Standard instrumentation used on reciprocating compressors

Gaia Rossi – Thorsten Bickmann

GE Measurement & Control

Contents

Introduction

- Recommended measurements for protection and diagnostic

Vibration and position

- Frame and Crosshead Vibration: transducer selection, purpose, technology
- Piston Rod Drop and Vibration, transducer technology, examples
- Installation pitfalls
- Ultrasonic measurements

Pressure

- Purpose and derived parameters, installation pitfalls, examples

Temperature

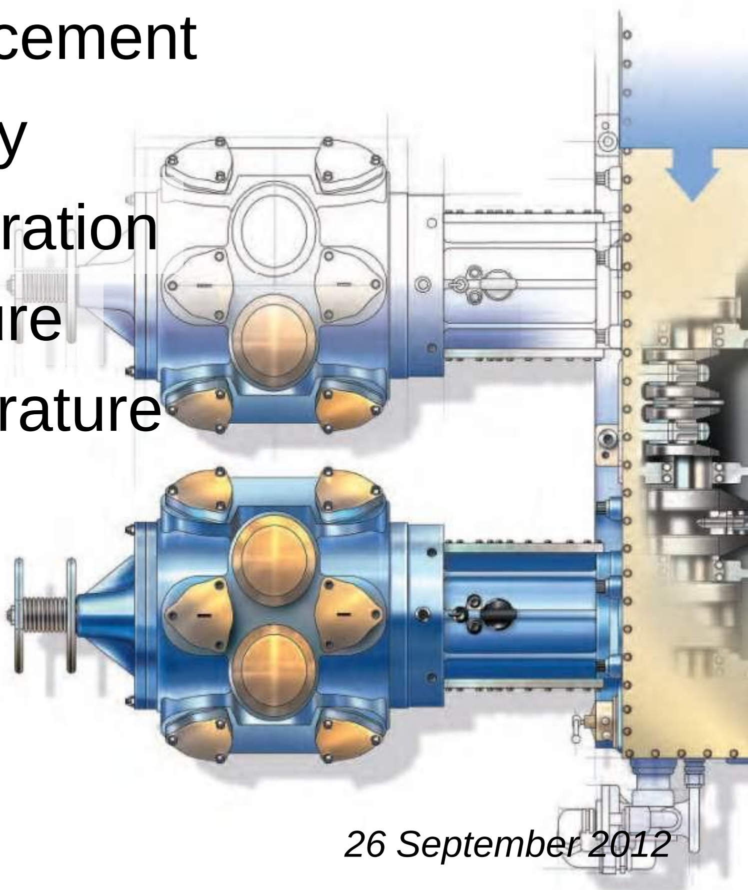
- Locations, purpose and available technologies, examples

Reciprocating Compressor Measurements

Design, malfunction modes determine measurements types:

- Compressor Valves
- Piston rods
- Rider Bands
- Pressure Packing
- Piston Rings
- Crosshead pin

- Displacement
- Velocity
- Acceleration
- Pressure
- Temperature
- ...



Standard measurements for reciprocating compressor

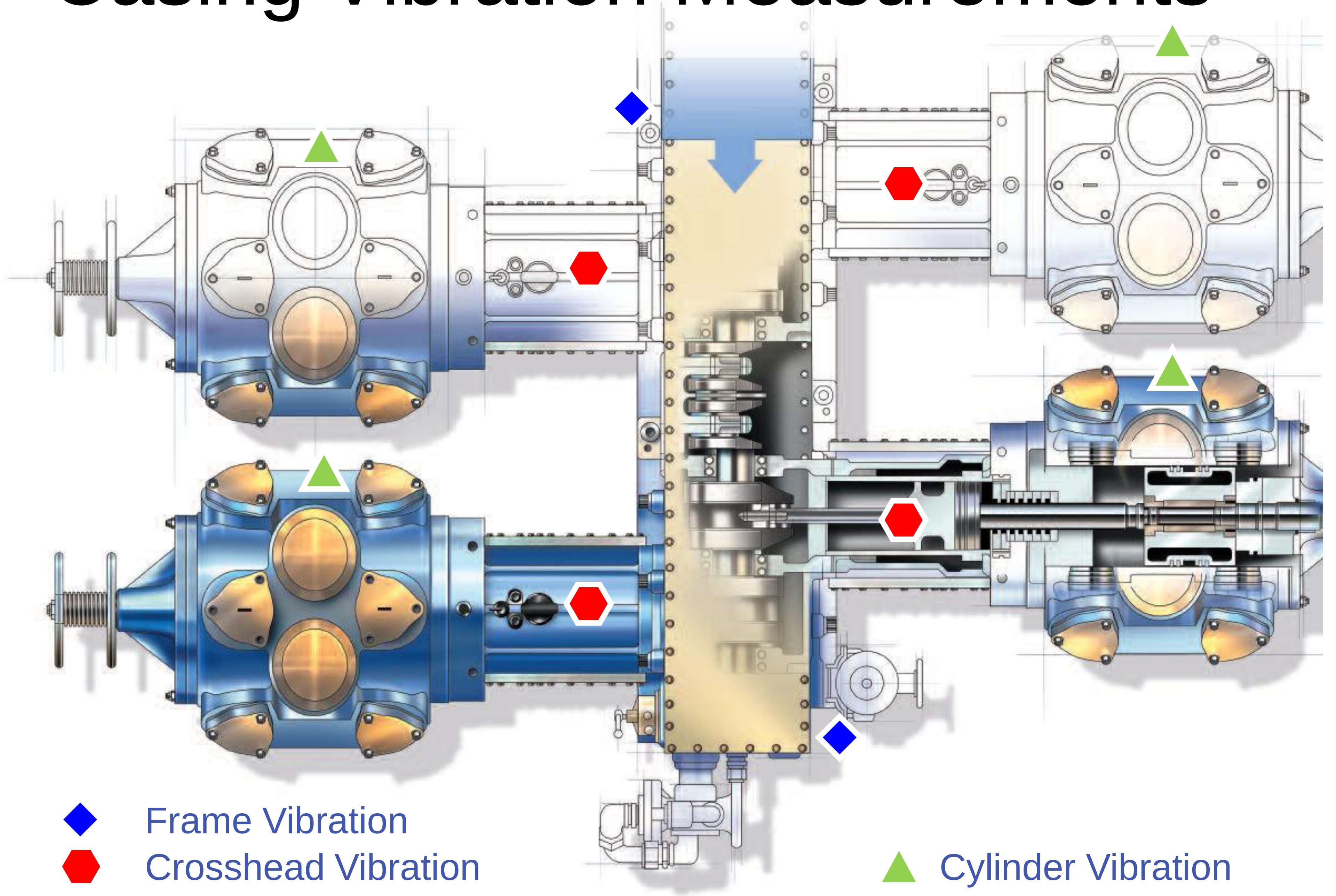
Limited information from standards on measurements for Condition Monitoring.

- API 618 mentions frame vibration as alarm and shutdown parameter
- API 670 mentions also rod drop and casing velocity as protection parameters
- Generic indications in ISO standards for vibration validation of recip machinery.

Technology developments and practical experience over recent years lead to additional recommended measurements for monitoring and diagnostics:

- Crosshead and cylinder vibration
- Piston rod runout, rod vibration
- Cylinder pressure

Casing Vibration Measurements



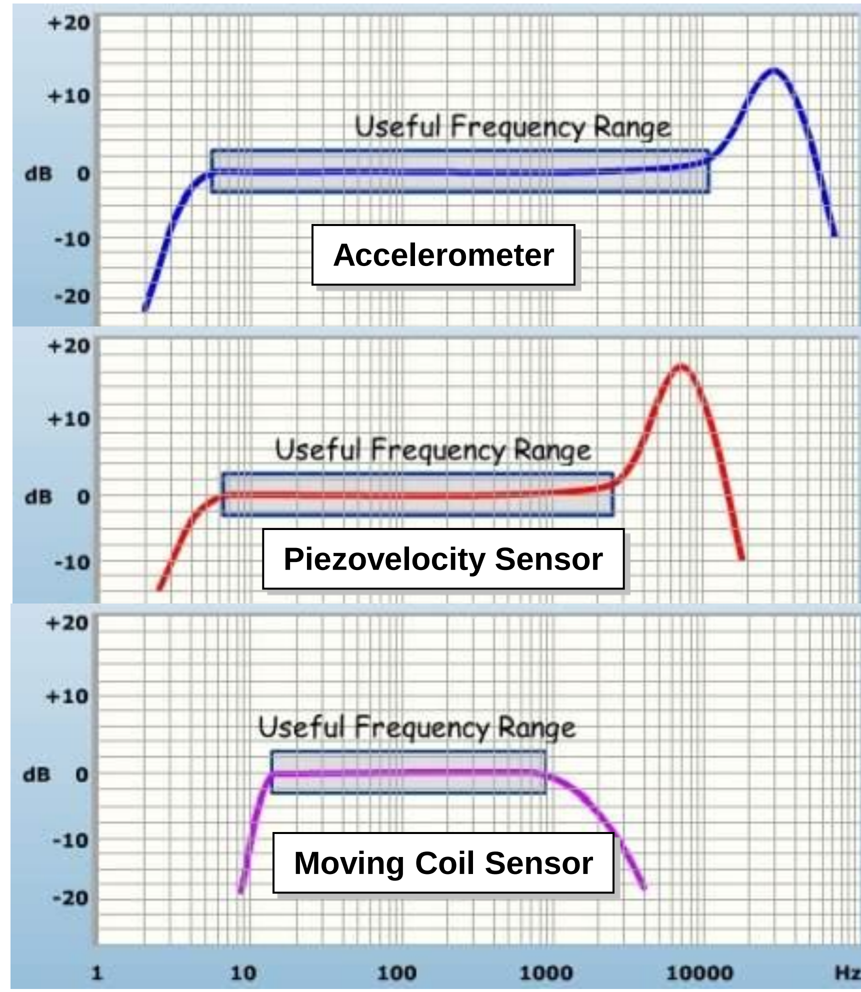
Typical Frequency Ranges

Seismic Transducers

Accelerometer: Highest frequency response. Used for crosshead and cylinder impulse/impact monitoring

