Preventing Gauge Failures

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Pressure Measurement Products for Swagelok

Swagelok

Agenda

- Pressure Gauge Basics
- Common Gauge Failures
  - Causes
  - Risks
  - Potential Solutions
- Gauge Maintenance
- How to Specify a Gauge for an Application

Pressure Gauge Basics

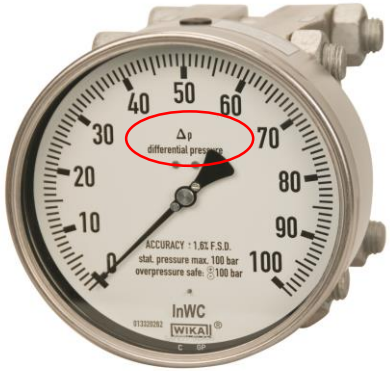
Three Basic Pressure Types

- **Absolute Pressure** – Pressure with a reference to the vacuum of empty space (psia)
- **Gauge Pressure** – Positive or negative pressure with a reference to atmospheric pressure (psig)
  - ***Vacuum Pressure*** *– Negative pressure with a reference to atmospheric pressure(vac)*
  - ***Compound Pressure*** *– Combination of positive and negative pressure with a reference to atmospheric pressure (psig & vac)*
- **Differential Pressure** – The difference between two applied pressures (psid)

Gauge Pressure

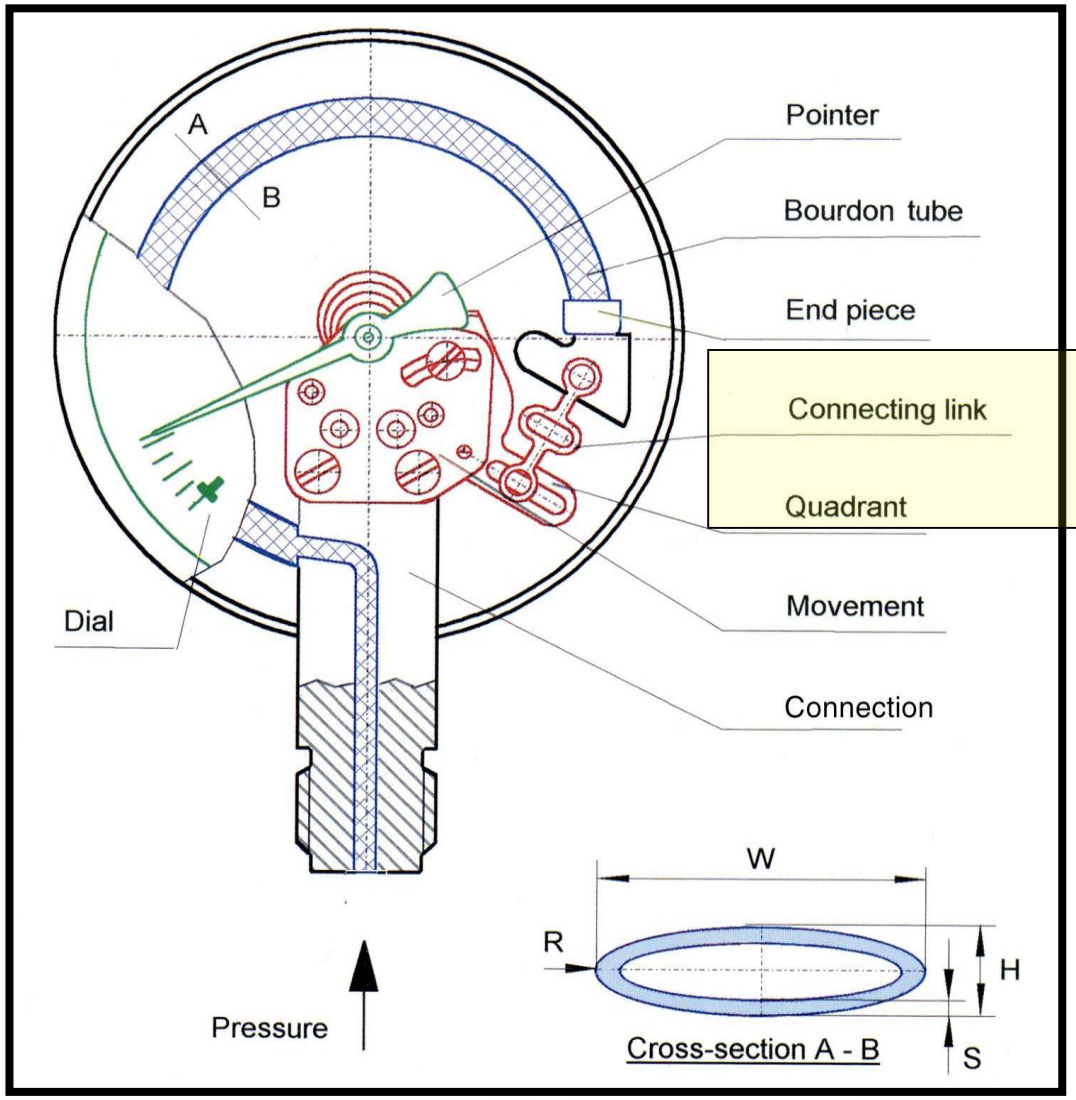
Absolute Pressure

Differential Pressure



Pressure Gauge Basics - Behind the Scenes

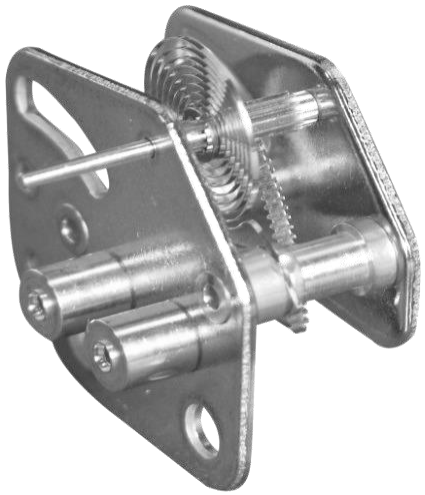
The components of a Bourdon tube pressure gauge are an integral part of the overall system design.



