Automotive manufacturing accelerometer applications

Wilcoxon
SENSING TECHNOLOGIES

Automotive manufacturing applications

- Spindle bearings
- Motor bearings
- Cooling tower motor and gearbox
- Stamping press motor and gearbox
- Paint booth air supply and exhaust fans
- Paint oven air supply and exhaust fans
- Factory air supply fans

Benefits of vibration monitoring

- Minimize unplanned downtime
- Plan for maintenance during downtimes
- Improve product quality because
  - Machines are in a known condition and can be relied to work when needed
  - Smooth running machines are critical in some applications
    - Machining operations
    - Robot arm movement such as paint spray arms
    - Paint nozzles
    - Maximize cutting tool usage
- Ensure quality of working environment for all employees
  - Contribute to plant safety because of better running machinery
- Equipment is monitored and analyzed while it is running
- Identifies a variety of machinery faults

Causes of vibration

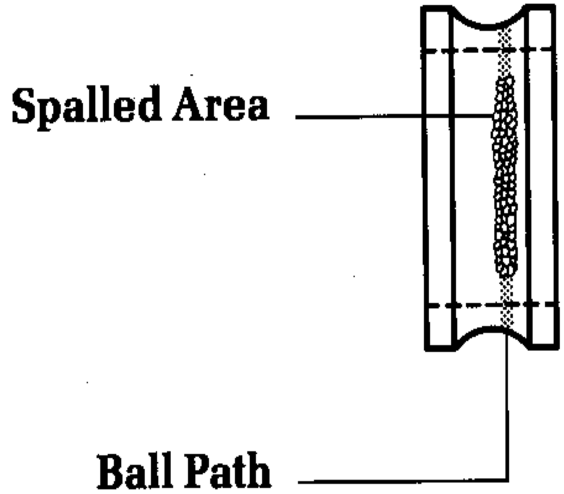
- Mechanical defects
  - Bearings
  - Gears
  - Impellers
  - Blades
- Mechanical conditions
  - Imbalance
  - Soft foot
  - Resonance
  - Misalignment
- Electrical conditions
  - Stator
  - Windings
  - Rotor

Bearing faults which can be detected with vibration analysis

- Excessive loads
- Over heating
- True brinelling
- False brinelling
- Normal fatigue failure
- Reverse loading
- Contamination
- Lubricant failure
- Corrosion
- Misaligned bearings
- Loose fits
- Tight fits

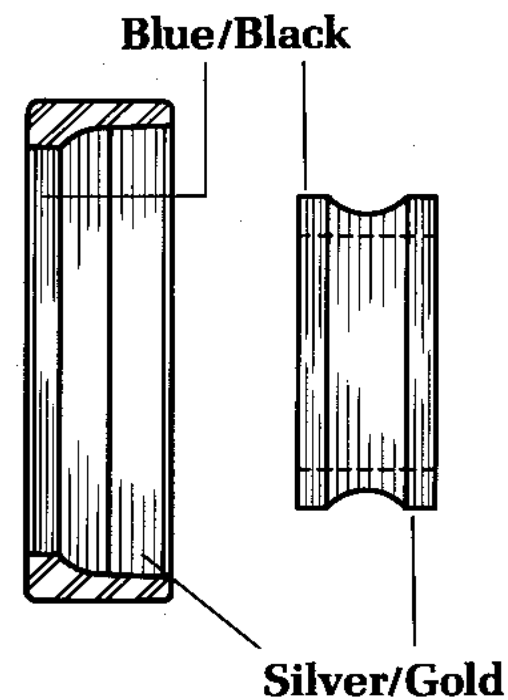
Excessive loads

- Usually causes premature fatigue
- Can be alleviated by reducing the load or redesigning with a bearing of greater capacity



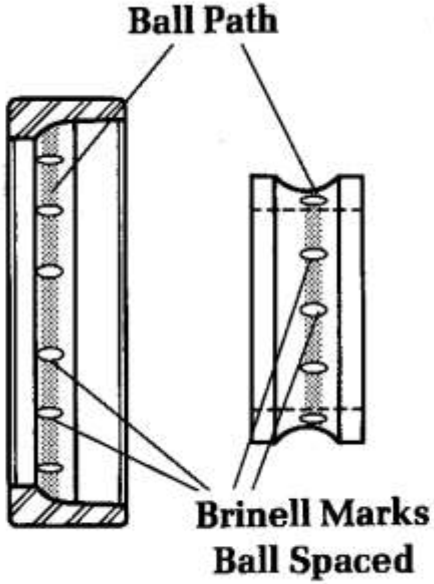
Overheating

- Symptoms are discoloration of the rings, balls and cages from gold to blue
- Temperature in excess of 400° F can anneal the ring and ball materials and degrade or destroy lubricant
- The resulting loss in hardness reduces the bearing capacity, causing early failure
- In extreme cases, balls and rings will deform