Piezovelocity Sensor: Lower high frequency response, but less noise than using an external integrating amplifier with an accelerometer, used for frame vibration

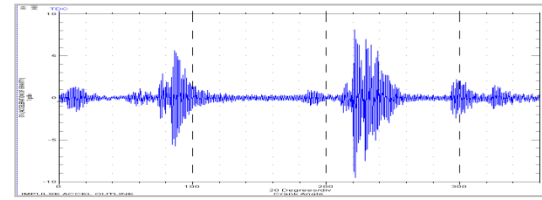
Moving Coil Sensor: Limited frequency response, no requirement for an external power supply. Widely used before piezo sensors perfected

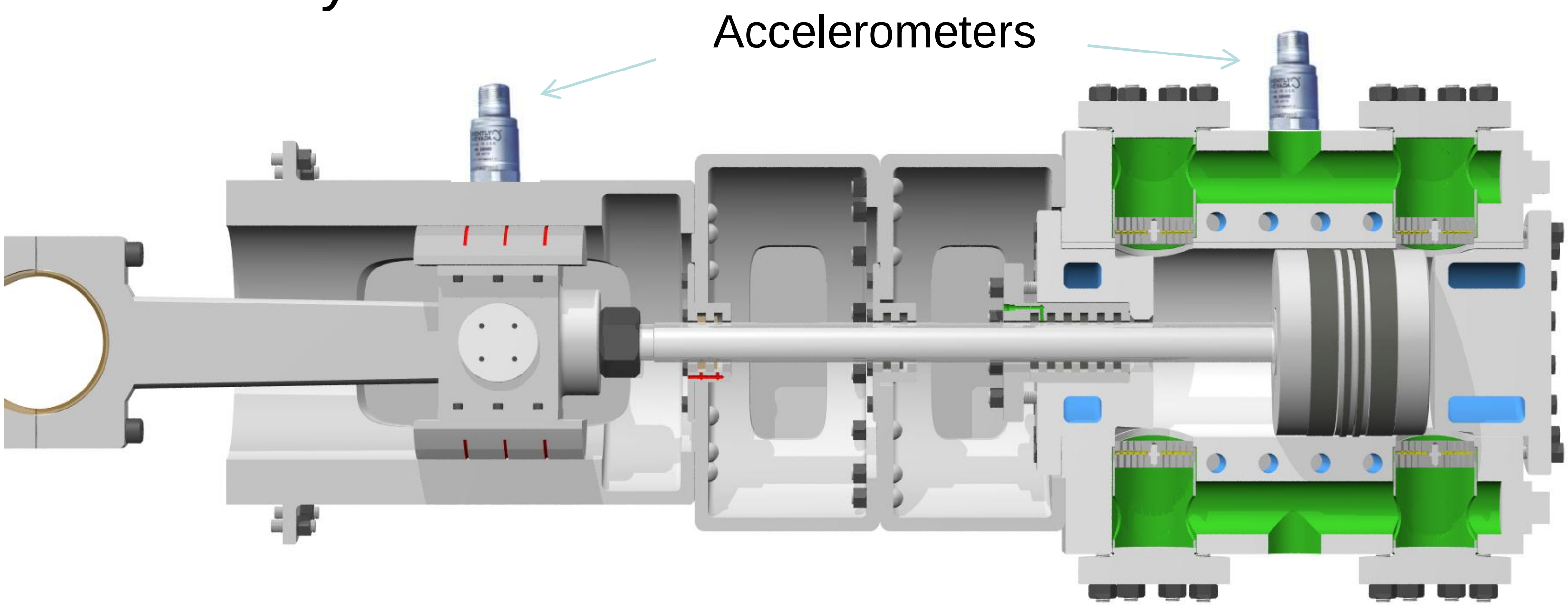


Typical Frequency Ranges

Crosshead and Cylinder Vibration (Acceleration)

Accelerometer is suitable for monitoring impact events at crosshead guide and valve signatures at cylinder.

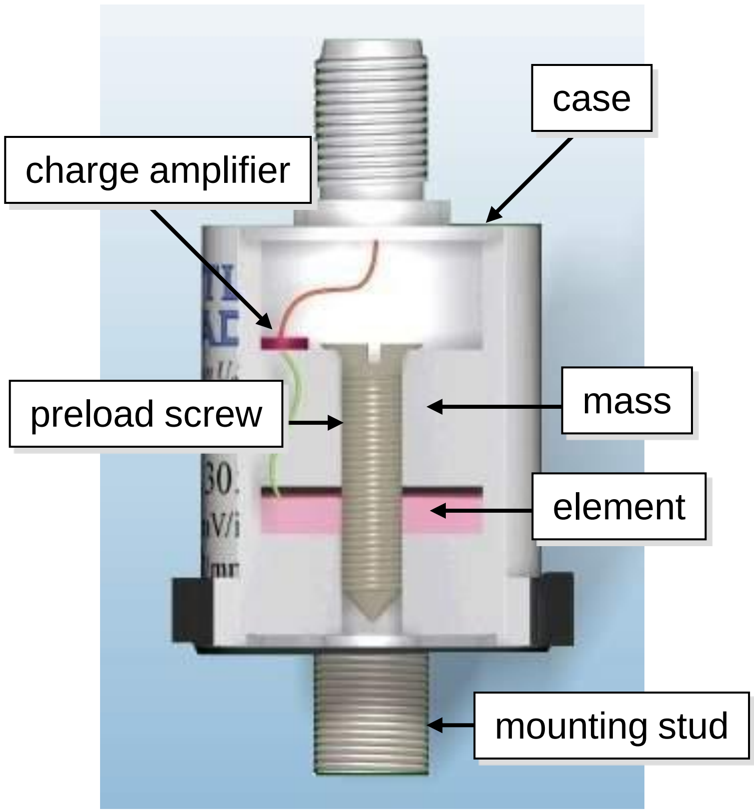




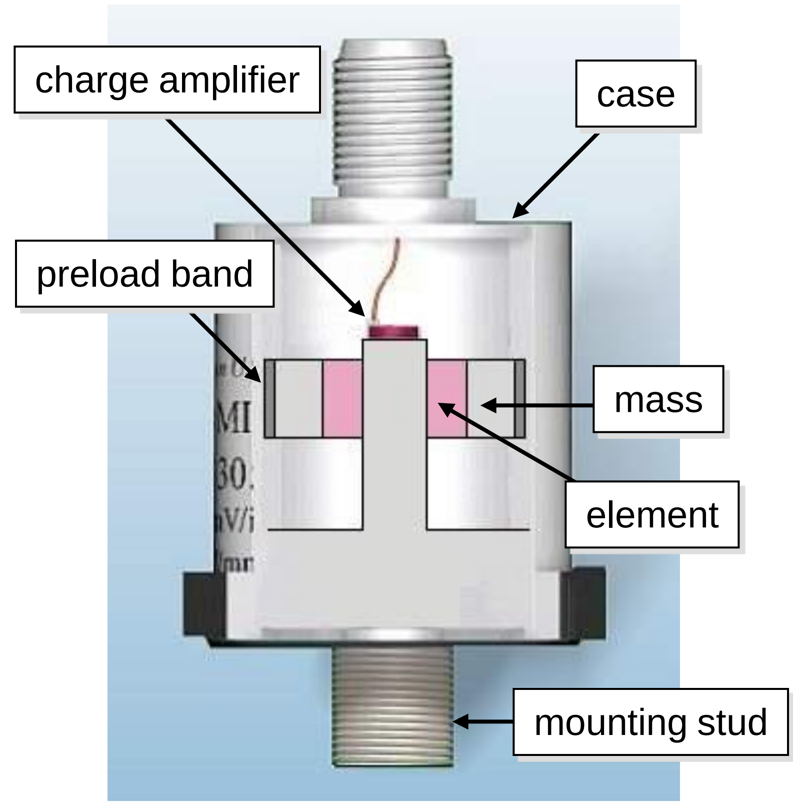
- Units: meters per second^2 (m/s^2), inches per second^2 (in/s^2), or Gravity (g)
- High frequency response (up to ~20 kHz)
- Typical Scale Factor 100mv/g (p-p)

