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Innovations & Best Practices for monitoring Pressure in Hydropower stations

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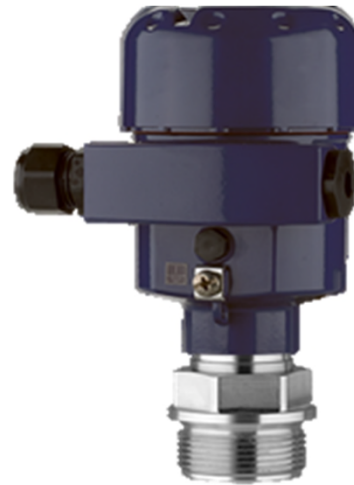
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Pressure Instruments – Gauges , Switches , Transmitters



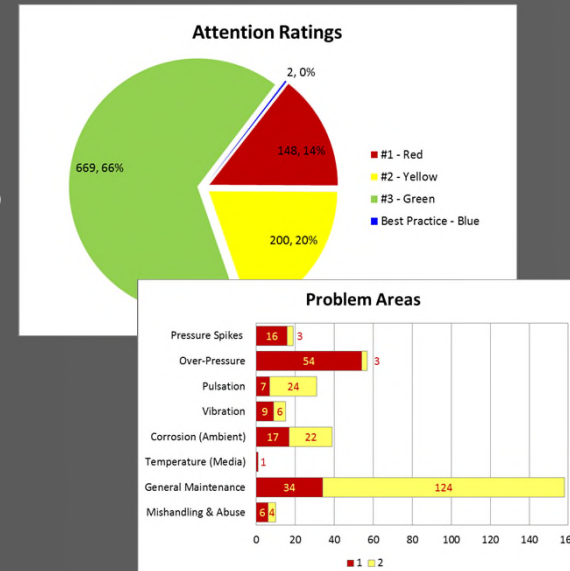


Pressure Instruments: Sole Source of Data

- Discharge pressure
- Suction pressure
- Differential pressure
- Mechanical seal flush pressure
- Inlet / Outlet pressure(s)

Hydropower Plant Example

- 1 FAST engineer onsite 3 days
- 373 Gauges / Instruments Recorded
- 49 **Reds** / 66 **Yellows**
- Overpressure and General Maintenance were top concerns
- Reduced unique models from 160 to 57 – a 64% SKU reduction
- Plant standards created for materials and ranges
- New standards incorporated into SAP

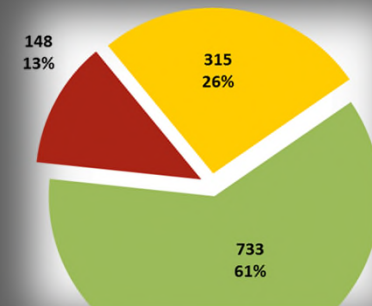
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Another Hydropower Case Study

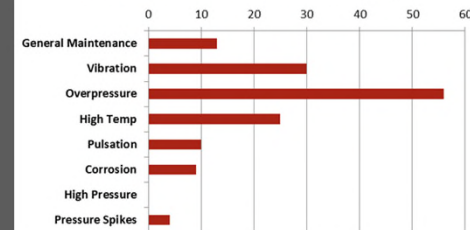
- 2 FAST engineers onsite 2 days
- 399 Gauges / Instruments Recorded
- 48 **Reds** / 105 **Yellows**
- Overpressure and Vibration were top concerns
- Created standards for hazardous material lines
- Implemented features and visual distinctions for various criticality levels



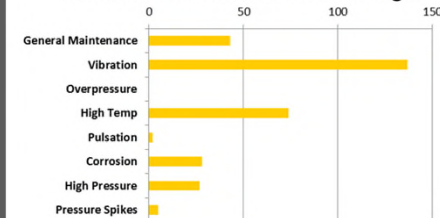
Attention Levels of Observed Gauges



Observed Conditions of Red Gauges



Observed Conditions of Yellow Gauges

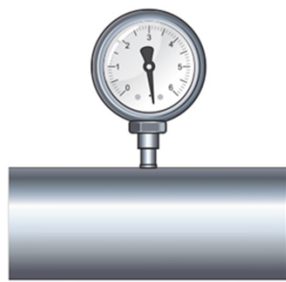


Best Practices :