Adjusted during manufacturing to achieve desired accuracy

Pressure Gauge Basics - Movement

- For higher accuracy, all moving components are machined, not formed or pressed
- Precision Movement provides higher accuracy, smoother pointer travel and longer life
- Typically used with Bourdon tube pressure gauges



Bourdon Tube Designs – C-Shape

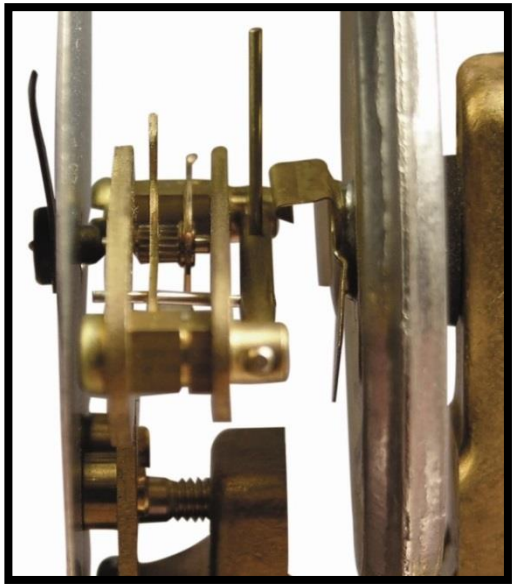
- C-shape bourdon tubes are used for 10 psi to 1000 psi systems
- Made with copper alloy, stainless steel and Monel

Bourdon Tube Designs – Helical/Spiral

- Helical/Spiral tubes are used for 1000 psi and above systems
- Made with copper alloy, stainless steel and Monel

Capsule Element – Low Pressure System

- Capsule elements are used for 10 psi and below pressure systems
- Some models can measure as low as 1 inch of water column (0.036 psi)
- Can only be used for air and dry gaseous media (not liquids)



Swagelok Tube Adapter

Key Features

- Easy Gauge Positioning
- Reliable Connection
- Fast Installation

Common Gauge Failures

Common Gauge Failures

What causes a gauge to fail?

- ✓ **Mechanical Vibration**
- ✓ **Pulsation**
- ✓ **Temperature / Steam**
- ✓ **Pressure Spikes / Overpressure**
- ✓ **Corrosion**
- ✓ **Clogging**
- ✓ **Mishandling / Abuse**

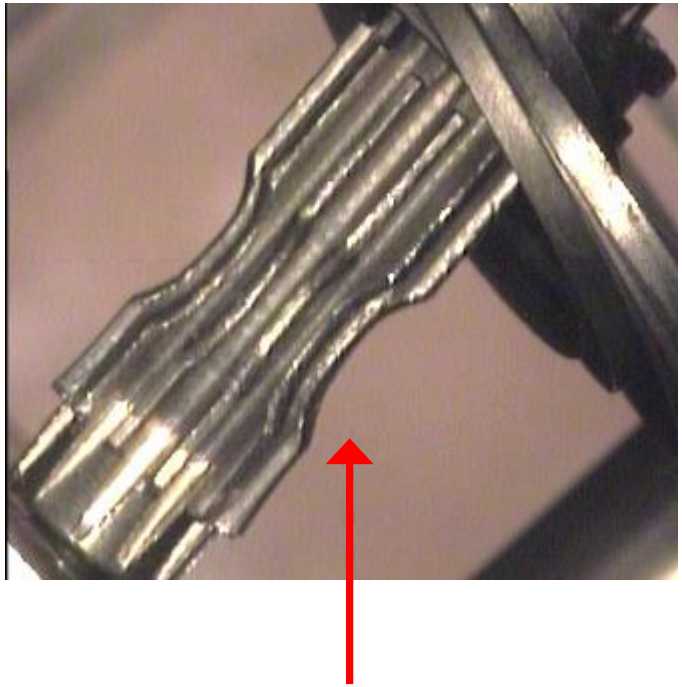
What Causes Gauges to Fail?

Mechanical Vibration

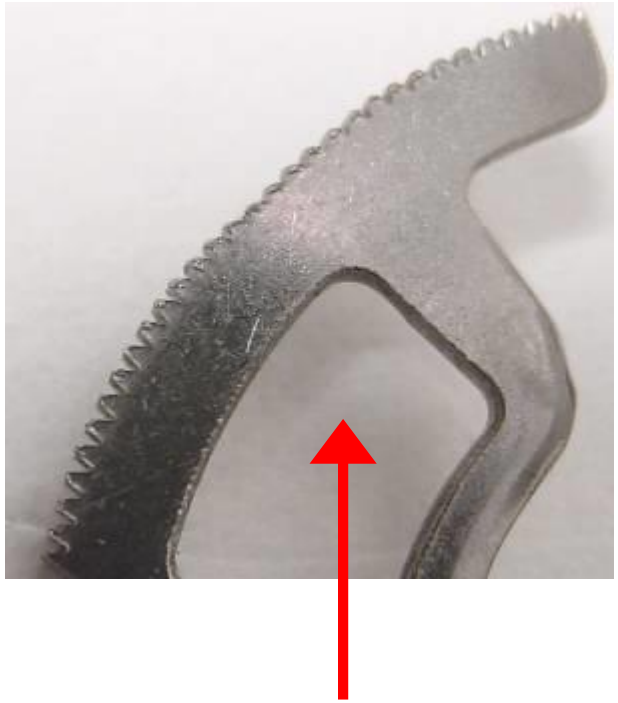
Failure Mode – Mechanical Vibration

- Caused by vibrating equipment near the gauge
- Usually occurs from pumps or similar type of reciprocating equipment
- Increases wear on movement & internal components
- Difficult to read pressure due to gauge vibration
- Similar to premature failure caused by pulsation