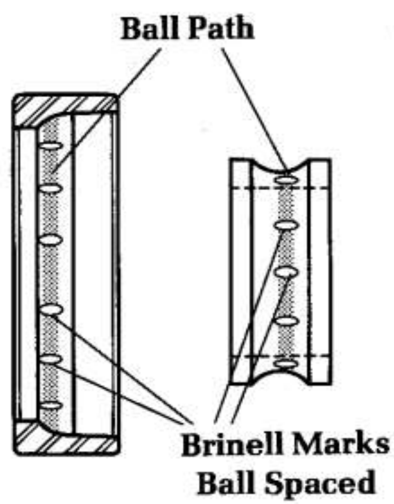
True brinelling

- Occurs when loads exceed the elastic limit of the ring material
- Creates brinell marks which show as indentations in the raceways and increase bearing vibration (noise)
- Caused by any static overload or severe impact



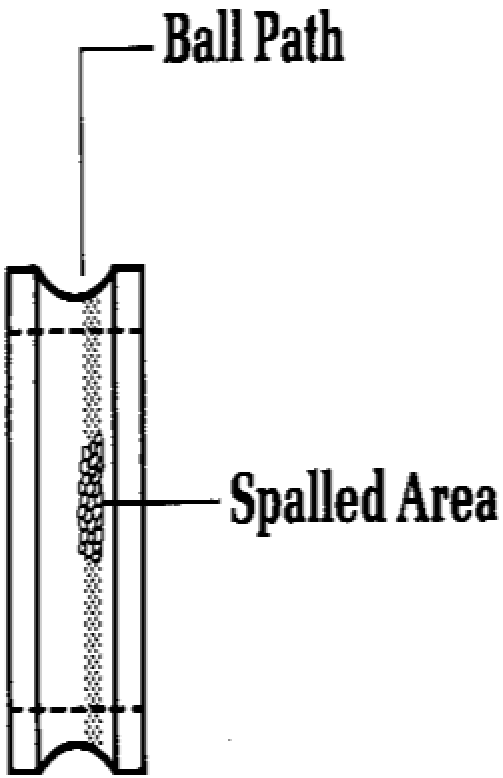
False brinelling

- Creates elliptical wear marks in an axial direction at each ball position with a bright finish and sharp demarcation, often surrounded by a ring of brown debris
- Indicates excessive external vibration
- Corrected by isolating bearings from external vibration, and using greases containing anti-wear additives



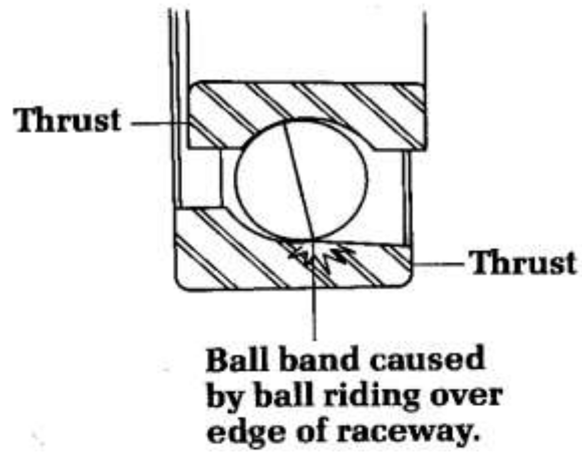
Normal fatigue failure

- A fracture of the running surfaces and subsequent removal of small discrete particles of material
  - Also referred to as spalling
- Can occur on the inner ring, outer ring, or balls
- A “progressive” failure
  - Once initiated, it will spread with continued operation
  - It will always be accompanied by a marked increase in vibration
- Remedied by replacing the bearing or redesigning with a bearing that has a greater calculated fatigue life



