Vibration Monitoring Application Solutions

Systems for condition monitoring of machines

www.ifm.com/uk/octavis

Vibration monitoring

Introduction

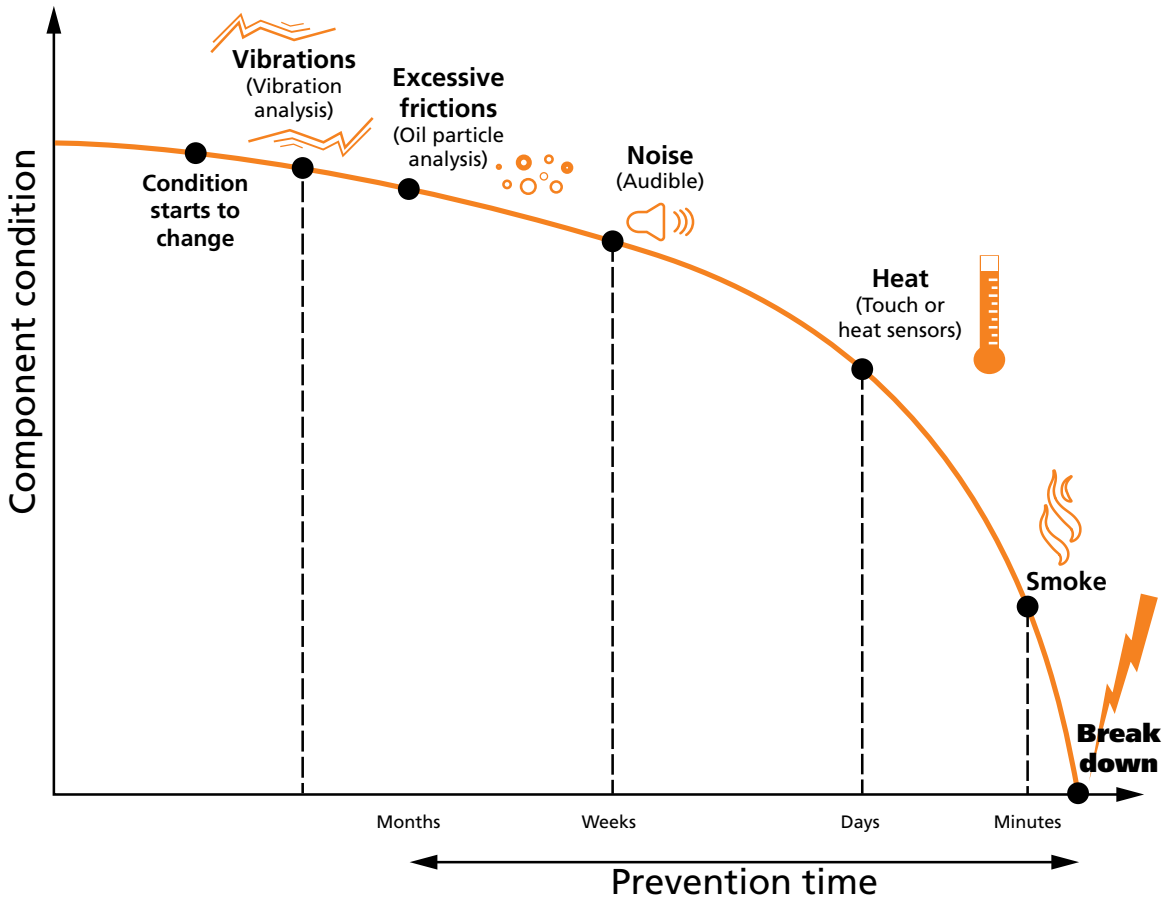
All machines are subject to vibrations. A rise in vibration levels can be detrimental to machine health and can result in the following:

- Unexpected machine failure
- Unplanned production downtime
- Expensive repair costs
- Secondary damage to machinery
- Safety issues

A wide range of vibration monitoring options can be applied to inform the user about a change in the condition of the machine. The type of vibration monitoring solution used can depend on various factors such as:

- Type of machine
- Criticality of machine
- Accessibility of machine
- Level of data that can be understood by employees
- Automation / Control / IT systems and infrastructure already on site

Vibration monitoring sensors and systems are used for condition-based maintenance of machines and installations. They help to detect machine damage in good time and prevent costly consequential damage. Vibration monitoring is the most commonly applied condition monitoring technique as it will detect defects before most other techniques.



Common vibration problems

Unbalance

An unbalanced machine contains a 'heavy spot' which when rotated, exerts a force. This is one of the most common causes of vibration problems. On a fan, unbalance could be caused by a build up of dirt on the blades or a damaged blade. Activity is detected at 1X the rotational speed of the machine. Unbalance can lead to many other vibration defects due to excess force being put on components such as bearings.

Mis-alignment

Misaligned machines create a bend between two shafts due to them not being aligned correctly. When the shafts rotate this exerts a repeating force on the machine. It is often caused by inaccurate assembly, uneven floors, thermal expansion, incorrect torque of fasteners and couplings not installed correctly. Activity is normally detected at 1X, 2X & 3X rotational speed of machine.

Bearing defects

As a bearing defect develops, activity will become apparent in the high frequency range up to 10kHz. This is usually monitored with a special echnique called Enveloping or Demodulation to monitor the inner-race, outer-race and rolling element fault frequencies of the bearing. As the fault continues to worsen, activity will start to occur at lower frequencies which can be detected by monitoring the rotational speed of the machine x the fault frequency for each of the bearing components.

Looseness

This is often due to excessive bearing clearances, loose mounting bolts, mismatched parts, corrosion and cracks in the structure. Depending on the type of looseness, activity can be detected at harmonics of up to 10X the rotational speed of the machine. Looseness can cause vibrations in both rotating and non-rotating machinery.

Gears

A number of problems can occur on a gearbox, such as: gear meshing, tooth wear, eccentric gears, broken teeth, misaligned gears. Most of these are detected by monitoring the rotational speed x the number of gear teeth frequency. For a number of these gear defects there will be sidebands around the main gear fault frequency that are visible in the frequency spectrum.

Belt drives

Common issues with drive belts are: misaligned sheaves, belt resonance and worn belts. Misaligned pulleys and belt resonance defects cause activity at 1X the rotational speed of either the primary or secondary drive shaft. A worn or loose belt will show a peak at the belt rate, and its harmonics. The predominant frequency is known as the "belt rate". This is the rate at which a point on the belt passes a fixed reference point.

Impact detection

Impacts can be caused by a number of issues and can generate vastly different levels of force depending on the application. Small impacts or 'ticking' on a rotating shaft can signify damage to either the shaft or a component. On applications such as spindles, it is crucial to detect 'machine crash' should the cutting tool come into unexpected contact with an object. On mobile applications, monitoring for unexpected impacts can signify a poor operator. Impact detection can also be used to monitor a manufacturing process by confirming that an acceptable level of 'shock' has taken place when it should. Monitoring the peak acceleration levels is usually required to detect impacts.

Fluid noise

Cavitation occurs when there is lower pressure on the suction side of the pump. The liquid tends to vapourise when coming off the impeller creating vacuum bubbles that implode. Cavitation normally creates random higher frequency vibrations, or 'noise'. It is often observed as a low amplitude wideband 'hump' in the vibration spectrum. The highest peak in the spectrum can be at the vane pass frequency – number of vanes x rotational speed.

Rubbing

This can be caused by a number of issues. Worn components exert a repeating force on the machine because of the rubbing of uneven worn surfaces. Wear in bearings, gears and belts is often due to improper mounting, manufacturing defects, overloading and poor lubrication. High vibration levels can usually be detected in the frequency range of 2kHz to 5kHz and are normally viewed as a high amplitude wideband 'hump' in the frequency spectrum.