Let's start with most common failure conditions



Spikes



Overpressure



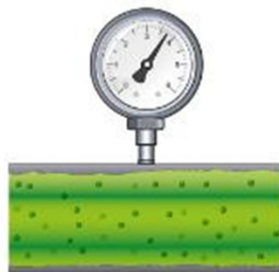
Mechanical Vibration



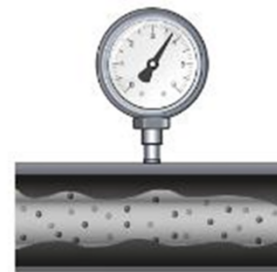
Pulsation



Temperature



Corrosion



Clogging



General Maintenance/
Mishandling

Common Pressure Gauge Failures and Solutions

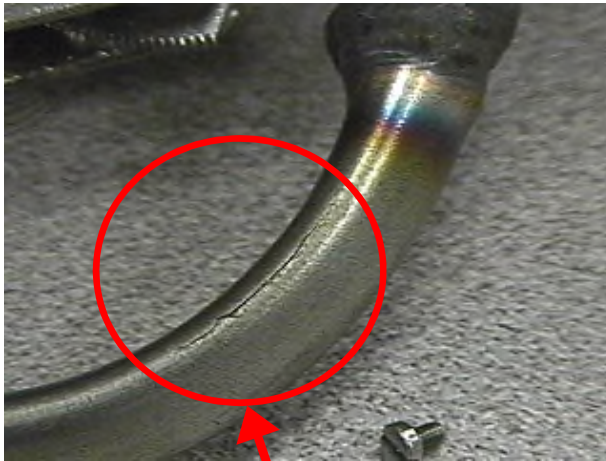
Pulsation – Symptoms & Analysis

- Caused by media rapidly cycling the pressure gauge.
- Increases wear on internal components and Bourdon tube.
- Difficult to read pressure due to pointer flutter.
- If the pointer pulsation increments are greater than 5% of full scale value, you must intervene to prevent damage to the gauge.
- Types of pulsation
 - Centrifugal – high frequency, low amplitude; causes extreme pointer movement, usually contained to small pressure increments.
 - Reciprocating – low frequency, high amplitude; causes rapid pointer movement, may fluctuate over larger pressure increments.