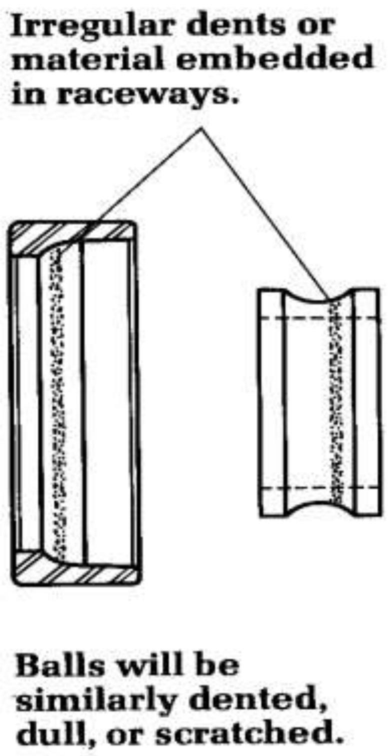
Reverse loading

- Angular contact bearings are designed to accept an axial load in one direction only
- When loaded in the opposite direction, the elliptical contact area on the outer ring is truncated by the low shoulder on that side of the outer ring
- The result is excessive stress and an increase in temperature, followed by increased vibration and early failure
- Corrective action is to re-install the bearing correctly



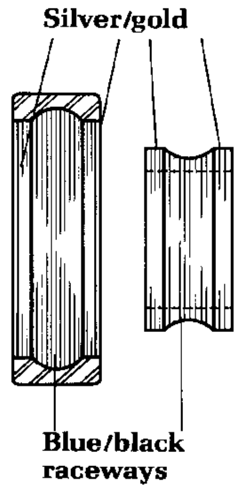
Contamination

- A leading cause of bearing failure
- Symptoms are denting of the bearing raceways and balls, resulting in high vibration and wear
- Clean work areas, tools, fixtures and hands help to reduce contamination failures
- Keep grinding operations away from bearing assembly areas and keep bearings in their original packaging until you are ready to install them



Lubricant failure

- Ball bearings depend on the continuous presence of a very thin (millionths of an inch) film of lubricant between the balls and races, and between the cage, bearing rings and balls
- Insufficient or ineffective lubricant results in excessive wear of balls, rings and cages, leading to overheating and subsequent catastrophic failure
- Discolored (blue/brown) ball tracks and balls can occur
- Failures are typically caused by restricted lubricant flow or excessive temperatures that degrade the lubricant's properties

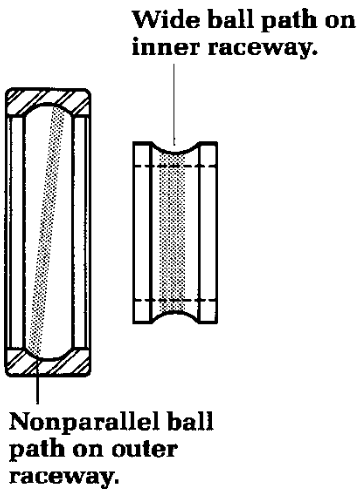


Corrosion

- Red/brown areas on balls, race-way, cages, or bands of ball bearings may be present
- Results from exposing bearings to corrosive fluids or a corrosive atmosphere
- In extreme cases, can initiate early fatigue failures
- Corrected by diverting corrosive fluids away from bearing areas and using integrally sealed bearings whenever possible

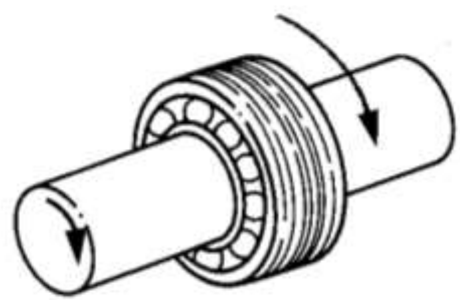
Misalignment

- Can be detected on the raceway of the non-rotating ring by a ball wear path that is not parallel to the raceways edges
- If it exceeds 0.001 in./in, will cause an abnormal temperature rise in the bearing and/or housing and heavy wear in the cage ball-pockets
- Appropriate corrective actions include:
  - Inspect shafts and housings for runout of shoulders and bearing seats
  - Use single point-turned or ground threads on non hardened shafts and ground threads only on hardened shafts
  - Use precision grade locknuts



