Kuwait 4th Flow Measurement Technology Conference
3-5 December 2019
Hilton Kuwait Resort
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Kuwait Oil Company

الراعي الرسمي
DUANE ROWAN
Global Product Champion – Sensia Measurement, Sampling & Blending
Bringing together the best of the best

Schlumberger
Unmatched Petrotechnical domain, measurement and instrumentation, software and analytics capabilities

Sensia
The most comprehensively integrated provider of measurement solutions, production domain expertise and automation to the oil and gas industry, from the reservoir to the refinery

Rockwell Automation
Pioneering process automation and safety expertise, real-time control and IoT technologies

Cameron Measurement (Jiskoot, Caldon, Nuflo, Barton, Clif Mock)
OFM Software
Avocet
Artificial Lift Optimization Controllers

Connected Production
iSense Wireless Transmitters
OptiLift

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Global experience:

- Nearly 50 years in the sampling system business
- +2000 Custom engineered sampling systems
- Manager of R&D is Chairman API Chapter 8 MPMS
- +1000 Water Injection Tests performed by our engineers

My experience:

- 26 year of technical oil and gas experience
  - JISKOOT - Sampling & Blending – 7 years
  - GE, Lufkin, Weatherford - Technical Sales & Service – 7 years
  - Enerplus – Operations, Optimization & Measurement - 13 years
Global Marine Crude Oil Cargo
- Over 4,730 shiploads
- 4.100 billion bbls
- 6.888 million bbls losses (-0.168%)

Kuwait Marine Export Cargo
- Over 99 shiploads
- 95.2 million bbls shipped
- 268K bbls shipping losses (-0.28%)

A custody transfer system is made up of two key systems:

**Metering System** which determines the Gross Crude Oil Volume

+ **Sampling System** which determines the water content

Net Crude Oil Volume = Basis of Payment

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Custody Transfer Chain of Uncertainty

- Metering System
  - Px
  - Tx
  - Density

  Gross Volume → Corrected Volume → Crude Oil Net Volume

- Sampling System

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How often do we verify these systems??

Metering System

- Calibration Frequency = annual

Gross Volume

Prover System

- Frequency = every batch

Corrected Volume

Sampling System

- Verification Frequency = ???

Crude Oil Net Volume

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To verify the performance of a sampling system

Inject a known flowrate of water

1% rate of water injection = 280 liter per min (74 GPM)

For short period of time!!!

REDUCING THE RISK!
REDUCING THE RISK!

Maritime Arbitrator and mediator

1.3 Contractual and Commercial Position

Under a normal FOB, CFR or CIF sale contract, risk in the crude oil passes from seller to buyer on loading, whilst the carrier’s responsibility for the crude oil passes to the buyer as the cargo is discharged from the claims for excess water based on robust outturn evidence are successfully pursued against sellers.

Certified Sampling System significantly decreases financial risk and the chance of litigation.
What do the standards recommend?

• Both API 8.2 (2016) and ISO 3171 recommend that water injection test should be completed.
• Both have procedures on how to execute a Water Injection Test and the level of performance acceptance.
When should you test a sampling system?

18.6 System Verification:

18.6.1 The automatic sampling system is an integral component of the total system used for custody transfer of crude oil. Once installed in the field, all of these components of the measurement system are tested (proven) and verified on a periodic basis to ensure the results they produce are accurate and repeatable to an accepted industry standard.

18.6.2 If required by contract or regulation, test the sampling system upon initial operation. The recommended period for retesting of the automatic sampling system is every five years not to exceed seven years. The need for retests is determined by the parties involved with the custody transfer of the crude oil.

15 Proving the sampling system

15.1 Introduction

A field test to prove the sampling system should be carried out after a new automatic sampler has been installed. The following procedure is intended to test the total sample system by injecting a volume of water for a period of time and confirming that the sample taken represents the total volume of water injected plus the baseline water. This procedure is a volume balance test.
When should you actually verify a sampling system?

- Significant changes in crude oil properties
  - Density
  - Viscosity
  - Water-cut
- Line Configuration
  - Introducing new piping elements
  - Changing flow paths
- Flow rate Changes
  - Reduction in avg. flow rates through system
  - Outside original design parameters of mixing technology
Who should do the water injection test?

Selecting the right party, to execute the water injection test is key for a successful test, so who should choose?