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Vibration Monitoring

Types of vibration measurement

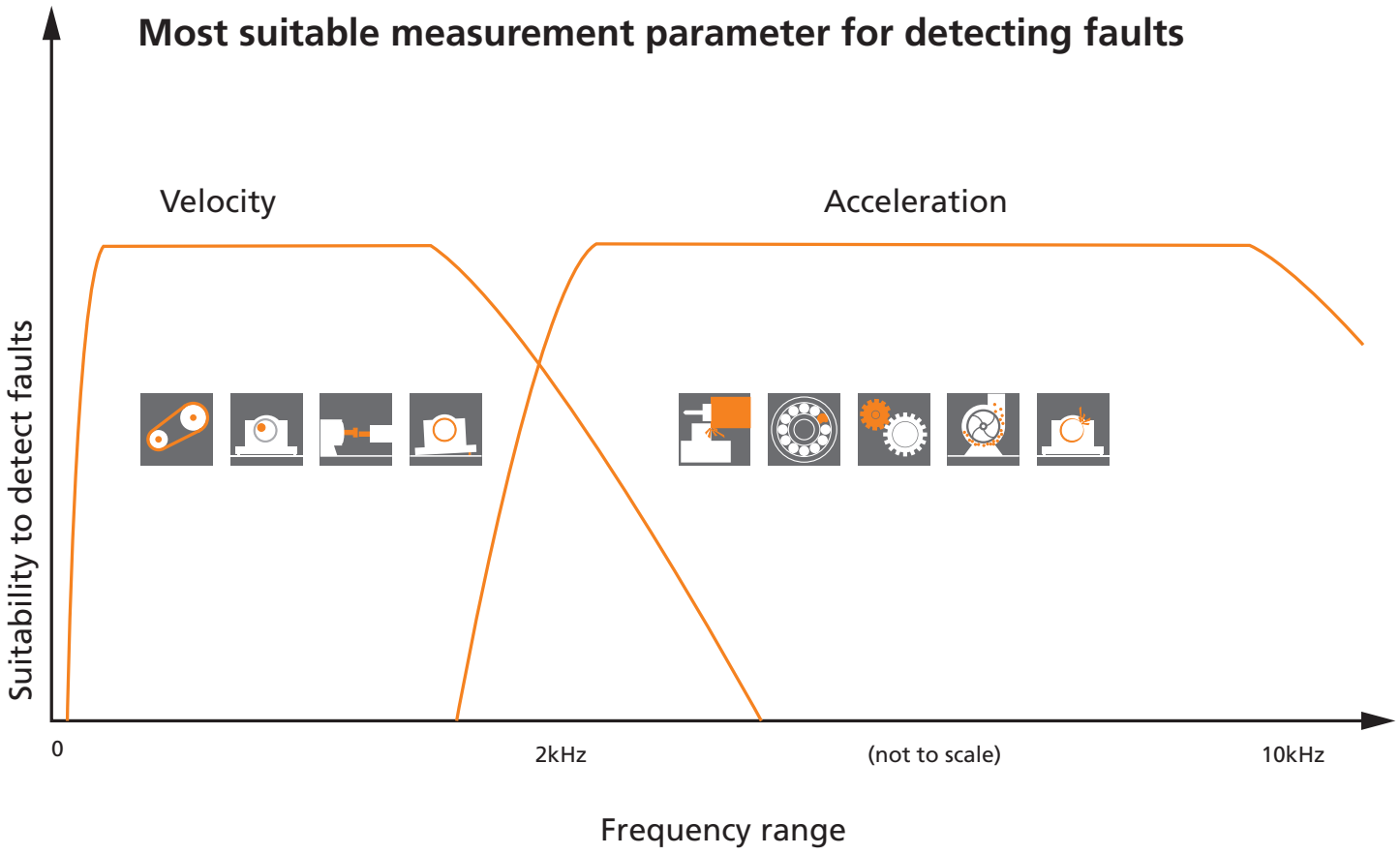
Velocity and acceleration are the two most common parameters that are monitored with vibration sensors to detect problems on rotating machinery. Velocity is the speed measured in a single direction. It is measured in 'mm/sec'. Acceleration is the rate of change of velocity. It is measured in 'g' or 'mg'. A mg is 1/1000th of gravitational force.

The main difference between monitoring in velocity or acceleration is the frequency range that is monitored.

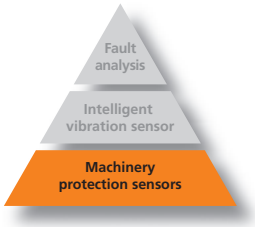
With velocity it is usually no more than around 3000Hz that is monitored. We use velocity measurements to detect faults which exert an energy, such as unbalance, misalignment, looseness etc.

With acceleration we are able to monitor much higher frequencies. We use acceleration measurements to detect faults that exert a force, such as small shocks and impacts that occur at the start of bearing damage, gearbox faults, pump cavitation etc.

The diagram below shows roughly which frequency ranges many common vibration defects would normally be observed in and which measurement parameter is best suited to detect them.

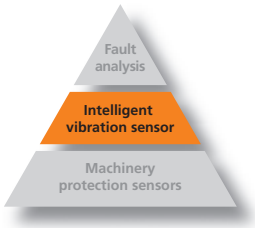


Different levels of monitoring available



Simple machinery protection sensors offer monitoring of the overall vibration levels, measured in velocity (mm/sec). These are commonly applied to the ISO 10816 standard. This level of monitoring will not diagnose a specific machine fault, but will detect a change in the overall vibration level caused by faults such as:

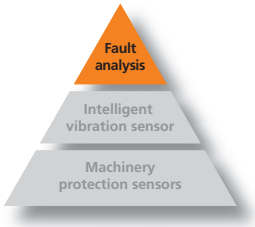
Unbalance | Mis-alignment | Looseness | Belt drives



Intelligent vibration sensors facilitate monitoring of both the velocity levels (mm/sec) and acceleration levels (g). This level of monitoring will not normally diagnose a specific machine fault. However, by monitoring both velocity and acceleration it is possible to detect vibration increases caused by a wider range of issues, such as:

Unbalance | Mis-alignment | Looseness | Belt drives | Bearing defects | Rubbing

Gears | Fluid noise | Impact detection



Fault analysis systems can be programmed to detect specific machinery problems by monitoring the individual fault frequencies that relate to these various vibration issues. Once detected, the user can then be notified which fault is starting to develop on the machine. This level of detailed analysis allows for more efficient maintenance procedures to take place. These systems can be programmed to diagnose specific machine faults such as:

Unbalance | Mis-alignment | Looseness | Belt drives | Bearing defects | Rubbing

Gears | Fluid noise | Impact detection

Systems for vibration monitoring – suitable products for all applications

Machinery protection sensors

Vibration sensors and transmitters for permanent monitoring of the overall vibration level of machinery to ISO 10816. The sensors measure the rms vibration velocity on a non-rotating component surface.

Intelligent vibration sensor

Compact vibration sensor monitors both the RMS velocity levels and the acceleration levels of machinery.
This facilitates detection of vibration increases caused by more defects than a simple machinery protection sensor.
It is characterised by easy parameter setting and a local display.

Online fault analysis modules

6-channel diagnostic system for the evaluation of dynamic signals (e.g. accelerometers) and analogue inputs.
Flexible, detailed monitoring and analysis.
Ethernet TCP/IP and fieldbus interface (only VSE15x) for connection to and integration into a higher-level system / the PLC.

Accelerometers

Acceleration sensors measure the dynamic forces at the machine surface and deliver the raw signal for offline vibration analysis or connection into diagnostic modules type VSE.

Software and accessories

The software VES004 is used for the parameter setting and the online data monitoring of all intelligent vibration sensors and diagnostic electronics.
The ifm OPC server software can be used for the connection of the vibration diagnostics to higher-level systems (SCADA, MES, ERP).

