Improving Pipeline Integrity and Performance through Advance Leak Detection and Control Systems

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Agenda

- Introduction
  - Krohne - Schneider Electric Alliance

- Transport Pipeline
  - A focus on E-RTTM

- Q&A
The global specialist in energy management
A global company

North America
€ 27%
28,000 people

Europe
€ 45%
49,000 people

Rest of the world
€ 10%
9,000 people

Asia-Pacific
€ 19%
31,500 people

€18.3B revenue
32% in new economies
120,000 people
Presence in 100+ countries

A global company
Building an integrated portfolio in energy management

- Safe
  - Installation Systems & Control
  - Building Automation & Security
  - End to End Services

- Productive
  - Energy Monitoring & Control
  - Critical Power and Cooling

- Reliable
  - Energy Monitoring & Control

- Efficient
  - Renewable Energy Solutions

- Green

End to End Services

solutions & energy efficiency
Building an integrated portfolio in energy management

Helping customers to focus on their core business with integrated solutions in energy management
- KROHNE is present on all 5 continents
  - 15 production facilities in 10 countries
  - 43 KROHNE-owned companies and joint ventures
  - 45 exclusive representatives

- Total Sales
  - 289 Mio €

- No. of employees
  - 2510

- Ownership
  - KROHNE is 100% owned by the Rademacher-Dubbick family

- Corporate Management
  - Michael Rademacher-Dubbick and Stephan Neuburger
Our Vision

‘We are the competence in process instrumentation and measurement solutions, serving key industrial market worldwide with leading-edge technology’
Our Alliance

• Our strengths
  • Comprehensive PMS SCADA
    • leading edge technologies
      • pipelines process, power management & integral security
  • Modular Integrated Pipeline Management Solution
    • facilities to delivery point
    • end–end supply and services
  • Single Source
    • supply and responsibility

Ensure safe, reliable and efficient pipeline operations
A unique solution from the Schneider Electric and Krohne alliance
Challenges

Ensure Safe, Reliable and Efficient Pipeline Management

- Pipeline integrity
  - Environmental, regulatory compliance and security
- Accurate & reliable custody transfer metering
  - Integrated state of the art metering
Enhancing Pipeline Integrity Management using Leak Detection System

- Accurate measurements
  - Pressure, Temperature and Flow
  - Associated infrastructure—Telemetry, RTU, Communication

- SCADA
  - Adapted for Pipeline Operations

- Leak Detection System
  - Mass-Balance
  - RTTM
  - others
Flow Measurement

- Performance Monitoring
  - Reflective chord designs
    - Wall build-up measurement
      - limitation of conventional parallel chord designs
  - Optimal solution
    - combines both technologies

- Unsurpassed Performance
  - Highest accuracy in custody transfer market segment
  - Swirl compensation in each plane
  - Reflection technology increases accuracy
    - doubling chord length

Altosonic V12
Citect SCADA Fully Redundant Architecture

- Redundancy
  - Servers
  - Communications
  - Networks
  - Alarming
  - Trending
- Auto-synchronization

- No single point of failure
- Out of the box configuration
Citect PipePatrol
Pipeline Management System (PMS)

- All SCADA Functionalities

- Operator training
- Throughput Optimization
- Energy/Efficiency Monitoring
- Maintenance -on-demand
- Pipeline Scheduling
- E-RTTM Virtual Pipeline
- Look Ahead & Scenario Analysis
- Online Simulation & Visualization
- Instrument Analysis
- Leak Monitoring Detection/Localization
- Batch Tracking
- Pig Tracking
- Slack Line Monitoring
- Maintenance -on-demand
Citect PipePatrol
Pipeline Management System (PMS)

- E-RTTM Virtual Pipeline
  - Leak Detection

- Look Ahead & Scenario Analysis
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- Slack Line Monitoring
- Operator training
Different Leak Detection Systems

- **Non-Continuous Systems**
  - Inspection by helicopter
  - Intelligent pigging

- **Continuous Monitoring Systems**

- **External based systems**
  - Acoustic emission detectors
  - Vapor/liquid sensing cables
  - Others

- **Internal based systems**
  - Balancing systems
  - Pressure/flow monitoring
  - Statistical Analysis
  - RTTM based
Citect-PipePatrol E-RTTM
Performance Criteria according to API 1155

