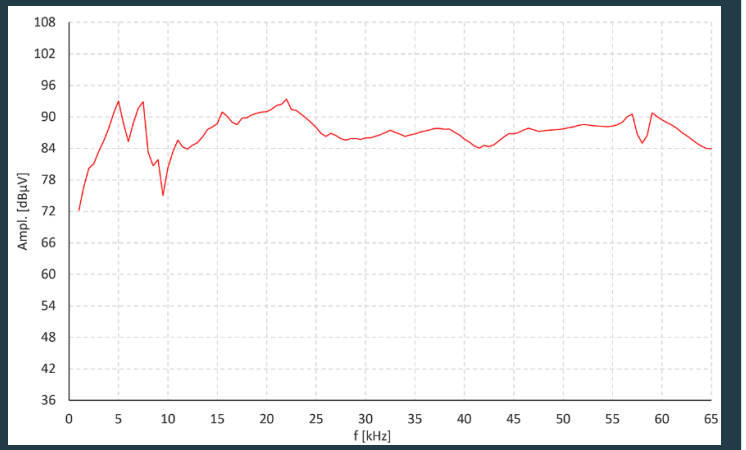
- → Seismic accelerometers have a linear frequency response and a distinct resonance frequency
- → Narrowband ultrasound sensors have distinct resonances with up to 40 dB increase of amplitude
- → Broadband Ultrasound Sensor BS40 exhibits an almost linear frequency response in the ultrasonic range



Sensor Frequency Responses Accelerometer



Narrowband Ultrasound Sensor



Broadband Ultrasound Sensor BS40

SONAPHONE Device and Software (I)

SONAPHONE

- → Smart handheld device
- → High sampling rate 256 kS/s
- → Different apps and sensors for different fields of use

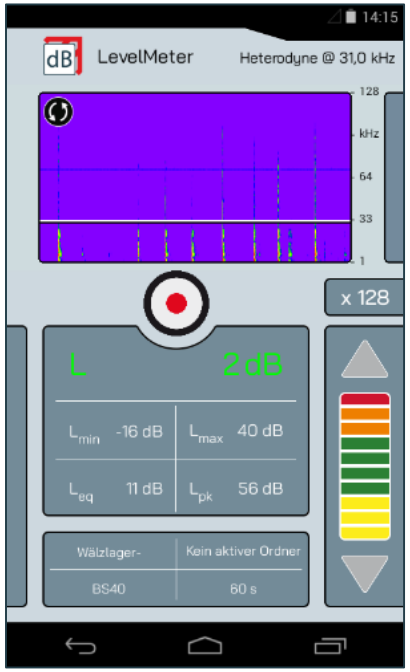
SONAPHONE DataSuite

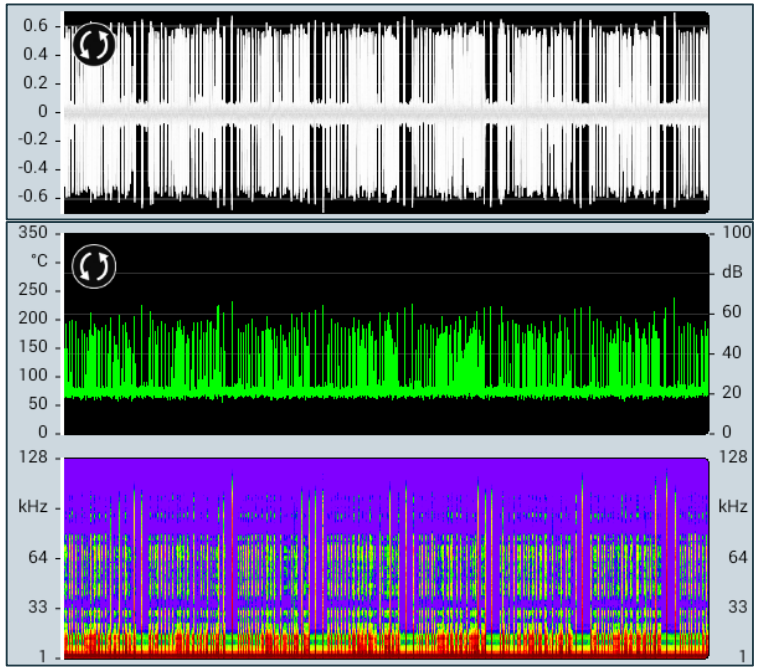
- → Management of asset tree an routes
- → Measurement and alarm settings
- → View and simple analysis functions

