Leak Detection Programs with case study in INA

PhD Ivana Kalicanin

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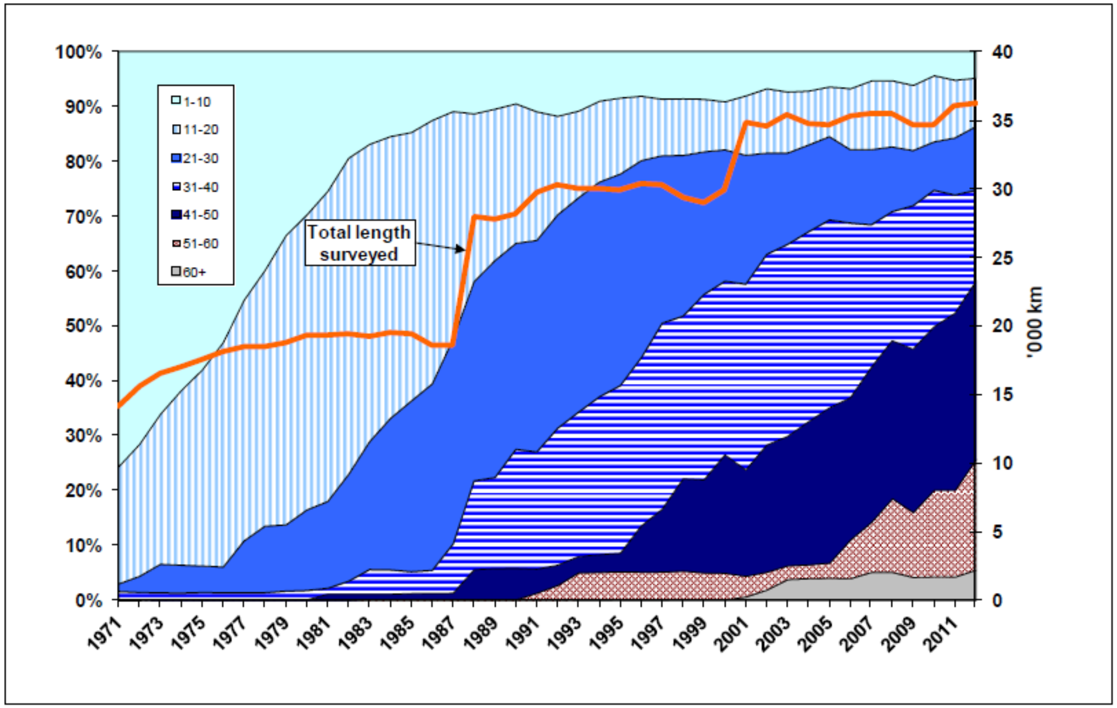
PRESENTATION AGENDA

- INTRODUCTION
- LEAK DETECTION PROGRAMS
- CASE STUDY – ATMOS PIPELINE LEAK DETECTION MAIN OIL PIPELINE STRUZEC – SISAK, CROATIA
- CONCLUSIONS

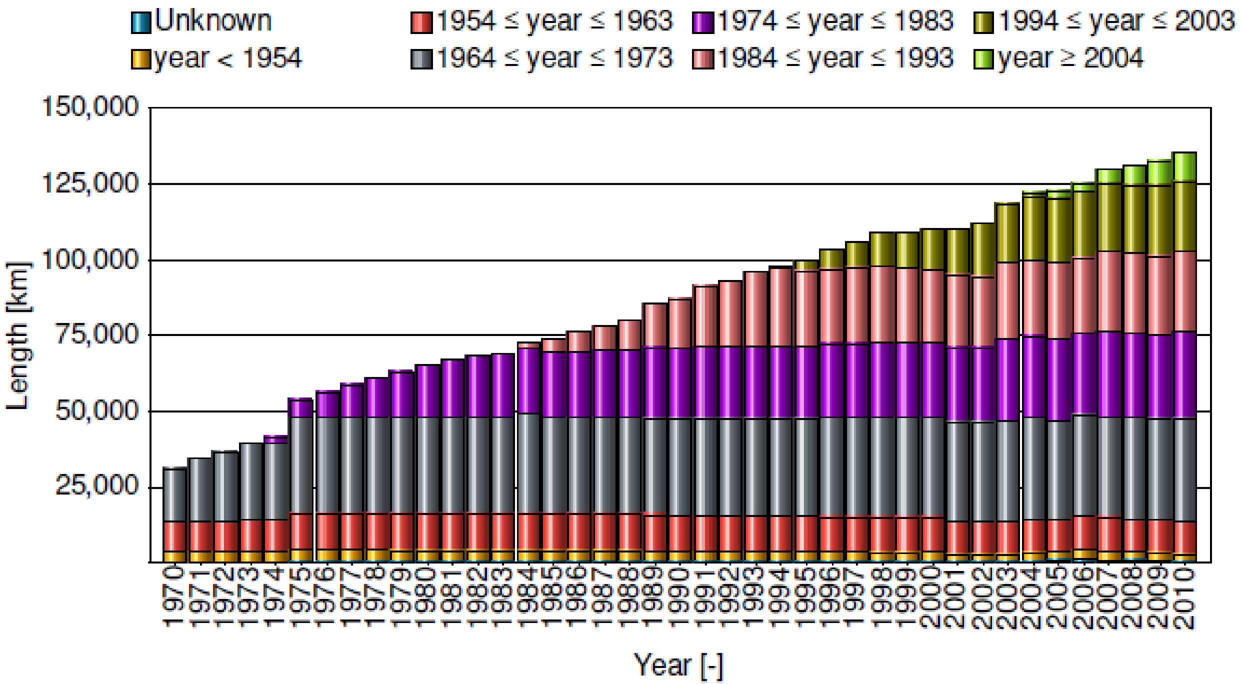
Concerned with environment protection but also the costs of cleaning oil spillage, more and more oil and gas production & transport companies use the pipeline leak detection systems on their main pipelines.