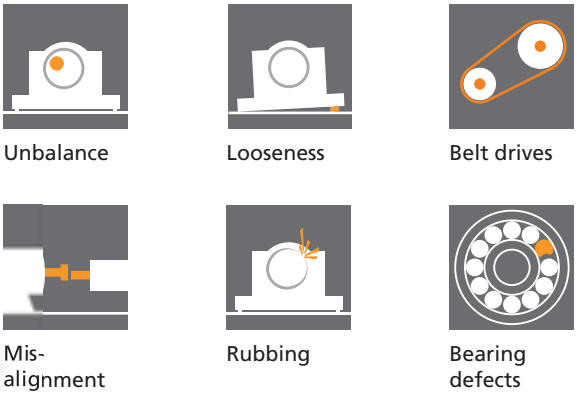
Type	Analogue output	Switching output	Fieldbus interface	Integrated display	History function	Network capability TCP/IP	Signal inputs e.g. temperature	Diagnostics	Counter
VTV	✓								
VKV	✓	✓							
VNB001	✓	✓		✓	✓		✓		
VNB211	✓	✓		✓	✓		✓		
VSE002 VSE100	✓	✓			✓	✓	✓	✓	✓
VSE15x	✓	✓	✓		✓	✓	✓	✓	✓
VSA VSP	✓								

OPC is a standard for manufacturer-independent communication in automation technology; it offers high flexibility and an easy implementation.
The ifm software SMARTOBSERVER is a software with many functions for online visualisation, storage and analysis of measured values with the purpose of monitoring the condition of machines and plants.
Besides mounting adapters ifm offers an extensive range of connection technology (e.g. sockets, Y cables) for different operating conditions as accessories.