SONAPHONE Device and Software (II)

LevelMeter App

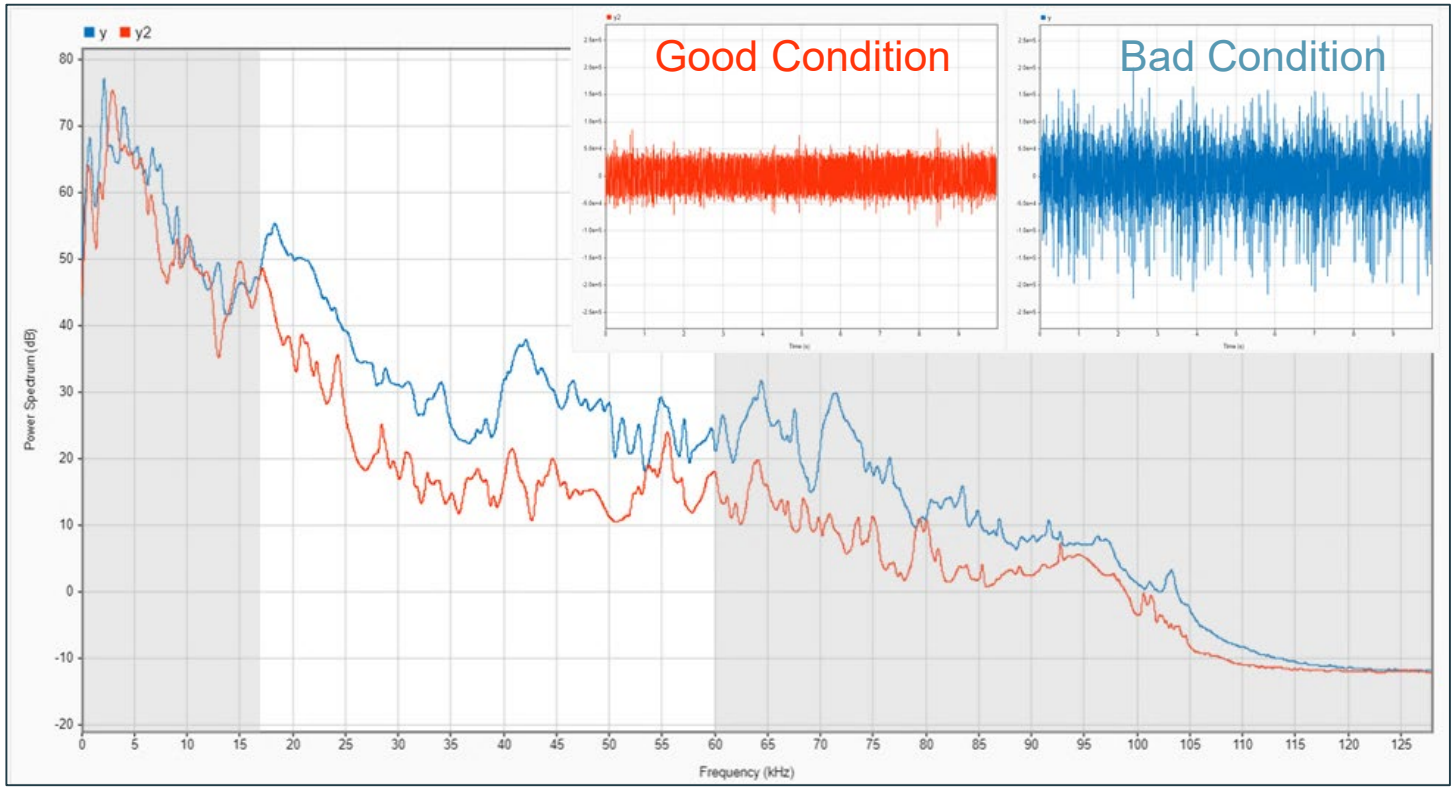
- → Broadband signal processing up to 128 kHz
- → Manual and auto gain
- → Adjustable frequency filter
- → Broadband and heterodyne audio output
- → Broadband and heterodyne levels
- → Time wave form, level graph, spectrogram