Leak Detection Programs with Case Study in INA



CONCAWE, Report 12/13

- In the 1970s over 70% of all European oil pipelines were less then 10 years old.
- In the 2010s more than 50% are 40 years old and older.



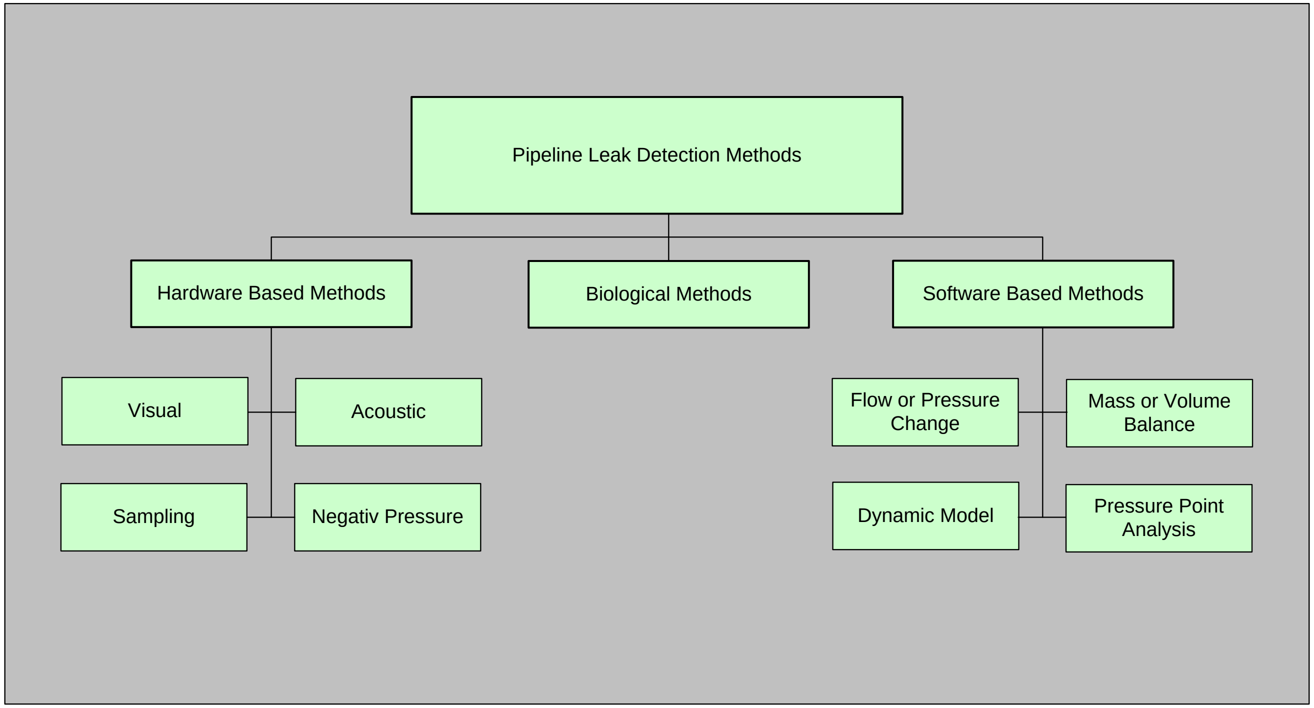
European Gas Pipeline Database shows that more than 50% pipelines are 25 years old and older.

