Mechanical Pressure Gauges 101
Today's Agenda

- Importance of Mechanical Gauges
- Gauge Design & Basic Principles
- Problematic Operating Conditions & Solutions
- Industry Trends
- FAST Services
- Summary & Questions
Importance of Mechanical Gauges

Why Maintain Them?
Importance of Mechanical Gauges

Why Maintain Them?

• Provide a local pressure indication

• Detect signs of degradation in process performance not otherwise tracked through DCS equipment

• Identify potential loss of process or loss of containment

• Predict how long a piece of equipment can be safely and economically run

• Diagnose causes of system and production disruptions
Pressure Gauges: Sole Source of Data

- Discharge pressure
- Suction pressure
- Differential pressure
- Mechanical seal flush pressure
- Steam quench pressure
Pressure Gauges: Calculating Risks

Pumps rank 1st in failure incidents and maintenance costs. And, repairs account for 27% of life cycle costs.

Source: Pump User’s Handbook
The Pressure Gauge: Current State

At least **25%** of pressure gauges require immediate replacement. And, and additional **40%** need corrective action.
Gauge Design & Basic Principles

Types of Gauges

- Bourdon Tube Process Gauge
- Direct Drive Process Gauge
- Process Gauge with Diaphragm Seal
Gauge Design & Basic Principles

Gauge Components

- Measuring element (Bourdon tube)
- Dial
- Movement
- Pull Rod (linkage)
- Pressure connection
- Pointer
- End piece of the tube

Pressure
Process Gauge

- Excellent load-cycle stability and shock resistance
- Standard 0.6 mm restrictor
- NEMA 4X/IP65 weather tight case
- Standard overload stop
- Liquid fillable
- Safety case design

Specifically designed for the chemical and petrochemical processing industries

Suitable for corrosive environments and gaseous or liquid media that will not obstruct the pressure system
Gauge Design & Basic Principles

Direct Drive Gauge

- A Direct Drive is ideal for heavy mechanical vibration
- Designed for high dynamic pulsation, vibration and shock
- Tube made of Inconel X-750 alloy, highly resistant to temperature extremes with excellent oxidation and corrosion properties
- No delicate internal movement
- No gears, linkages or springs to wear or break
- Safety case design
A diaphragm seal is ideal for severe duty applications:
- Pressure spikes
- Pulsation
- High temperatures
- Corrosive media
- Suspended solids
- Highly viscous, crystallizing or clogging media

Acts as a chemical barrier and/or thermal barrier.
Problematic Operating Conditions

Gauge Failures & Solutions
The most common gauge failures (in order of criticality):

- Spikes
- Overpressure
- Mechanical Vibration
- Pulsation
- Temperature
- Corrosion
- Clogging
- Mishandling and Improper Use
Problematic Operating Conditions & Solutions

Risk: Bourdon Tube Rupture

- Pressure Spikes
  - Indicators
    - Bent, broken, fish-hooked pointer
    - Knicked pointer (hitting stop pin)
  - Root Cause/Effects
    - Abrupt increase/decrease in pressure
    - Often caused by pump on/off or valve open/close
    - Bourdon tube rupture & media release
Problematic Operating Conditions & Solutions

Risk: Bourdon Tube Rupture

- Overpressure/High Pressure
  - Indicators
    - Operating near or past maximum pressure
    - Pointer pegged against stop pin
  - Root Cause/Effects
    - Using incorrect pressure range
    - Bourdon tube rupture & media release

Pictures from actual gauge failures
Problematic Operating Conditions & Solutions

Risk: Bourdon Tube Rupture

- Solutions/Recommendations
  - Investigate
    - Appropriate pressure range?
    - External factors?
  - Model – Process Gauge
    - Overload stop standard
    - Liquid case fill to reduce internal wear
    - Extreme cases – Diaphragm seal with internal super restrictor (0.3 mm)
  - Accessories
    - Snubber
    - Overpressure protector

Best Practice: 2X normal operating pressure
Risk: Bourdon Tube Fatigue

- Pulsation
  - Indicators
    - Pointer flutter
  - Root Cause/Effects
    - Media rapidly cycling through pressure system
    - Dynamic (cyclic) loading wears movement components down

Video recorded in the field
Risk: Bourdon Tube Fatigue

- **Pulsation**
  - **Root Cause/Effects**
    - Movement no longer anchors Bourdon tube
    - Thin wall of Bourdon tube fatigues and cracks
    - Media release

**Picture from actual gauge failures**

**Elliptical Form**

**Bourdon Tube Crack**

**Worn Pinion Gear**

**Worn Segment Gear**
Problematic Operating Conditions & Solutions

Risk: Bourdon Tube Fatigue

- **Vibration**
  - **Indicators**
    - Missing pointer
    - Black dust on dial
    - Scrapes on dial from loose pointer
    - Missing window, window ring or back plate
  - **Root Cause/Effects**
    - Misaligned pumps
    - Reciprocating compressors
    - Poor fixture mount
Vibration

- Root Cause/Effects
  - Vibration breaks movement
  - Movement no longer anchors Bourdon tube
  - Thin wall of Bourdon tube fatigues and cracks
  - Media release

Pictures from actual gauge failures
Problematic Operating Conditions & Solutions

Risk: Bourdon Tube Fatigue

Solutions/Recommendations

- Investigate
  - Determine root cause of vibration
  - Other equipment in disrepair?