Applications

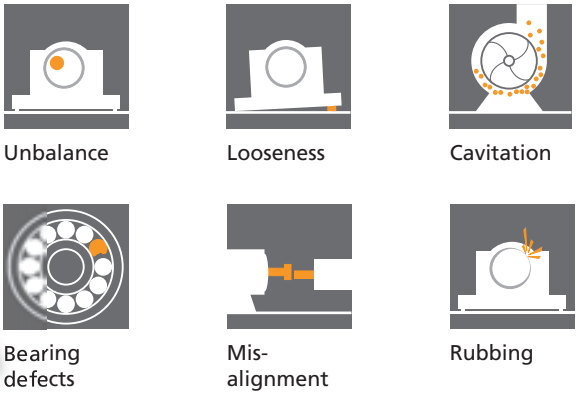
Fans

Common problems



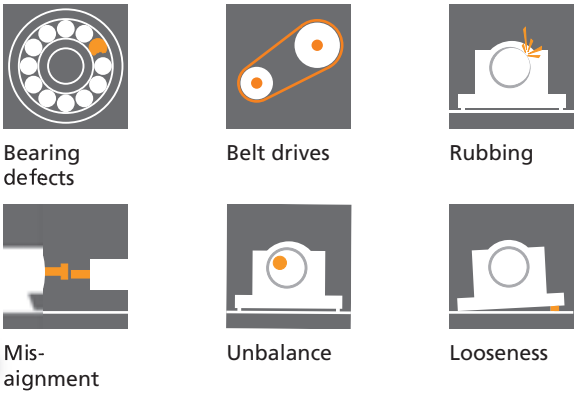
Pumps

Common problems



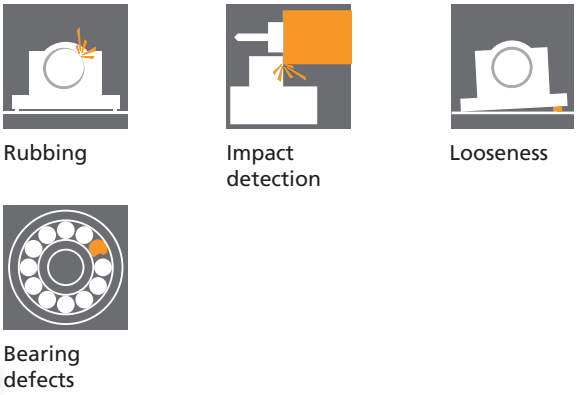
Motors

Common problems



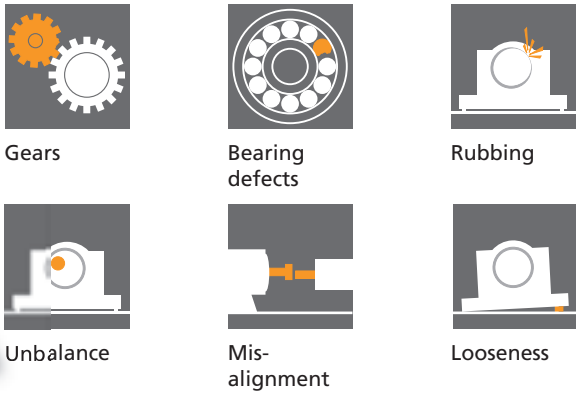
Lifts

Common problems



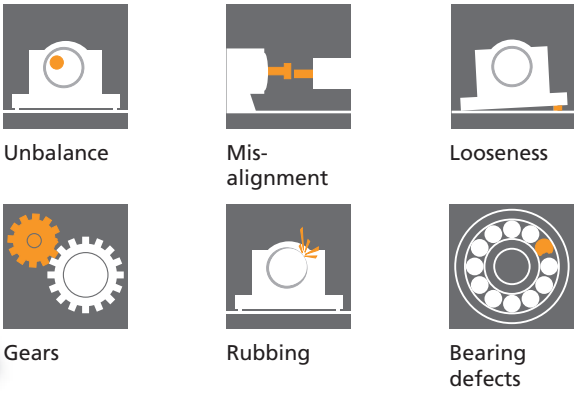
Gearbox

Common problems

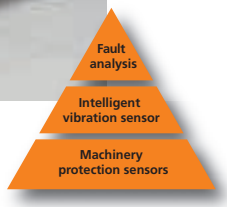


Dynamometer

Common problems

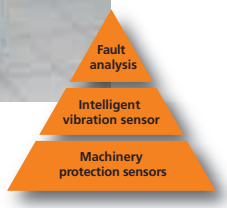


Applications



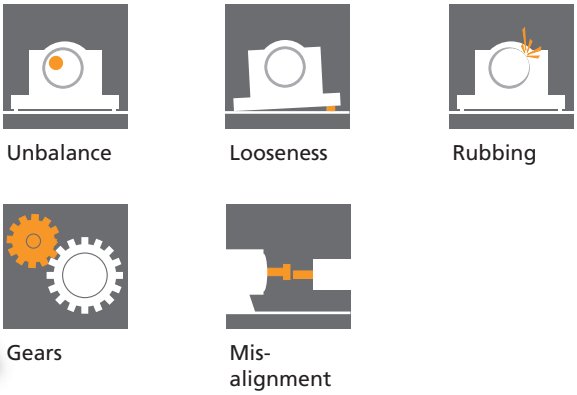
Homogeniser

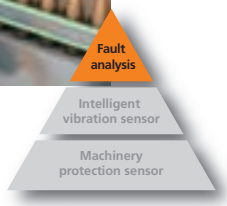
Common problems



Separator

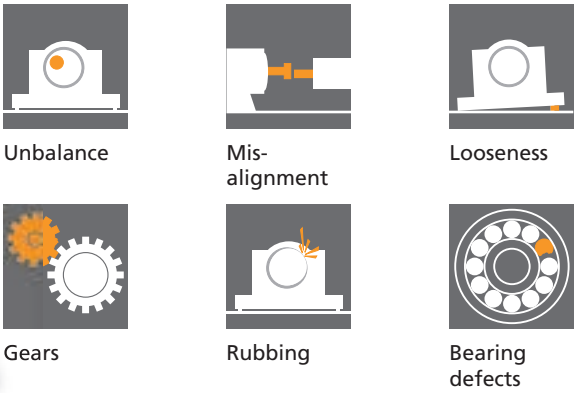
Common problems





Rotary fillers

Common problems



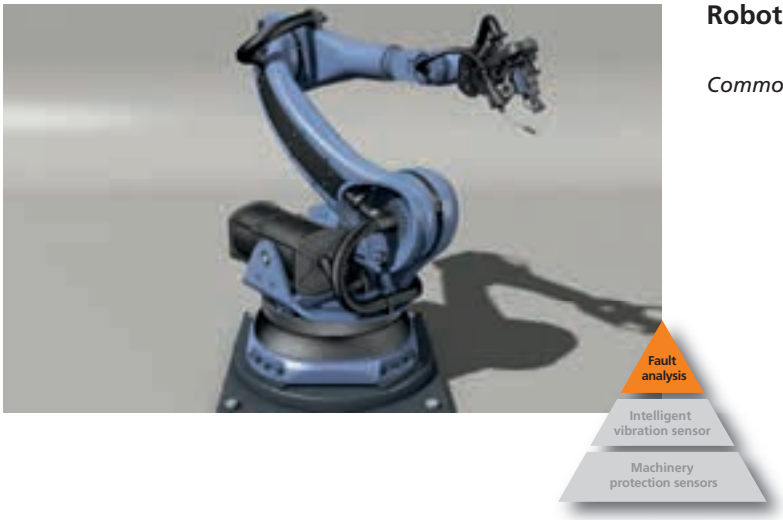
Machine tools

Common problems


Impact detection


Bearing defects


Unbalance



Robots

Common problems


Rubbing


Impact detection

Alternators

Common problems


Bearing defects


Gears

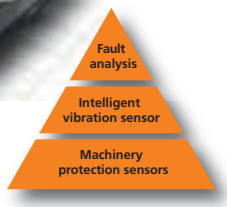

Unbalance


Mis-alignment


Looseness

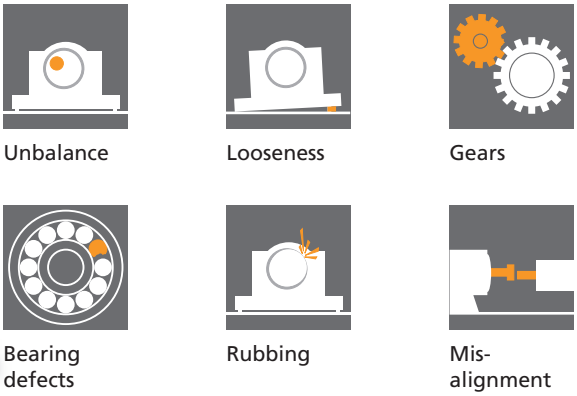

Rubbing

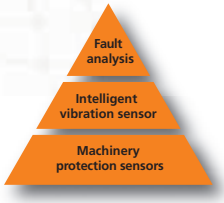
Applications



Mixer

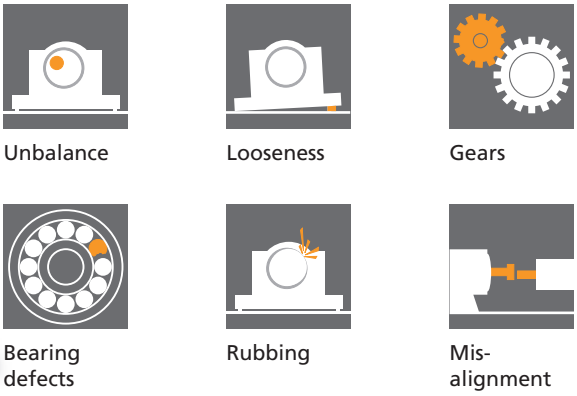
Common problems

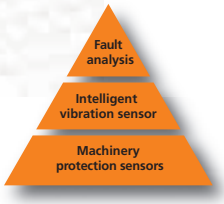




Pre-refiner

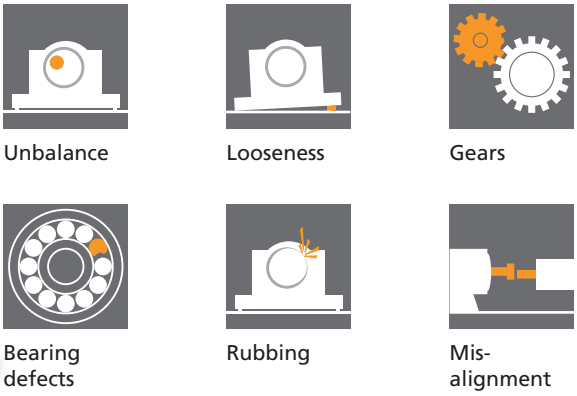
Common problems

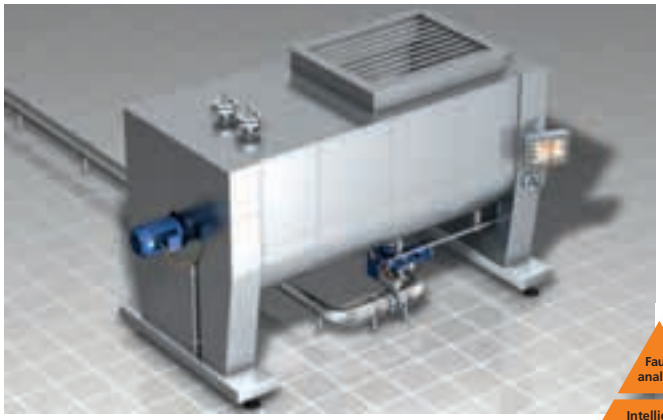


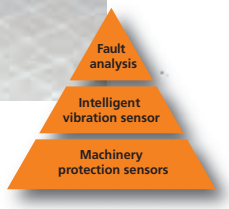


Refiner

Common problems

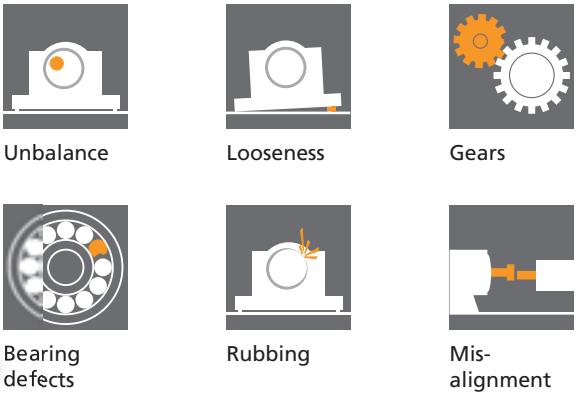


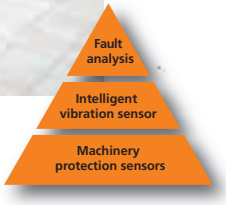




Conche

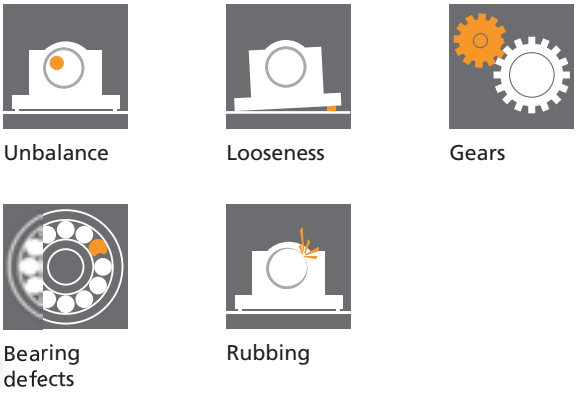
Common problems

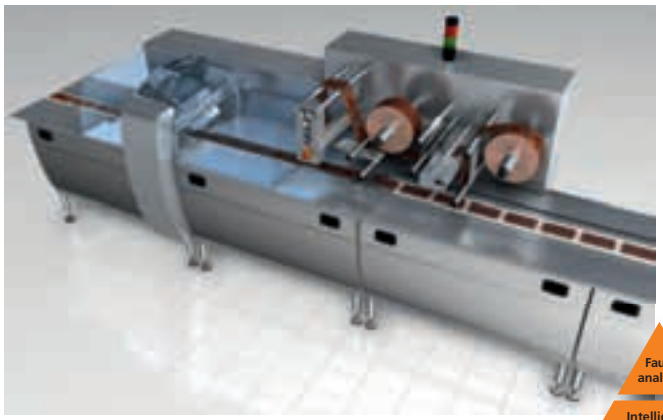


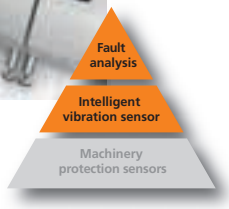


Mixers

Common problems

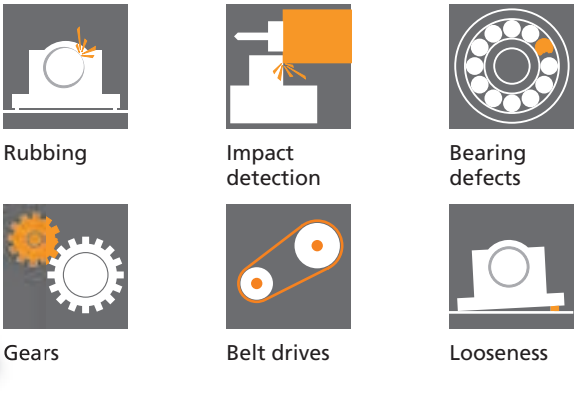