**Sensitivity**
- Detect small leaks fast
  - Typical smallest detectable leak rate approx. 0.5% /1.0% (Nom. Flow)
  - Very fast detection time, typically < 3 min. /<15 min. (liquid/gas)

**Reliability**
- Produce no false alarms
  - < 2 per year guarantee
  - Reliable detection of smallest leaks

**Robustness**
- No need to shut down leak detection due to component failure
  - Redundancy option combined with robust hardware
  - Fall back strategy upon sensor failure

**Accuracy**
- Calculate accurate leak rate and position
  - Leak localization accuracy typically between 1-2% of segment length
Conventional Leak Detection System

Outlet flow, measured by flowmeter

Inlet flow, measured by flowmeter

Difference between inlet and outlet flow, not zero due to transient pipeline behaviour
Citect PipePatrol E-RTTM Principle
Reliable and Proven Leak Detection using E-RTTM technology

- **E-RTTM**
  - Extended Real-Time Transient Model
  - Uses sophisticated mathematical model
    - Virtual Pipeline
  - Calculates local profiles in real time
  - Extended by <Signature Analysis>
    - archive zero false alarms

- **Virtual Pipeline** (RTTM)
  - Flow (No Leak)
  - Residuals X and Y
  - Signature Analysis
    - Leak Yes/No
      - Yes= location and rate
      - No= save signature
Block Diagram – Virtual Pipeline
Leak Monitoring

Virtual Pipeline

Profiles

PLC/RTU/VCitect SCADA

Leak Monitoring Signature Analysis

VCitect Pipepatrol
Pipeline Management System
Citect PipePatrol E-RTTM

Outlet flow,
Measured by flowmeter (green)
Calculated by RTTM (brown)

Inlet flow,
Measured by flowmeter (blue)
Calculated by RTTM (orange)

Outlet flow residual,
Difference between calculated and measured flow

Inlet flow residual,
Difference between calculated and measured flow
Daily Flow and Pressure Measurements

Leak Detection Examples
Detailed Flow Measurement Activities

Leak Detection Examples

![Graph showing flow measurement activities with inlet measured and outlet measured data.](image-url)
Measured and calculated flow

Leak Detection Examples

Flow

- Initial estimated
- Q1 estimated
- Initial measured
- Outlet measured

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Flow</th>
<th>Q1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>2.5%</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>3000</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

Q&A
Residuals X and Y

Leak Detection Examples

2.5% 0.5% 1%
Leak Localization

● Three simultaneous algorithms
  ● Gradient Intersection Method
  ● Wave Propagation Method (Time of Flight)
  ● Extended Time-of-Flight

● Ensure accurate results under all operating conditions
Citect PipePatrol
E-RTTM Leak Localization Principle

● Providing Accuracy
  ● Simultaneous calculation of leak position with three different methods
    ● Gradient Intersection
    ● Time-of-Flight
    ● Extended Time-of-Flight
  ● Main advantages
    ● Combines strengths, avoids weaknesses
    ● Provides excellent overall accuracy
Citect PipePatrol
E-RTTM LDS Principle

- Gradient Intersection Method
  - RTTM technology: No need of additional pressure sensors

- Pros
  - Good accuracy during stationary conditions
  - Independent of leak characteristic (spontaneous, creepy)

- Cons
  - Accuracy based on whole pipeline length $L$
  - Poor accuracy during transient conditions
Citect PipePatrol
E-RTTM LDS Principle

- Time-of-Flight-Method
  - RTTM technology reduces influences of transients significantly
- Pros
  - Good accuracy during stationary and transient conditions for appropriate leak characteristics
- Cons
  - Accuracy based on whole pipeline length $L$
  - Not applicable for small and/or creeping leaks
  - Requires fast sampling
Citect PipePatrol
E-RTTM LDS Principle

- Extended Time-of-Flight-Method
  - RTTM-based technology with additional pressure sensors

- Pros
  - Accuracy based on reduced segment length $\Delta x_i$
  - Significantly improves accuracy versus simple Time-of-Flight
  - Suitable for small leaks

- Cons
  - Not applicable for creeping leaks
  - Requires fast sampling
E-RTTM performance
Leak Detection and Localization

