



Condition Monitoring

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Condition Monitoring



PCC Oktoberfest 2015
John Ditter – WAGO Corporation

What is Condition Monitoring?

Condition monitoring is the process of monitoring machinery health or condition, such that a significant change is indicative of a developing failure. It allows maintenance to be scheduled, or other actions to be taken to avoid the consequences of failure, before the failure occurs. The main goal of condition monitoring is to improve plant production capacity and make the process more profitable.

A 1998 study by the Department of Trade and Industry in the UK reported that companies who implement a Condition Monitoring (CM) program at their plant on average spend 25% less on maintenance than companies that do not have a CM program.

Types of Maintenance ...

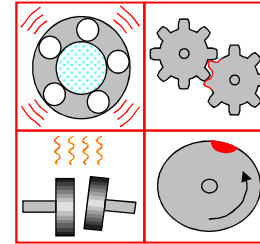
- **Reactive maintenance or 'breakdown maintenance'** – Unplanned machine breakdown. Usually expensive because replacement parts may need to expedited and overtime man-hours are often required. In some cases, cascading failures occurred.
- **Preventive maintenance** – Scheduled maintenance in an effort to avoid equipment breakdown and failures. Can be further broken down into Periodic and Predictive Maintenance.
- **Periodic maintenance** – Time-based maintenance requiring periodic checks that include inspecting, servicing and cleaning of the equipment. Replacing gaskets, lubricating friction points and inspecting for wear are common activities.
- **Predictive maintenance** – Utilizing data about the equipment and its operation to anticipate wear conditions. Through analysis of use trends and information about the expected useful life of components, maintenance is scheduled and performed in a manner that maximizes the parts' useful service life.

Why Condition Monitoring...

- Reduction of Breakdowns
- Anticipate and Plan Repairs
- Increase Profits
- Maintain Plant Production Capacity
- Provide Reasonable work Hours for Maintenance People

Metrics of Condition Monitoring

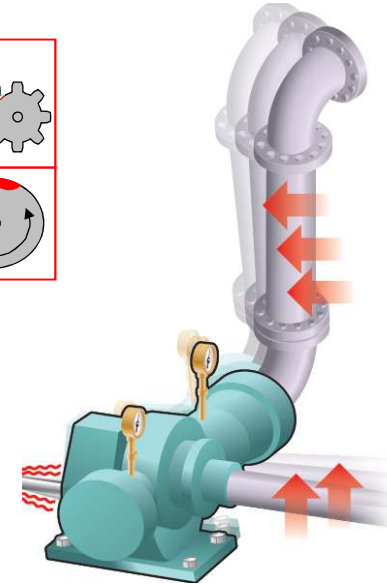
Vibration



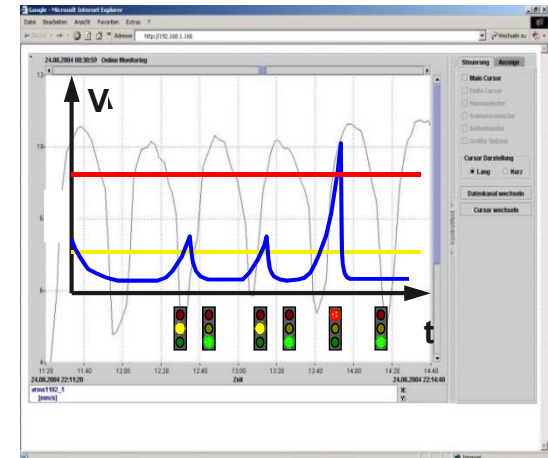
Shock



Current



Temperature



How do I monitor these Metrics??

Portable devices???



Continuous Online Monitoring is a Better Approach!!