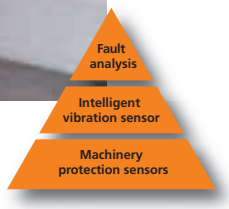


Packaging machine

Common problems

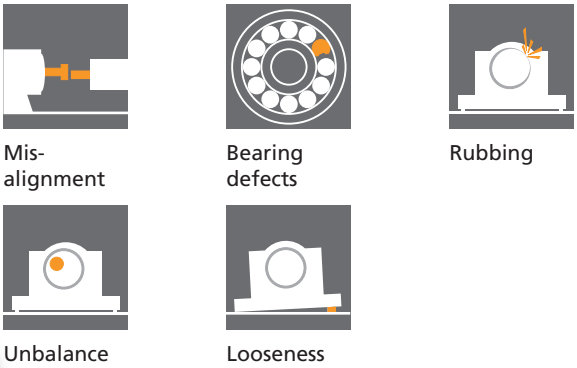


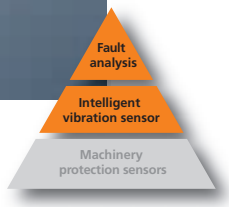
Applications



Compressor

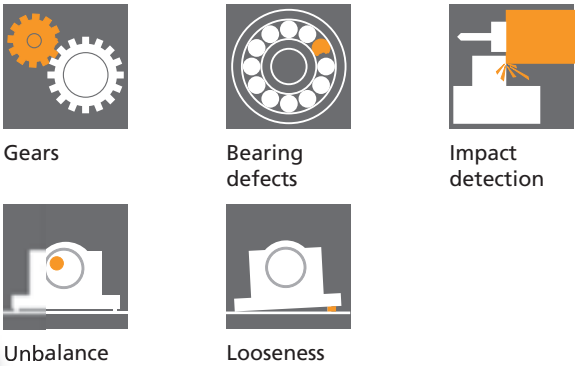
Common problems

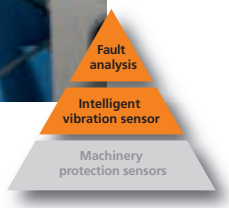




Wind turbine

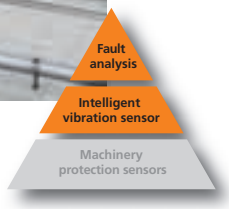
Common problems





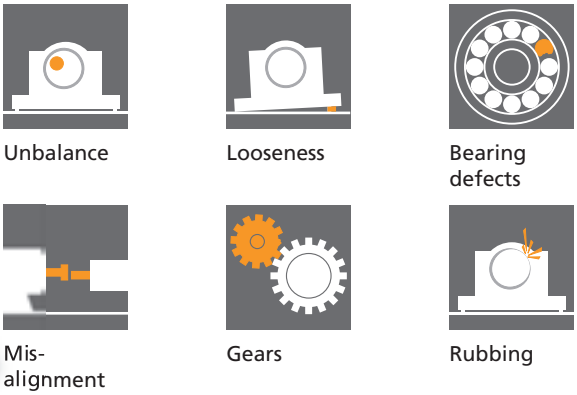
Slow rotating shafts

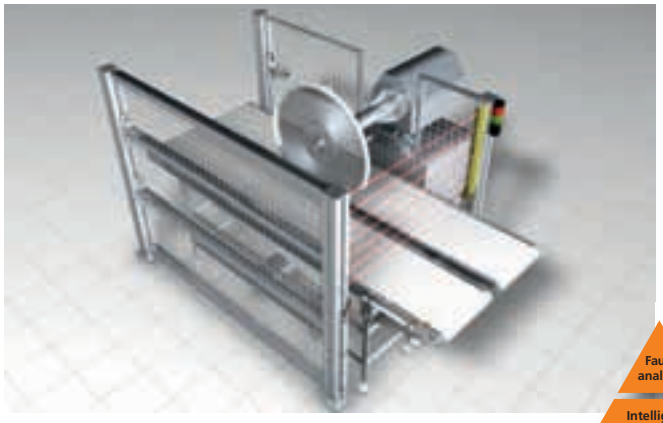
Common problems

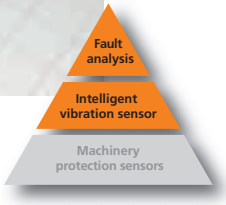


Mill

Common problems

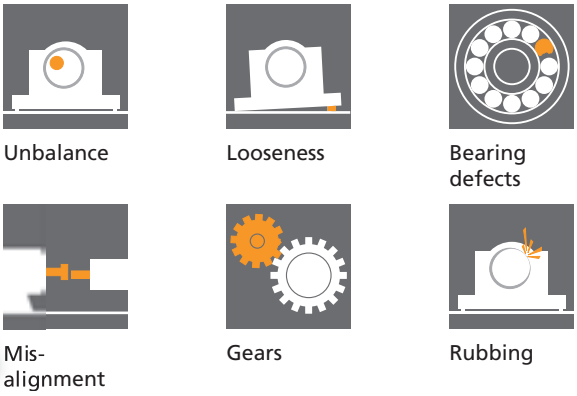


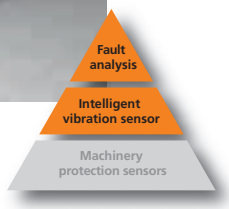




Saw

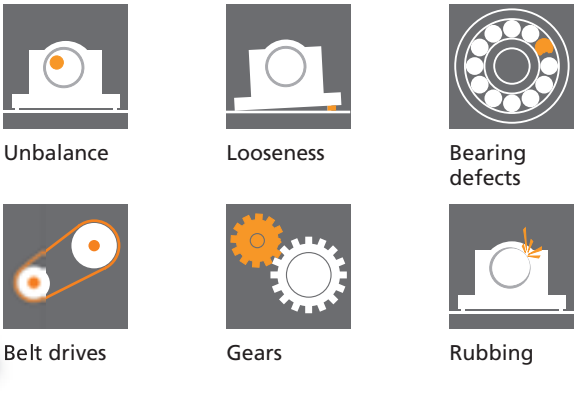
Common problems



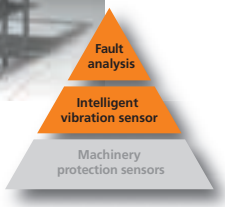


Tumbler

Common problems

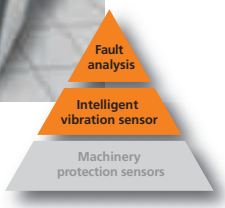


Applications



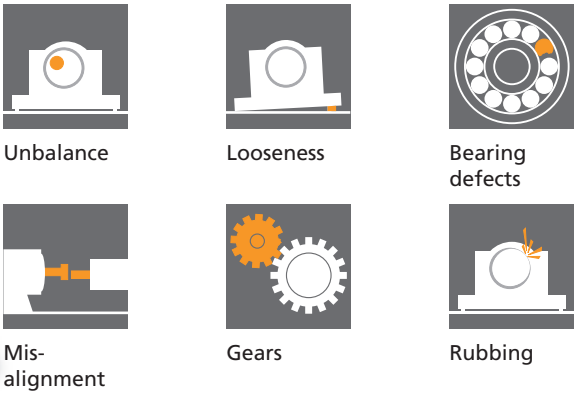
Mixer / grinder

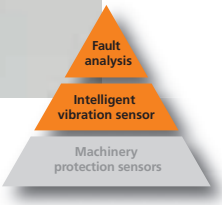
Common problems



Cutter

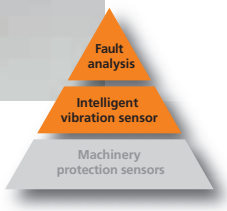
Common problems





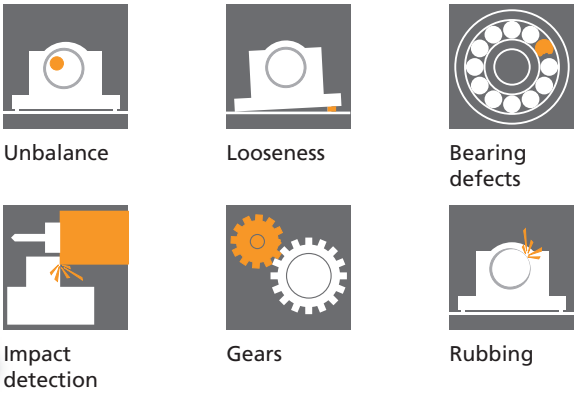
Screw conveyor

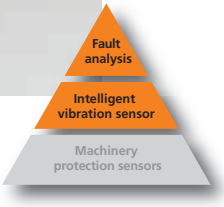
Common problems



Bucket elevator

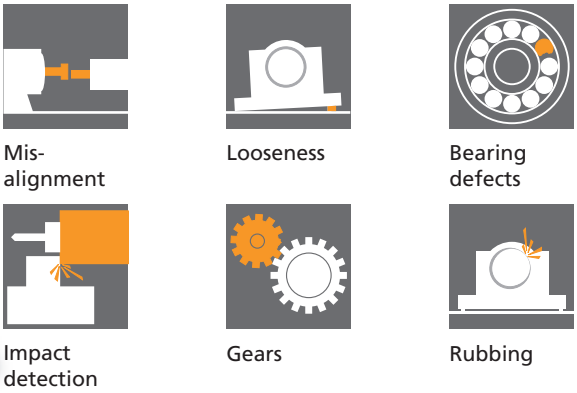
Common problems

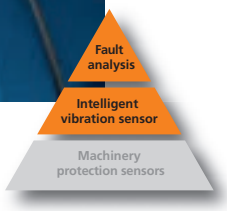




Chain drives

Common problems

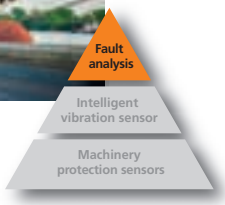




Sleeve / Journal bearing

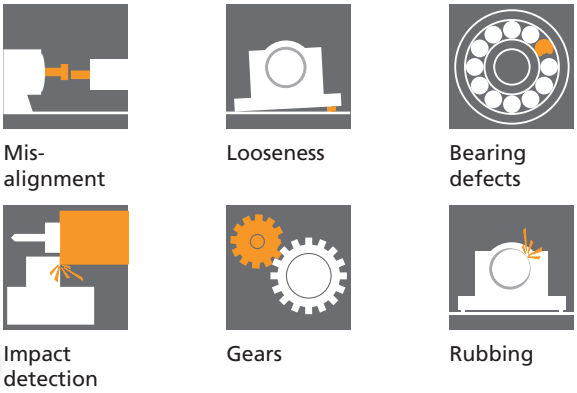
Common problems

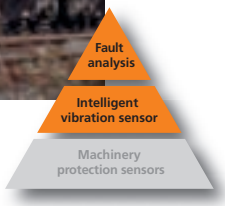
Applications



Ship to shore crane

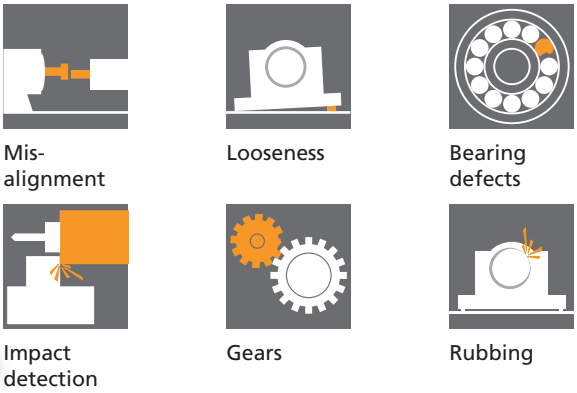
Common problems

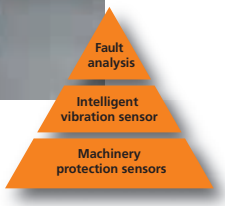




Rail vehicles

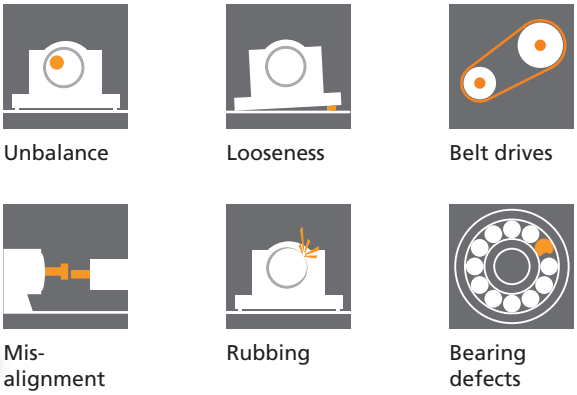
Common problems

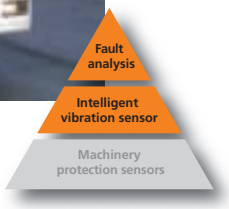