Failure Mode – Mechanical Vibration

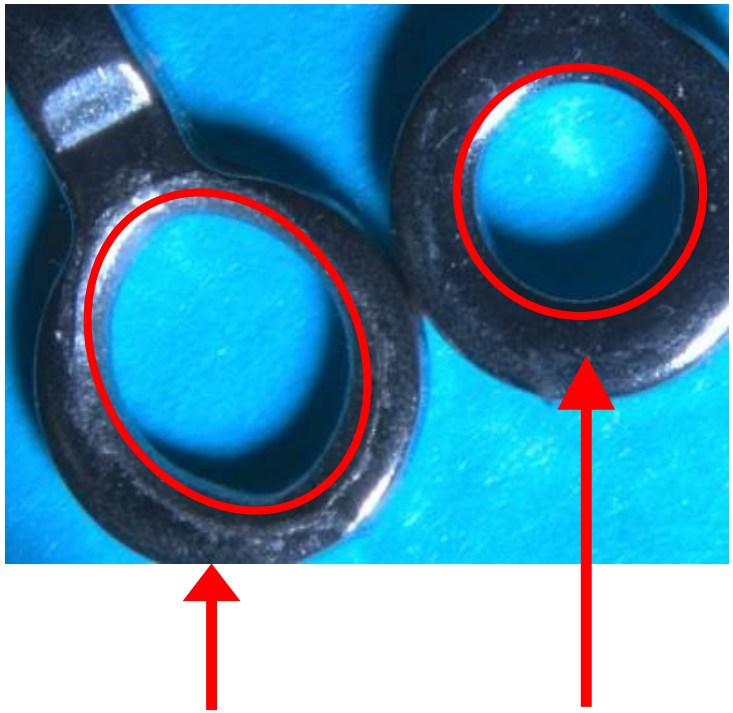


Worn Pinion Gear



Worn Segment Gear

Failure Mode – Mechanical Vibration



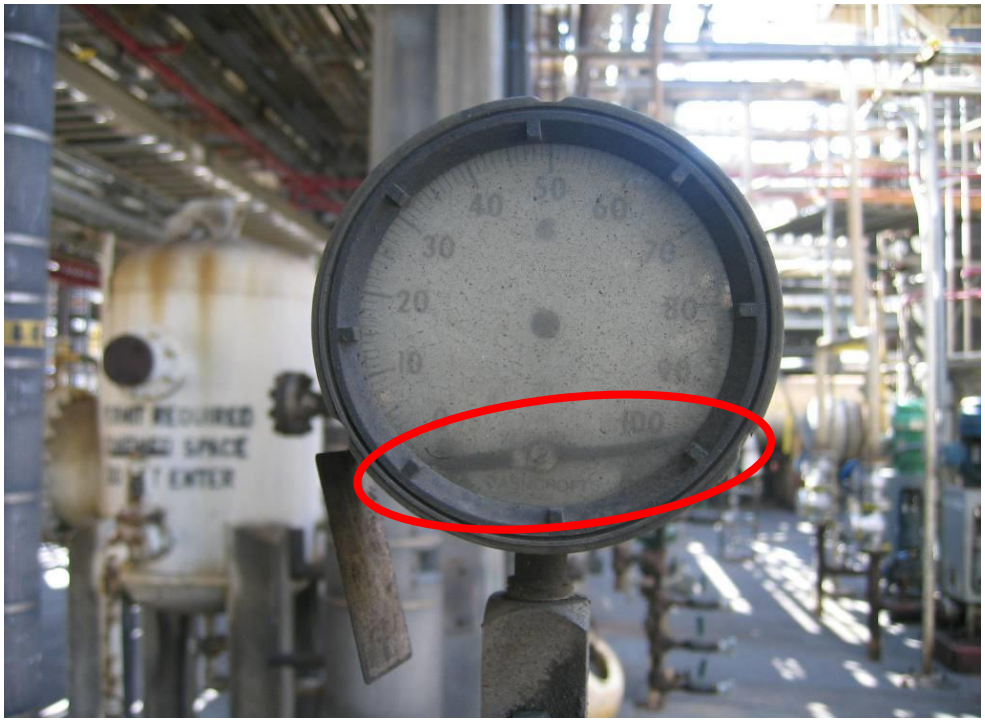
Worn Link

Normal Link

Crack in Bourdon Tube

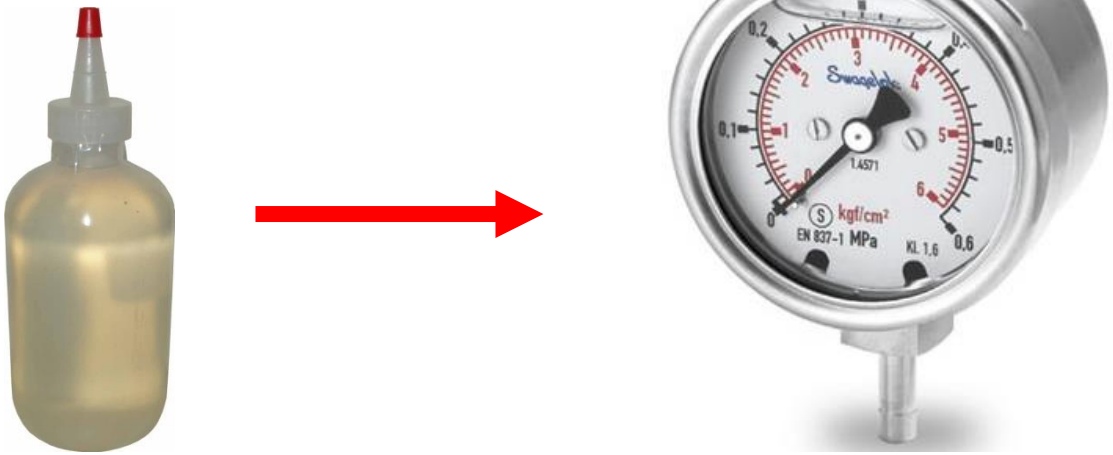
Failure Mode – Mechanical Vibration

- Pointer has fallen off due to severe vibration
- Dust on inside of window from wear of internal components