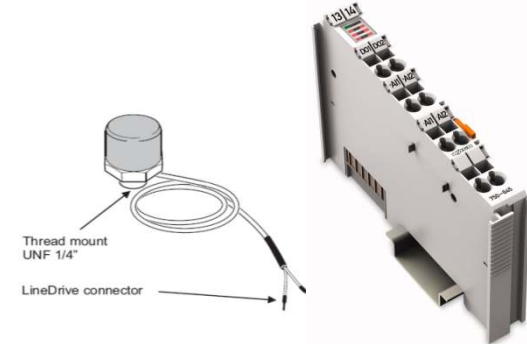


24/7 Monitoring

RTDs, Thermocouples, and Thermistor Modules



Vibration Module & Accelerometer

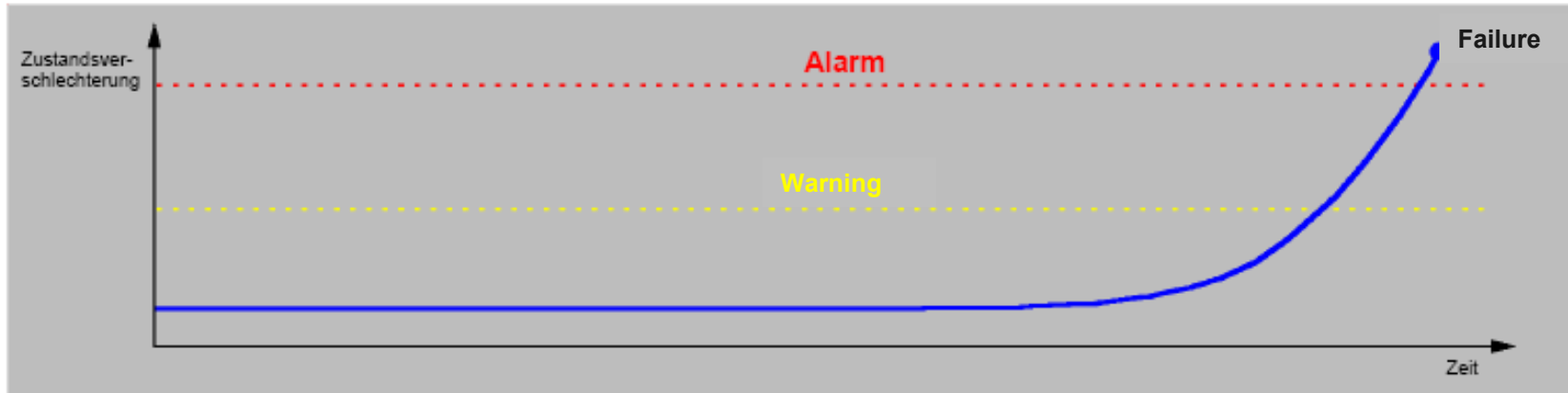


Power Measurement Modules and Accessories

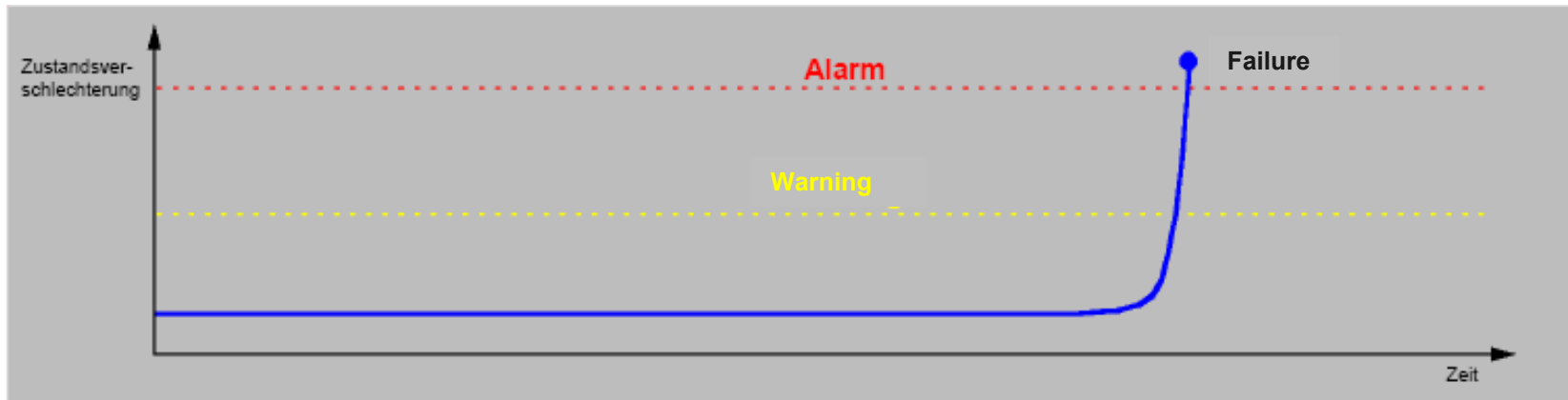


Failures can be Fast or Slow

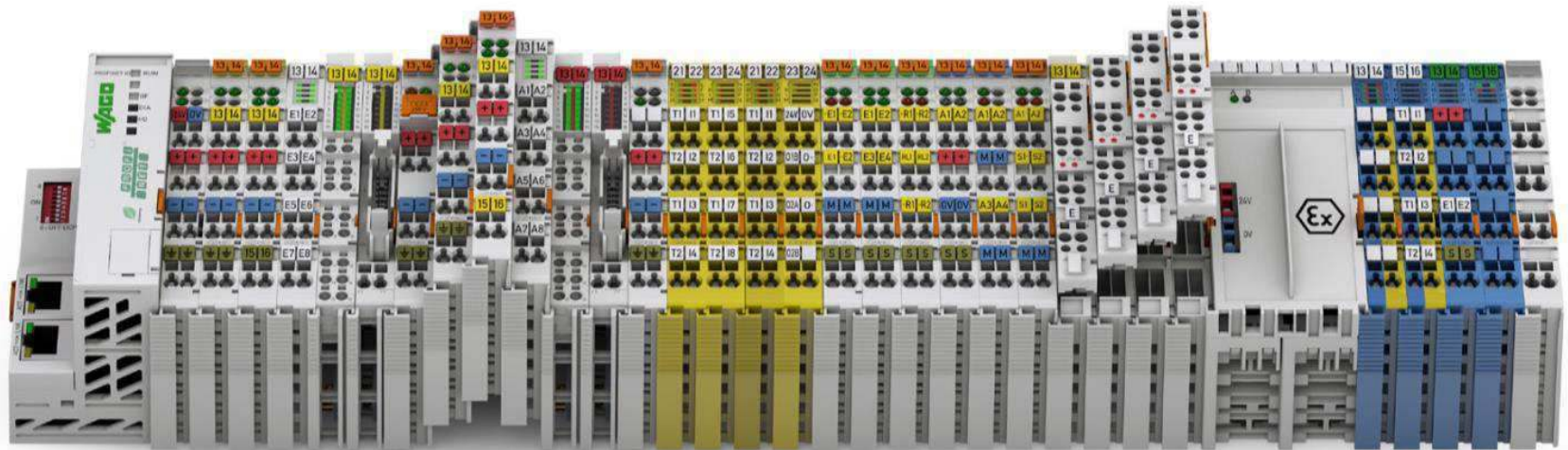
Slow Failure (e.g. Outer Ring – roller bearing damage , tooth flank wear)



Quick Failure (e.g. Inner Ring – roller bearing damage , wave cracks)



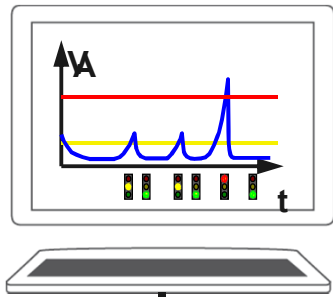
WAGO-I/O-SYSTEM 750 – Fieldbus-Independent IO and PLC



Versatile and flexible

- PLCs and/or Remote IO
- Fieldbus-Independent
- Compact (16 channels in 12 mm (0.47in))
- Integrate into existing systems or standalone
- Mounts directly on DIN rail
- More than 500 function modules
- Modular design, easy handling
- Scalable control solutions
- Up to 250 modules/node

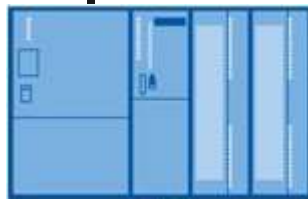
Remote IO Example – Extension of Existing PLC System



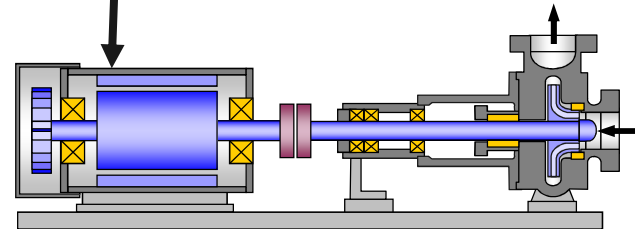
Visualization
& Historian

- Continuous Monitoring (24/7)
- Monitor Shock, Vibration, Current, and Temperature in one system
- Per-made function blocks for Siemens and Rockwell

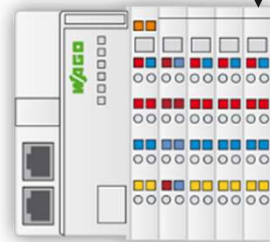
Siemens, AB, ...



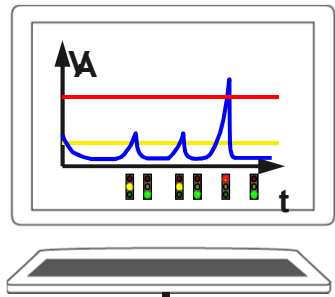
Sensors



PROFINET, PROFIBUS, EtherNet/IP,...



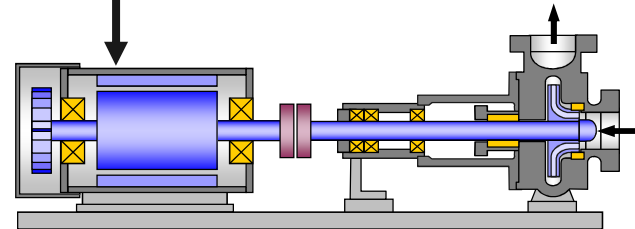
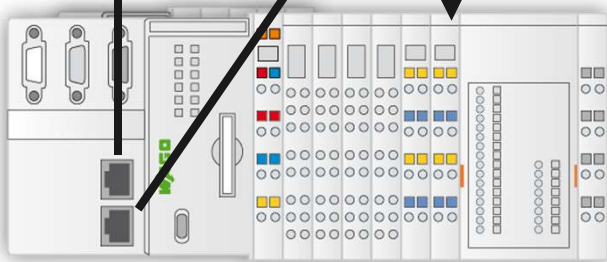
Example - Standalone System



Visualization
& Historian

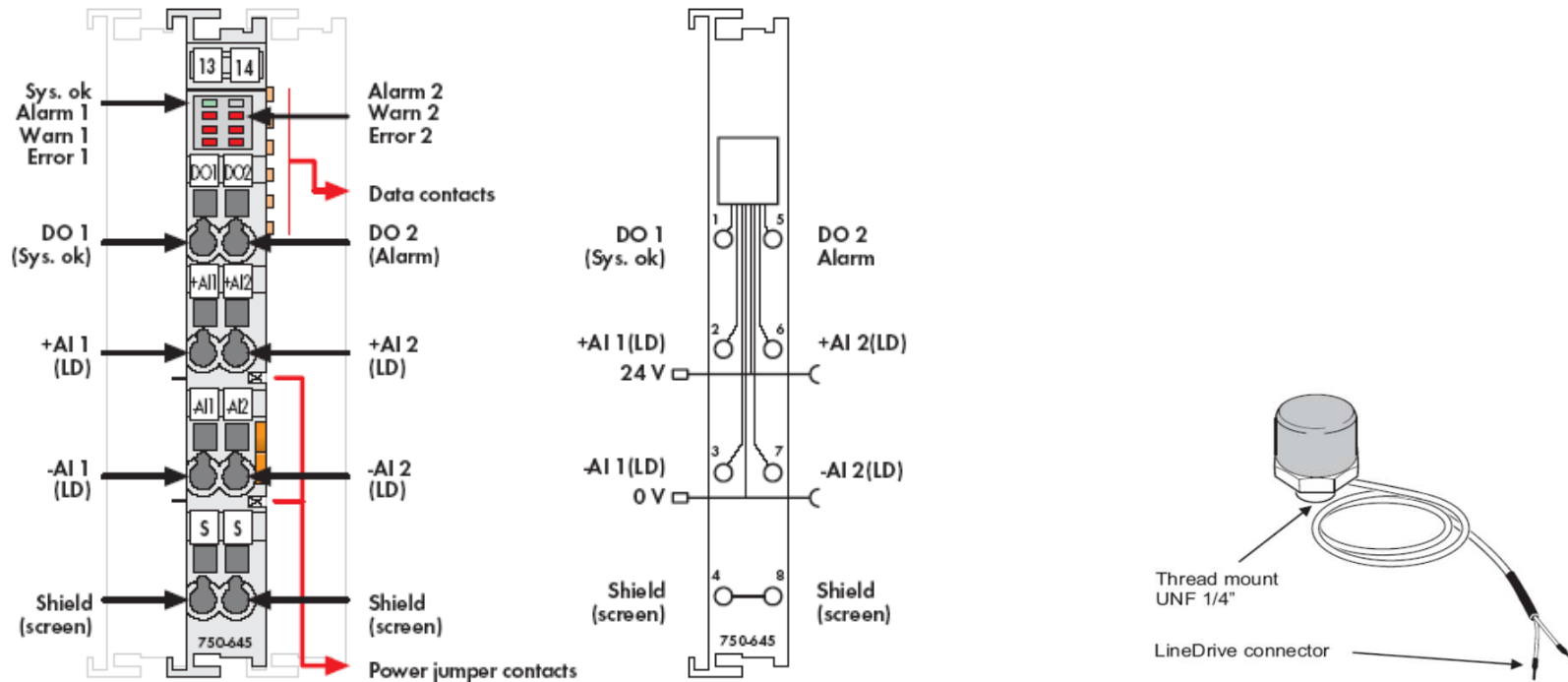
Email Alerts,
Cloud Storage,
SQL ...