Roller conveyors

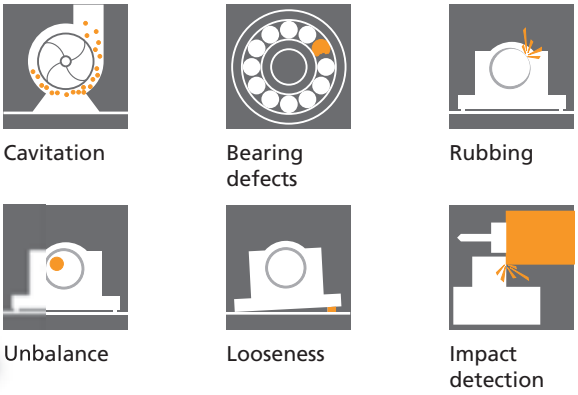
Common problems

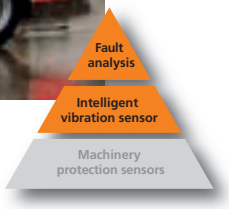




Refuse truck

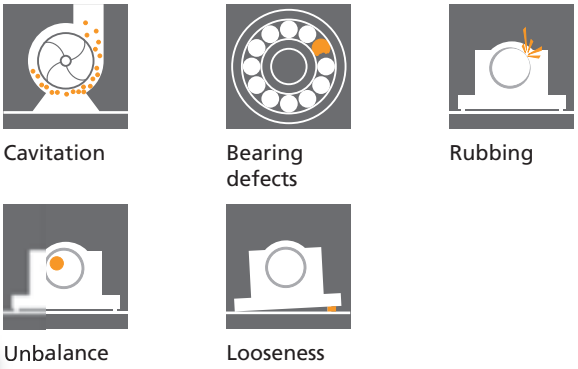
Common problems

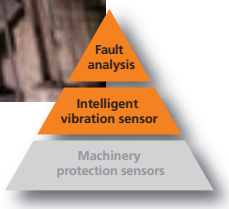




Fire engine

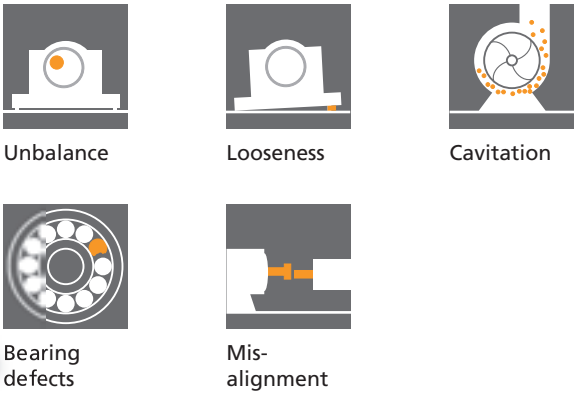
Common problems



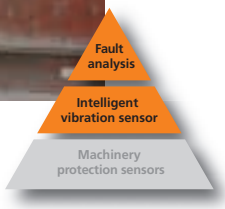


Rotary mill

Common problems

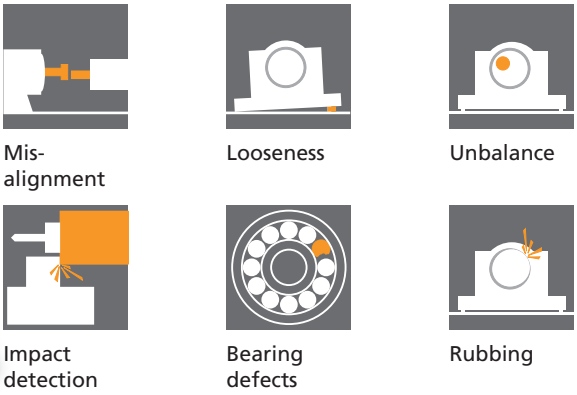


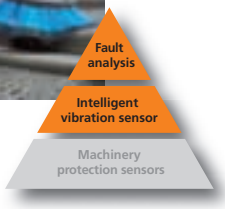
Applications



Stone crusher

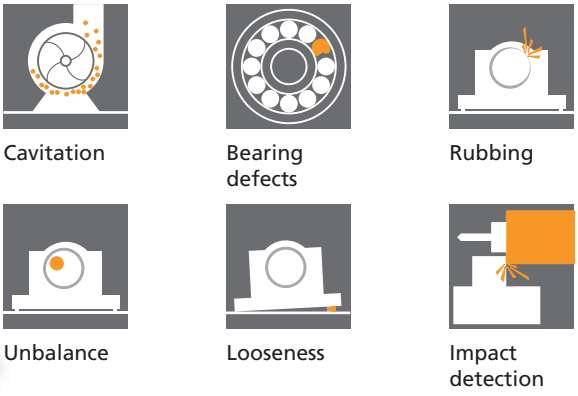
Common problems

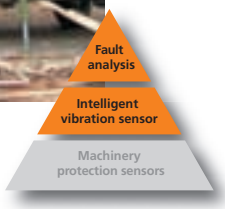




Sweeper

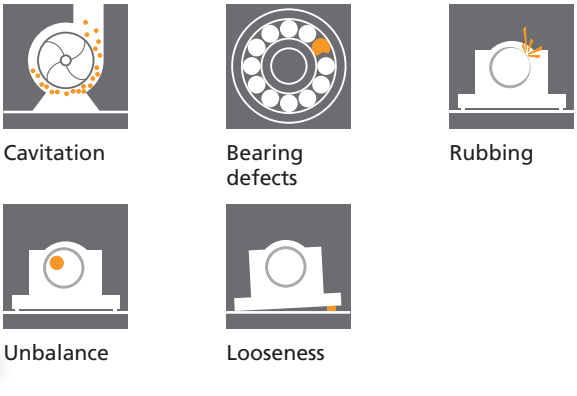
Common problems

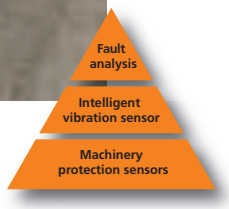




Shredder

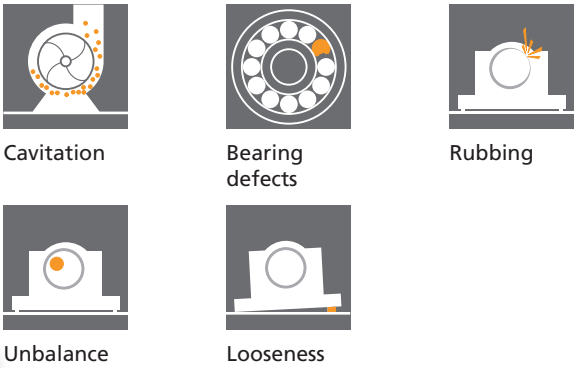
Common problems

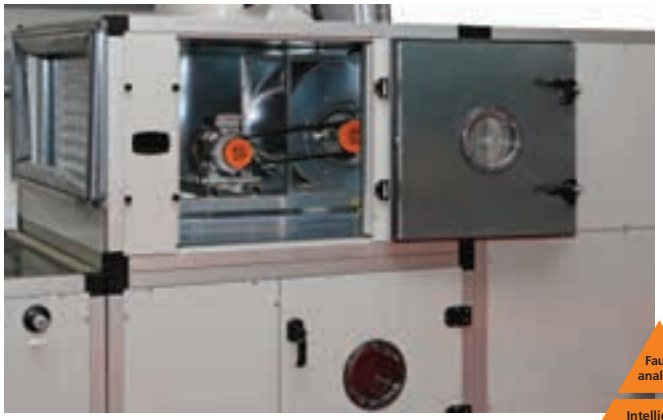


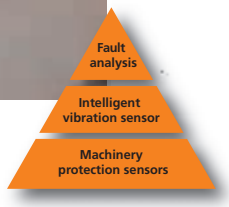


Hydraulic power pack

Common problems

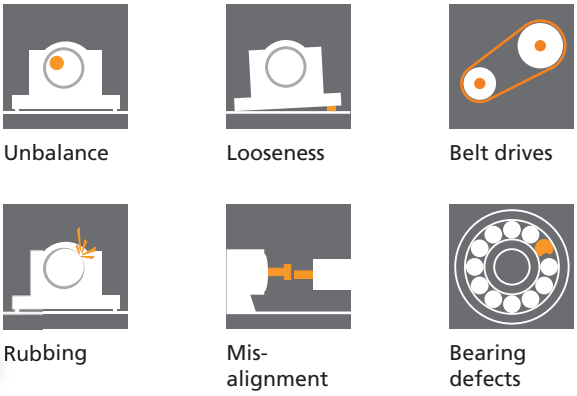


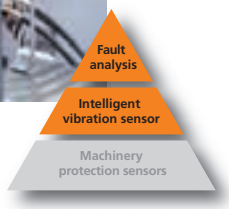




Air handling unit

Common problems

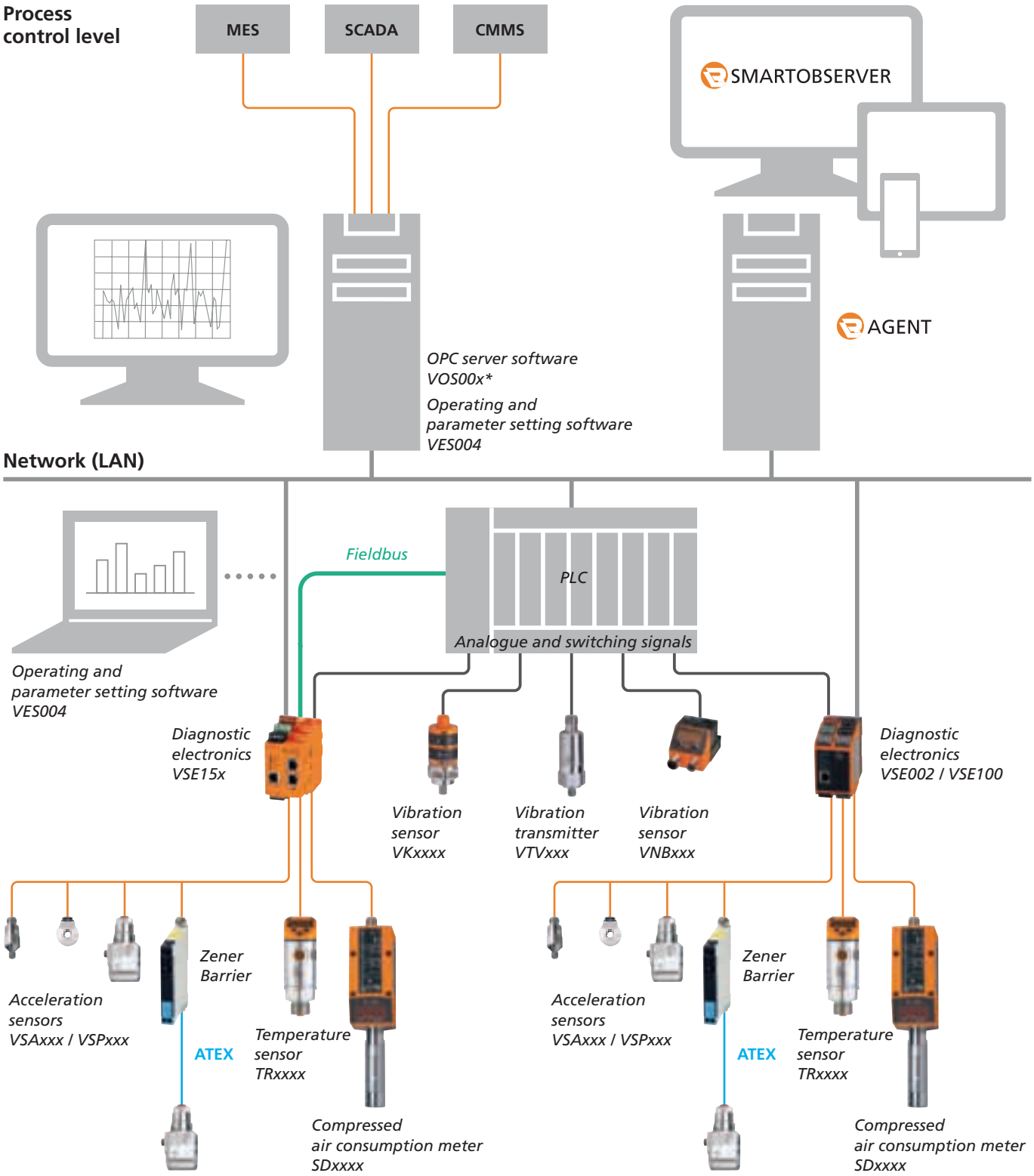




Injection moulding machine

Common problems

Systems for vibration monitoring – from sensor to ERP



*not compatible with VSE15x

Systems for vibration monitoring – the choice is yours

Machinery protection sensors

Description	Order no.
Vibration sensor to ISO 10816; RMS velocity 10…1000 Hz; analogue output 4…20 mA, switching output PNP, response delay and switch point adjustable via setting rings, measuring ranges 0…25 / 0…50 mm/s	**VNB001** **VKV021** **VKV022**
Vibration transmitter to ISO 10816, 10…1000 Hz RMS velocity, analogue output 4…20 mA, measuring ranges 0…50 / 0…25 / 0…25 mm/s, use in hazardous areas (type VTV12A)	**VTV121** **VTV122** **VTV12A**