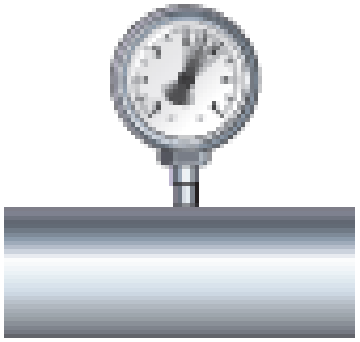
Mechanical Vibration - Solutions

- Relocate the gauge away from the source of vibration
- Liquid-filled gauge – dampens vibration to movement, Bourdon tube and internal components. Lubricates moving parts and eliminates or reduces resonant frequency**.**
- Available case fills are Glycerine, Low temp Glycerine, Silicone, Halocarbon and Fluorolube



What Causes Gauges to Fail?

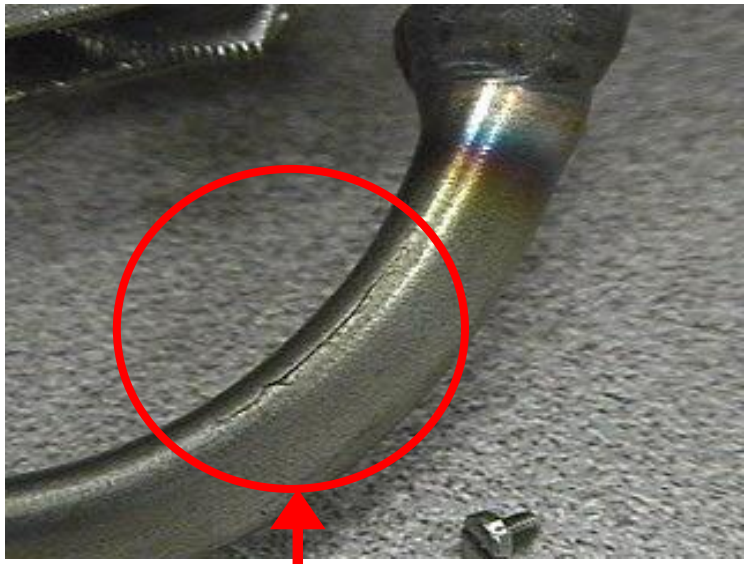
Pulsation



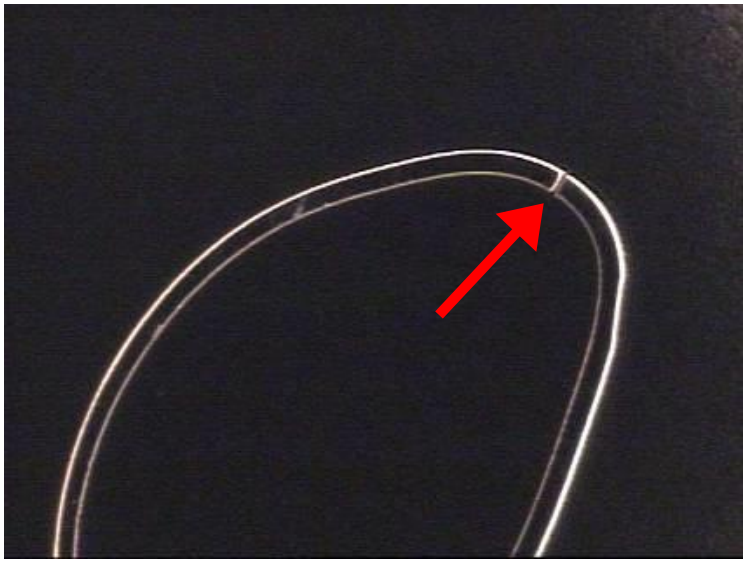
Failure Mode – Pulsation

- Caused by media rapidly cycling the 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

Failure Mode – Pulsation



Bourdon Tube Split



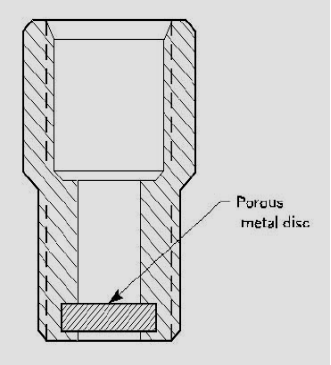
Magnified Cross Section

Pulsation - Solutions

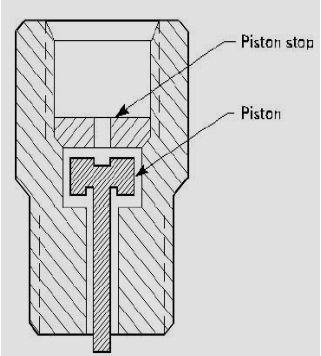
- Socket restrictor – Allows pressure to equalize slowly. Economical and low cost solution
- Liquid filled case – Dampens pulsation. Lubricates and cools moving parts

Pulsation - Solutions

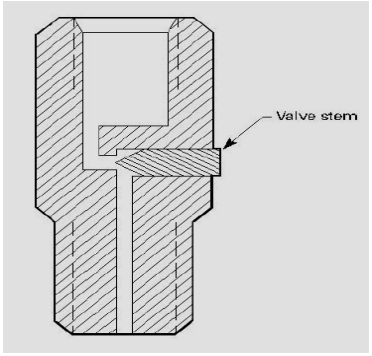
Porous Snubber



Piston Snubber



Adjustable Snubber



Pulsation - Solutions

- A liquid-filled case and a restrictor will resolve most pulsation problems, but extreme pulsation requires accessories.
- Needle valves and gauge cocks can be used to throttle down pressure pulsations.