Sensors



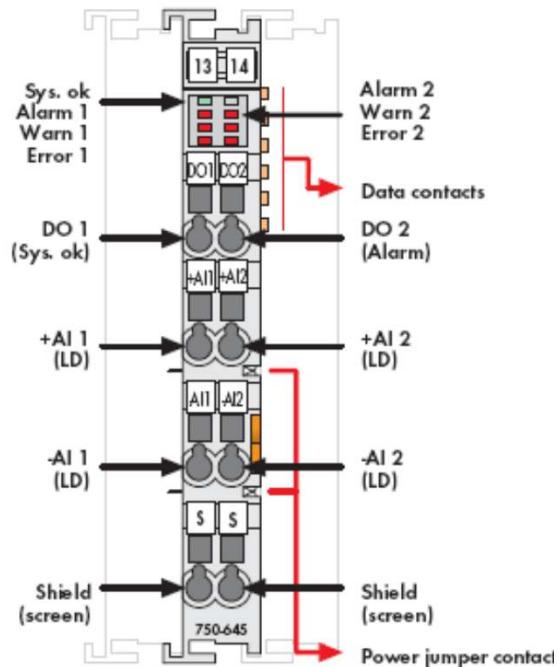
- WAGO PLC with CoDeSys Program
- Continuous Monitoring (24/7)
- Monitor Shock, Vibration, Current, and Temperature in one system
- Send alerts via Email and Text-Message
- Send Condition data directly to SQL via PLC

750-645 Vibration Monitoring Module



The WAGO 750-645 module is used for online monitoring of machine vibration. The module collects the two most important parameters for machine condition analysis: Vibration Velocity and Shock Pulse.

750-645 Technical Data



2-Channel Module

2 Threshold limits can be configured:

Warning, & **Alarm**

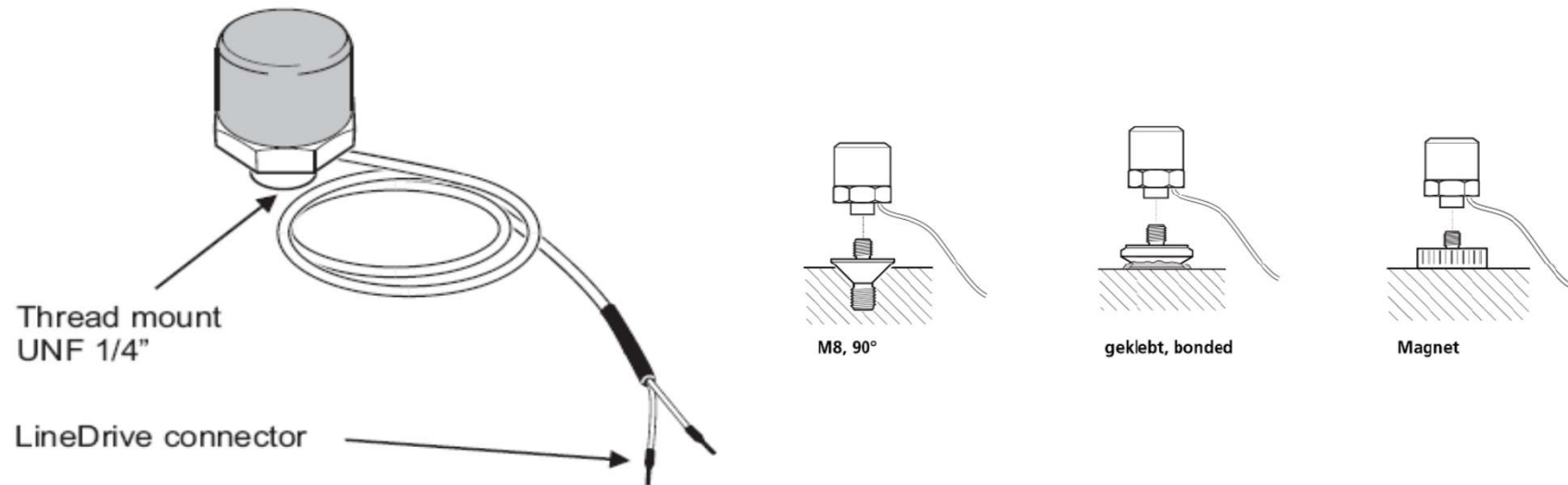
2 Digital Outputs for diagnostics

RMS and SPM can be read as process data from the module

Module is configured via WAGO-IO-CHECK or WAGO-IO-PRO program

WAGO-IO-CHECK includes ISO 10816-3 Guidelines for vibration

750-925 Tandem-Piezo® Acceleration Sensor



The WAGO 750-645 uses of a special Tandem-Piezo® sensor allows measurement of machine vibration and high frequency shock pulses at the same time.

It is suitable for vibration measurements up to 10 KHz, shock pulse measurement on rolling bearings, as well as pump cavitation measurement.

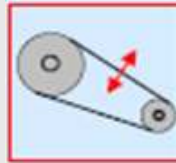
Vibration Velocity and Shock Causes

Lower Frequency Oscillations and Strong Spikes – measured in mm/s RMS

Vibration
Velocity



Misalignment



Belt
Vibration



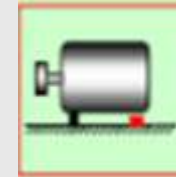
Motor
Failure



Unbalanced
Loads



Turbulence
Aerodynamics



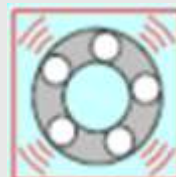
Foundation
Failure

Higher Frequency Oscillations with Impact Pulses and Acceleration

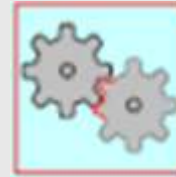
Shock
Pulse
(SPM)



Bad or No
Lube



Bearing
Failure



Gear
Issues

Vibration based condition monitoring

The following illustration shows the criteria for an analysis of the vibration severity values. The classification depends on the capacity and installation of the machine.

ISO 10816-3 RMS vibration velocity

A: newly commissioned

B: unlimited long-term operation admissible

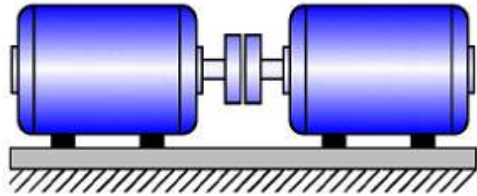
C: short-term operation admissible

D: vibration causes damage

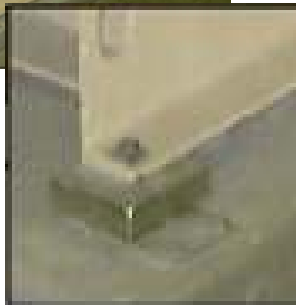
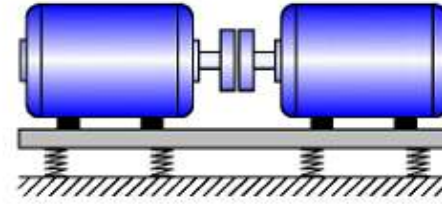
								Velocity	
								11	0.43
								7.1	0.28
								4.5	0.18
								3.5	0.14
								2.8	0.11
								2.3	0.09
								1.4	0.06
								0.71	0.03
								mm/s rms	inch/s rms
rigid	flexible	rigid	flexible	rigid	flexible	rigid	flexible	Foundation	
pumps > 15 kW radial, axial, mixed flow				medium sized 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				C Short-term operation allowable					
B Unlimited long-term operation allowable				D Vibration causes damage					