LEAK DETECTION PROGRAMS

There are four requirements for leak detection systems:

- Sensitivity,
- Reliability,
- Accuracy,
- Robustness

- API 1149 Leak Detectability,
- API 1130 Compliance with CPM's (Computational Pipeline Monitoring),
- TRFL (Technical Rule for Pipeline Systems),



Pipeline Leak Detection Methods (Zhang, 1999)

- **Compensated mass balance**, based on the solution of the steady state set of equations which model a specific pipeline, know as RTM – Real Time Model,
- **Real Time Model**, but also solving transient set of equations, known as RTTM – **Real Time Transient Model,**
- **Pressure wave behavior,**
- **Statistical modeling.**

- API Publ 1149 equation as follows:

$$\frac{Q_{leakrate}}{Q_{pipelineflowrate}} \geq \sqrt{(Flow_{in}Uncer^2 + Flow_{out}Uncer^2) + \left(\frac{LinefillUncert}{\Delta Time \times Flowreate}\right)^2}$$

- **Acoustic monitoring techniques** – utilize acoustic emission sensors
- **Gas sampling methods** – use a flame ionizion detectors
- **Soil monitoring**
- **Software base dynamic modeling**
- **Optical methods of leak detection**

$$\frac{gAH_1}{Q_0 a}\frac{\partial H^*}{\partial x^*}+\frac{\partial Q^*}{\partial t^*}+\frac{V_0}{a}Q^*\frac{\partial Q^*}{\partial x^*}+\frac{fLQ_0}{2DAa}(Q^*)^2$$

$$-\frac{V_0}{a}\frac{C_d A_L\sqrt{2gH_1}}{Q_0}Q^*\sqrt{\Delta H_L^*}\delta(x^*-x_L^*)=0 \quad (9)$$

Because V_0/a is normally small, the second term in Eq. (8) and the third and the last terms in Eq. (9) can be neglected. The dimensionless equations become

$$\frac{\partial H^*}{\partial t^*}+\frac{1}{F}\frac{\partial Q^*}{\partial x^*}+M\sqrt{\Delta H_L^*}\delta(x^*-x_L^*)=0 \quad (10)$$

$$F\frac{\partial H^*}{\partial x^*}+\frac{\partial Q^*}{\partial t^*}+RQ^{*2}=0 \quad (11)$$

where

$$R=\frac{fLQ_0}{2aDA},\quad M=\frac{C_d A_L}{A}\frac{2a}{\sqrt{2gH_1}},\quad F=\frac{H_1}{H_J}$$

and $H_J=aV_0/g$=the Joukowsky pressure head rise, resulting from an instantaneous reduction of velocity V_0 to zero. The dimensionless quantities R, M, and F are used to characterize the leak problem.

Linearized Solutions

and using

$$\frac{1}{F}\frac{\partial q^*}{\partial x^*}=-\frac{\partial h^*}{\partial t^*}-M\frac{h^*}{2\sqrt{\Delta H_{L0}^*}}\delta(x^*-x_L^*) \quad (16)$$

from the continuity equation, Eq. (14), results in

$$\frac{\partial^2 h^*}{\partial x^{*2}}=\frac{\partial^2 h^*}{\partial t^{*2}}+\left[2R+M\frac{\delta(x^*-x_L^*)}{2\sqrt{\Delta H_{L0}^*}}\right]\frac{\partial h^*}{\partial t^*}$$

$$-2RM\frac{h^*\delta(x^*-x_L^*)}{2\sqrt{\Delta H_{L0}^*}} \quad (17)$$

Eq. (17) simplifies to

$$\frac{\partial^2 h^*}{\partial x^{*2}}=\frac{\partial^2 h^*}{\partial t^{*2}}+[2R+F_L\delta(x^*-x_L^*)]\frac{\partial h^*}{\partial t^*}$$

$$-2RF_L\delta(x^*-x_L^*)h^* \quad (18)$$

in which $F_L=M/2\sqrt{\Delta H_{L0}^*}$ is the leak parameter. Since $\Delta H_{L0}^*=(H_{L0}-z_L)/H_1$, if $z_L=0$, the leak parameter is

$$F_L=\frac{\frac{C_d A_L}{A}\frac{2a}{\sqrt{2gH_1}}}{2\sqrt{\frac{H_{L0}}{H_1}}}=\frac{C_d A_L}{A}\frac{a}{\sqrt{2gH_{L0}}} \quad (19)$$

Wang, X.-J. at al. (2002): Leak Detection in Pipelines using the Damping of Fluid Transients, Journal of Hydraulic Engineering

- **SCADA** stands for *supervisory control and data acquisition*.
- It generally refers to industrial control systems: computer systems that monitor and control industrial, infrastructure, or facility-based processes.