Block & Bleed Needle Valve

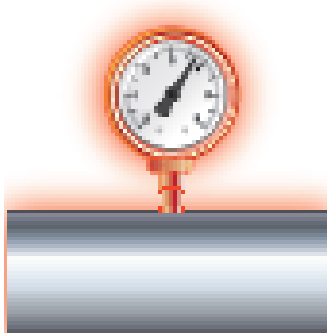
Multi-Port Needle Valve

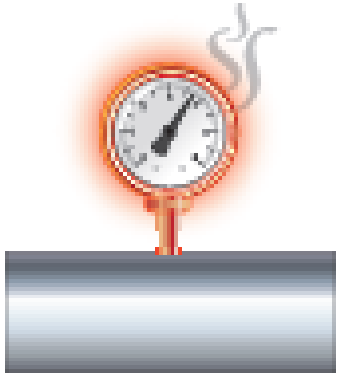
Mini-Needle Valve

Gauge Cock

What Causes Gauges to Fail?

Temperature & Steam





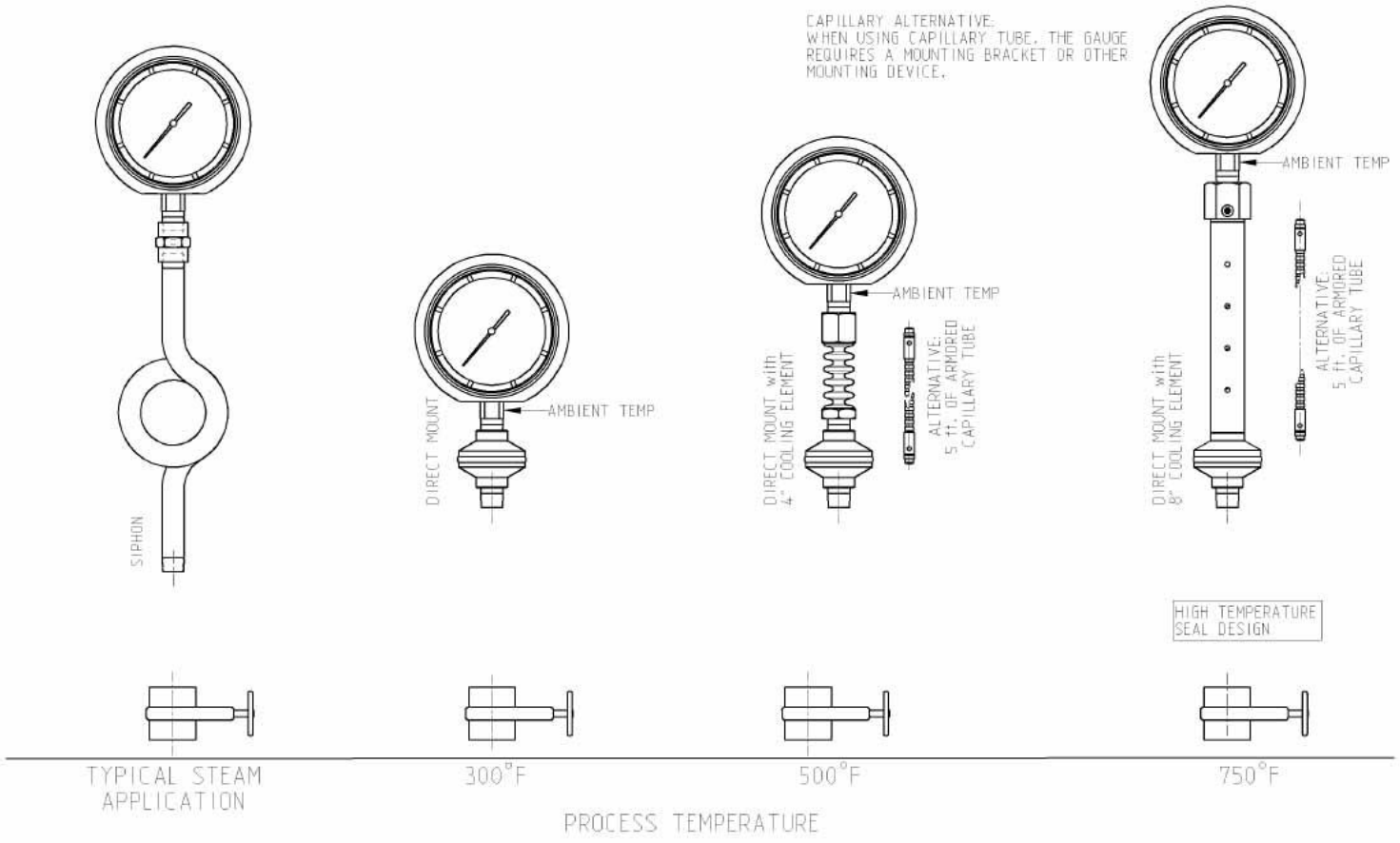
Failure Mode – Temperature

- Ambient temperatures are just as important as process media temperatures

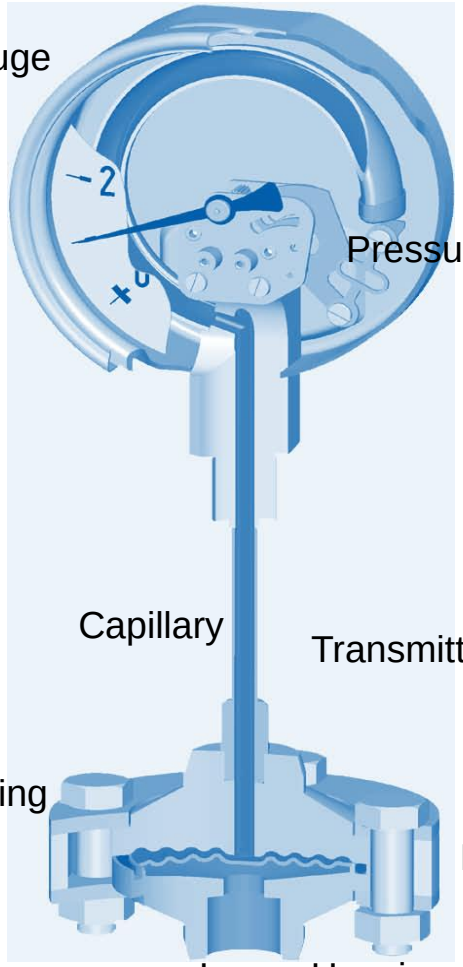
Temperature - Solutions

- 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

Temperature - Solutions



Temperature - Solutions



Diaphragm Seal Operating Principle

Temperature - Solutions

Diaphragm Seal Applications

- The media is **corrosive** and may damage a sensitive element such as a Bourdon tube gauge, pressure switch or transmitter diaphragm.
- The **temperature** of the media may be too high for a standard gauge, switch or transmitter to operate properly.
- The media is **highly viscous** or tends to **crystallize**, or **polymerize** and may clog the pressure port of a gauge, switch or transmitter.
- The media is **non-homogenous** or contains **suspended matter** such as wood pulp which may clog the pressure port of a gauge, switch or transmitter.
- **Remote reading** is required. A diaphragm seal with a capillary line will allow remote installation of a pressure instrument.
- The **sanitary cleanliness level** is critical. A flush mounted or INLINE SEAL™ sanitary type diaphragm seal avoids dead space and cavities.