EFRC

Accelerometer Specifics



compression type sensor



shear type sensor

Piezoelectric Accelerometer

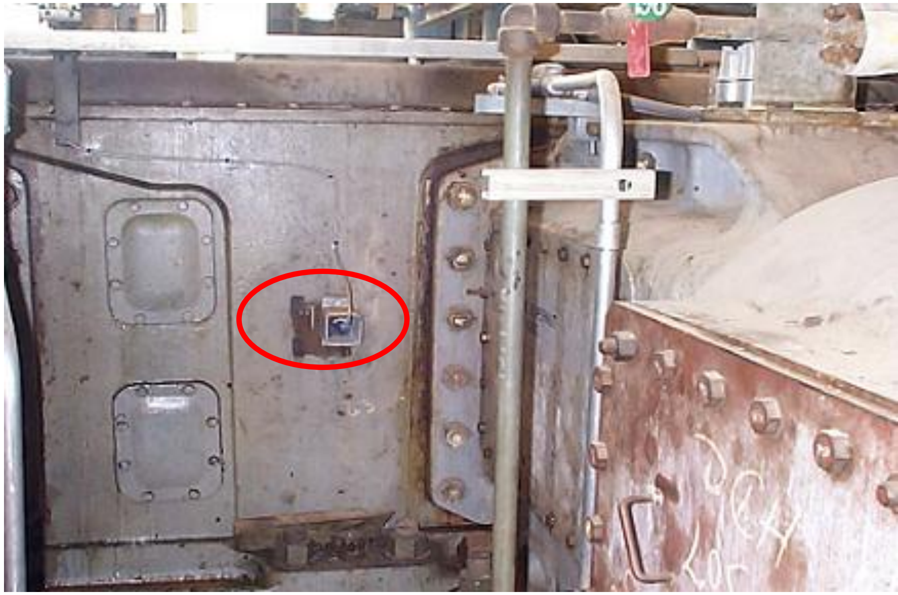
Frame Vibration (Velocity)

Frame vibration is the response of the system to dynamic loads: gas load, inertial load, gas unbalance.

Many years of analysis and study of velocity data before perfecting piezo-sensors has resulted in vibration monitoring guidelines (such as ISO standards) that include recommended severity levels based on units of velocity.

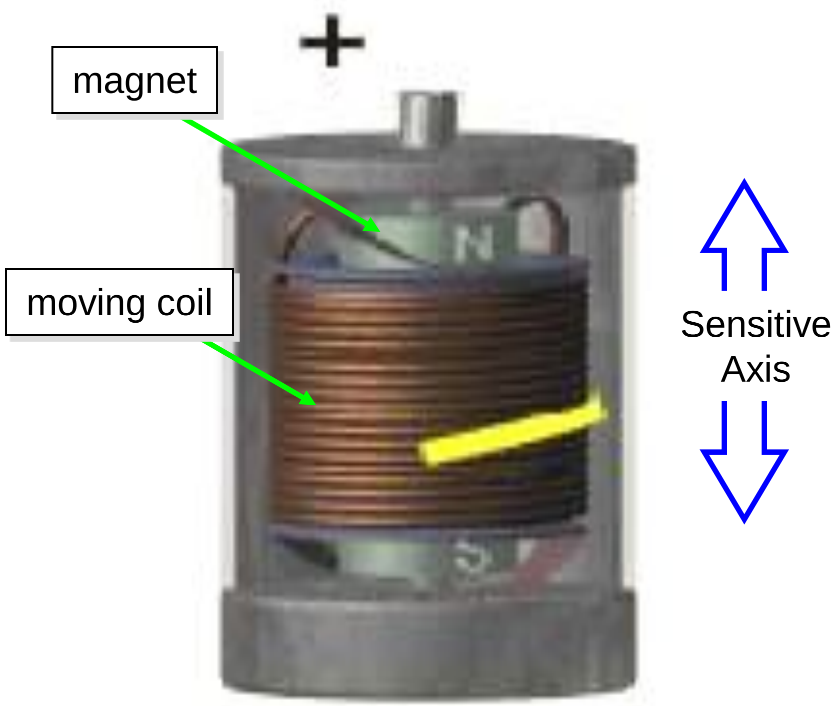
Excess or unbalanced load, inertial imbalance, loose foundation can be detected by frame vibration measurement.

Units: millimeters per second (mm/s) or inches per second (ips)
Typical Scale Factor: 100mv/in/s (p-p).

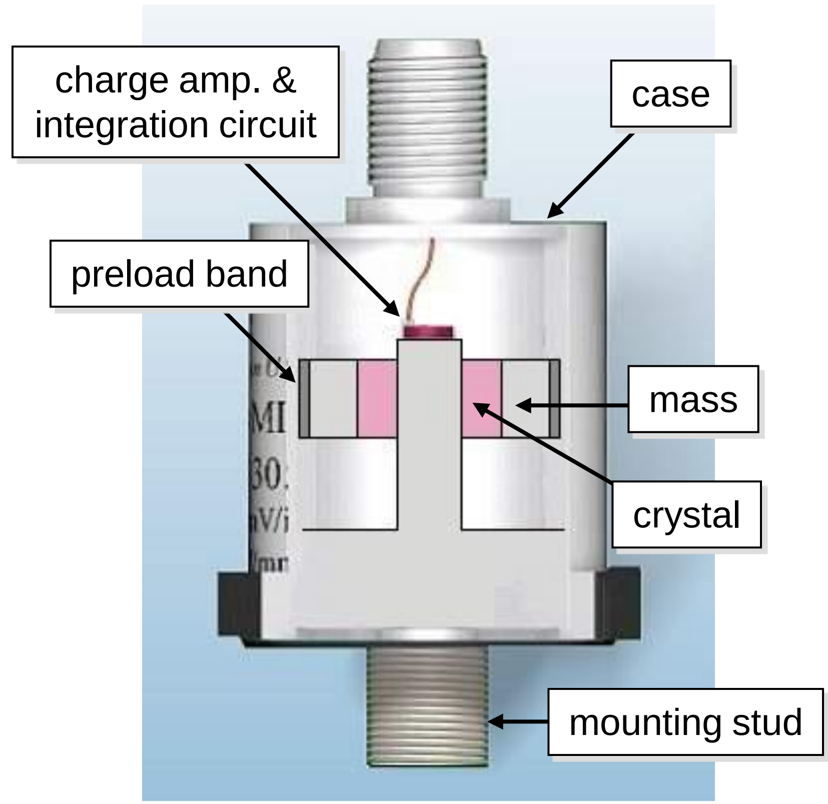


Frame vibration installation

Velocity Sensor Specifics



Traditional Moving-Coil Sensor
(self-powered)