Rigid versus Flexible Foundation

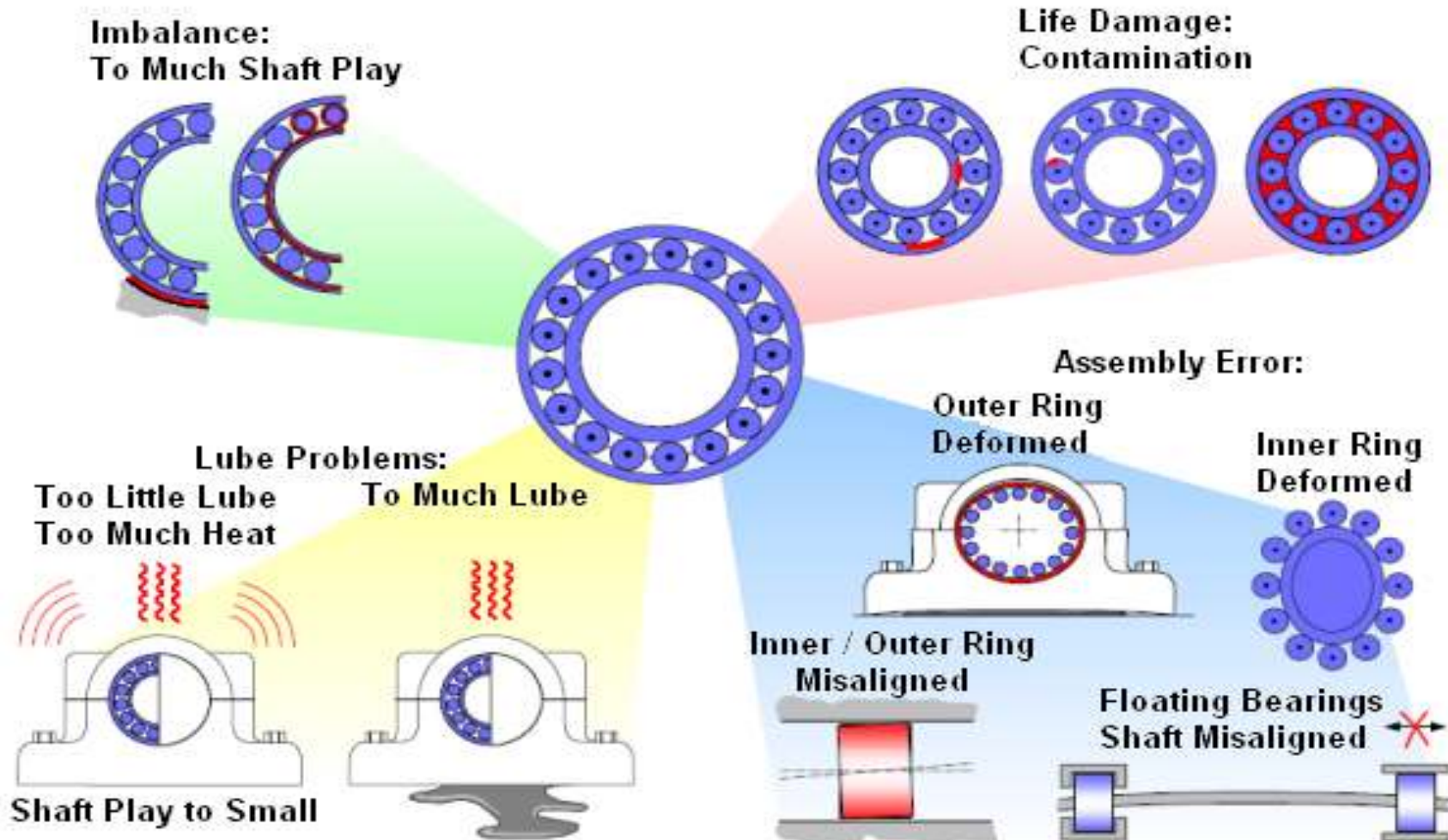
Rigid installation



Flexible installation



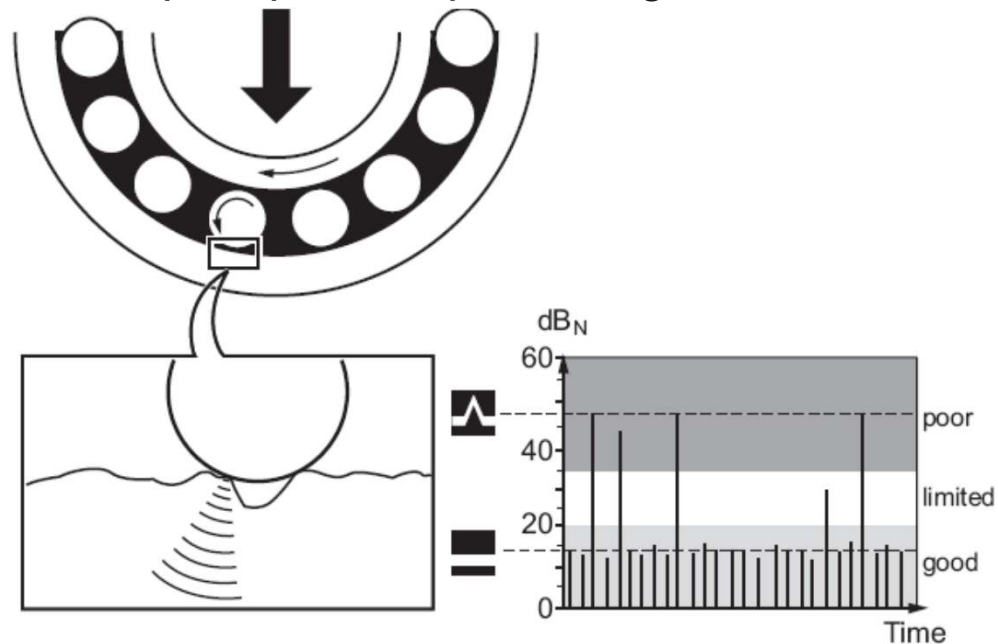
Shock Pulse Measurement – Roller Bearings



Shock Pulse Measurement – Roller Bearings

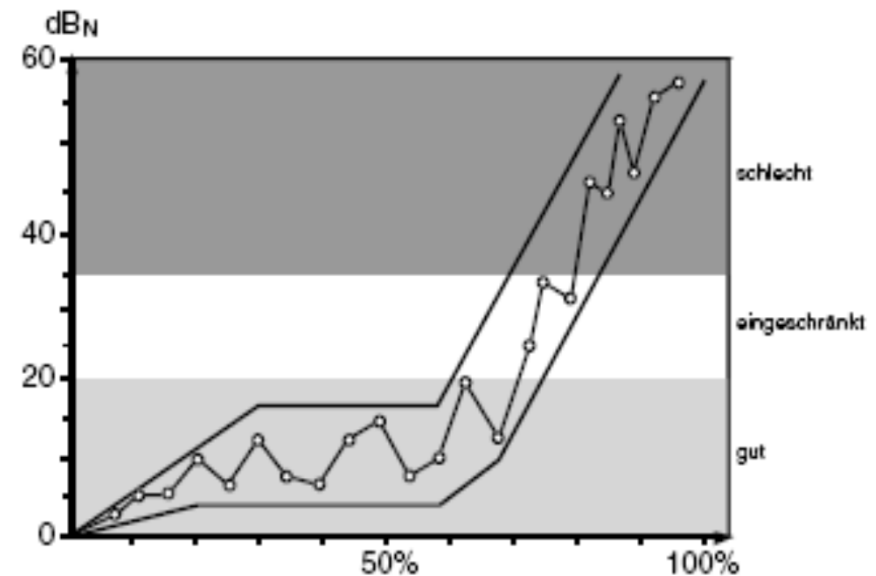
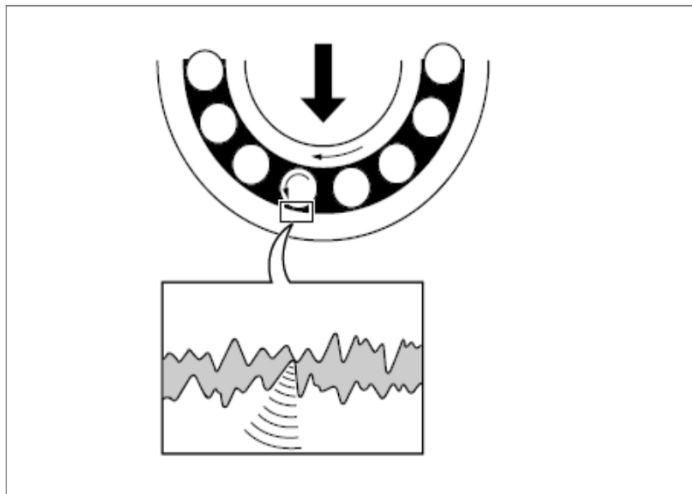
There are two shock waves that are continuously monitored:

- Carpet - Is the general operating noise of the bearings and machine – baseline noise
- ▲ Peak - Is the sharp amplitude spike as age and wear become a factor.