● Liquid Pipeline
  ● Smallest detectable leak flow typically ≤ 0.5%
  ● Fast leak detection typically ≤ 3min
    ● Metering consideration
  ● Accurate leak localization
    ● Typical accuracy ≤ ±1% of segment length

● Gas Pipeline
  ● Smallest detectable leak rate between 1.0% - 2.0 %
  ● Detection time typically ≤ 15 minutes
    ● Length, volume and metering consideration
  ● Accurate leak localization
    ● Typical accuracy ≤ ±2.0% of segment length

● False Alarm Rate < 2 per year
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Pipeline Management System (PMS)

- E-RTTM Virtual Pipeline
  - Real-time line packing

Diagram:
- Operator training
- Throughput Optimization
- Energy/Efficiency Monitoring
- Maintenance -on-demand
- Pipeline Scheduling
- Look Ahead & Scenario Analysis
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- E-RTTM Virtual Pipeline
Block Diagram – Virtual Pipeline
Look Ahead & Scenario Analysis

- Virtual Pipeline
  - Profiles
  - PLC/RTU/VCitect SCADA
    - Rapid RTTM
    - Prediction Profiles Diagnostics
    - Leak Monitoring Signature Analysis
    - VCitect Pipepatrol Pipeline Management System
Murphy Oil Malaysia
Typical Application

- **Product**
  - Dehydrated Gas

- **Pipeline**
  - Length 138 km
  - Depth 1350m
  - Sub sea
  - On demand gas re-injection into reservoir

- **Instrumentation**
  - Inlet and outlet flow (turbine)
  - Inlet and outlet pressure
  - Inlet and outlet product temperature

- **Flow**
  - Design flow 5.66 MMSCMD
  - Design pressure 357 bar
  - Always transient

Leak Detection and Location
Look Ahead & Scenario Analysis
Murphy Oil Malaysia
Typical Application

Kikeh Development

- FPSO Kikeh
- Tender Assist Rig (TAD)
- Mobile Offshore Drilling Unit (MODU)
- SPAR DTU

Key Infrastructure:
- Kikeh Gas Pipeline (to Labuan)
- Pipeline End Manifold (PLEM)
- Gas Injection Manifold (GIM)
- Pipeline/Riser
- Subsea Equipment
Citect PipePatrol PMS

- A brief history overview
- Many references

BAYER Germany (CO)
Sagess France (batches with brine, gasoline etc.)
Sagess France (crude)
BG Tunisia (Condensate)
InfraServ Germany (C₂H₄)
KAFCO Kuwait (Jet A1)

Krohne Schneider Electric Alliance
VCitect PipePatrol PMS

Shell Germany (5 batches)
Tamco1 Italy (2 batches, DRA)
Basell Germany (LPG)

BREGA Lybia (1 x 3 batches, 1 x 4 batches, gasoline etc.)

InfraServ Germany (C₂H₄)

BAYER Germany (CO)
BAYER Germany (O₂)

BP Germany (7 batches)

DEA Germany (crude oil)

DEA Germany (4 batches)
DEA Germany (4 batches)

OMV Austria (LPG 1, LPG 2)

Gelsenkirchen University
/ w Krohne

Damstadt University / w Start-up Company

Steady State Liquid Only

Basic RTTM Gas Only

Basic RTTM Gas & Liquid

E-RTTM Gas & Liquid

Basic SMB Gas & Liquid


SCADA PMS-E-RTTM Gas & Liquid

PMS-E-RTTM Gas & Liquid
Ensure safe, reliable and efficient pipeline operations

A unique solution from the Schneider Electric and Krohne alliance

How can I...
- ensure safe and reliable operations 24/7?
- manage my assets with a system that will minimise my opex?
- mitigate risks and alleviate my environmental concerns?
- be able to react immediately to leaks, accidents, and other external hazards?
- secure communications and power availability?

Solutions
- Pipeline management system
- Energy management
- Custody transfer flow metering & pipeline instrumentation
- Integral security
- Leak detection, cathodic protection
- Asset management

Benefits
- Improved pipeline management enhances overall performance and safety
- Energy and process management ensures maximum efficiency
- Improved security reduces operational risk and costs
- Real-time monitoring enables rapid response to leaks and accidents
- Heightened availability allows for safe, reliable operations
Q&A

Thank You!
Make the most of your energy