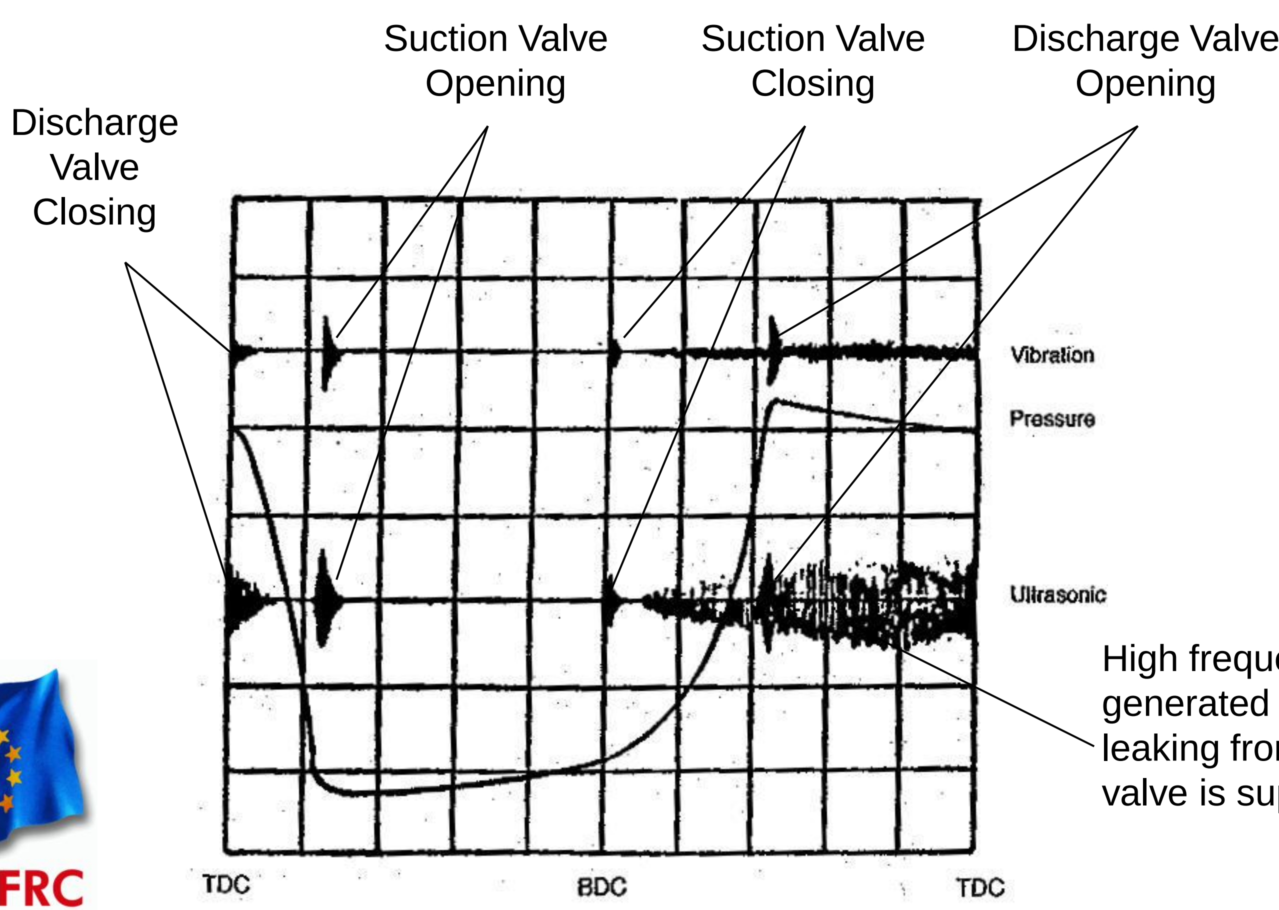


Piezo-Velocity Sensor
(Accelerometer with onboard integrating circuit)

Integration within the sensor minimizes signal noise

Ultrasonics: Acoustic Emission for Valve Leakage Detection

High frequency signatures generated by leaks in valves, piping and other process systems can be identified using ultrasonics. Measurements are usually made as snapshots with portable systems.

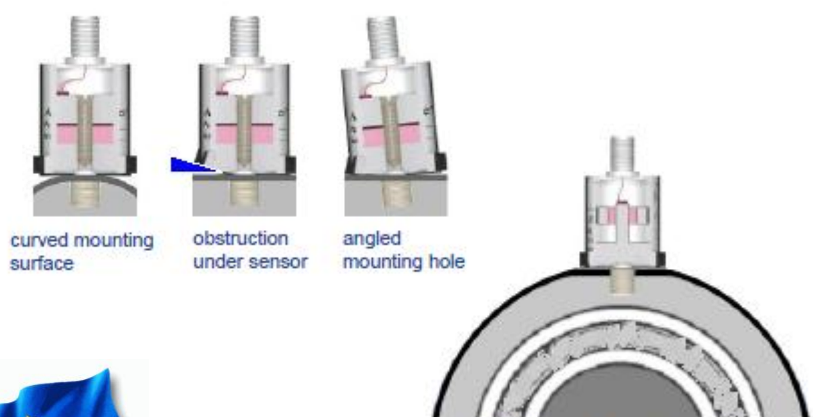


High frequency vibration (AE) generated by the turbulent flow of gas leaking from a suction valve when the valve is supposed to be closed.

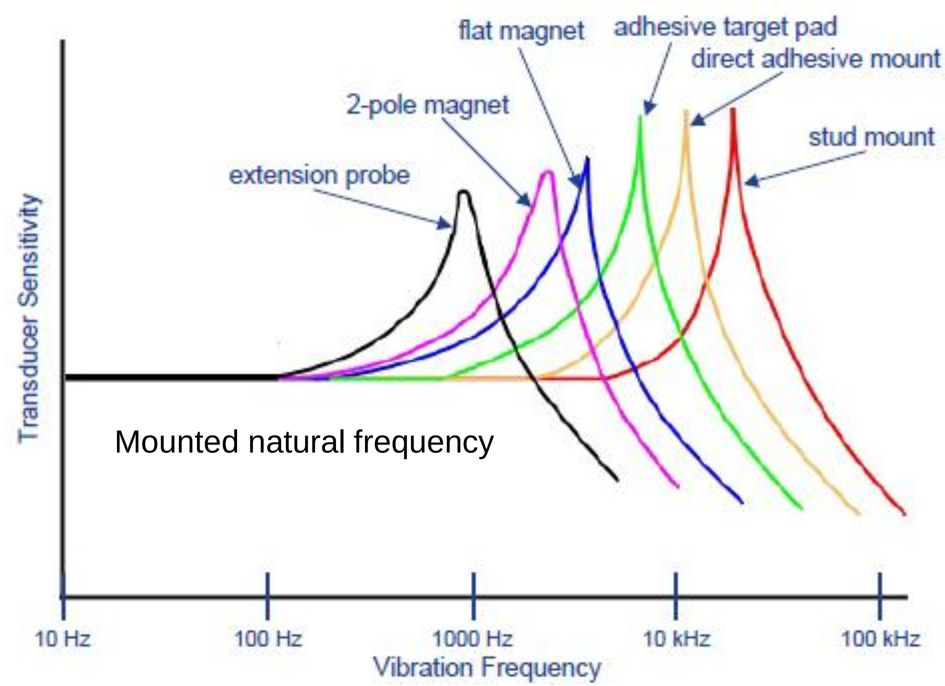
Mounting considerations

To ensure accurate and consistent readings, transducer mounting is key. Accelerometers are extremely sensitive to the method of attachment.

Permanently installed stud-mounted transducers need flat surface meeting specified tolerances and mounting torque.
Signal noise can also be produced by badly tied or loose cabling.



Spot-faced mounting surface (recommended practice)

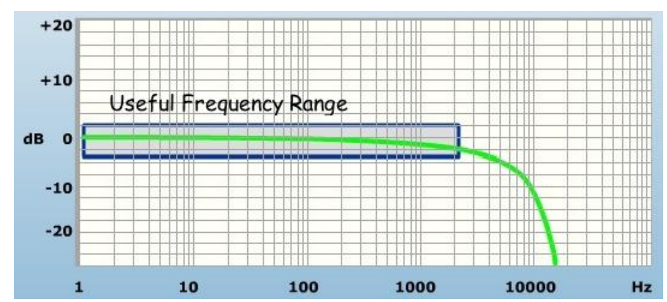


Piston Rod Displacement

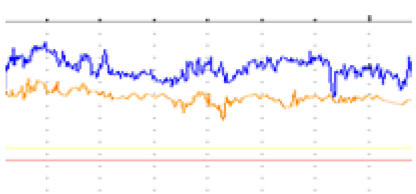
- Eddy current proximity transducer
- Units: microns (μm) or 1/1000 of an inch (mil)
- Measuring rod drop and rod or plunger vibration
- Calibrated to target material

Pitfalls:

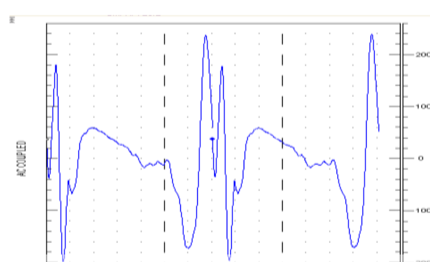
- Wrong material calibration
- Bracket vibration / resonance
- Improper application (rod drop)



Frequency Response down to 0 Hz
Typical Scale factor -200 mv/mil (p-p)



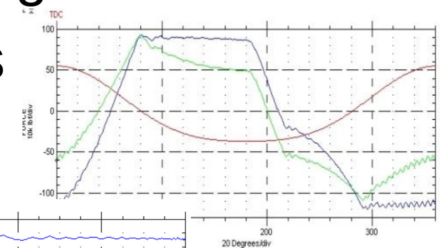
Rod Drop trend

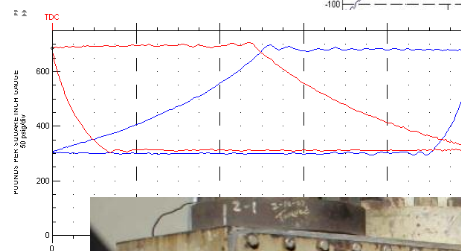


Rod vibration waveform

Cylinder Pressure

- Used to identify leaks at valves, rings, packing case
- Used to determine rod load and load reversal degrees
- Dynamic pressure by piezoresistive transducers
- Absolute pressure for performance calculation
- Isolation valve required for safety
- Snapshot or permanent mount



