Leak Detection Systems
and the Use of Ultrasonic Meters
Agenda

• The Importance of Pipeline Leak Detection
• Overview of Leak Detection Systems
• Why Ultrasonic Meters?
• Application Considerations
• Conclusions
Types of Leak Detection Systems

Non-Permanent
- Visual Inspection
- Aircraft Flyover
- Vehicle, etc.

Internal Permanent LDS
- Flow and Pressure Change
  - Volume Balance
  - RTTM
- Statistical Model
  - Negative Pressure Wave

External Permanent LDS
- Fiber Optics
- Vapor and Liquid Sensing
- Acoustic Sensing
- Infrared
Internal Leak Detection Systems

Volume Balance
• Essentially Measures Volumeric Flow In / Out of a pipeline section

Sequential Probability Ratio Test (SPRT)
• Based on Hypothesis testing method to identify leaks using inventory compensated volume balance
• Calculates the ratio of probability between a leak / no leak situation

Negative Pressure Wave
• Relies on high speed pressure reading (>60 Hz)
• Fast response; can detect very small leaks and thefts
• Cost Effective
SPRT Leak Detection System

Advantages
• Cost effective
• Low false alarm rate
• Works effectively under transient and steady state operations
• Compliant with recommended practices API 1130 and API 1149

Disadvantages
• Dependent on the quality of flow meters, SCADA and telecom system
SPRT Leak Detection System

Pipeline Inlets

Intermediate Pump Station

Block valves

Pipeline Outlets

200 m - 200 km

Logger/
Controller

Logger/
Controller

Logger/
Controller

Logger/
Controller

Wireless/satellite/etc.

Legend

FT
Flow metering

DT
Density meter or interface detector

PT
Pressure sensor

Logger/
Controller
Flow computer (custody txr) or RTU (non-custody txr)

OPC
Translates data into standard OPC format

SCADA

Server

OPC

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Principles of ATMOS SPRT

**SPRT: Sequential Probability Ratio Test**

Testing $H_1$ against $H_0$ at sample time $t$,

$$
\lambda(t) = \ln \frac{P(t)}{P_0(t)}
$$

$$
\lambda(t) = \lambda(t-1) + \frac{\Delta m}{\sigma^2} (\tau(t) - M - \frac{\Delta m}{2})
$$

$\tau(t) = \text{The Corrected Flow Difference} = \text{Inlet Flow} - \text{Outlet Flow} - \text{Pressure Compensation}$

$M = \text{The mean corrected flow difference} \ (\text{normal Flow Diff for the pipeline})$

$\Delta m = \text{The leak size that we are seeking}$

The Apparent Leak Size $= \text{The current corrected flow difference} - \text{the mean corrected flow difference}$

The apparent leak size $= \tau(t) - M$
SPRT – Working Example

Diagram showing various states:
- Steady State
- Leak
- Transient
- Pressure
- Lambda
- Alarm

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SPRT – Working Example

Steady State

Leak

Inlet Flow

Outlet Flow

Transient

Lambda
Negative Pressure Wave Flow Example

Pressure record over 1 hour 3 minutes

Pressure record of 68 seconds to be processed

Pressure output of 68 seconds processed by Algorithm 1

3-D pattern map by Algorithm 2

Leak identified by Algorithm 3 & circled in white

Wave direction confirms a leak within pipeline

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Pressure Wave Flow – Accurate Theft Indication
Why Ultrasonics?
## Comparison of Flow Technologies in LDS

<table>
<thead>
<tr>
<th>Feature</th>
<th>Turbine</th>
<th>PD</th>
<th>Coriolis</th>
<th>Ultrasonic</th>
</tr>
</thead>
<tbody>
<tr>
<td>No moving parts</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Measurement drift over time</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>No filters/strainers required</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Viscosity independent</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Flow profile independent</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>No Pressure drop</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Bi-directional measurement</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Advanced diagnostics</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Piggability</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Typical line sizes</td>
<td>≤ 12”</td>
<td>≤ 12”</td>
<td>≤ 12”</td>
<td>≤ 72”</td>
</tr>
<tr>
<td>Externally Mounted Solution</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
LCT4 Installation

See tutorial regarding confidentiality disclosures.
In-Line (Wetted) USMs

- Highest Level of Performance
- Calibrated for Application
- Permanent Measurement
- Serviceable Under Pressure
- Remote Access
- Multi-Path Diagnostics
Clamp-On USM

- Economical and Flexible Installation
- Serviceable under pressure
- Can be installed in Hard-to-Access Areas
- Extremely wide size range
- Best applied with Negative Pressure Wave Systems

Installation Uncertainty
Application Considerations

Types of Fluids

- Refined Products?
- Crudes?
- Multi-product line?