Loose fits

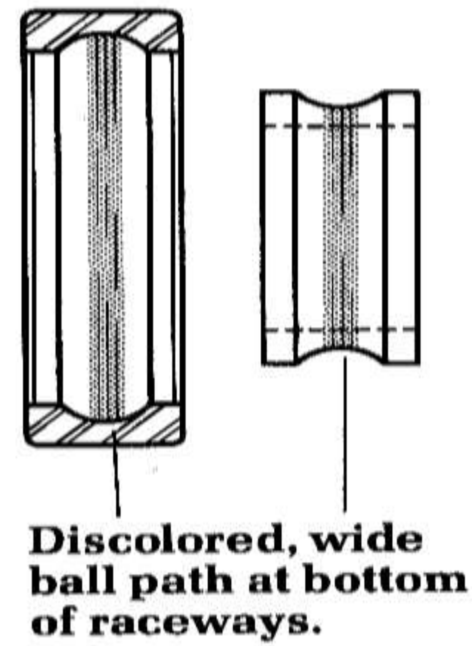
- Can cause relative motion between mating parts
- If the relative motion between mating parts is slight but continuous, fretting occurs
  - Fretting is the generation of fine metal particles which oxidize, leaving a distinctive brown color. This material is abrasive and will aggravate the looseness. If the looseness is enough to allow considerable movement of the inner or outer ring, the mounting surfaces (bore, outer diameters, faces) will wear and heat, causing noise and runout problems.



Outer ring slippage caused by improper housing fits.

Tight fits

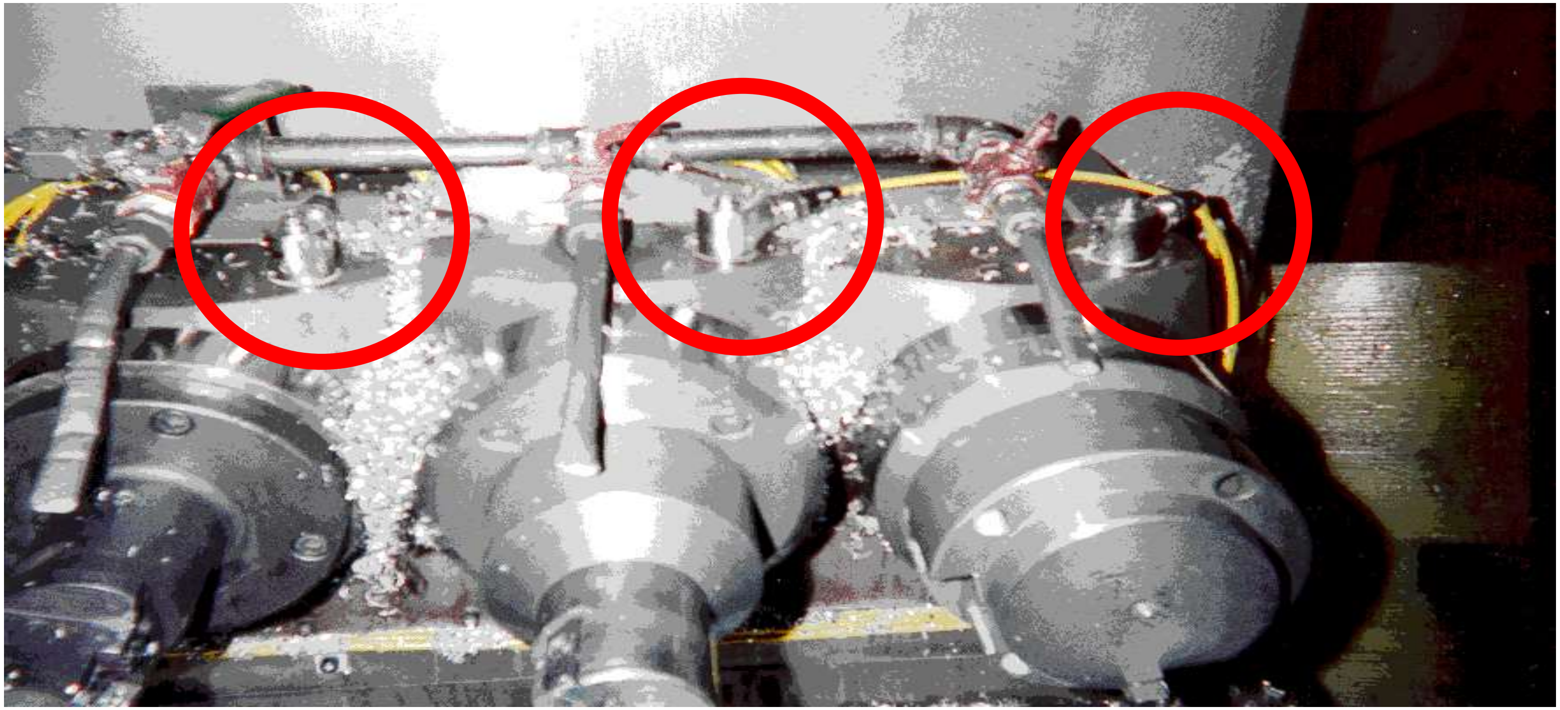
- Indicated by a heavy ball wear path in the bottom of the raceway around the entire circumference of the inner ring and outer ring
- Where interference fits exceed the radial clearance at operating temperature, the balls will become excessively loaded, resulting in a rapid temperature rise accompanied by high torque
- Continued operation can lead to rapid wear and fatigue
- Corrective action is a decrease in total interference