Model – Process Gauge

- Liquid case fill
  - Reduce internal wear
  - Lubricates and cools moving parts
  - Dampens the effects of vibration
- Extreme cases of pulsation: Snubber or diaphragm seal with internal restrictor

Model – Direct Drive Gauge

- Made to withstand significant shock
- No internal movement
  - Direct connection between pressure system and pointer
Corrosion (Ambient)

- Indicators
  - Corroded dial or pointer
  - Build-up in case
  - Fogged window
  - Discolored liquid case fill

- Root Cause/Effects
  - Contaminants getting inside the case
  - Missing fill plug
  - Cracked case or window
  - Corrosion of the Bourdon tube - media release
Problematic Operating Conditions & Solutions

Risk: Material Deterioration

- Temperature (Media & Ambient)
  - Indicators
    - Breakdown of gauge components (window, dial and associated elastomers)
    - Discolored dial or liquid case fill
  - Root Cause/Effects
    - Incorrect mounting
    - Incorrect accessories
    - Elevated temperature stresses the pressure system
    - Media release
Problematic Operating Conditions & Solutions

Risk: Material Deterioration

- Solutions/Recommendations
  - Investigate
    - Determine cause of ambient corrosion or source of high temperature

- Model – Process Gauge
  - Hermetically sealed pressure gauge (weather protection IP65/NEMA 4X)
  - Liquid case fill
    - Insulates and protects internal components
    - Extreme cases – Diaphragm seal for media temperatures over 212°F

- Accessories
  - Mini-siphon
Problematic Operating Conditions & Solutions

Risk: Loss of Functionality

■ Clogging
  ■ Indicators
    • Gauge shows no pressure when system is operating
  ■ Root Cause/Effects
    • Media that is highly viscous, crystallizing, hardens, or contains particles or solids that can clog the socket orifice
    • Inoperable gauge
    • Shows no pressure
Problematic Operating Conditions & Solutions

Risk: Loss of Functionality

- General Maintenance/Mishandling & Abuse
  - Indicators
    - Cracked, broken or missing windows
    - Leaking case fill
    - Missing back plates or fill plugs
  - Root Cause/Effects
    - Old or neglected gauges
    - Accelerated degradation and corrosion of the internal components
Problematic Operating Conditions & Solutions

Risk: Loss of Functionality

- Solutions/Recommendations
  - Investigate
    - Implement maintenance plan
      - Inspect gauges on a routine basis
    - Determine if gauge should be on diaphragm seal to address clogging
  - Model – Process Gauge
    - Designed to be easily serviced in the field
    - Various spare parts available to address minor issues
Problematic Operating Conditions & Solutions

Accessories

- SS Gauge Tags
  - Mark each gauge with a stock number
  - Ensures correct gauge replacement

- Mini-Siphon
  - Water hammer (pressure spike) & high temperature (media)
  - Small form factor reduces gauge whip

- Over-Pressure Protector

- Snubber

- Individual Gauge Components
Industry Trends

Current state & Path Forward
Industry Trends

Complexity of Configurations

- Plants have unnecessary complexity from proliferation of configurations
  - Simplify configurations to reduce guesswork for operators and installers
    - Manufacturer, gauge type and model, pressure range, wetted materials, etc.
  - Develop an effective storeroom inventory that will:
    - Maximize field coverage
    - Minimize complexity of configurations
    - Eliminate redundant, obsolete or wasted inventory

Average Reduction in Unique Gauge Configurations*

- 75%
- Eliminate Duplicate Configurations
- Reduce Make/Model Complexity
- Standardize on Common Pressure Ranges

* Averages from WIKA FAST Instrument Audits
How did we get here?
Aging Infrastructure
More than 40% of all oil and gas professionals will retire in the next 10 years.

Source: Cambridge Energy Research Associates
Compounding the Issue of Instrument Failure

AGING INFRASTRUCTURE
Missing documentation
Processes change, specs outdated

+ RETIRING EXPERTS
“BRAIN DRAIN”
Doing more with less experience

+ UNDER INVESTMENT
Don’t know what is failing or what to do about it

= INCREASING RISKS
Improving Reliability &
Total Operating Costs

**OBJECTIVE**
Reduce complexity and standardize

**RESULT**
Eliminate misapplications and repeat failures

**OBJECTIVE**
Specify correct configurations for process conditions

**RESULT**
Improve reliability with configurations that can handle operating conditions

**OBJECTIVE**
Prevent expensive, essential equipment failure

**RESULT**
Provide functional gauges for troubleshooting, PdM capabilities
FAST Services

Offerings & Benefits
Questions

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