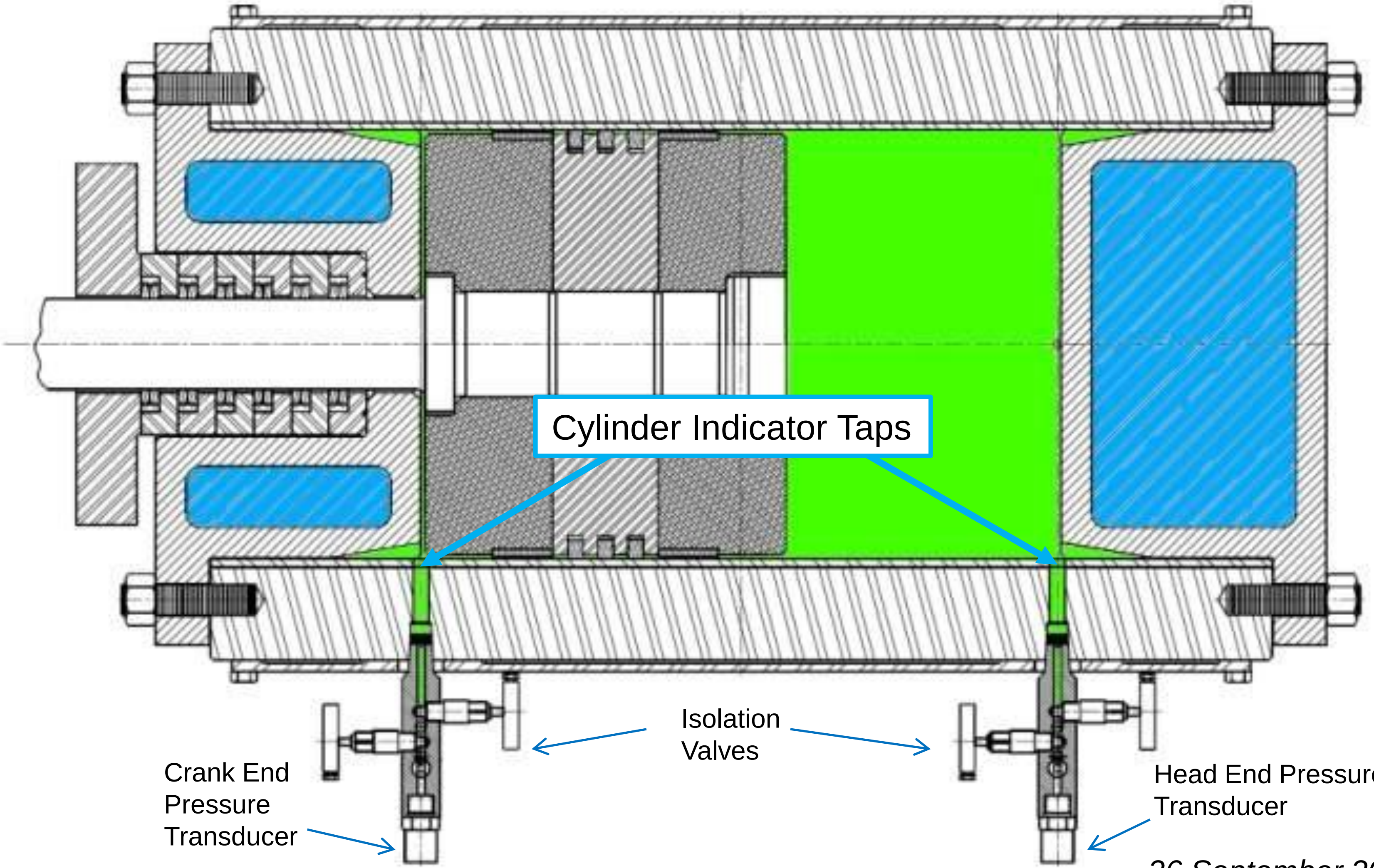


Pitfalls:

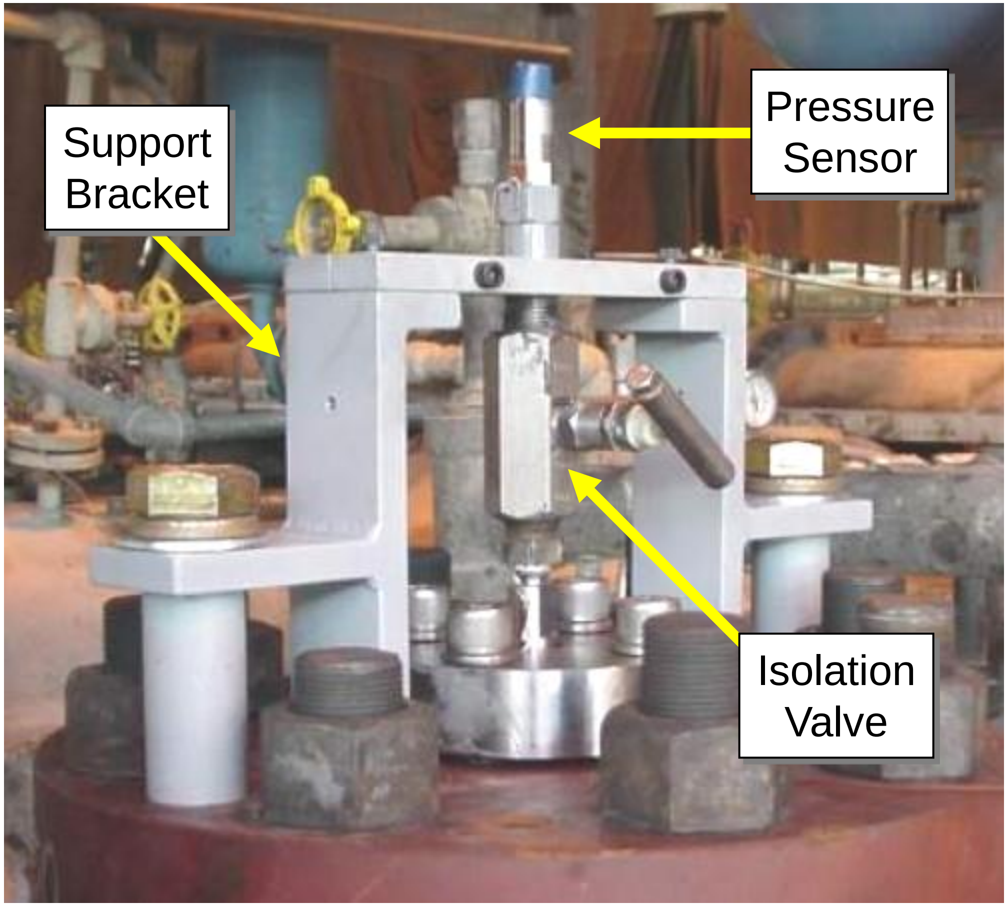
- Channel resonance due to unproper mounting design
- Overpressure damage due to wrong pressure range selection

Pressure Sensor Installation

Pressure sensors should be mounted as close to the chambers as possible with straight, short and constant diameter gas passage