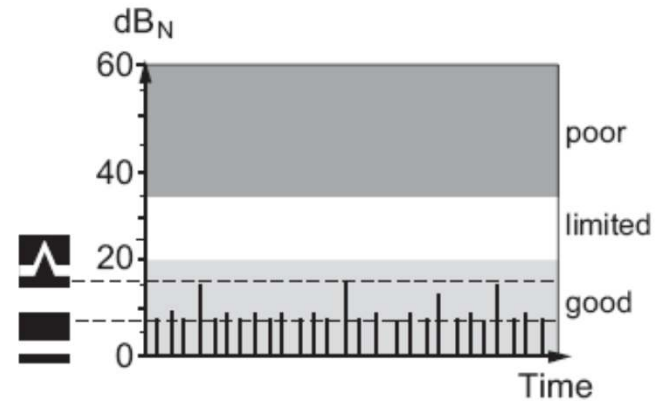
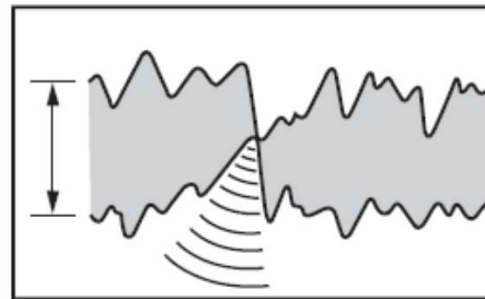
Shock Pulse Measurement – Roller Bearings

As the machine wears and ages, the carpet value will start to rise.
As shock pulses increase the information can diagnose the state of the machine.
Maintenance can schedule a shutdown to fix the performance of the machine before it costs big money and production losses.



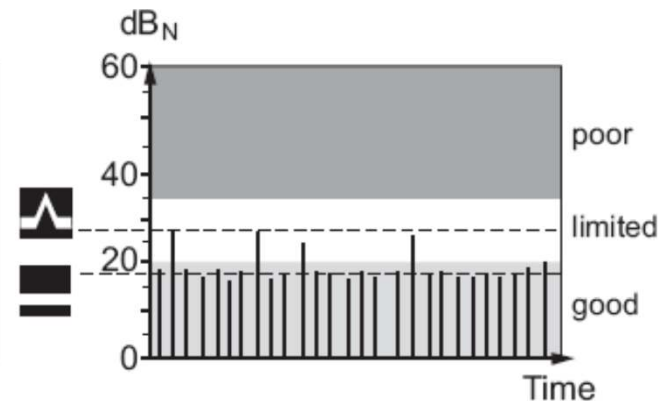
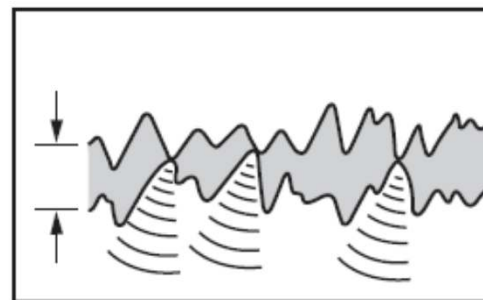
Shock Pulse Measurement – Roller Bearings

Low Carpet + Low Peak
= Good Condition

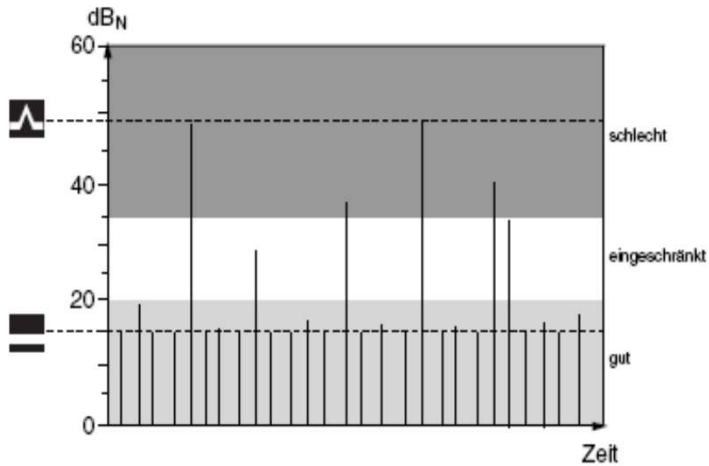


The carpet value rises when the lubrication layer decreases and rolling path and roller bearings touch at more and more locations. The diagram below shows an increased carpet value

High Carpet + Low Peak
= Needs Grease

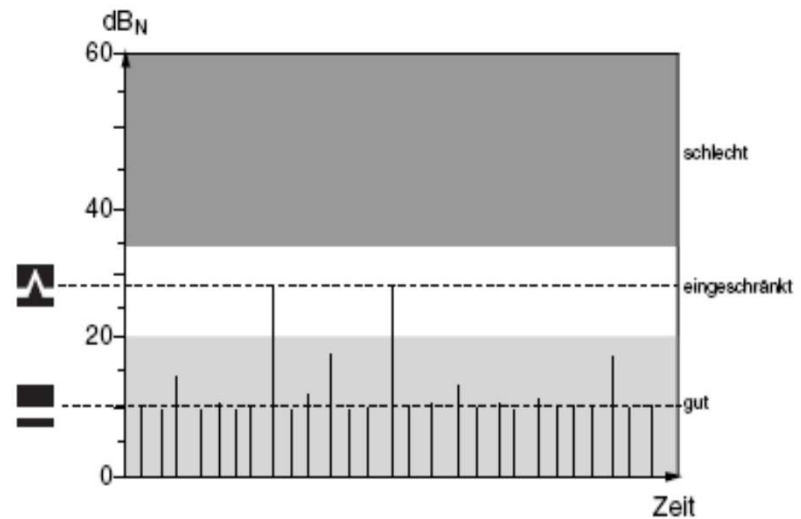


Shock Pulse Measurement – Roller Bearings



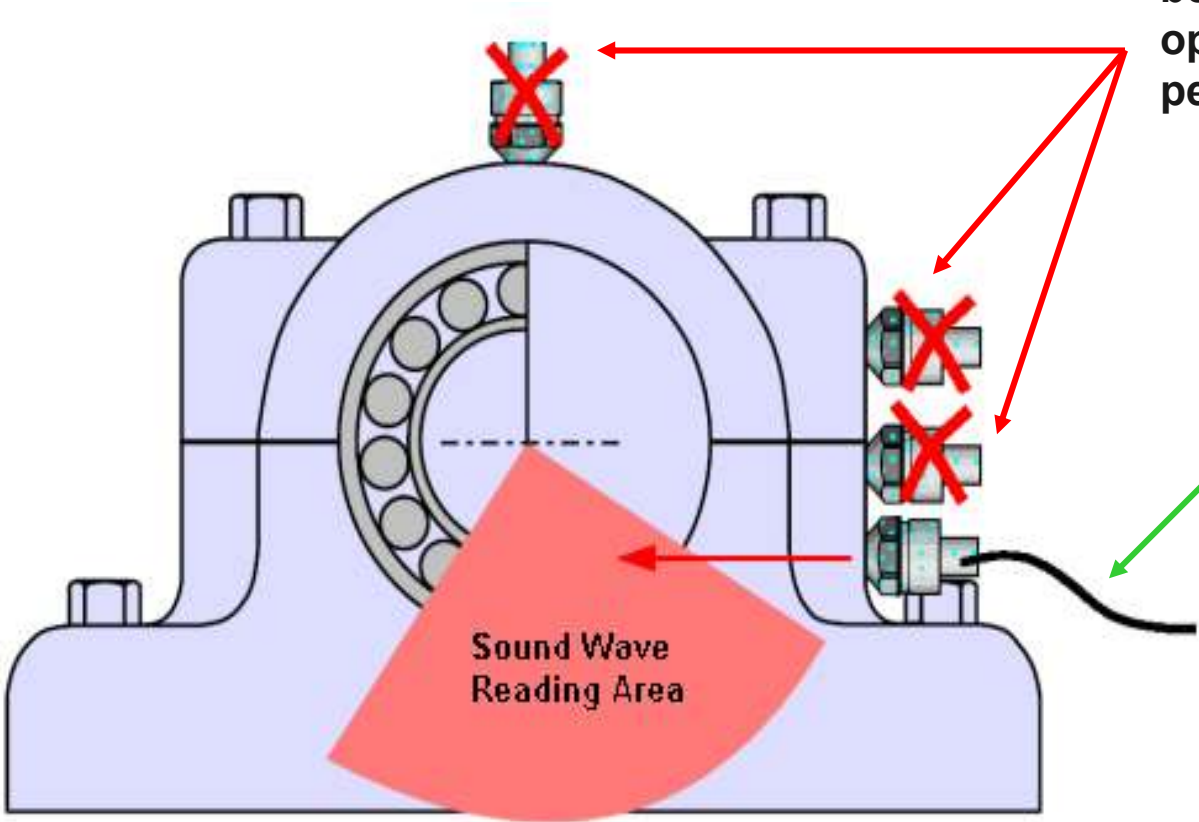
low carpet + high peak
= damaged bearing or polluted
grease

rising carpet + rising peak
= limited operation possible, bearing will
be damaged soon



Sensor Mounting

If the sensor is mounted on the bolted section or welded area the sound waves will not provide the best of conditions for optimum sensor performance.



