Kuwait 4th Flow Measurement Technology Conference
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Hilton Kuwait Resort
Born on Aruba (Caribbean) in 1963
School and College in the Netherlands
Resident in Romania - Bucharest
Mechanical Engineer (3 years) at Stork
Instrument Engineer (7 years) at MW Kellogg
Metering Engineer (17 years) at Polar Systems / Imtech Systems
Metering Consultant (4 years) at SGS - Kuwait
Metering Consultant (1 year) at BGC - Iraq
Metering Consultant at Intertek - Kuwait
Sharing experience regarding back pressure control with flow metering:

- Back Pressure theory
- Aspects during engineering
- Aspects during commissioning
Back Pressure on Liquid Flow Measurement

What is Back Pressure and why is it addressed for liquid flow metering:

• Back Pressure of the flow meter is the static pressure of the fluid downstream the flow meter

• To ensure that the liquid in the flow meter stays liquid, and cavitation and flashing does not occur
Back Pressure on Liquid Flow Measurement

Requirement for Minimum Back Pressure for liquid flow metering

• The equation can be found in many Standards for flow metering and is an estimation
• The vapor pressure of the fluid at line conditions (Temperature) shall be used

\[ BP = (2 \times \Delta P) + 1.25 \ V_p \]

Where: 
- \( BP \) = Minimum back pressure
- \( \Delta P \) = Pressure drop at maximum flow rate
- \( V_p \) = Absolute vapor pressure at operating temperature
Back Pressure on Liquid Flow Measurement

From where do we obtain the meter pressure drop $\Delta p$:

Depends on the type of flow meter
- Some manufacturer provides a pressure drop chart and/or an equation
- Always consult the manufacturer for special applications (low specific gravity)

$$\Delta P = 3.6 \times d \times v^{0.2} \times \left(\frac{Q}{Q_{\text{max}}}ight)^2$$

with:
- $P$ : Pressure drop (PSI)
- $d$ : Relative density
- $v$ : Kinematic viscosity (cSt)
- $Q$ : Flowrate (Bbl/h)
- $Q_{\text{max}}$ : Maximum flowrate (Bbl/h)
Back Pressure on Liquid Flow Measurement

Coriolis meter Back Pressure:

• Small diameter tubes causes higher velocities, and as a consequence a lower static pressure (Bernoulli)

• Beside the conventional Back Pressure Equation, also manufacturer calculation (sizing and selection tool) of static pressure inside the tube is a requirement.
How to Control the Back Pressure

- Restrict the flow downstream the flow meter.
Back Pressure on Liquid Flow Measurement

How to combine Back Pressure Control and Flow Control:

- Flow controller
- Pressure controller
- Low signal selector
Which type of liquid flow meters are subject for Back Pressure Control:

- All single phase liquid flow meters (e.g. Turbine, PD, Coriolis, Ultrasonic, Orifice)
- Ensure that all operating cases are calculated, i.e. minimum, normal, maximum, viscosity and specific gravity.
Back Pressure on Liquid Flow Measurement

When using a control valve for Back Pressure Control:

- Proper selection of the type of control valve
- Proper sizing of the control valve
- Actuator response time
- Hydraulic pipe loss calculation is essential to determine the pressure loss in the downstream piping system
- Back Pressure controller with fast response
Commissioning aspects with Back Pressure:

- Proper tuning of the pressure controller. The control action should be fast.
- Trending of static pressure and control valve signal to investigate issues.
- Verify that the actual pressure corresponds with the pressure on the data sheet
- Sometimes you have to think out of the box
Back Pressure on Liquid Flow Measurement

Case 1 (Fractured Pig)

• Crude Oil Metering Skid in Kuwait for vessel loading
• Subsea pipeline under slope to vessel
Case 1: Fractured pig between crude oil tank and metering skid.
- Strainer almost blocked
- Cavitation in the turbine flow meter
- Bill of laden with higher figures (Addressed by our Loss Control department)
Back Pressure on Liquid Flow Measurement

Case 2 (Line Fill Coriolis Meter)
- Subsea pipeline which require Line Fill Meter
- Existing skid without Line Fill Meter (16” Turbine Meters)
- MOC to install a Line Fill Meter
Back Pressure on Liquid Flow Measurement

Case 2 (Line Fill Meter)

Engineering Criteria
- Very Low pressure in the subsea pipeline due to shrinkage
- Coriolis Meter selected: sensitive for back pressure!!

Design Criteria for Back Pressure:
- Manual Valve with fixed setting
- Sizing of manual valve (high diff. pressure $\rightarrow$ Cavitation)
- Proper sizing of manual valve
Commissioning/Operation:

- The Manual valve to be manually set during commissioning
- To be adjusted if required for viscosity
Case 3: New Crude Oil Metering Skid

- Coriolis flow meter to be installed in an existing installation in Romania (EU)
- Mandatory installation between Crude Oil Tank and Transfer Pump
Back Pressure on Liquid Flow Measurement

Case 3
Skid contained a booster pump to compensate for the pressure loss in the strainer and Coriolis meter
Back Pressure on Liquid Flow Measurement

Case 3
(Commissioning)
Case 3 (Commissioning)

Frequency controlled pump too slow when starting the transfer pump.

Startup of the transfer pump resulted in:
- Instability of the booster pump
- Back Pressure of the Coriolis meter dropped below vapor pressure
- Coriolis meter stopped functioning, and could only be activated by restarting by switching off/on the power supply
Back Pressure on Liquid Flow Measurement

Project (Engineering)
Restriction orifice on the outlet flange of the metering skid solved the issue
Back Pressure on Liquid Flow Measurement

Conclusion

• “Everybody” is aware of the Back Pressure requirements, but are we actually applying them?
• Hydraulic calculation for each system is essential
• Proper control valve selection, and not just ‘Line size’
• Back Pressure Control is essential in Metering Systems, and needs to be tuned for fast control
• Think sometimes out of the box for simple solutions like restriction orifices
Back Pressure on Liquid Flow Measurement

Questions?
THANK YOU