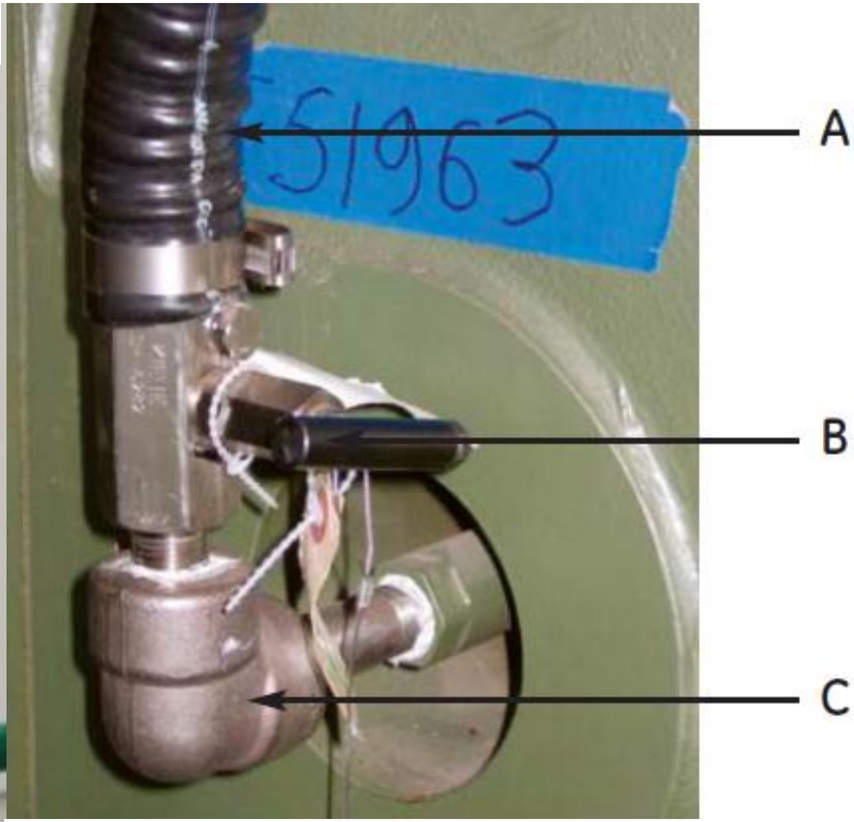


Pressure Sensor Installation



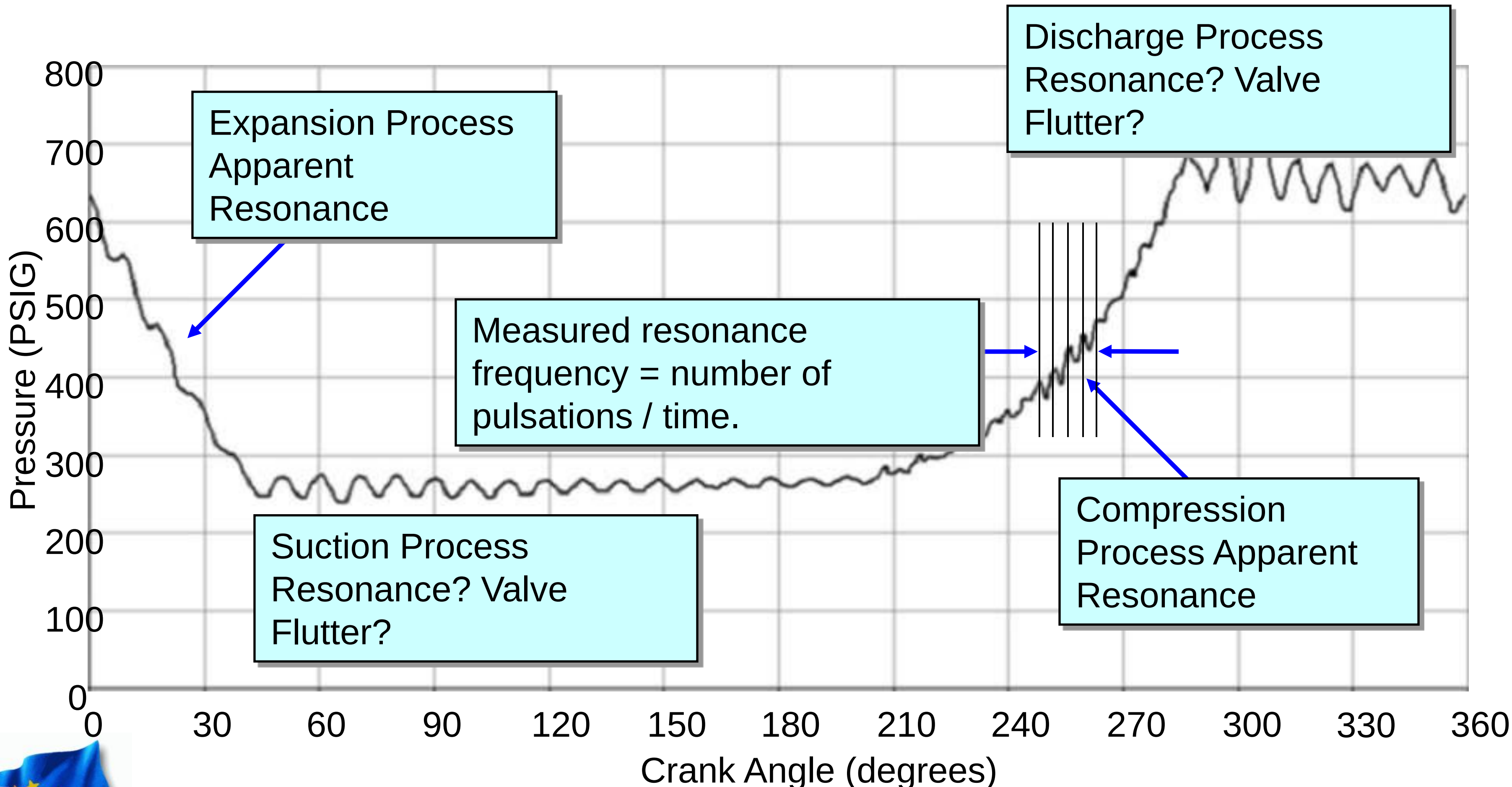
Installation Pitfalls: Channel Resonance

Improper installations leading to channel resonance



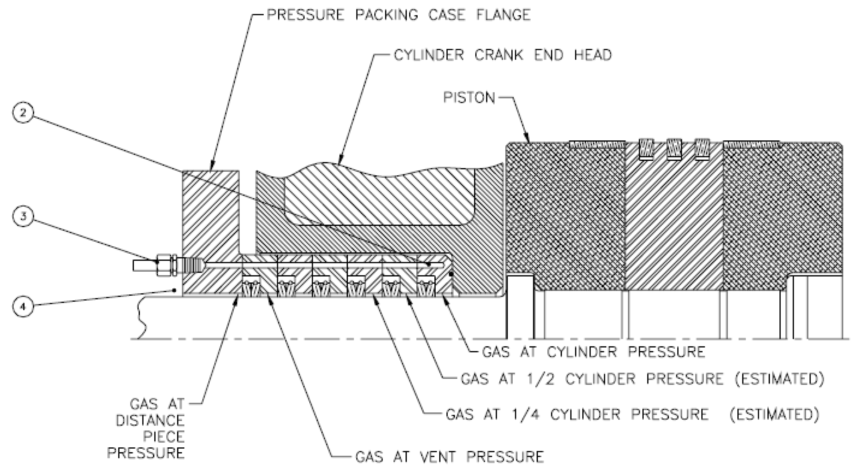
Protective conduit (A) covering transducer and field wiring, isolation valve (B), and 90-degree elbow (C).

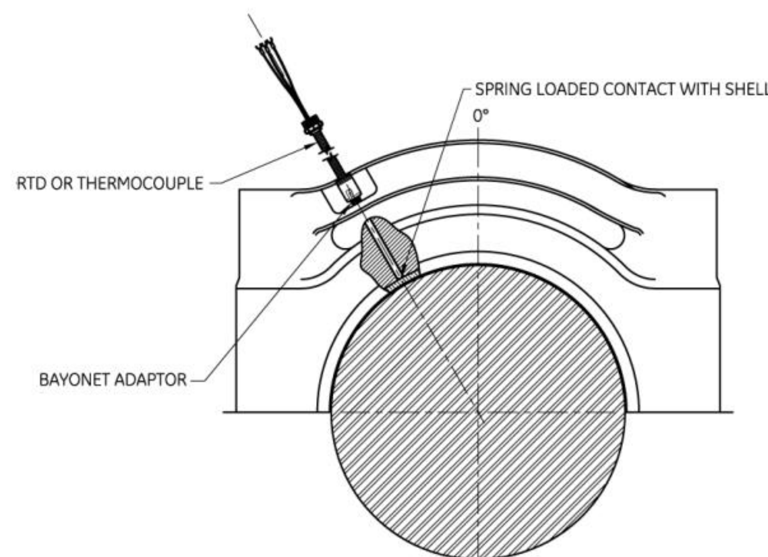
Acoustic Resonance Noise



Temperature measurements

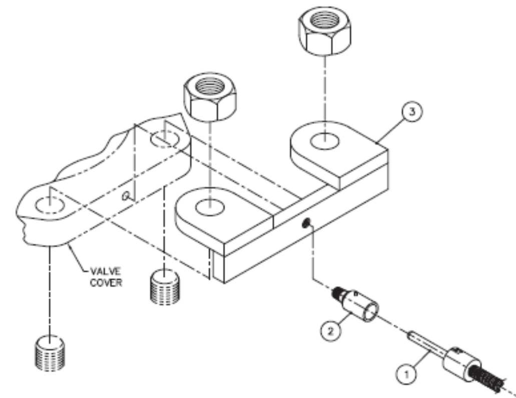
- Main Bearing
- Valve
- Packing Case
- Connecting Rod bearing and Crosshead Pin



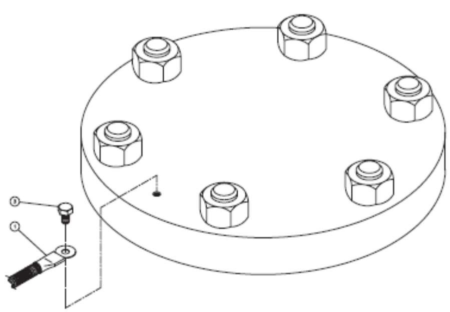


Valve Temperature

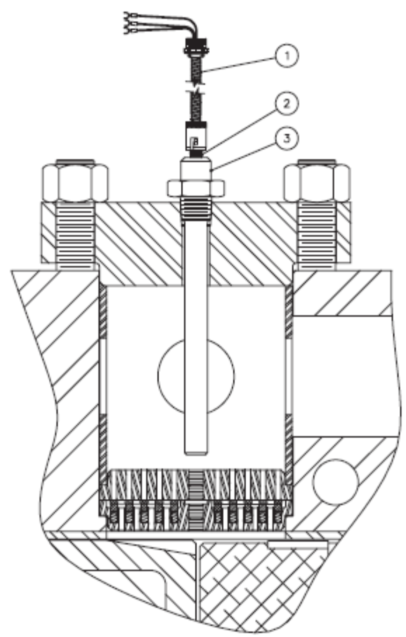
- Valve leaks cause gas recompression and temperature increase
- Monitoring with Thermocouple or RTDs
- Tradeoff between installation effort and benefit
- Also performed with portable instruments