Check metering?

Custody Measurement?

Type of Leak Detection System
Meter Calibration

Water Calibration?
• Large meters >24” are often used

Multi-Viscosity Calibration?
• Reynolds number for pipeline applications rarely can be matched using water
• Installations are rarely proved – so uncertainty of installation must be considered!
Comparison of Clamp on and In-line Ultrasonic Flow Meters in SPRT Leak Detection System

<table>
<thead>
<tr>
<th></th>
<th>In-line</th>
<th>Clamp-on</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy</strong></td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Repeatability</strong></td>
<td>Very High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>Custody transfer, control, leak detection</td>
<td>Leak detection</td>
</tr>
<tr>
<td><strong>Installation cost</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Retrofit</strong></td>
<td>Difficult</td>
<td>Easy and cost effective</td>
</tr>
<tr>
<td><strong>Minimum leak detectable</strong></td>
<td>0.15%</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Accuracy of leak size estimate</strong></td>
<td>Very high</td>
<td>Medium to high</td>
</tr>
<tr>
<td><strong>Reliability of leak detection system</strong></td>
<td>Very high</td>
<td>Medium to high</td>
</tr>
<tr>
<td><strong>Leak location accuracy using pressure profiling</strong></td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td><strong>Leak location accuracy using Time of Flight</strong></td>
<td>Very high</td>
<td>Very high</td>
</tr>
</tbody>
</table>
Application Considerations

Line Size?

Existing Instrumentation?

New or Existing Pipeline?
Line Size Considerations

48” Diameter Gas Pipeline

8” Diameter Liquid Pipeline
Additional Application Considerations

Pigging

Meter location

Remote Access!

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Meter Diagnostics Dashboard

[Image of a Meter Diagnostics Dashboard with various metrics and settings.]
Meter Diagnostics Dashboard

Calibration:
- Vol: 712.8294 gpm
- Velocity: 4.531 ft/s
- Re #: 500.00
- KV: 0.000 cSt
- CycleTime: 26.78 ms

Errors:
- CH1: E0: No Error
- CH2: E0: No Error
- CH3: E0: No Error
- CH4: E0: No Error
- COMP: E0: No Error

Logging:
- Start
- Record Count
- LogA
- Pause
- LogB

Velocities:
- CH1: 4.281 ft/s
- CH2: 4.409 ft/s
- CH3: 4.096 ft/s
- CH4: 3.575 ft/s

Soundspeed:
- CH1: 4539.133 ft/s
- CH2: 4516.652 ft/s
- CH3: 4519.804 ft/s
- CH4: 4520.647 ft/s

Transit Times:
- CH1: 220.158 ns
- CH2: 283.267 ns
- CH3: 281.204 ns
- CH4: 164.274 ns

ActiveTw:
- CH1: 8.569 us
- CH2: 8.118 us
- CH3: 8.412 us
- CH4: 8.500 us

Gain:
- CH1: HIGH
- CH2: 4.47
- CH3: 171.29
- CH4: 141.04

Attenuator:
- OFF

SNR:
- CH1: 4.15%
- CH2: 3.19%
- CH3: 3.13%
- CH4: 5.15%

Intensity:
- CH1: -80.0%
- CH2: -80.0%
- CH3: -80.0%
- CH4: -80.0%

Thresholds:
- Screen Capture

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Conclusions

• Proper Leak Detection Systems are of Increasing Importance

• Many types of Internal LDS – focus on less false alarms and fast, accurate Leak Detection

• Ultrasonic Flow Meters are the preferred flow measurement instrument for Leak Detection Applications...

• However – they must be correctly applied!

• Luckily – many options are available – be sure to consider all parameters during design
Thank You

Questions?