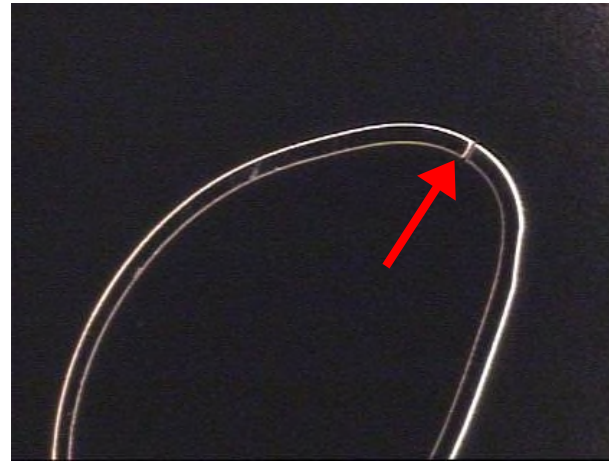


Common Pressure Gauge Failures and Solutions

Failure – Dynamic (cyclic) Load
From Pulsation



Bourdon Tube Split

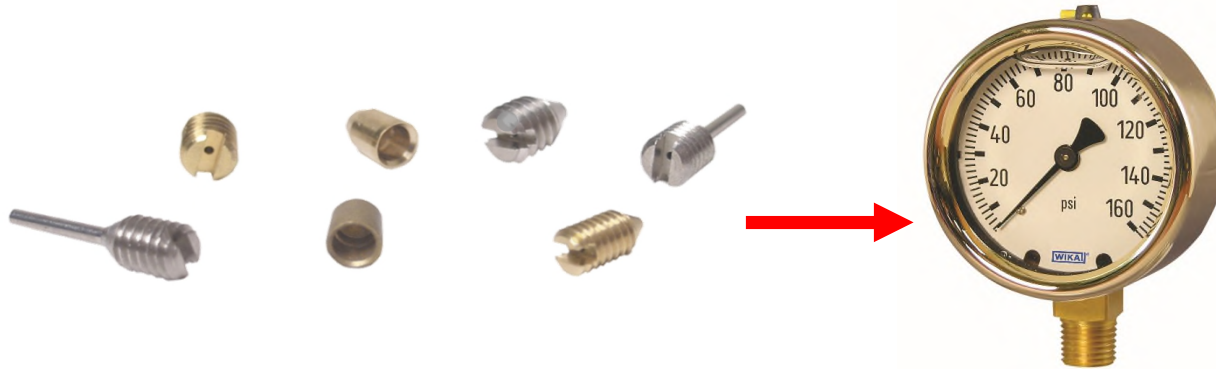


Magnified Cross Section

Common Pressure Gauge Failures and Solutions

Best Practice - Pulsation

- Socket restrictor – Allows pressure to equalize slowly. Economical and low cost solution.
- Liquid filled case – Dampens pulsation. Lubricates and cools moving parts.



Common Pressure Gauge Failures and Solutions

Best Practice - Pulsation

- Needle valves and gauge cocks can be used to throttle down pressure pulsations.
- During periods of extreme pulsation, needle valves and gauge cocks can be used to isolate or block- off the instrument.

Block & Bleed
Needle Valve



Multi-Port
Needle Valve



Mini-Needle Valve



Gauge Cock

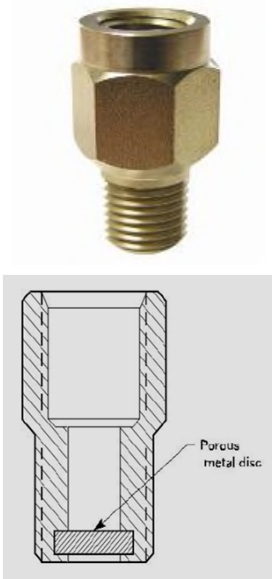


Common Pressure Gauge Failures and Solutions

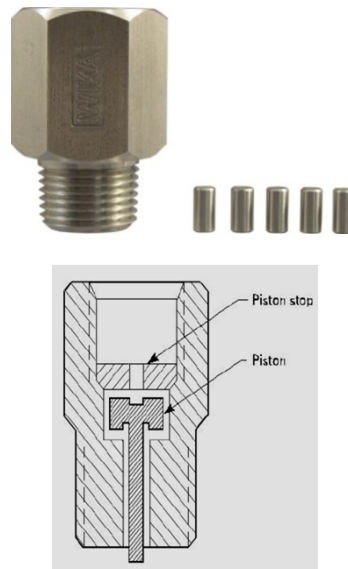
Best Practice - Pulsation

- A liquid-filled case and a restrictor will resolve most pulsation problems, but extreme pulsation requires the use of a snubber.

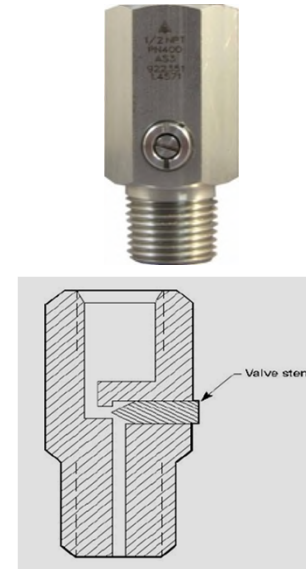
Porous Snubber



Piston Snubber



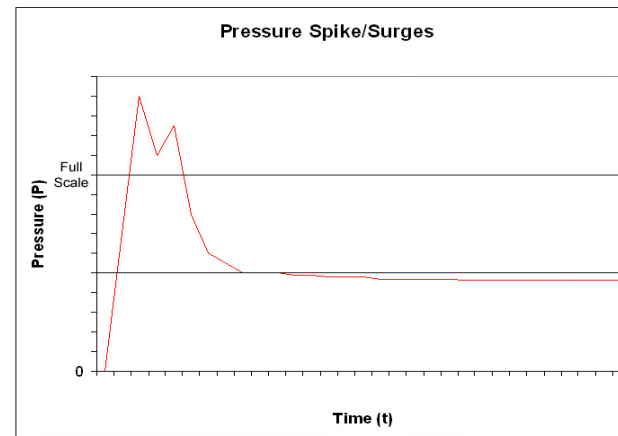
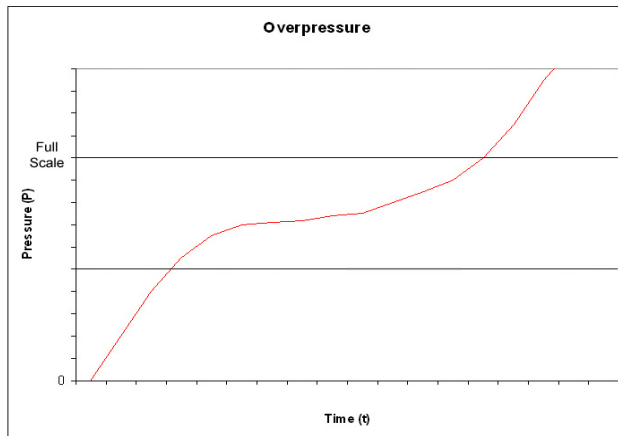
Adjustable Snubber