Valve cover temperature



Valve cover skin temperature



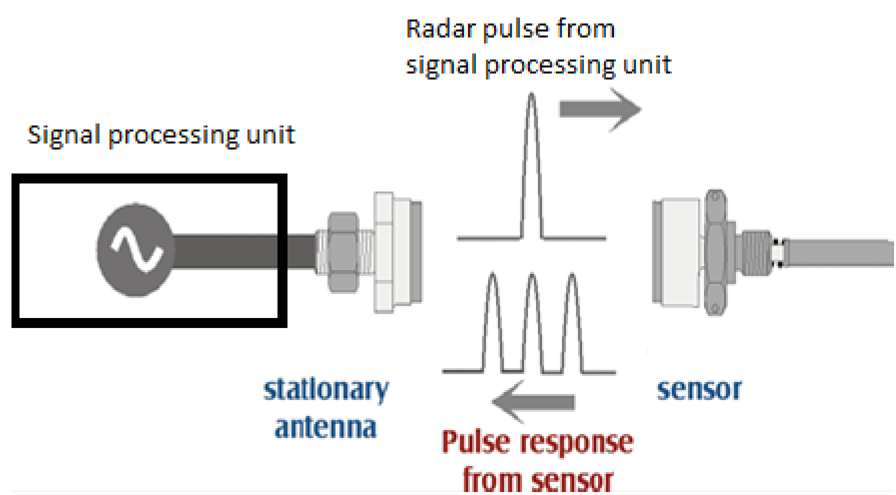
Internal valve temperature

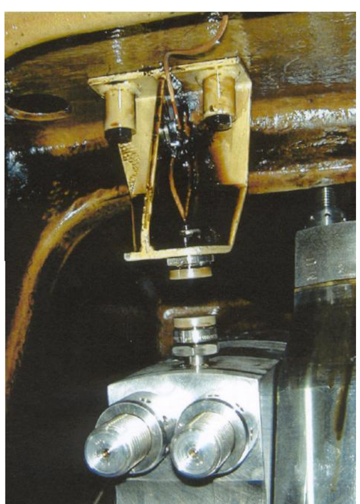
Wireless connecting rod big and small end bearing temperature

A low energy / high frequency Radar Pulse is generated by the Signal Processing Unit (SPU)