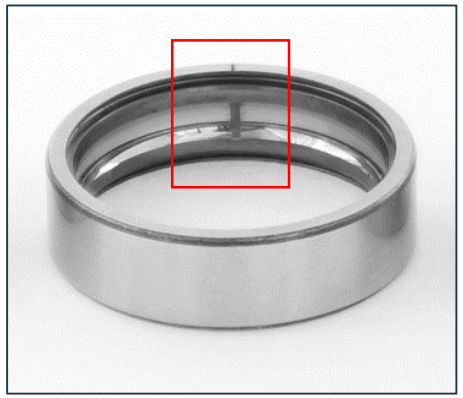
Application Example: Machine Model (I)

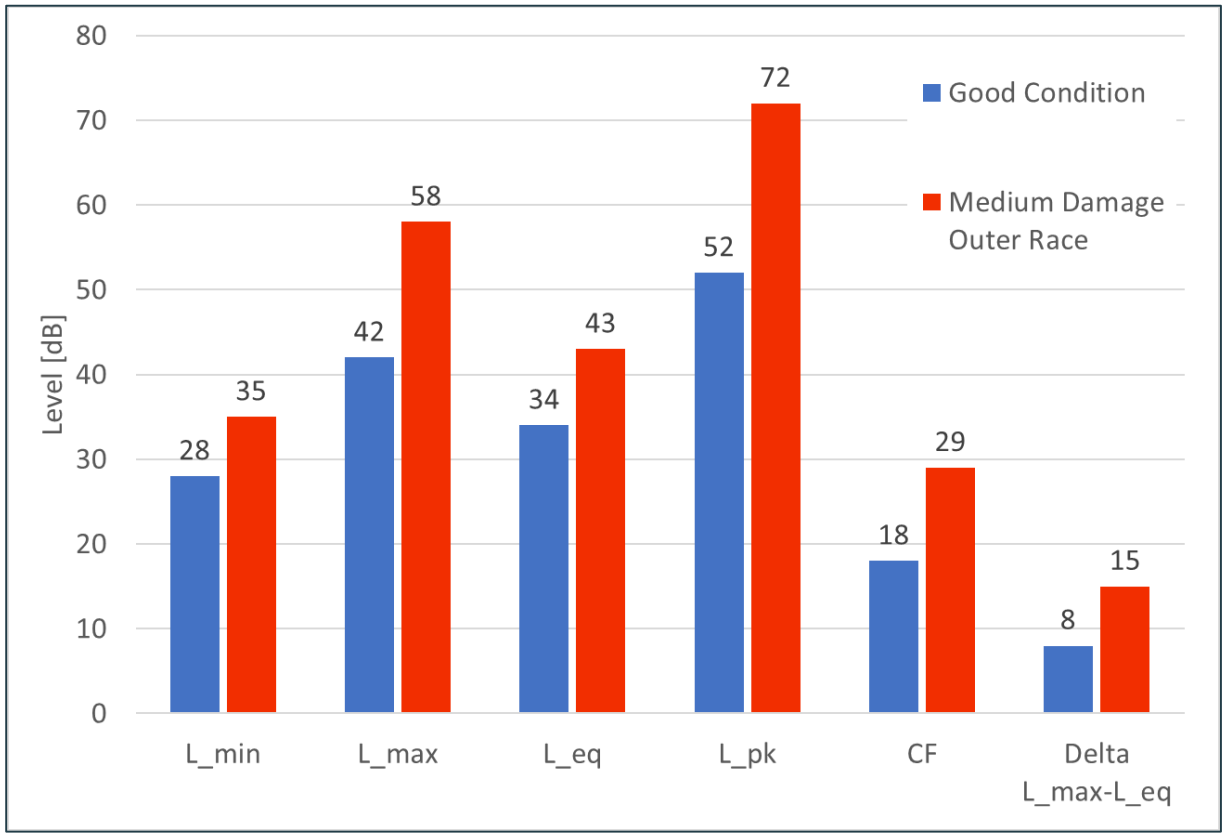
- → Time waveform and frequency spectrum of rolling bearing
- → Bad condition is shown by peaks in time waveform
- → Significant signal increase very broadband
- → Bandpass of 16 to 60 kHz was selected for the characteristic value determination



Application Example: Machine Model (II)

- → Laser engraved test damage
- → All characteristic values increase in the case of damage
- → Damage level 3 to 4 according to VDI 3832