Common Pressure Gauge Failures and Solutions

Overpressure and Spikes – Symptoms & Analysis

- In general, an overpressure failure is caused by the application of a pressure greater than the rated capacity of the measuring element.
- In some cases ultra fast (*msec*) pressure increases can cause the pressure element to fail well before its “rated” rupture pressure.



Common Pressure Gauge Failures and Solutions

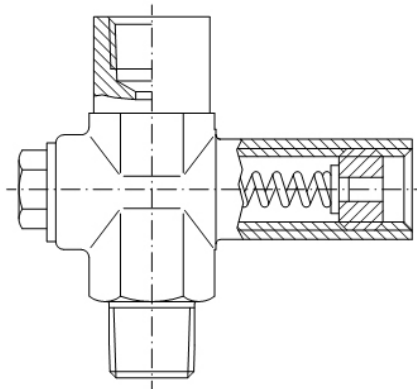
Overpressure and Spikes



Bourdon Tube Warped & Split

Best Practice – Overpressure and Spikes

- At a predetermined pressure, the overpressure protector "shuts-off" pressure to the gauge, preventing damage to the sensing element and protecting the calibration.
- The set-point is externally adjustable. Overpressure protectors generally feature a piston valve which is designed to dampen system pulsation.



Common Pressure Gauge Failures and Solutions

Temperature – Symptoms & Analysis

- Excessively high media temperatures:
 - Place additional stress on the measuring system which can reduce its operating life.
 - Cause components of the pressure gauge to break down and erode (*window material, gaskets, dial, etc*).
 - Can cause the pressure system to fatigue and rupture.



Common Pressure Gauge Failures and Solutions

Best Practice - Temperature

- Ensure that ambient and media temperatures are within allowable temperature limits of the gauge.
- Excessive temperature applications may require the use of accessories or diaphragm seal solutions.
- In addition to Stainless Steel Gauge:
 - Long Pipe (6" to 12")
 - Siphon
 - Cooling Element
 - Cooling Tower
 - Capillary
 - Diaphragm Seal



Common Pressure Gauge Failures and Solutions

Corrosion - Symptoms & Analysis

- Corrosion failure occurs when process media is not compatible to the wetted parts material of the pressure gauge.



Holes in Bourdon
tube

Hole in Bourdon
tube

Common Pressure Gauge Failures and Solutions

Corrosion - Symptoms & Analysis

- Corrosion failure not only occurs from media attacking the wetted parts, but also from corrosives in the environment attacking the case, window and gauge internals.



Corroded Dial



Fogged Window

Best Practice - Corrosion

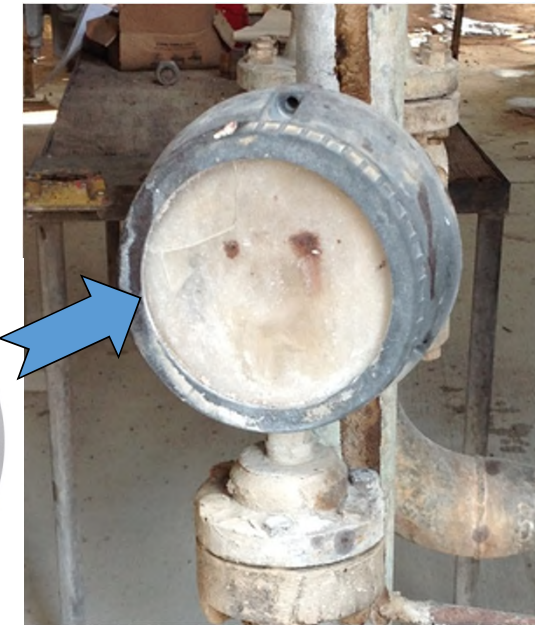
- Ensure that the wetted parts material, case material and internals of the gauge are compatible to the process media and atmospheric conditions
- Excessively corrosive media applications may require the use of diaphragm seal solution