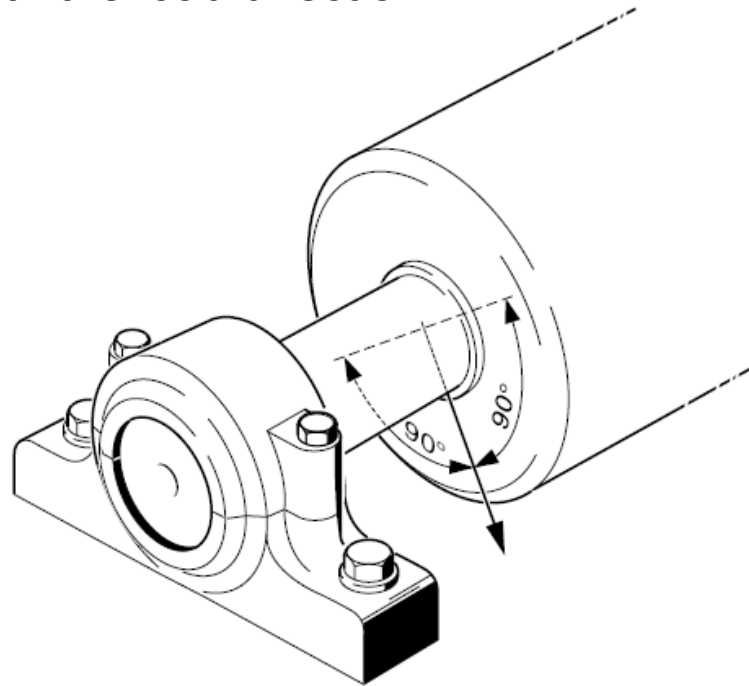
The Tandem-Piezo Sensor must be mounted on the solid bearing block.

This transfers the best shock waves to the sensor

Sensor Mounting Rules

Loaded region

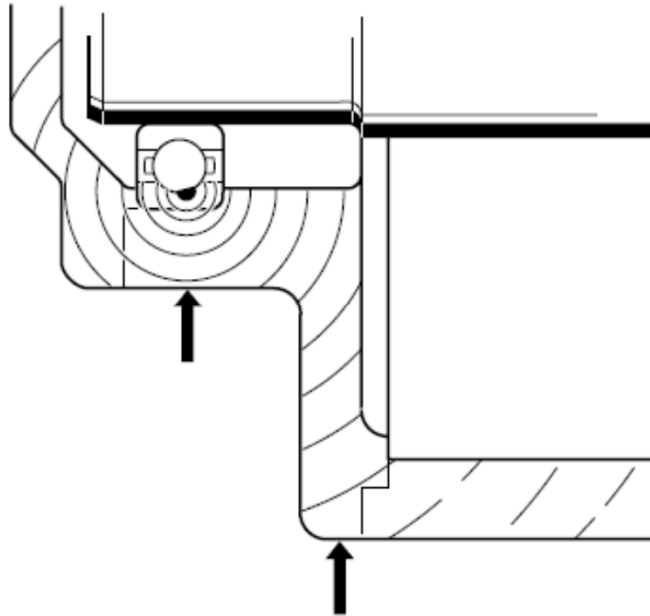
Shock pulses are generated mainly in the rolling interface, where the load carrying element touches the raceway. Therefore, the measurement must be located in the loaded region of the bearing housing (as defined by the bearing's emission window see below). Ideally, the measurement point should be in line with the load direction.



Sensor Mounting Rules

One mechanical interface

Each interruption (or interface) in the material dampens the signal to be measured. Therefore, the signal path must contain only one mechanical interface, that between the bearing and the bearing housing.



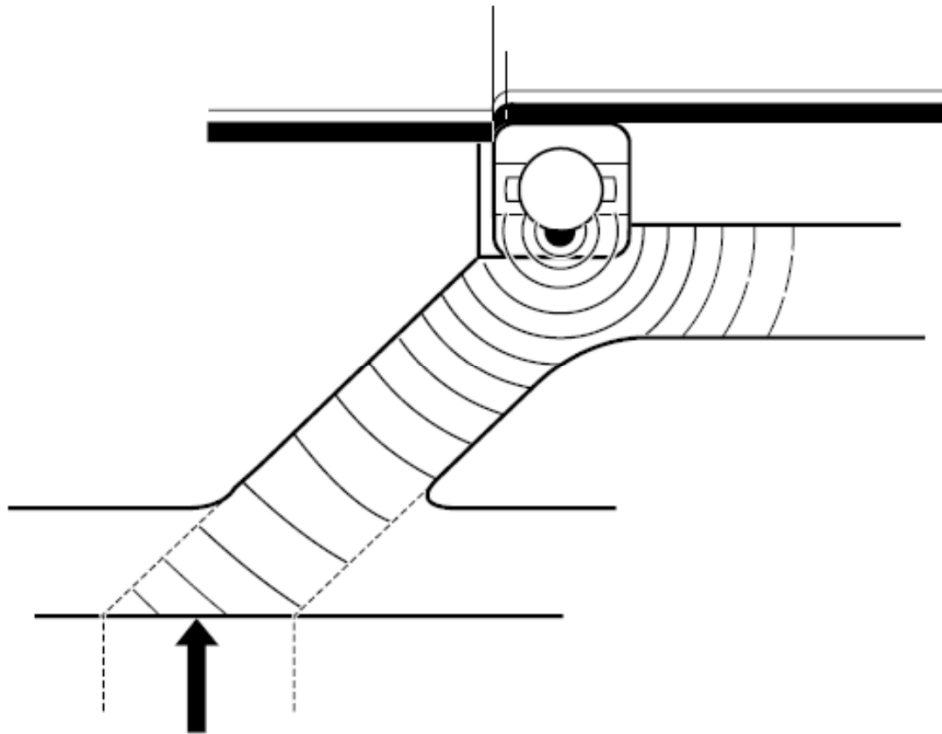
The amount of signal loss at an interface can be considerable.

Welds, for example, are regarded as interfaces.

Sensor Mounting Rules

Short signal path

The signal path between the bearing and the measurement point must be as short and straight as possible.



Shock pulses lose strength over a long signal path (especially when it has a large cross section) and are dampened when deflected by bends in the path. Note that measurement is possible only in the area defined by the dotted lines.

WAGO-I/O-Check Configuration

Pos. 1: Settings for 750-645

750-645
2AI/2DO VIB VRMS/SPM Multi
Version 03

WAGO

Exit Open Save Read Write Factory Settings Copy Help

Measuring Point
Channel 1: Sensor 1 Rename...

Operation Mode
Vibration Monitoring (RMS) + Antifriction Bearing Monitoring (SPM)

Common
Item No. : 750-645
SW-Version 03
HW-Version 03

Vibration Monitoring (RMS)
Alarm Limit: 7.1 mm/s Velocity
Alarm Delay: 3 s 0.6 mm/s
Warn Limit: 4.5 mm/s ISO 10816-3 Pre-settings
Warn Delay: 3 s
Effective Range: 100.0 mm/s
Lower Frequency Limit: 2 Hz

Antifriction Bearing Monitoring (SPM)
Alarm Limit: +10 dBsv Peak
Alarm Delay: 1 s -7 dBsv
Warn Limit: +5 dBsv Carpet
Warn Delay: 10 s -10 dBsv
Effective Range: +40 dBsv

Bereit

Wago-I/O-Check ISO Settings

Group 1: 400HP - 67051HP

Group 2: 20HP – 400HP

Group 3: Pumps External Drive

Group 4: Pumps Internal Drive

Rigid / Flexible Foundation

VIB-I/O Module - Pre-setting according to ISO 10816-3

Classification by type of machine, rated output or axle height:

Group 1

- large machines with rated output over 300kW
- electrical machines with an axle height over 315mm

Group 2

- medium size machines with rated output between 15kW and 300kW
- electrical machines with an axle height between 160mm and 315mm

Group 3

- pumps with external drivers

Group 4

- pumps with internal drivers

Classification by type of foundation:

- rigid foundation
- flexible foundation

OK Cancel

Vibration & Shock Demo



3-Phase Power Measurement Modules



Power Measurement Modules

Monitoring Current can help diagnose...