Route based program vs. permanent mount solutions

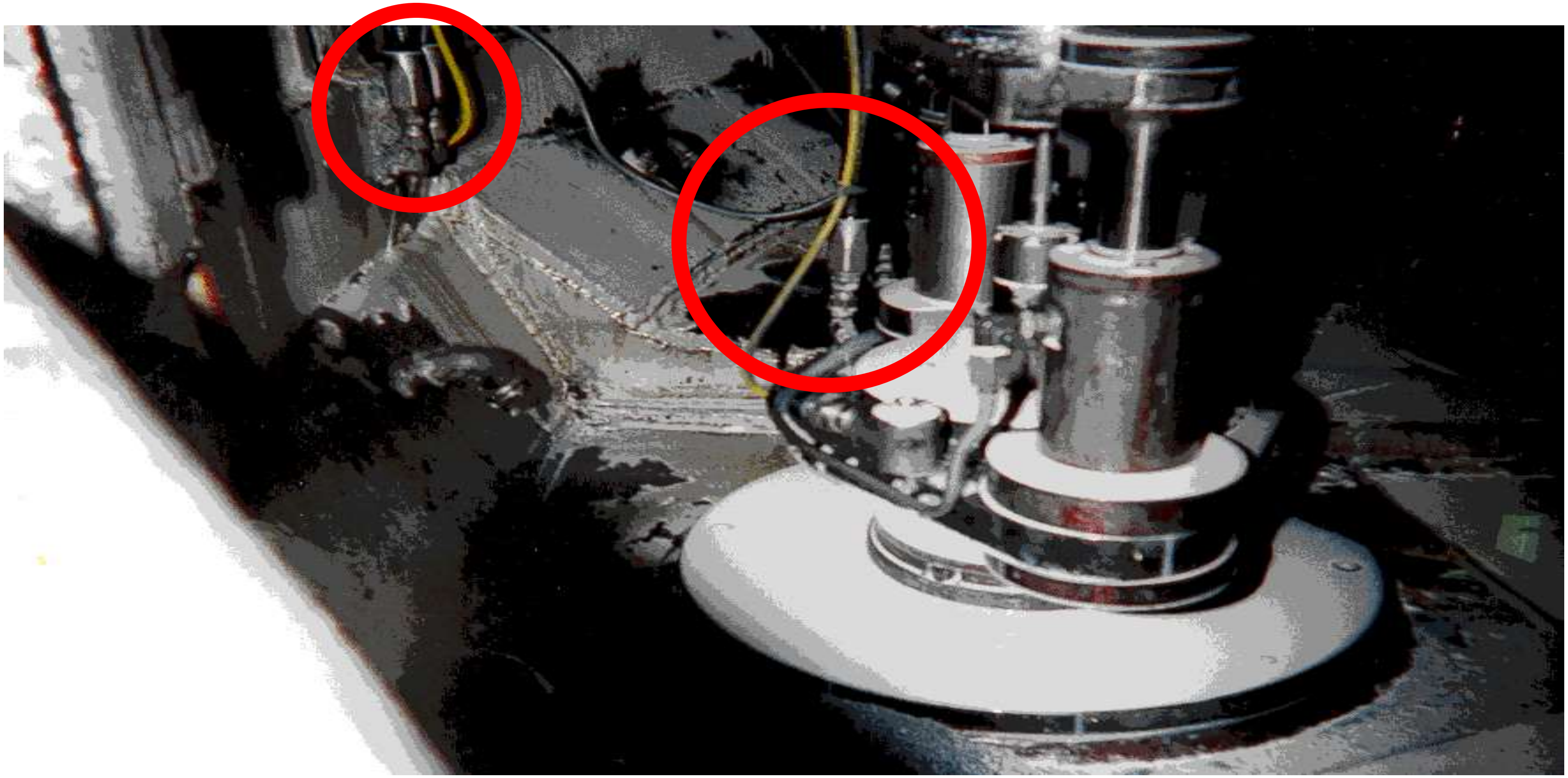
- Route based is usually less costly to implement
  - Exposes the data collector to hazardous conditions
  - Single transducer can add to data collection time
- Permanent mount sensors have a higher up front cost
  - Simplify route based data collection
  - Cable connections can be done in safe locations
  - Machining operations can be monitored because the sensor is in place
- Some examples of permanent mounted sensors follow