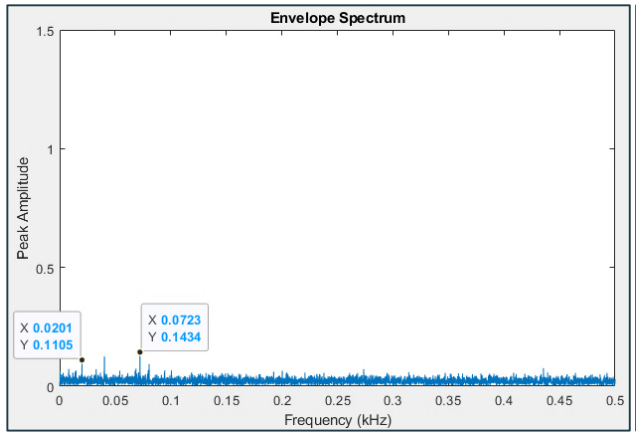


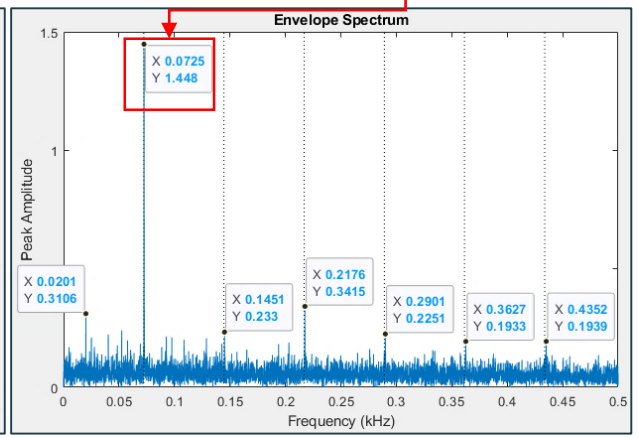


Application Example: Machine Model (III)

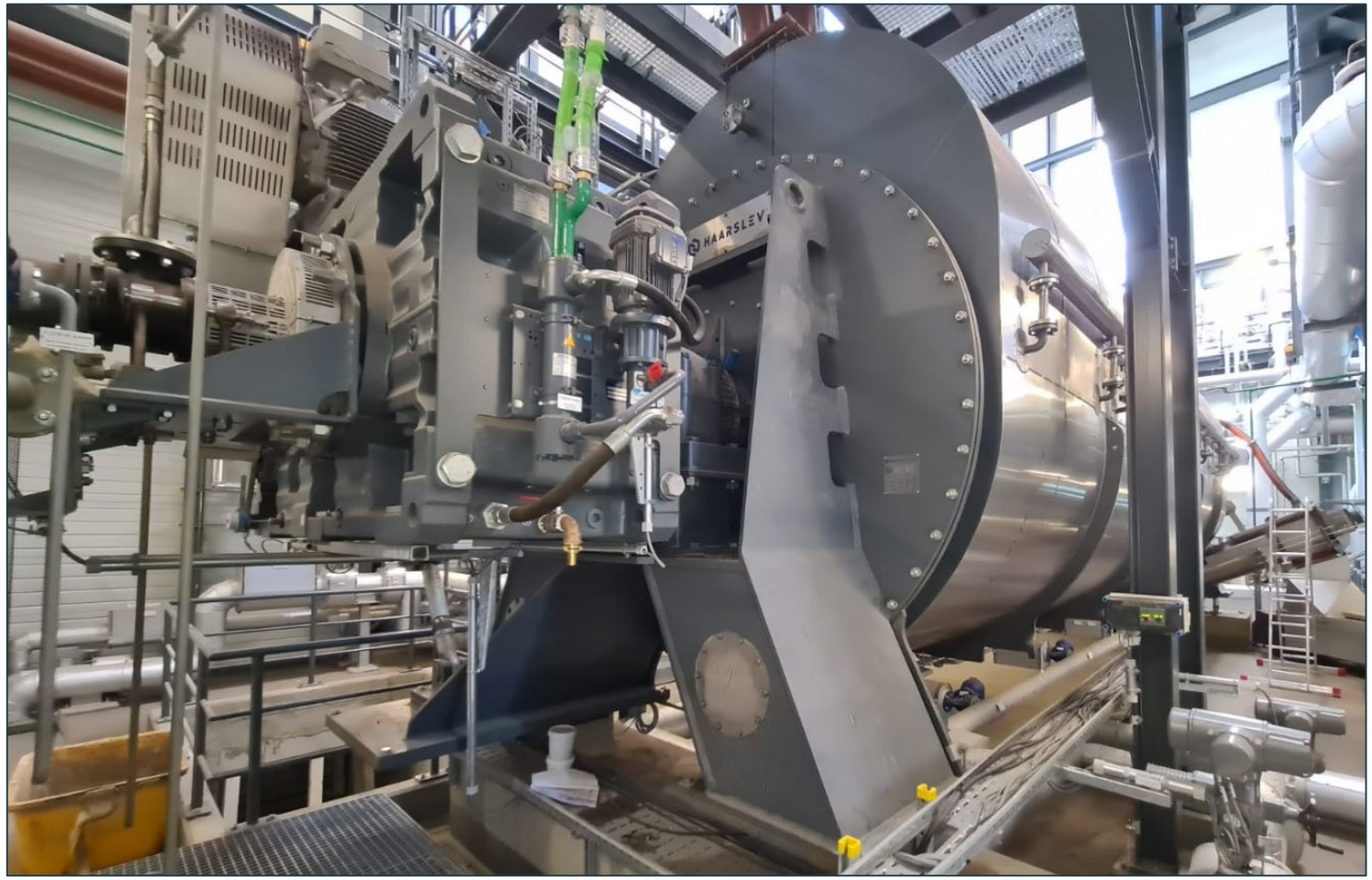
- → Laser engraved test damage
- → Analysis of the data for characteristic rollover frequencies
- → Matlab Signal Processing Toolbox
- → Outer race damage level 3 - 4 according to VDI 3832
- → Result is consistent with the classification based on the characteristic value increase