Transmission to the wireless passive sensor via the stationary antenna

Reflection of a pulse back to the SPU modified in function of the temperature

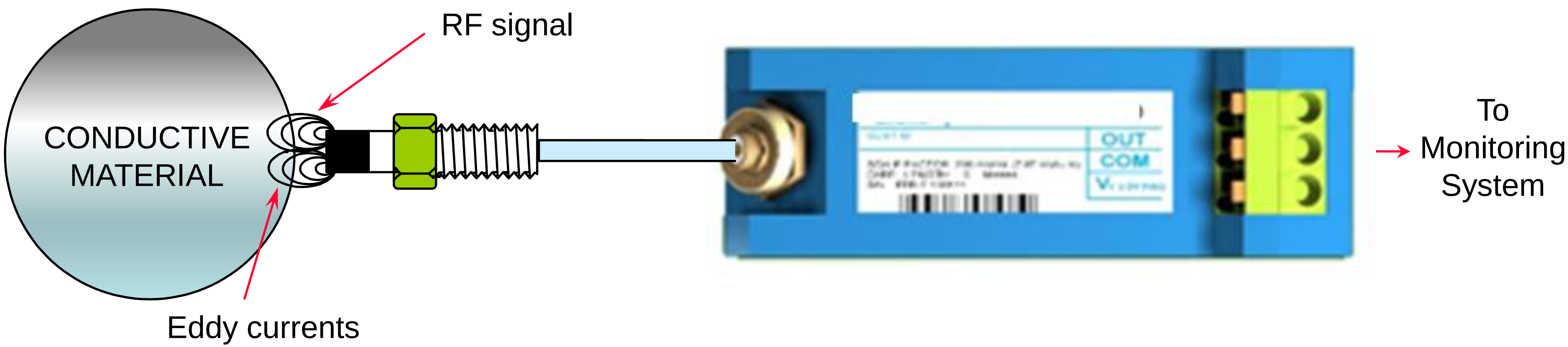


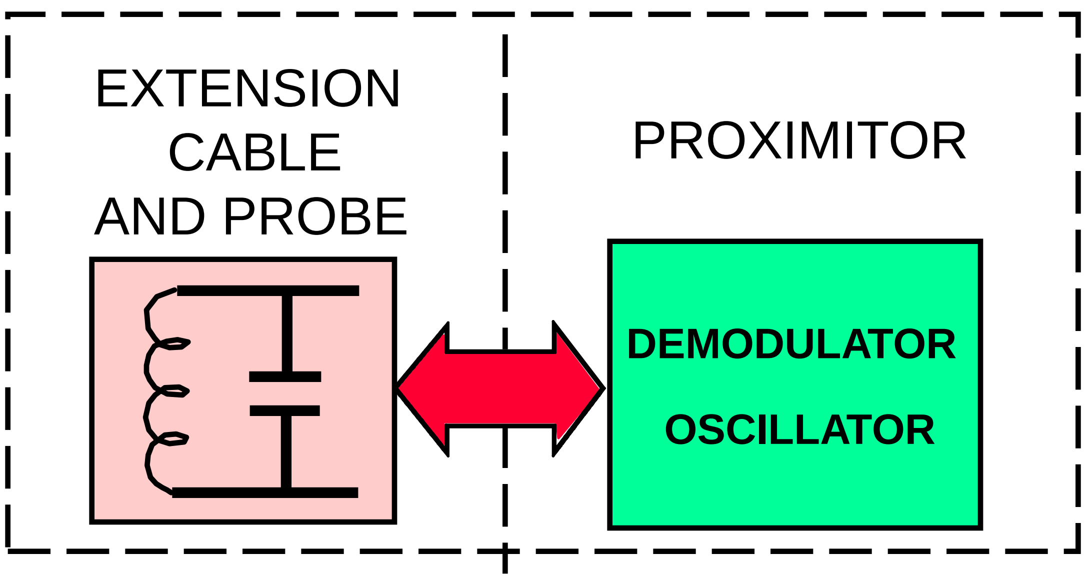


Connecting rod big and small end / crosshead pin

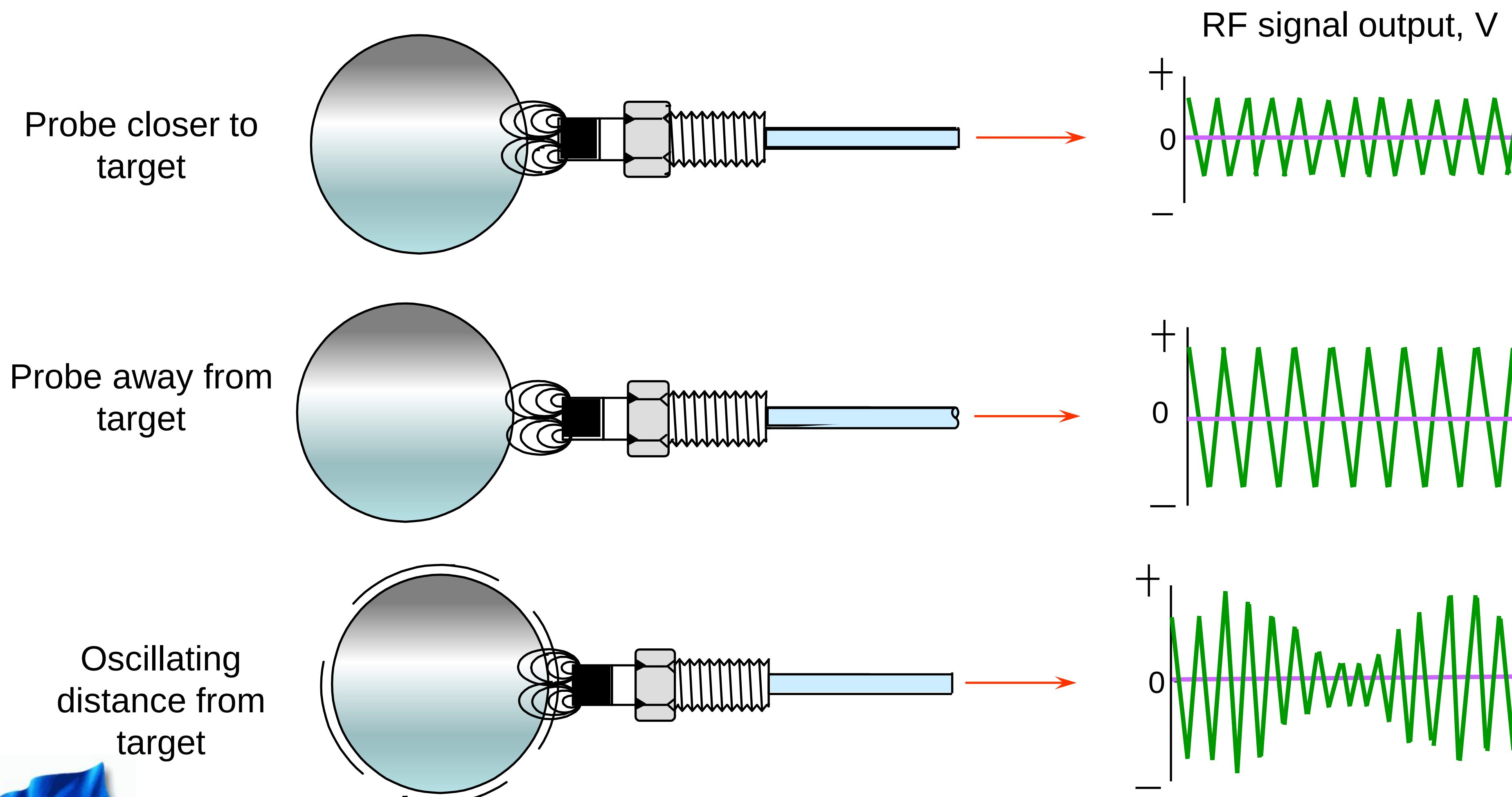
Backup

Proximity Transducer System



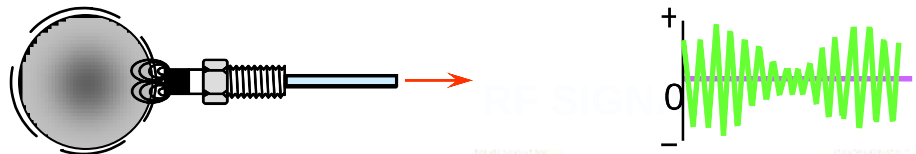


Observed vibration



Target vibration causes the oscillator signal amplitude to be modulated at the same frequency as the vibration.

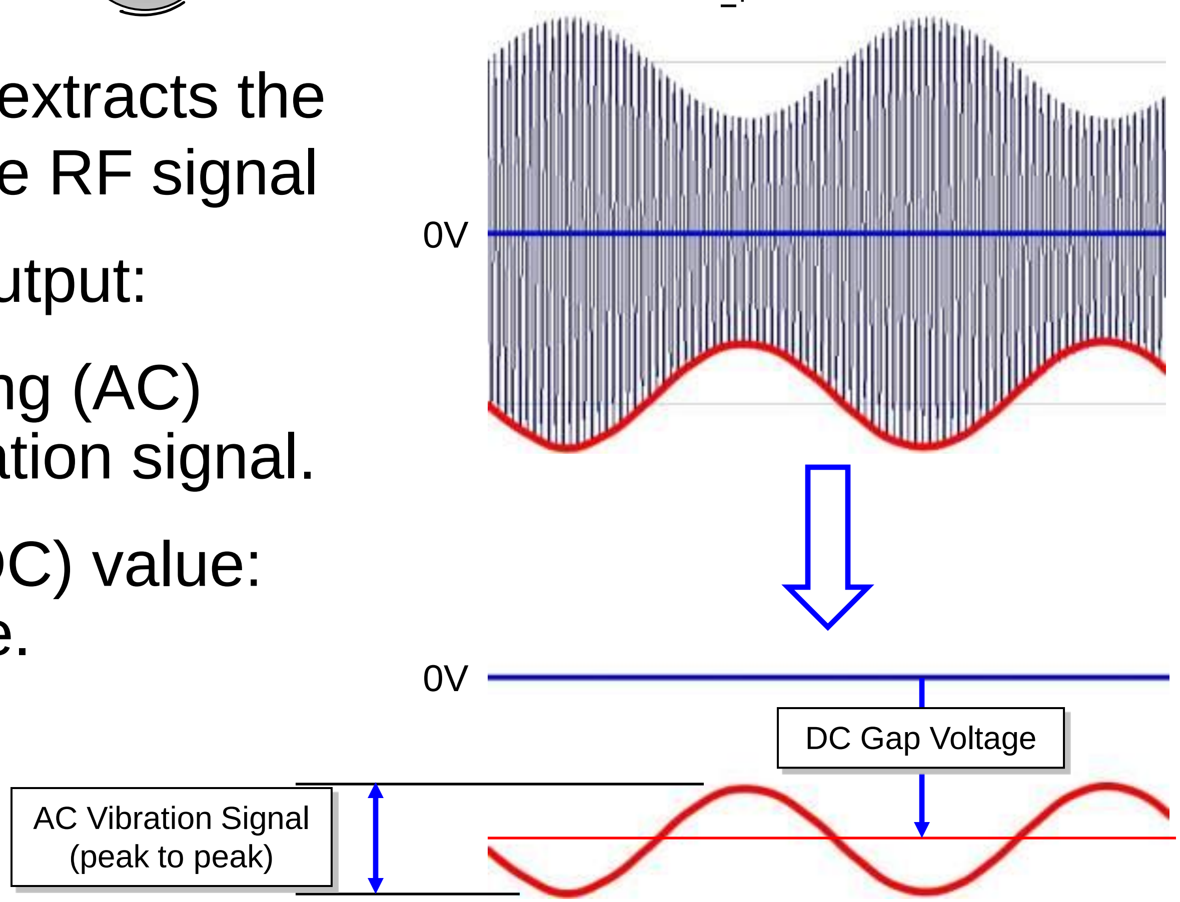
Output values



Demodulator extracts the signal from the RF signal

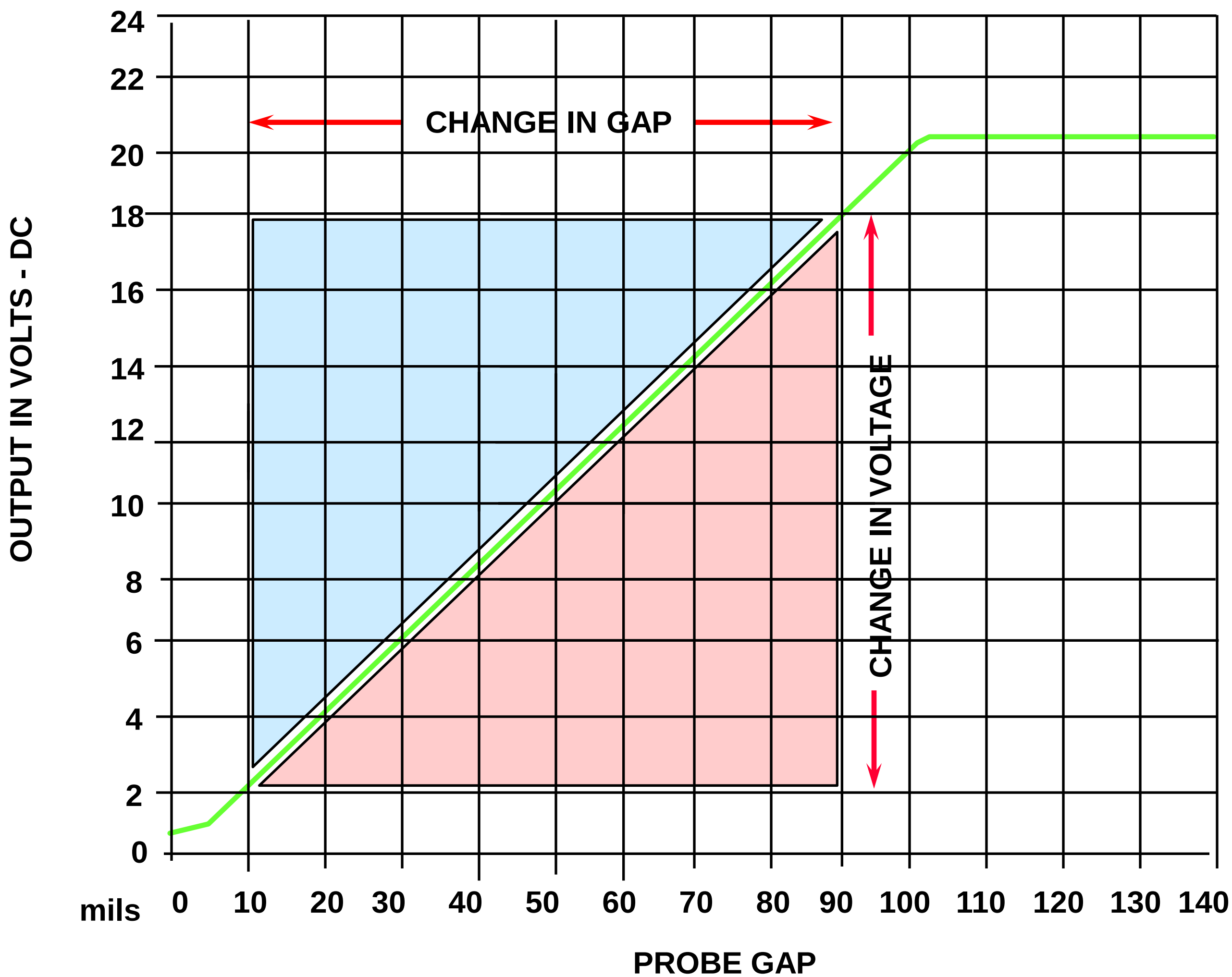
Transducer output:

- Time-varying (AC) value: vibration signal.
- Average (DC) value: gap voltage.



Probe Response Curve

Operational Verification



Shaft Surface Material