- The media is **toxic or hazardous** and may pollute the environment. A suitably designed diaphragm seal will provide additional protection.
- The application requires **high overpressure protection**. A diaphragm seal with a contoured diaphragm bed can be configured to provide overpressure protection and protection to the instrument.

Temperature - Solutions

Process gauge with an All Welded Seal

Process gauge with an All Welded Seal and Cooling Element

Temperature - Solutions

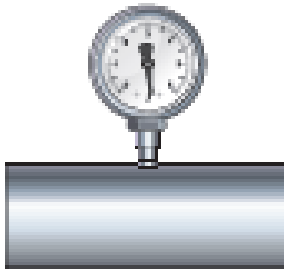
- Prevent steam and "water hammer" from reaching gauge internals
- Must be filled with water upon installation
- Actual temperature reduction is a function of process pressure

Coil – For Horizontal or Vertical Installations

Pigtail – For Vertical Installations

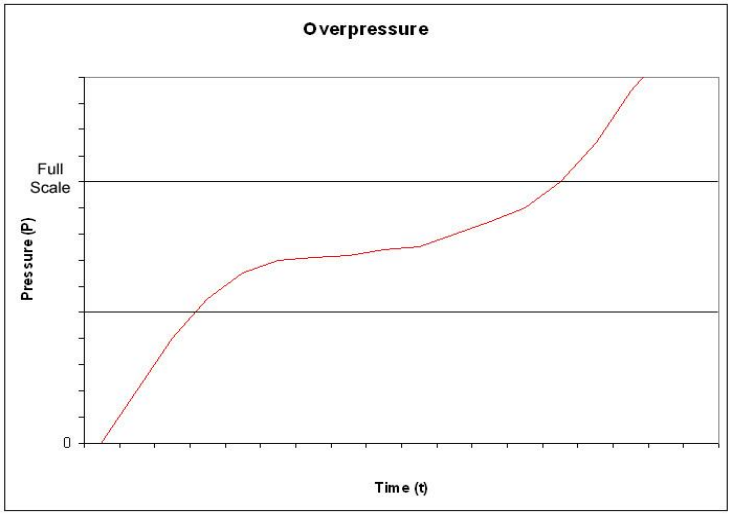
What Causes Gauges to Fail?

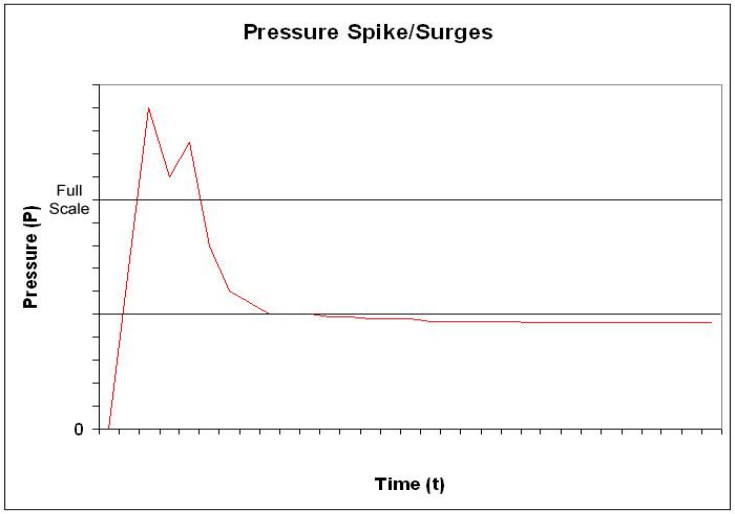
Pressure Spikes / Overpressure



Failure Mode – Pressure Spikes / Overpressure

- 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.





Failure Mode – Pressure Spikes / Overpressure

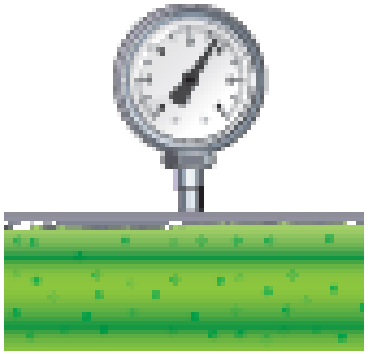
Bourdon Tube Warped & Split

Pressure Spikes / Overpressure - Solutions

- 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. Some overpressure protectors may feature a piston valve which is designed to dampen system pulsation.