Chemical Seal →

General Maintenance

- General Maintenance - Heavy Build-Up on Instrument housing
- Utilizing process instrument covers can save time and expense ; extend lifetime



Selection / Configuration of Pressure Instruments

- Pressure media composition (compatibility, clogging, crystallizing, etc.)
- Pressure media temperature
- Ambient conditions (temperature and corrosives)
- Pressure range (2 X normal operating pressure)
- Conditions affecting wear of the system (pulsation, vibration, shock, etc.)
- Method of mounting (stem mount, etc)
- Required accuracy

The Pressure Gauge: *Current State*

39.6% of pressure gauges reviewed in refineries or chemical plants have failed or are in danger of failing.

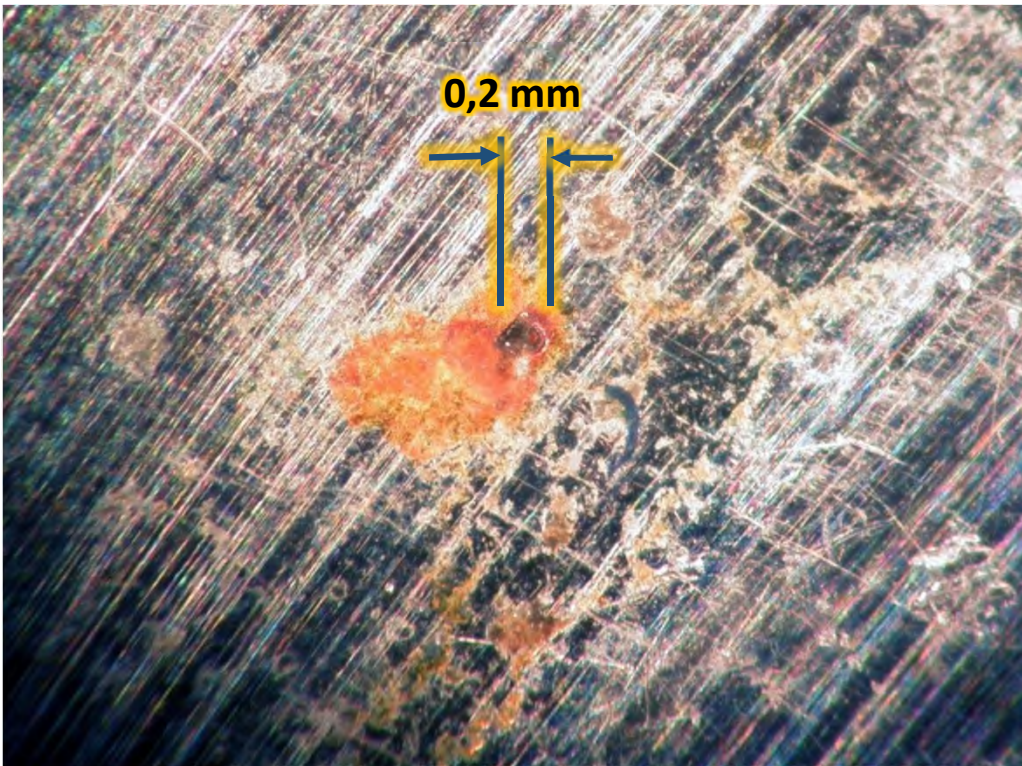
Typically 30% in hydropower systems could be similar or much higher.
Do you know if your gauges have failed or near failure?



Best Practice / Innovation on Pressure Instruments



Pressure transmitter damage ?