CASE STUDY - ATMOS PIPE PIPELINE LEAK DETECTION MAIN OIL PIPELINE STRUZEC – SISAK REFINERY

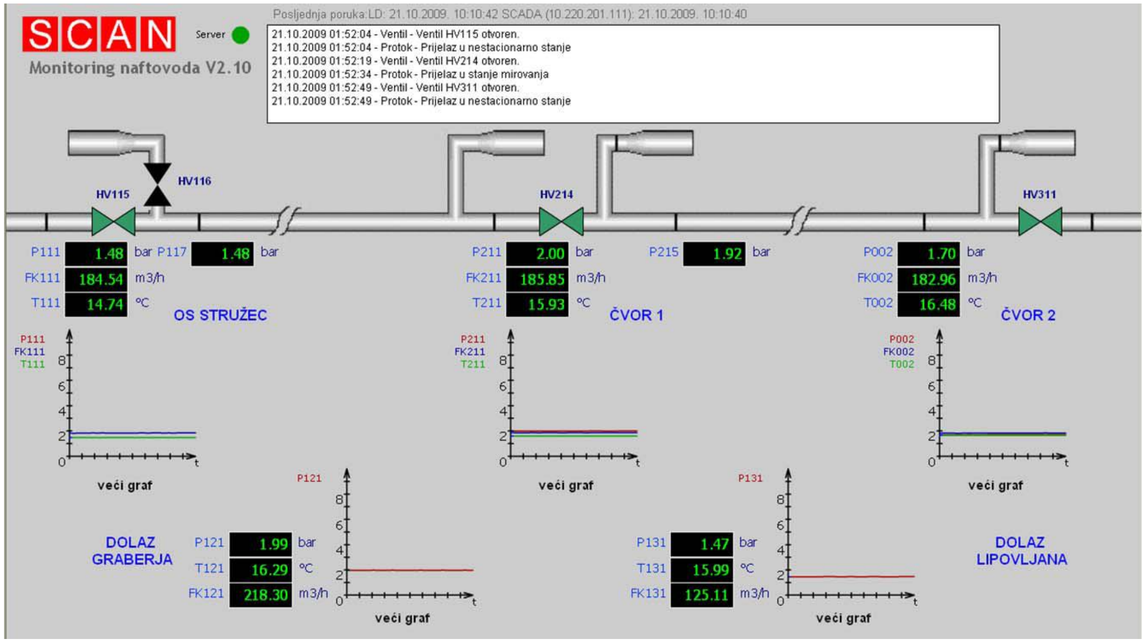
- Statistical pipeline leak detection and location system **Atmos Pipe Pipeline Leak Detection** by Atmos International was installed on the main oil pipeline Struzec – Sisak Refinery.

Gathering station
Struzec

Cleaning station
Brezovica

Cleaning station
Topolovac

Sisak Refinery



- Main crude oil 20”/12”/20”pipeline from main station Struzec – Sisak Refinery is 22 km long, has two cleaning stations and measurements of flow, pressure and temperature at the beginning (Main station Stružec), at the second cleaning station (Čvor 1 Topolovac) and the end of the pipeline inside the refinery.
- Monitoring system SCADA was installed more than 10 years ago.

The reference for the applications we ask for:

- Compability with existing SCADA system,
- Dealing with existing data of measurement of flow, temperature and pressure,
- Statistical method of leak detection based on corrected flow balance,
- Learning capability function in differences of flow measurements in regular use and drift of instruments true lifetime to decrease falls alarms,
- Detection of leakage in all dynamic and static conditions of the transportation through pipeline including transient time,
- Leak location,
- Minimum of false alarms,
- API 1155 (Evaluation Methodology for Software based Leak Detection System),
- API 1130 - Sept. 2007 (Computational Pipeline Monitoring for Liquids).

Project: STRUŽEC-SISAK CRUDE OIL PIPELINE
Factory Acceptance Test

ATMOSi PIPELINE SOFTWARE
Revision: 1.0

Contents

- The application was installed in April 2012
- The leak detection probe was done in May 2012
- Some more adjustments were made to solve the problems that occurred during probe.
- As a result of optimization of Upstream Division changes in transportation routine occurred.