Boring machine spindles



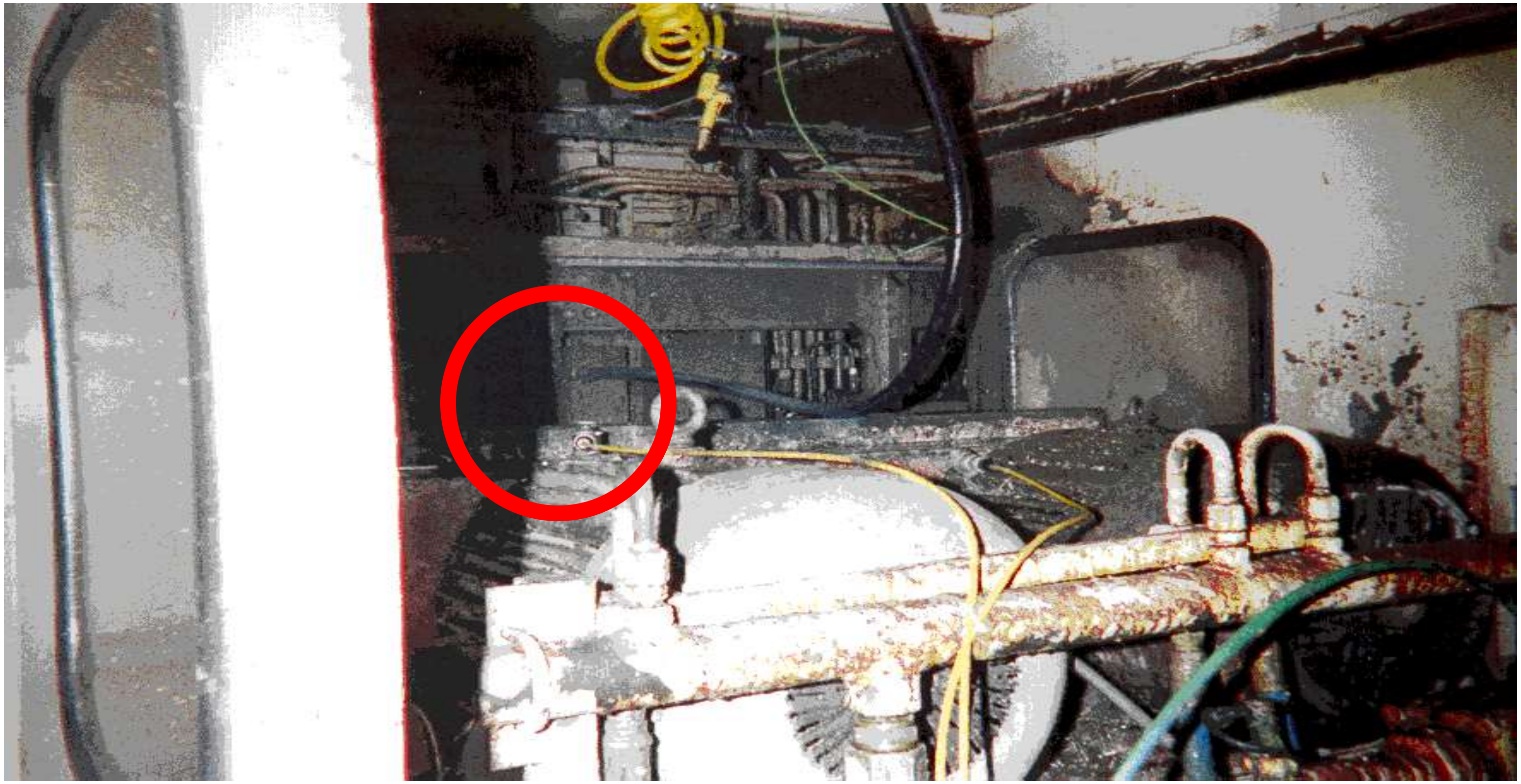
Turnmat machine

Bores engine head



Motor

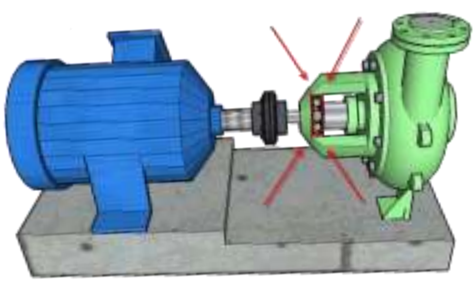
Boring machine for crank shaft and rods

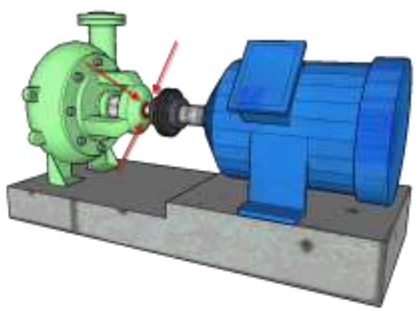


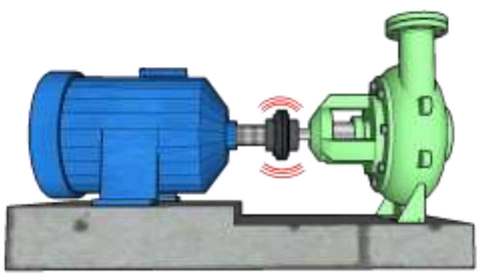
Permanent mount sensors on a center hung pump

Effects of vibration

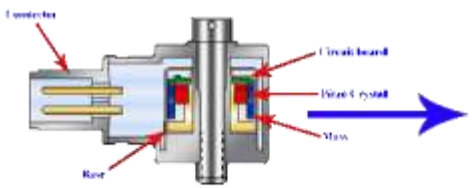
- The expended energy from vibration causes wear of components, reduced performance, increased energy consumption and reduced reliability
- Vibration can excite natural frequencies causing significant vibration at the components