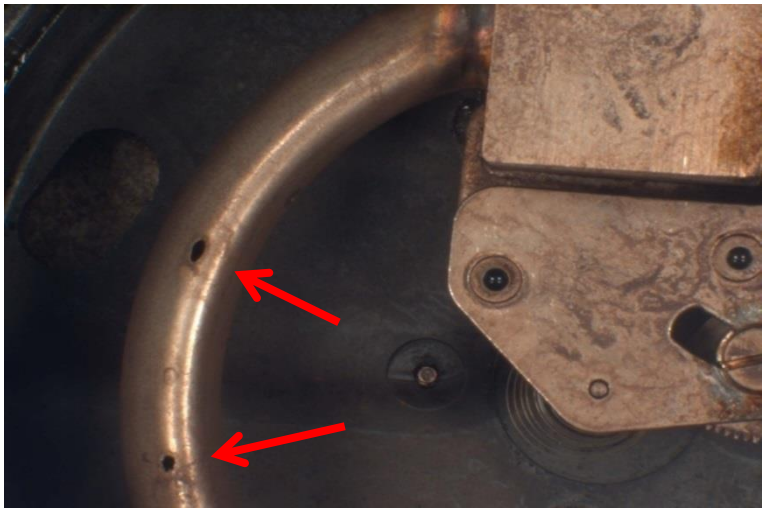
What Causes Gauges to Fail?

Corrosion

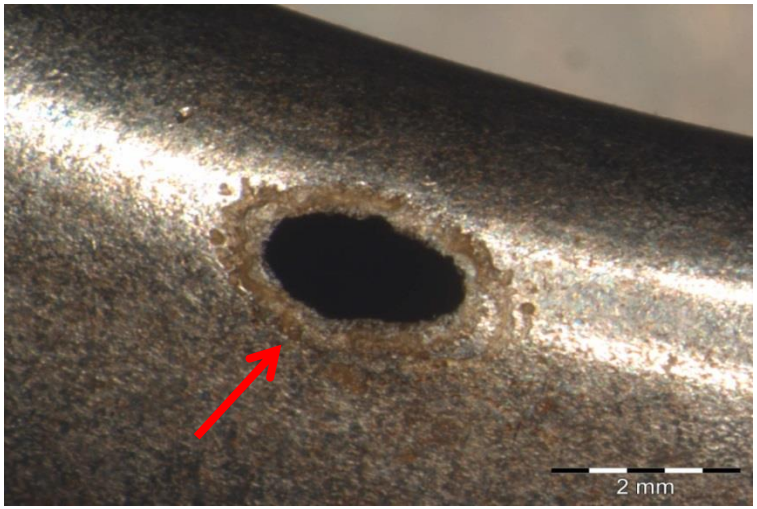


Failure Mode – Corrosion

- Corrosion failure from media attacking the wetted parts material of the pressure gauge



Holes in Bourdon tube

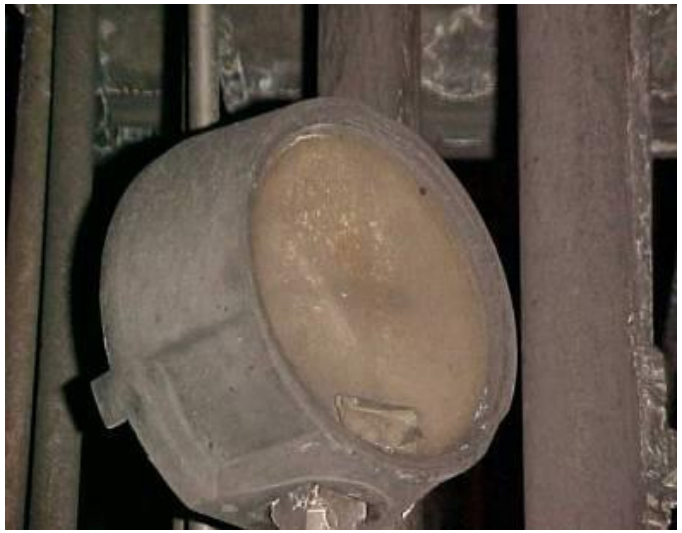


Hole in Bourdon tube

Failure Mode – Corrosion

- 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



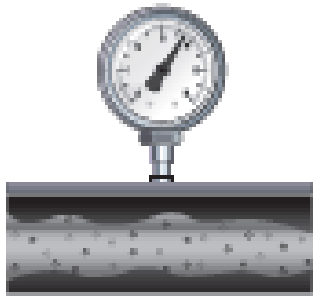
Fogged Window

Corrosion - Solutions

- 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
- Gauge covers protect against environmental corrosion
- Consider alternative case materials – 304SS, 316SS, Plastic, Reinforced Thermoplastic

What Causes Gauges to Fail?

Clogging



Failure Mode – Clogging

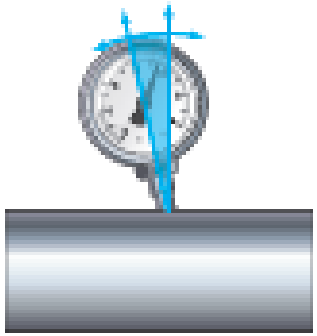
- Media does not have to be aggressive or hostile to require the use of diaphragm seals
- For Example: Chocolate - when warm and molten it will flow. However, when cooled it will become a solid.