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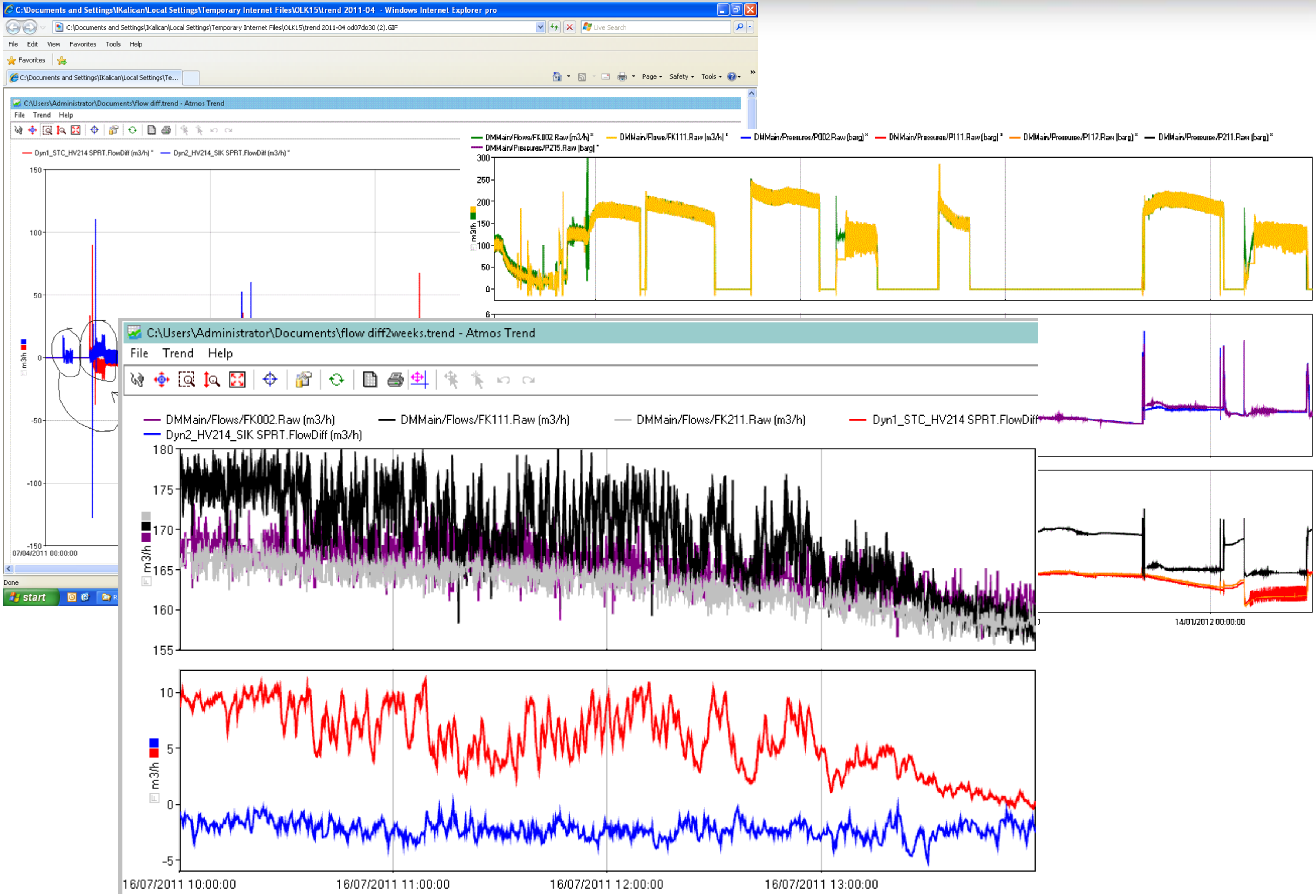

Leak Detection Programs
(Case study main oil pipeline Struzec – Sisak)

Problems with the program:

- Serious numbers of false alarms in transient time
- After tuning the program (transient time) – no response of alarm testing leakage

Contractor suggests:

- New measurement units at two points of pipeline
- New tuning of remote closing valves
- Programs upgrade

CONCLUSIONS

- **Leak detection programs are good way to increase pipeline integrity**
- **In time of decision which program should be used:**
  - **existing measurement points,**
  - **new devises (measurement point)**
  - **program’s quality**

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ivana.kalicanin@ina.hr