SKF	Rotational frequency				Frequency of over-rolling		
Designation	Inner ring	Outer ring	Rolling element set & cage	Rolling element about its axis	Point on inner ring	Point on outer ring	Rolling element
	f_i (Hz)	f_e (Hz)	f_c (Hz)	f_r (Hz)	f_{ip} (Hz)	f_{ep} (Hz)	f_{rp} (Hz)
☆■ 6002-2Z	20	0	7.974	47.323	108.237	71.763	94.645





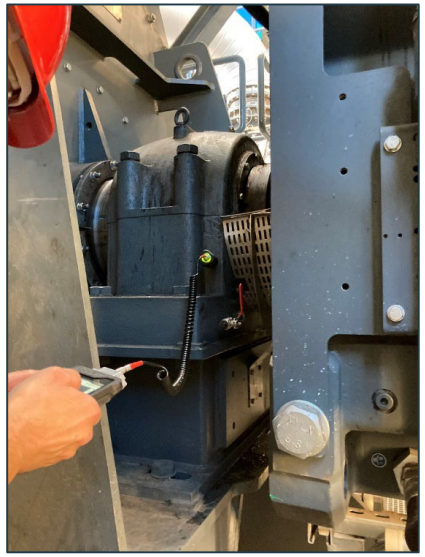
Application Example: Slow Speed Rolling Bearing (I)