- Phase lose
- Imbalanced Phases
- Overloaded Systems/Motors
- Blinding of mechanical parts
- Lubrication Issues
- Failing Motors

3-Phase Power Measurement Modules

750-493



750-494



750-495



	750-493	750-494	750-495
Voltage measurement	3~ 480 V	3~ 480 V	3~ 480 V / 690 V
Current measurement	1 A (750-493) 5 A (750-493/000-001)	1 A (750-494) 5 A (750-494/000-001)	1 A (750-495) 5 A (750-495/000-001)
Active energy/power/factor	✓	✓	✓
Phase position	✓	✓	✓
Reactive power/energy	via function block	✓	✓
Apparent power/energy	via function block	✓	✓
Rotary field detection		✓	✓
Power factor	(✓)	✓	✓
Frequency measurement	✓	✓	✓
Four-quadrant operation (inductive, capacitive, load, generator)		✓	✓
Harmonic analysis (up to 41th harmonic)		✓	✓
Tamper detect (Neutral measure)			✓

3-Phase Power Measurement Modules

Rogowski Coil



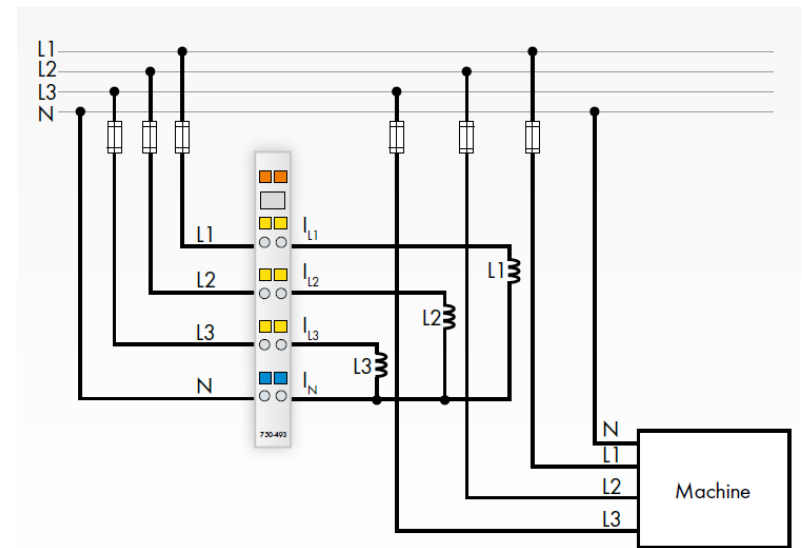
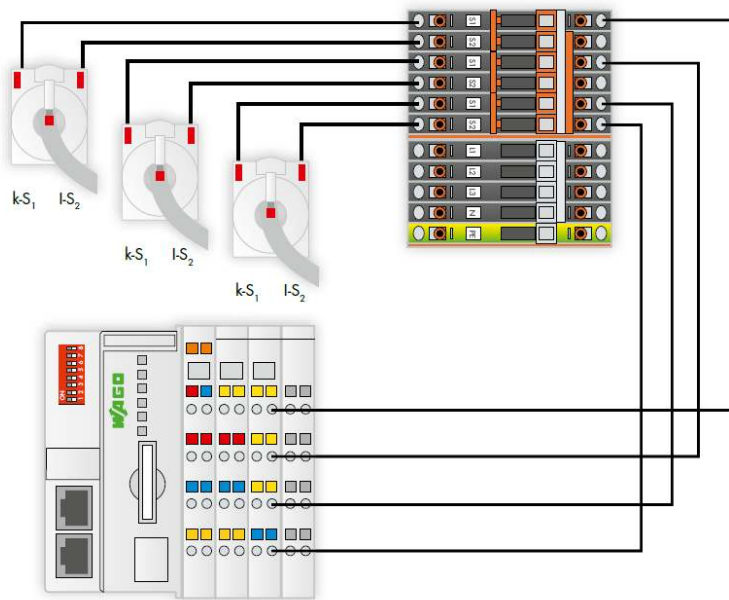
Split Core Current Transformer



Solid Core Current Transformer



3-Phase Power Measurement Modules



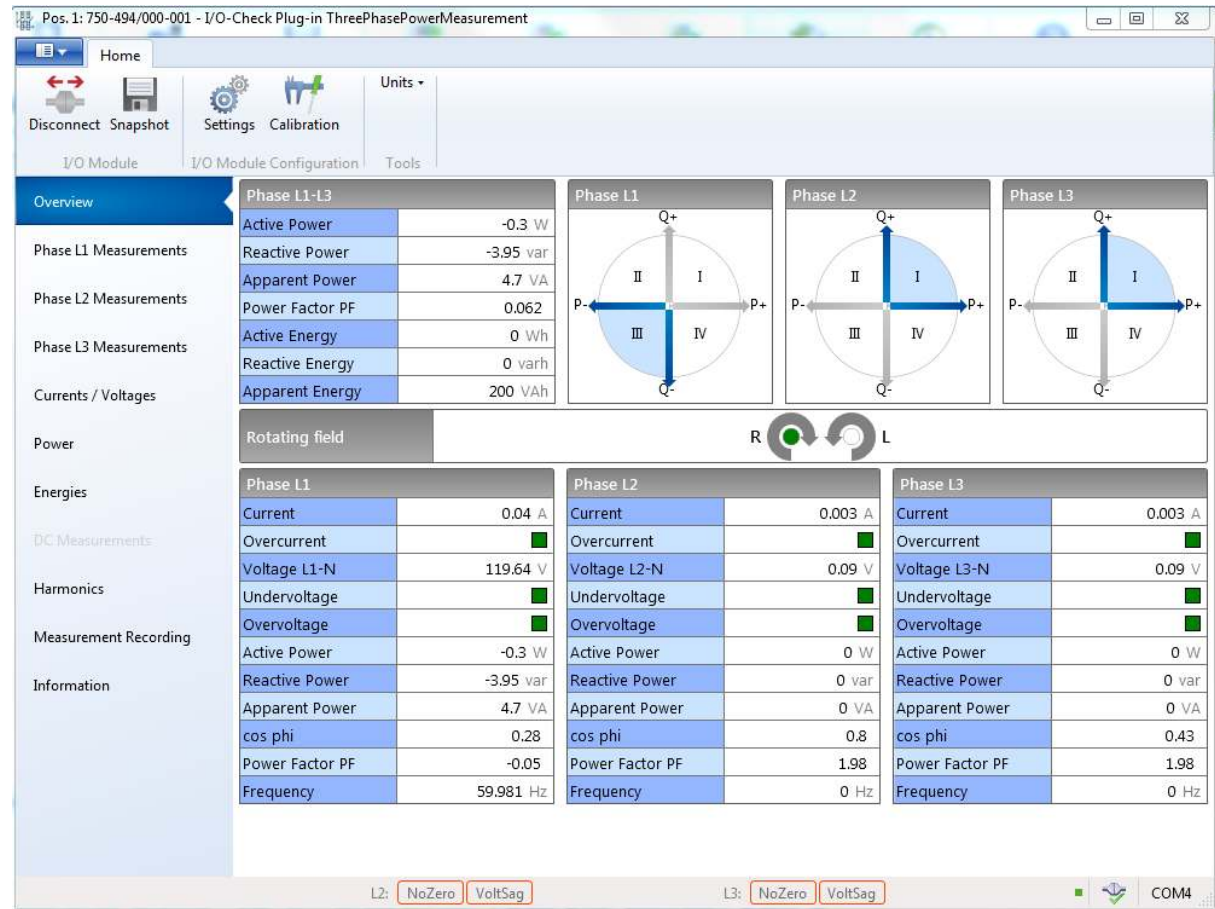
3-Phase Power Measurement Modules

WAGO-I/O-CHECK

Visualization of measured values

Adjust parameters

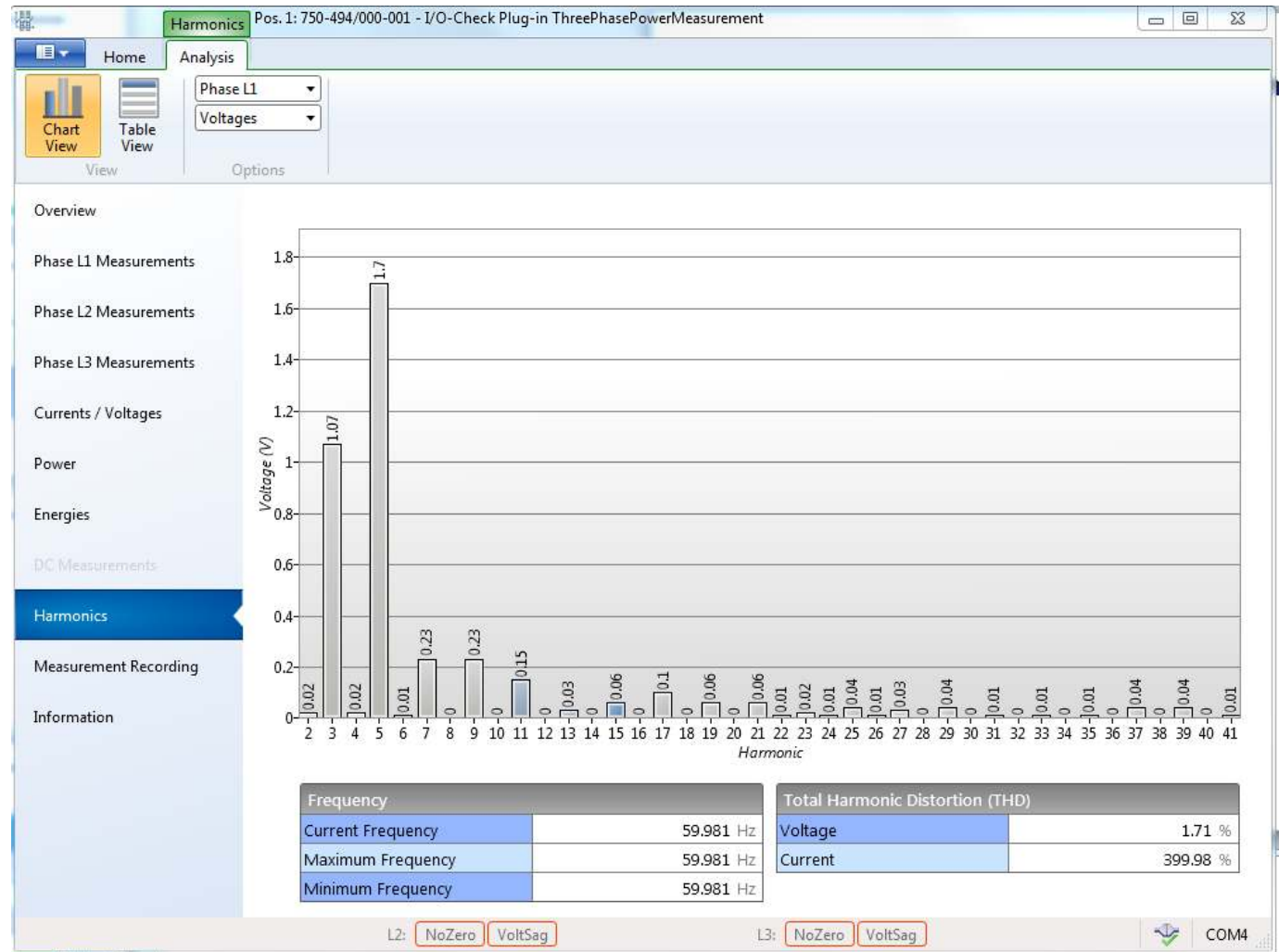
Calibration of 3-Phase Power Measurement Modules