- A contractor who understands the complexity of the test process
- A technical background and experience to successfully execute test
- Must understand the core systems, sub-components and processes

Specialized expertise must include:

- Sampling systems & products
- Sampling System Controllers/Control Systems
- Flow computers
- Process and logistics associated with doing the test
- Metering System
- Laboratory processes & equipment
Water injection test should always be done in worst-case process conditions that the sampling system will be required to perform in.

- Lowest Pipeline Flow Rates
- Lightest Fluid Densities
- Lowest Fluid Viscosities
What should they do first?

1. Identify water injection point
   - Upstream of mixing device
   - Location where oil and water is guaranteed to pass through mixing technology and sampling system
2. Test Individual sampling components
   - Sampler
   - Receiver System
3. Sample receiver mixing and handling component test (API 8.3)
   - Test the lab and make sure they are giving the correct results

Once these are completed, only then should you proceed with a test.
+/-.15\% on 1\% volume of injected water, on two consecutive tests
But I don’t want a bunch of water in my oil!!!

For the typical water injection test:

- The normal amount of water injected into a crude shipment is about 0.02%.
- Which is equal to resolution of best water cut analysis method.

### Reproducibility of Standard Test Methods for Water Determination

<table>
<thead>
<tr>
<th>TEST METHOD</th>
<th>WATER VOL %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifuge (D-4007)</td>
<td>0.20  0.28</td>
</tr>
<tr>
<td>Water by Distillation (D-4006)</td>
<td>0.11  0.11</td>
</tr>
<tr>
<td>Karl Fischer Titrination Weight Injection (D-4928)</td>
<td>0.02  0.06</td>
</tr>
<tr>
<td>Karl Fischer Titrination Volume Injection (D-4928)</td>
<td>0.02  0.07</td>
</tr>
</tbody>
</table>

Ref: Determining Moisture Content in Crude Oil: Karl Fischer vs. Distillation vs. Centrifuge - Kam Mohajer, Kam Controls Inc.
Sampling System Water Injection Test Failure!

- Cause of system certification failure can be any number of things
  - Pacing Errors
  - Water Injection Errors
  - Line Conditioning/Mixing Issues
  - Sampler Failure
  - System Failure
  - Procedural Error

- Eliminate as many component variables as possible beforehand
Sampling Ongoing Performance Monitoring

“Once certified, a sampling system needs ongoing evaluation and monitoring”

- Flow Sensor Accuracy
  \[ \text{Flow Sensor Accuracy} = \left( \frac{\text{Custody Transfer Volume}}{\text{Actual Parcel Volume}} \right) \]
  Between 0.90 & 1.10

- Sampling Time Factor
  \[ \text{Sampling Time Factor} = \left( \frac{\text{Total Sample Time}}{\text{Total Batch Time}} \right) \]
  Between 0.95 & 1.05

- Sample Grab Performance Factor
  \[ \text{Sample Grab Performance Factor} = \left( \frac{\text{Sample Volume}}{\text{Grab Size} \times \text{# of Grabs}} \right) \]
  Between 0.95 & 1.05

- Batch Performance Factor
  \[ \text{Batch Performance Factor} = \left( \frac{\text{Sample Volume}}{\text{Grab Size} \times \text{# of Grabs} - \text{during a batch}} \right) \]
  Between 0.95 & 1.05

- System Performance Factor
  \[ \text{System Performance Factor} = \left( \frac{\text{Sample Volume}}{\text{Grab Size} \times \text{# of Grabs} - \text{since last overhaul}} \right) \]
  Between 0.90 & 1.10
Ongoing Operational Support

- Sampling System Documentation
  - System Event Logs
  - System Audit Trail
  - System Alarm Logs
  - Batch Reporting on every batch
- Laboratory Documentation and Auditing
  - Data Analysis
  - Lab Testing (API 8.3 Lab Test)
  - Internal Training
Case Study – Refinery Sampling System

• Sampling System
  • Designed/installed in 2010
  • Ships load/offload through 36” pipeline
  • System design based on 34°API crudes
  • Now handling from 33°API to 52°API crudes
• Through water injection testing in 2016:
  • Identified a -0.365% deviation in water-cut with light crude oils
  • Optimized ramp up and ramp down procedures
  • Justified upgrade of existing system
Summary

Through periodic Water Injection Testing:

- Identify areas that may require improved line mixing & conditioning
- Identify improvements to sampling systems and associated technologies
- Optimize your export and import operations
- Better manage the financial risk associated with sampling errors
- Reduce contractual risk and chance of future litigation
- Improved bottom line!!
THANK YOU