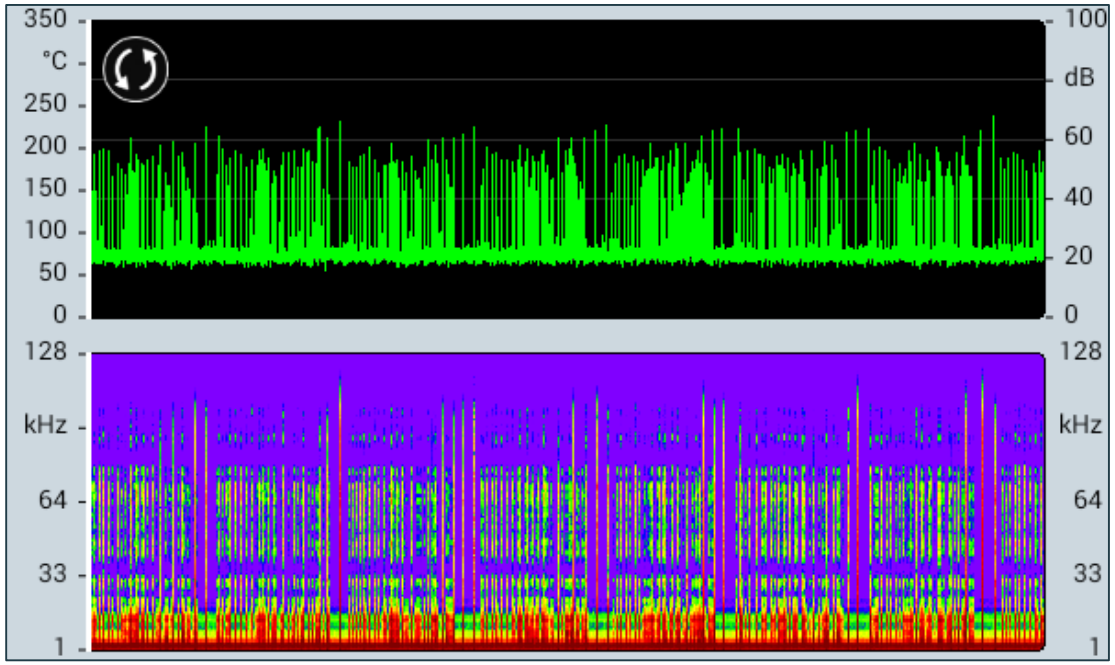


**Slow speed dryer,
payload 26 tons,
7.4 rev/min**

Application Example: Slow Speed Rolling Bearing (II)

- → The problem could be heard, but vibration measurement got no results
- → Huge peak levels could be measured with the BS40 and SONAPHONE





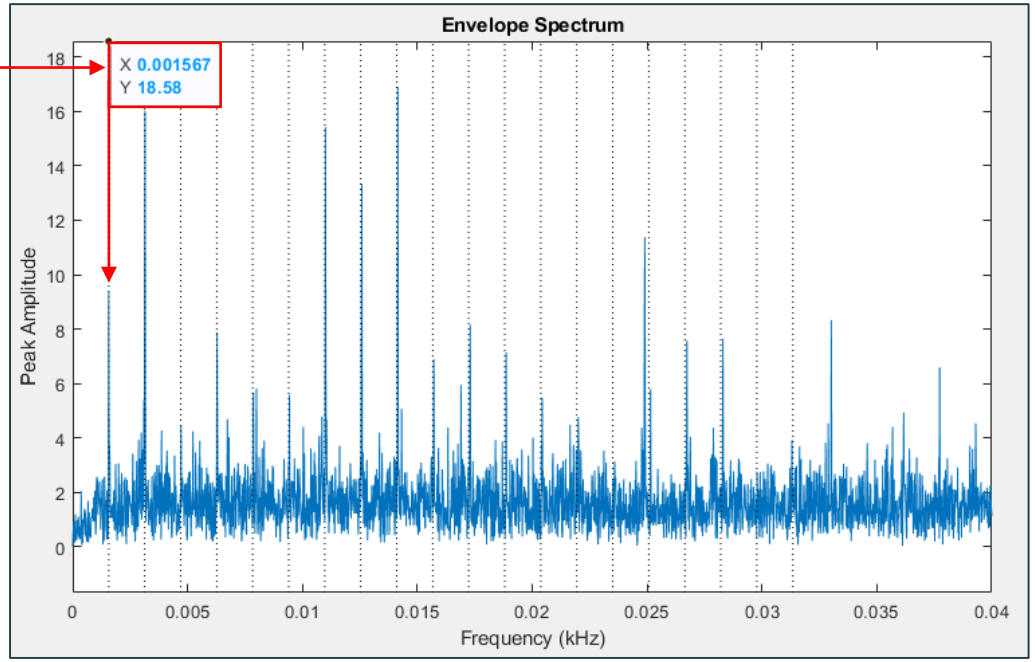
Application Example: Slow Speed Rolling Bearing (III)

- → Envelope analysis indicated capital outer ring damage
- → Numerous harmonics of the BPFO with large amplitudes

SKF

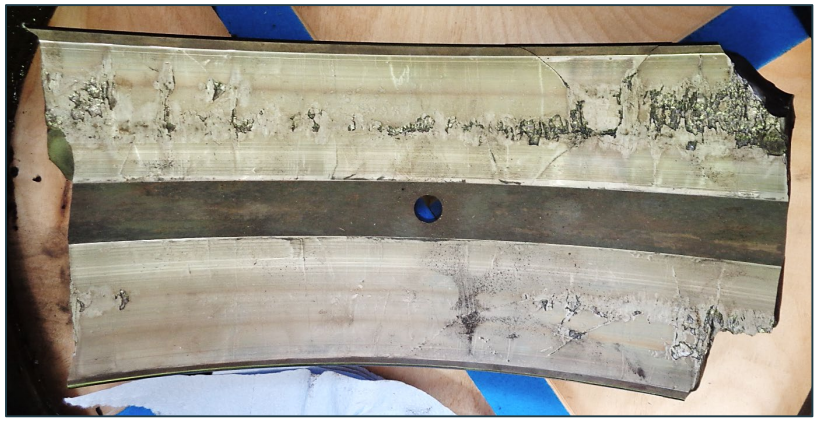
Designation	Rotational frequency			
	Inner ring	Outer ring	Rolling element set & cage	Rolling element about its axis
	f_i (Hz)	f_e (Hz)	f_c (Hz)	f_r (Hz)
☆ ■ 23076 CCK/W33	0.123	0	0.056	0.647