Destruction of the diaphragm via pitting corrosion



Mechanical damage

Innovation : Diaphragm Monitoring => reduced failure risk

- Design -

- measuring instrument
- diaphragm seal with double diaphragm
- Monitoring element

Monitoring element

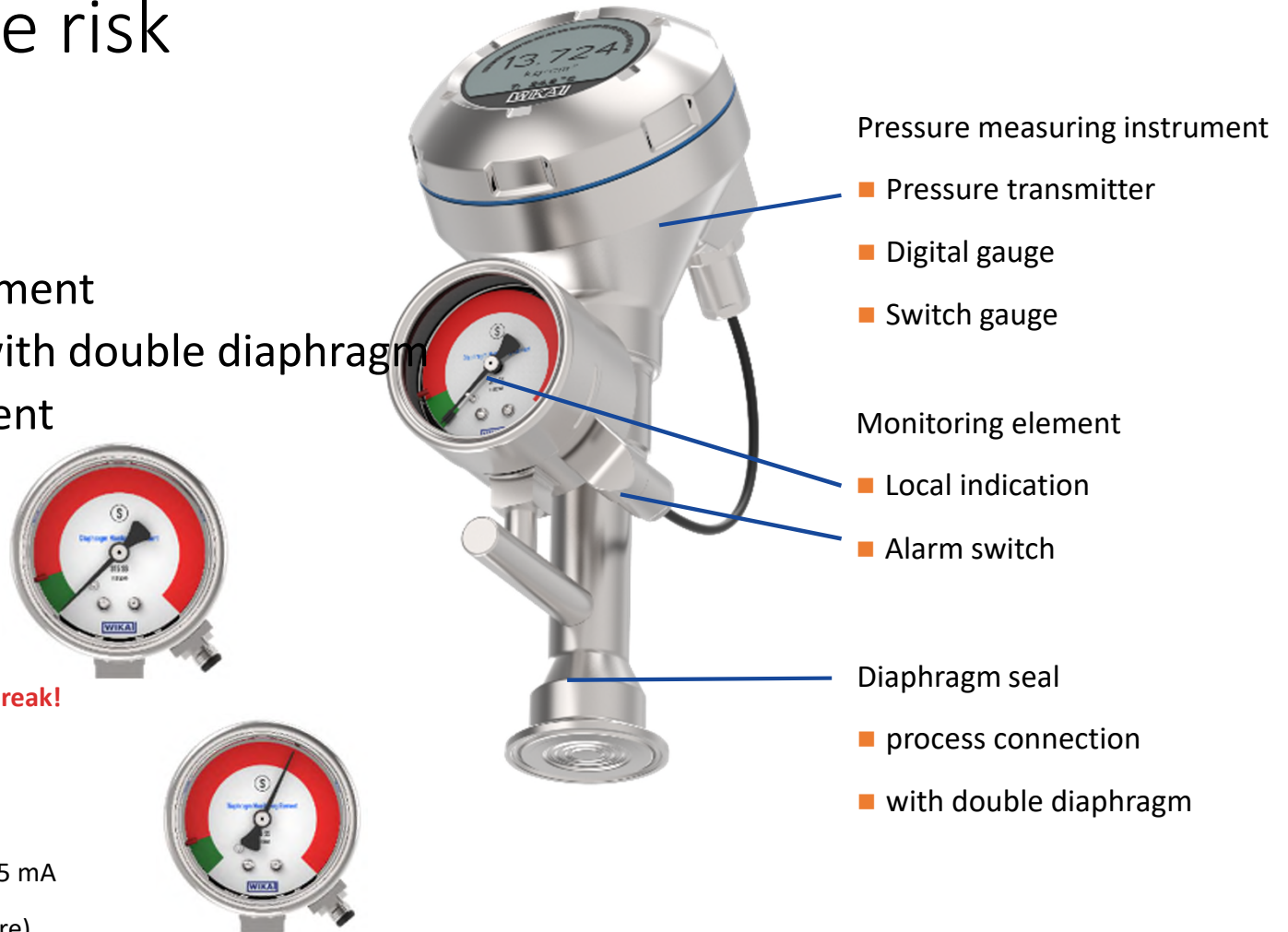
- Local indication

- Pointer in the **green area: OK**

- Pointer in the **red area: Diaphragm break!**

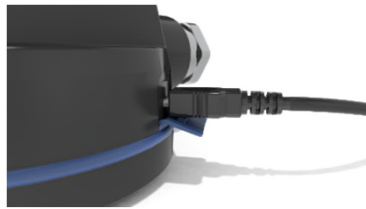
- Alarm switch

- Failure mode signal: Output 3.5 mA
- HART status (Diaphragm rupture)



Innovations in Pressure Measurement

- Electronic differential pressure measurement
- Connectivity – Bluetooth , USB
- Battery powered





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