Online fault analysis modules

Description	Order no.
Diagnostic electronics for evaluation of dynamic signals, e.g. of acceleration sensors type VSA / VSP; panel mounted; frequency-selective machine monitoring of up to 4 measuring points; TCP/IP Ethernet interface; integrated history memory with real-time clock; 2 digital outputs or 1 analogue and 1 digital output; counter function; further interfaces: - / 8 digital inputs/ouptuts / Profinet / Ethernet IP / Modbus TCP	**VSE002** **VSE100** **VSE150** **VSE151** **VSE153**

Accessories

Description	Order no.
Conical washer, 5 pcs., mounting accessories for acceleration sensors type VSA001, VSA101, VSA201, VNA001	**E30115**
PEEK adapter, mounting accessories for electrical insulation of the sensor, for acceleration sensors type VSA001, VSA101, VSA201, VNA001	**E30132**
Safety barrier for acceleration sensors type VSP01A, VSP02A	**ZB0633**
Acceleration sensor for connection to vibration sensor type VN	**VNA001**
Y cable for vibration sensor type VN	**E12405**
USB cable for vibration sensor type VN	**E30136**
Protective cover for vibration sensor type VK	**E30094**
Cross-over patch cable for diagnostic electronics type VSE, 2 m / 5 m	**EC2080** **E30112**
Socket for acceleration sensors type VSA / VSP, M12, straight, PUR cable, shielded, 5 m / 30 m	**EVC527** **EVC561**
Socket for acceleration sensors type VSA / VSP, M12, angled, PUR cable, shielded, 20 m	**EVC597**

Intelligent vibration sensor

Description	Order no.
Vibration sensor to ISO 10816; 2 switching outputs or 1 switching output and 1 analogue output, history memory with real-time clock, 4-digit alphanumeric display, data interface USB; 2/10...1000 Hz RMS velocity; measuring range 0…25 mm/s; external input 4…20 mA / 4…20 mA or VNA001 acceleration sensor	**VNB001**