Clogging - Solutions

- Clogging problems and highly viscous or clogging media may require the use of a diaphragm seal or a Sealgauge

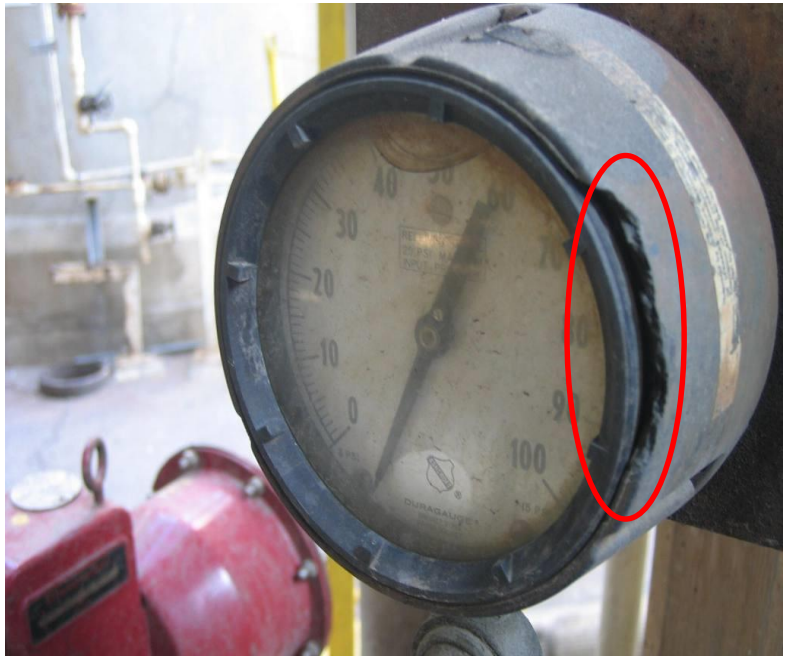
What Causes Gauges to Fail?

Mishandling/Abuse

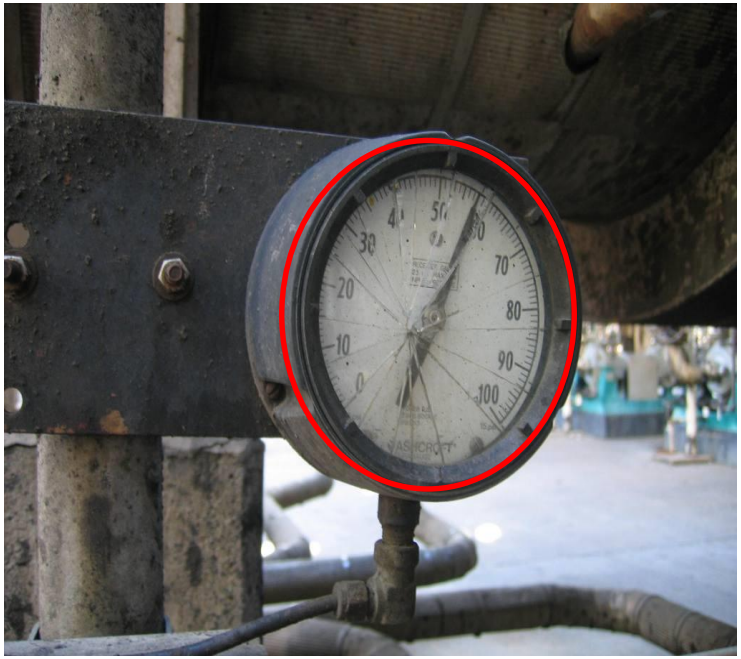


Failure Mode – Mishandling/Abuse

Cracked Case



Broken Window



Mishandling/Abuse - Solutions

- Use the wrench flats to install the gauge – do not tighten by grabbing the sides of the case and turning
- Do not overtighten a gauge
- Consider protective cases for impact damage
- Do not drop gauges, internal components can be damaged

Application Solutions Summary

0 = Not Effective 1 = Marginally Effective 2 = Highly Effective (shaded areas)

Option/Configuration	Mechanical Vibration	Pressure Pulsation	High Temperature Media	Overpressure	Pressure Spikes
Liquid Fill Case	2	2	0	0	2
Restrictor	0	2	0	1	2
Pourous Snubber	0	2	0	1	2
Piston Snubber	0	2	0	1	2
Throttling Snubber	0	2	0	1	2
Higher Pressure Range Gauge	1	1	0	2	2
Dampened Movement	1	1	0	0	1
Siphon	0	0	2	0	0
Cooling Tower	0	0	2	0	0
AWS (all welded seal)[1)]	0	1	1	1	1
Needle Valves	0	1	0	1	1
Overpressure protector	0	1	0	2	2
Sealgauge	1	1	1	2	2
AWS with Cooling Tower[1)]	0	1	2	0	1
Diaphragm Seal with Capillary	2	2	2	0	2

Gauge Maintenance

Gauge Maintenance

- In General, gauges can be considered “maintenance free”. Regular checks should be carried out to inspect the gauge for proper performance.
- Inspect the gauge for any physical damage or signs of wear as noted in the “Gauge Failures” section.
- Clean the exterior of the gauge with a dry cloth or non-abrasive solution.
- Regular checks should be carried out to ensure the measurement accuracy.

How Do you Specify a Gauge?

How Do You Specify a Pressure Gauge?

- What is the Application?
  - Indoor
  - Outdoor
  - Vibration/pulsation
- What is the Media?
  - Material Compatibility
  - Gas/Liquid
- What is the Temperature?
  - Media
  - Ambient

How Do You Specify a Pressure Gauge

- Dial Size
  - 1.5”, 2”, 2.5”, 4”, 4.5”, 6”
- Pressure requirements
  - Scale & pressure units
  - Size to operate in the middle 1/3
- End Connection
  - Location (lower, upper, right, left, back)
  - NPT, Straight Thread, Tube Adapter
- Options/Features
  - flanges, cleaning, certs, etc
- Delivery Requirements – Stock item/MTO?

Thank You for Attending!