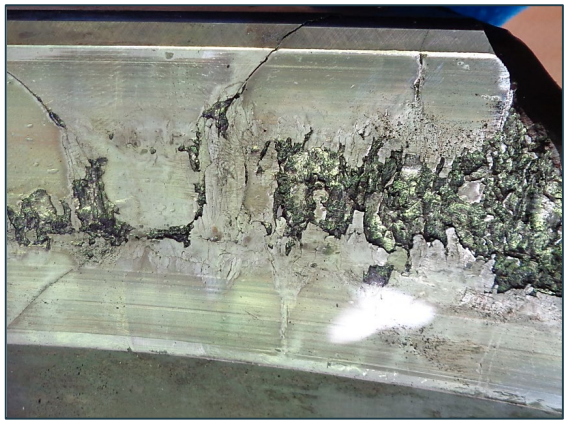
Frequency of over-rolling		
Point on inner ring	Point on outer ring	Rolling element
f_{ip} (Hz)	f_{ep} (Hz)	f_{rp} (Hz)
1.888	1.565	1.293

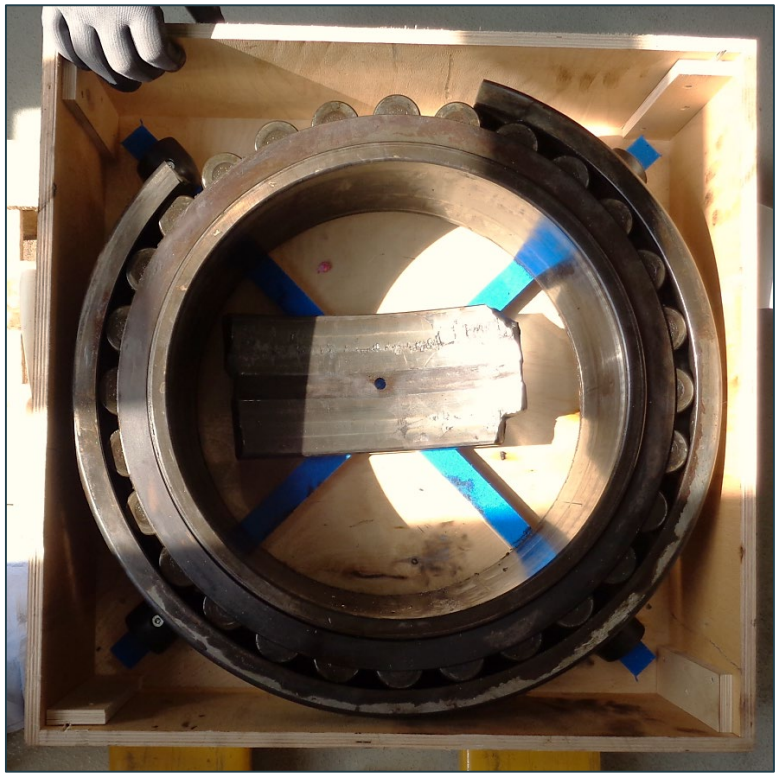


Application Example: Slow Speed Rolling Bearing (IV)

- → Dismounted rolling bearing confirms the measurement data evaluation
- → Outer ring piece has finally broken off during disassembly
- → Fracture surface indicates fatigue fracture
- → Many cracks in the outer ring
- → Excessive spalling in the outer race







Conclusions

- Piezocomposites form the foundation for broadband ultrasonic sensors
- Broadband ultrasonic sensors lead to improved measurement reproducibility
- High sensitivity in wide frequency range
- High sensitivity for low speed rolling bearing failure detection
- SONAPHONE and software provide many possibilities in signal processing

Ultrasound is our Strength

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