National Association of Regulatory Utility Commissioners (NARUC)

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LEOS Leak Detection and Location System

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Basic principles of LEOS

**Task**
- Detection, localization of leaks and assessment of leak rate in pipelines, tanks and waste deposits

**Physical basis**
- Transportation of leaking material according to diffusion process

**Measuring technique**
- Permeable and pressure-tight sensor tube along the component to monitored
- Central measuring system including a pump and sniffing gas detectors

**Evaluation parameters**
- Measuring of the gas concentration collected in the sensor tube as a function of the pumping time
  - **Leak detection:** crossing of gas concentration above a threshold (detection time)
  - **Leak location:** detection time multiplied by the measured gas flow velocity
  - **Analysis:** gas probe analysis, pattern recognition methods by neural networks using up to 7 sensors
Diffusion around the Pipe - Phase 1

LEOS (Leak- and Location System)
Diffusion around the Pipe - Phase 2

LEOS (Leak- and Location System)
Diffusion around the Pipe - Phase 3

LEOS (Leak- and Location System)
Diffusion around the Pipe - Phase 4

LEOS (Leak- and Location System)
Diffusion around the Pipe - Phase 5

LEOS (Leak- and Location System)
LEOS (Leak- and Location System)
Structure of Sensor Tube

- Perforated gas transport tube of modified hard PVC *
- Protective braiding of thin PE strips
- Diffusion Layer of EVA

*) alternative materials for special applications:
- PP (polypropylene)
- PVDF (polyvinylidenfluoride)

LEOS (Leak- and Location System)
LEOS (Leak Detection and Location System)
LEOS capabilities

**Detectable materials**
- All types of carbonates such as propan, crude oil, petrol, halogenized hydrocarbons, alcohols, ester, ether, ketones
- Anorganic gases (hydrogen, ammonia)

**Detection limits**
- Sensor tube: $\leq 10 \mu l / l$ for fluids
- $\leq 5 \text{ ml} / l$ for gases
- Leaking material: $\leq 1 l / h$ for fluids
- $< 0.1 \text{ m}^3 / h$ for gases

**Monitoring length / area**
- For each measuring system: pipeline: 15 km (up to 50 km for methan)
- Waste deposits: $< 100 \text{ ha} (\leq 35 \text{ km})$

**Location accuracy:**
- Better than $\pm 25 \text{ m}$ for 5 km ($\leq 0.5 \%$)

**Response time:**
- Normal application: 24h
- Special gas application: $\geq 0.5h$ (for short distances)

**Evaluation:**
- Automatic leak alarm
- Trending of leak indication
- Identification of leaking material

LEOS (Leak Detection and Location System)
LEOS Reference Location Plot
High Background of Methane at Selected Positions

LEOS (Leak- and Location System)
LEOS Reference Measurement
Low Background at VTG (BP) Pipeline Bundle

LEOS (Leak- and Location System)
LEOS (Location System)
LEOS 2.21-Veba Oel AG-Messstation-Nr.1-Brösweg

| Datei | Vorbelegen | Überwachen | Analyse | Diagnose | Fenster | Hilfe |

| K6 - M 919 - RR - Str.Nr.1 |

- * 1 mV

methan-unempfindlicher Sensor

| K1 - M 919 - RR - Str.Nr.1 |

- * 0.10 V

methan-empfindlicher Sensor
LEOS Location Plot
Influence of Sensor Type and Filter Algorithm

LEOS (Leak- and Location System)
Pipeline monitoring with central computer

LEOS (Leak- and Location System)
<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Company, Location</th>
<th>Medium Transports</th>
<th>Piping Length</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater Protection Area</td>
<td>1978</td>
<td>BASF AG, Ludwigshafen</td>
<td>Ethylene $C_2H_4$</td>
<td>4 km</td>
<td>above groundwater level, sensor tube lies beside pipe</td>
</tr>
<tr>
<td>Rhine River Crossing /Foreshore</td>
<td>1978</td>
<td>BASF AG, Ludwigshafen</td>
<td>Ethylene $C_2H_4$</td>
<td>2 x 1.5 km</td>
<td>sensor tube at 12 o’ clock in Rhine River bed, in a depth of 24 m from the maximum water level</td>
</tr>
<tr>
<td>Piping Bundle in Rhine Foreshore</td>
<td>1983</td>
<td>Wintershall AG, Mannheim</td>
<td>Pentane and nonane cut, benzene, aviation fuel,</td>
<td>2 x 1.5 km</td>
<td>sensor tube at 12 o’ clock in Rhine River bed, in a depth of 24 m from the maximum water level</td>
</tr>
<tr>
<td>Chemical Storage Facility</td>
<td>1987</td>
<td>Cable Factory, Coburg</td>
<td>Ketone, mixed solvents, oil etc</td>
<td>225 m $^3$</td>
<td>sensor tube laid in ducts below building</td>
</tr>
</tbody>
</table>

LEOS (Leak- and Location System)
## Track Report on Monitoring Function / Field Experience

| LEOS in operation **since 1978** |
| Small leaks at valves during pipeline operation |
| **No leak undetected** including field tests |
| **Approved system for water protection** in Germany |
| **Methane emissions** from natural organic processes |
| Other background emissions from **industrial pollutants** |

**LEOS (Leak- and Location System)**
BSL Pipeline System - MS1 Kösterbeck

LEOS (Leak- and Location System)

Propane indication at x = 432 m (5° position)

Propane indication at x = 1590 m (1° position)
System Experience

- **100% reliability** of installed sensor tube buried in soil or water
- Highly reliable *electronic components*
- *Automatic* monitoring with specified capabilities
- Low equipment *maintenance*
- *Measurement Module* allows simple system adaptation to monitor loop or radial systems, (up to 8 monitoring lines for each module)

LEOS (*Leak- and Location System*)
BPXA Northstar Project

Stipulation of U.S. Army Corps of Engineers:
“oil spill leak detection system“

Design Basis: 15 years, plus
- 6 miles subsea oil pipeline
- water depth 0 to 39 ft, burial depth 5 to 11 ft
- 60 °F operating temperature
- ambient air temperature during construction: -50°F
- high salinity

Sensitivity: < 1 bbl/day (32.5 bbl/day requested)

Performance requirements:
- no false alarms
- robust to survive installation and long-term operation

LEOS (Leak- and Location System)
Main LEOS Components of Northstar Project

TPG (shore crossing) 6 mile LEOS sensor tube and armor tube MS (Seal Island)

Sensor tube (15 mm OD 0.8 mm WT)

Protective PE-X tube (50 mm OD 6.9 mm WT)

Twin 10 inch dia. steel pipes

LEOS (Leak- and Location System)
Construction - Protection during Installation

*Impact and abrasion resistance*
- Sensor hose installed in a protective PE-X perforated tube
- Sensor hose and PE-X assembly delivered in 300 m (1,000-ft) coils
- Splice and repair can be made in the field

*Low ambient temperature application*
- Modified inner sensor tube made from PVDF

*Installation QAQC*
- Pressure tests of the sensor hose after each relevant step
- Final pressure test of the complete monitoring line

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