3-Phase Power Measurement Modules

WAGO-I/O-CHECK

Visualization of measured values



3 Phase Power Monitoring Demo



Current Signal Conditioners



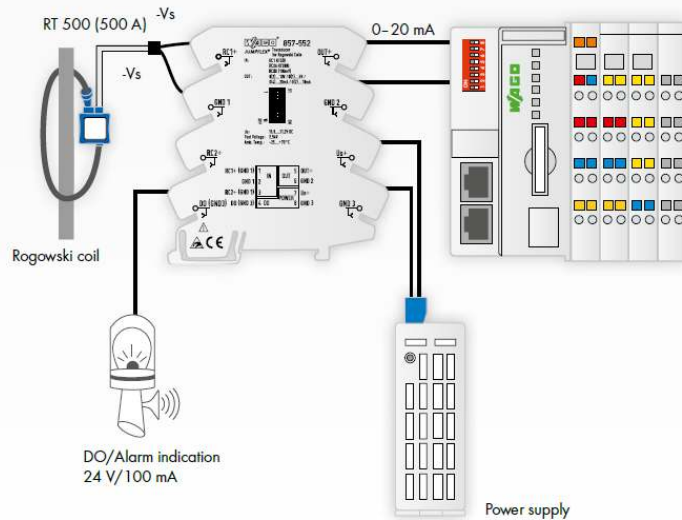
JUMPFLEX®-ToGo Configuration App –
DIP Switch Alternative



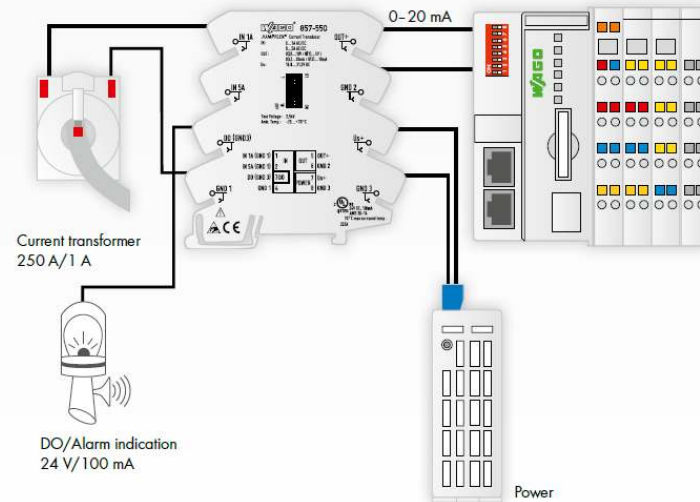
Jump Flex CT and Rogowski Signal Conditioners



**Rogowski Signal Conditioner
857-552**



**Current Signal Conditioner
857-550**



Temperature Measuring Devices



Thermocouple Modules

Type: J, K, B, E, N, R, S, T, U and L

RTD Modules

Pt 100, Pt 200, Pt500, Pt 1000,
Ni 100, Ni 120, Ni 1000
TK6180, TK5000,
KTY81 110, KTY81 210
NTC 20k

PTC Module

JumpFlex RTD and Thermocouple Modules

JUMPFLEX® Transducers and Isolation Amplifiers



JUMPFLEX® – 857 Series

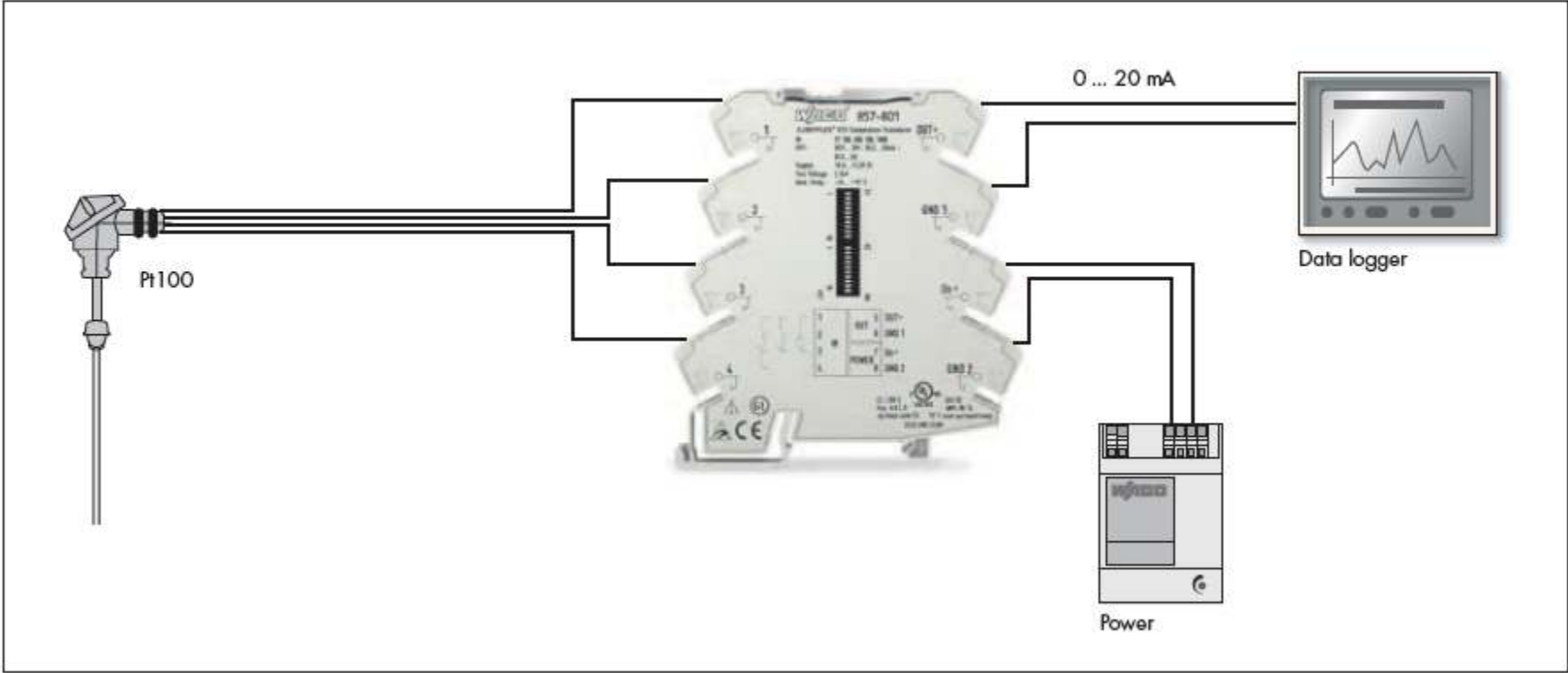


JUMPFLEX® – 2857 Series

JumpFlex RTD and Thermocouple Modules

Temperature Transducer for Pt Sensors and Resistance Sensors, 857-801

Temperature monitoring via Pt sensor



Summary

Condition Monitoring...



- is fast and easy to implement in new or existing machines.
- reduces unexpected downtimes.
- lowers overall maintenance costs and increases bottom line profits.
- helps provide a reasonable work schedule for maintenance personnel.

Thank you!