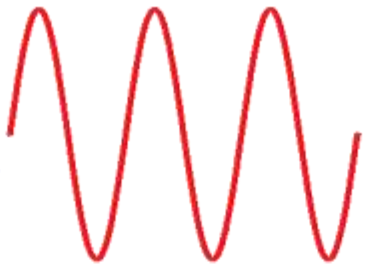




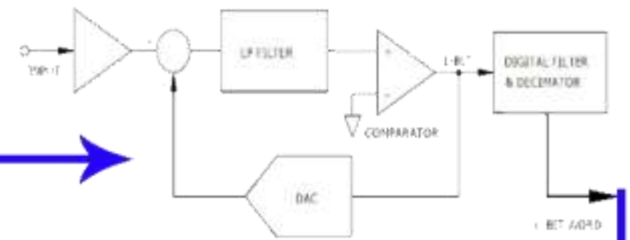


How to detect vibration

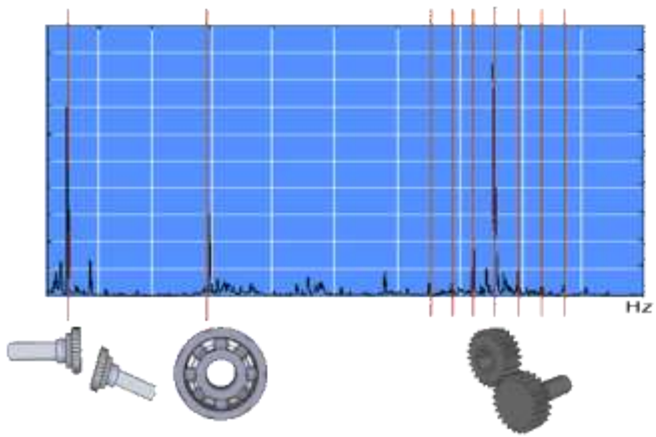




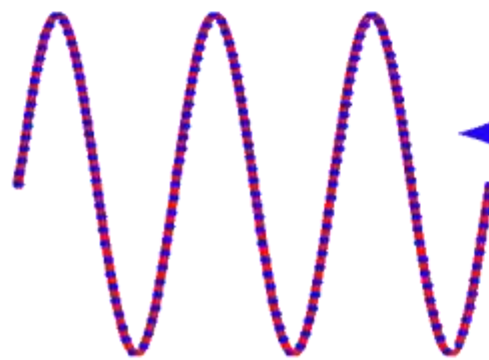
Raw signal from accelerometer



A/D conversion and signal processing



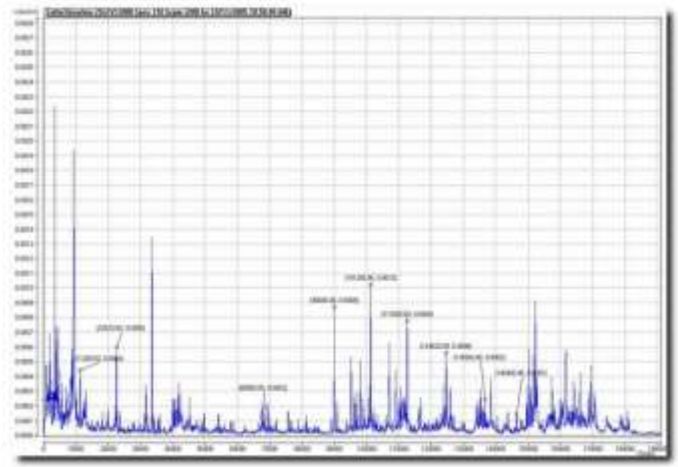
FFT or spectrum

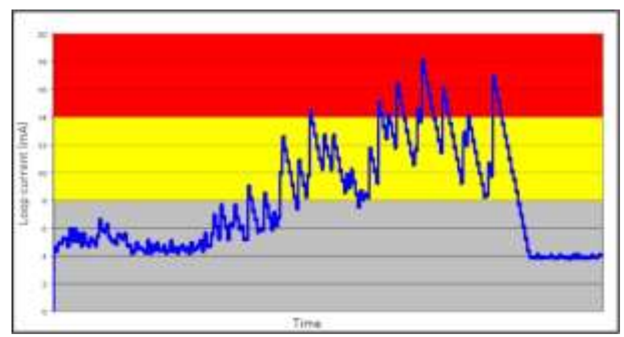


Digitized waveform

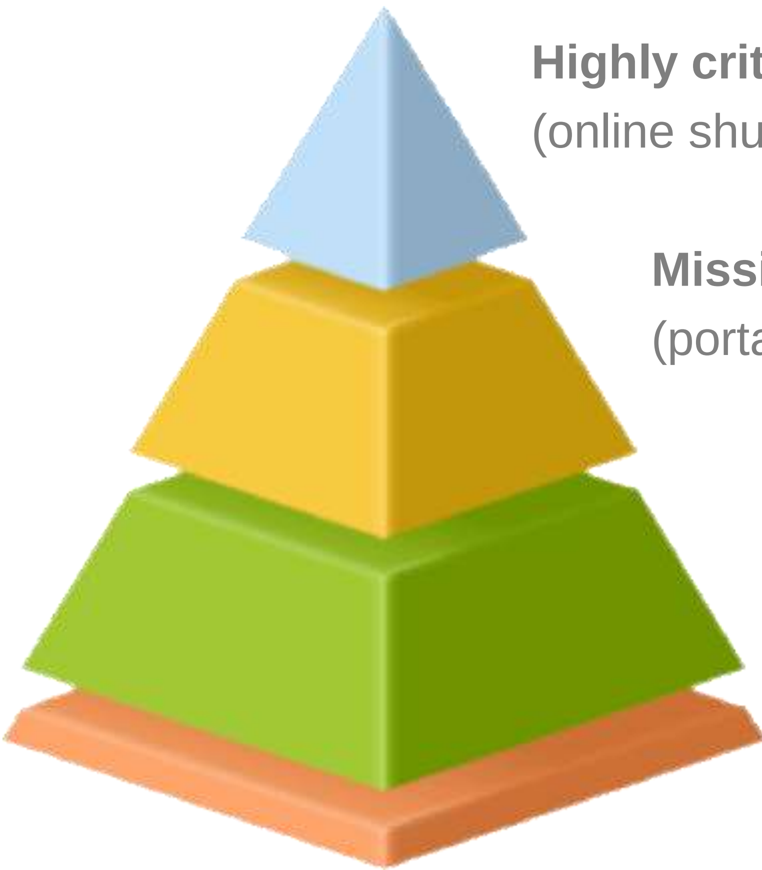
Vibration data collection methods

- 4-20 mA trending
- Portable data collection
- Online monitoring





When to apply vibration monitoring



Highly critical
(online shutdown protection)

Mission critical
(portable, online, or 4-20 mA)

Balance of plant
(4-20 mA)

Run to failure
(no monitoring)

Vibration analysis can detect many common problems

- Machine faults
  - Imbalance
  - Misalignment
  - Bent shaft
  - Mechanical looseness
  - Casing / foundation distortion
  - Bearing faults
  - Motor faults
  - Resonance
- Machine design
  - Universal joints
  - Asymmetrical shafts, cams
  - Gear mesh
  - Couplings
  - Bearings
  - Pumps and fans
  - Reciprocating machines
  - Motors / generators

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