Vibration sensor to ISO 10816; 2 switching outputs or 1 switching output and 1 analogue output, history memory with real-time clock, 4-digit alphanumeric display, data interface USB; RMS acceleration / velocity and a-Peak 0…6000 Hz; measuring range +/- 25 g; external input 4…20 mA / 4…20 mA or VNA001 acceleration sensor	**VNB211**

Accelerometers

Description	Order no.
Acceleration sensor for connection to diagnostic electronics type VSE, MEMS, frequency range 0...6000 Hz, measuring ranges ± 25 g / ± 250 g	**VSA001** **VSA201**
Acceleration sensor for connection to diagnostic electronics type VSE, MEMS, frequency range 0...1000 Hz, measuring range ± 3.3 g	**VSA101**
Acceleration sensor for connection to diagnostic electronics type VSE, MEMS; Frequency range 0…10,000 Hz, measuring range ± 25 g, 3 m cable / 10 m cable / 0.8 m cable and M12 connector / 6 m cable	**VSA004** **VSA005** **VSA002** **VSA006**
Acceleration sensor; piezo; 100 mV/g frequency range 0…10,000 Hz; measuring range ± 50 g	**VSP001** **VSP003**
Acceleration sensor for use in hazardous areas, group II category 1D/1G, connection via safety barrier, 100 mV/g; frequency range 2…10,000 Hz, measuring range ± 50 g	**VSP01A** **VSP02A**

Software

Description	Order no.
Parameter setting software for diagnostic electronics type VSE and vibration sensor type VNB	**VES004**
OPC server software (OPC DA) for diagnostic electronics type VSE002 and VSE100, licence depending on the number of connections 25 / 50 / 75 / 100 / 1000	**VOS001** **to** **VOS005**

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