Design of a pipeline rehabilitation including the modern approach of PIMS and RMS

Pipelines, pipeline rehabilitation, PIMS and RMS

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An Eastern European pipeline operator was facing challenges regarding the integrity of an existing pipeline system in which several leaks and accidents had already occurred. In order to render the system "Fit for Purpose" a number of tests and rehabilitation possibilities were analysed by ILF Consulting Engineers and an optimum rehabilitation concept defined. The actual condition of the pipeline system was first assessed with respect to current standards, resulting in recommendations for the replacement or rehabilitation of some pipeline sections. The future integrity and safety of the pipeline system will, however, depend on the continuing implementation of "Risk Management" and "Pipeline Integrity Management" systems.

1. Project

ILF Consulting Engineers (ILF) was awarded by an eastern European pipeline operator to elaborate a rehabilitation concept of their two wet natural gas pipelines. The goal was to reach compliance with the local National Regulation for Energy and to meet the internal company mandatory technical requirements as well as international standards on security and safety.

The company decided to carry out an "Integrity Assessment Study" before starting any rehabilitation works because the management wanted to know the actual condition of the pipelines.

ILF was informed that the 20 inch pipeline "Stretch A" was constructed in 1975 of which 25 km have been replaced with various sizes of pipe material (14, 16, 18, 20 and 22 inch) due to leakages and other reasons. The 16 inch pipeline "Stretch B" was constructed in 1982 and due to leakages the operator exchanged two sections of 200 m and 300 m length. The total length of both pipelines to be investigated is 127 km. Pipeline material was/is presumable comparable to API 5L (X52) with bitumen wrapping. Furthermore, ILF was informed that maintenance was initiated only on leakages, which indicated the necessity of immediate actions to be performed.

An internal diagnostic investigation by means of ILI (In-line inspection) was seen as the most effective first step in order to bring the pipeline condition to light. The measures necessary to achieve this possibility have been checked by ILF intensively. But it turned out that this was not possible because of various reasons:

- pipeline sections were constructed with different pipeline diameters
- repaired or replaced pipeline sections were performed with different diameters without transition pieces

The pipelines were constructed, and afterwards the bends for change of horizontal and vertical direction, were executed with diameters smaller than 3D or with non standard complying cut elbows. A total length of approx. 25.5 km was replaced mainly because of leakages and other integrity issues.

It was a real challenge for ILF to retrieve and evaluate the integrity status of these pipelines. There was no "As-built" documentation available, the routes are fairly unknown, the "Cathodic Protection System" that was installed on one of the pipelines, was not maintained.

The only way to assess the integrity status of these lines was by means of NDT (Non Destructive Testing) on the most critical pipeline integrity sensitive positions.

The SOW (Scope of Work) ILF offered included the following works:

- Terrestrial survey, 200 m corridor
- Topographic survey, 100 m corridor
- Pipeline detection survey,
- ROW (Right of Way) information for trespassing reimbursements and clarification with land owners
- LRUT/GWUT (Long Range/Guided Wave Ultrasonic Testing) and Emat (Electro Magnetic Acoustical Transducer)
- Excavations for field bend (types), coating, wall thickness inspections and LRUT/Emat investigations
- Visual inspection and evaluation of all above ground installations and their instrumentation

- X-ray (material investigation by X radiation) on suspicious pipeline welding

Almost all crossings with roads, ditches and rivers are above ground and the pipeline in the other sections has a ground cover of 0–1.2 meter (**Figure 1**). Some pipeline stretches are lying on the ground, without coverage and are only protected by a bridled bitumen coating (**Figure 2**).

The results and findings of the assessment were presented to the client in a comprehensive report with the results, findings and recommendations of/for the following topics:

- wall thickness,
- pipe material,
- corrosion,
- coating,
- welding quality,
- valves,
- status of the instrumentation and crossings.

There were frequent leakages on the pipelines because of internal and external corrosion, pipe stress and geotechnical influences (landslides). During our assessment we detected 6 leaks. Leakages are environmentally not acceptable and the public safety, as well as the safety of clients' personnel is in jeopardy. According to Company internal information, there were 28 leakages detected and reported in the last two years.

After all available parameters, observation and test results, were evaluated, ILF calculated the length of pipeline that has a probability of mechanical failure above a specified acceptable probability.

The acceptable probability of mechanical failure is 1 to a 1million, according to DNV RP-F116: Pf≤1.00E-06.

The calculation resulted in:

- Stretch A pipeline: 61.6% of the 75 km original old pipeline was above this minimum (**Figure 3**)
- Stretch B pipeline: 1.4% of the 27 km was above this minimum

2. Conclusion/LF recommendations to the client

The remaining old pipe material of "Stretch A Pipeline", 75 km, should be completely replaced by new pipe material, installing a dedicated CP system and bringing all crossings according to the new standards below ground.

"Stretch B Pipeline", 27 km, could be still "Fit for Purpose", but the execution of an ILI (In-line Inspection) was requested for confirmation. The client was advised to make the pipeline pig-able by exchanging the above ground crossings. If it turns out that the integrity of the 27 km Stretch B pipeline is still acceptable, it would save the Client expenditures of approx. 27 million Euros for constructing a complete new pipeline.

***Figure 1**. Above ground River crossing where the river bedding changed its position over the years.*

***Figure 2**. Ditch crossing with strange supporting and very bad coating conditions.*

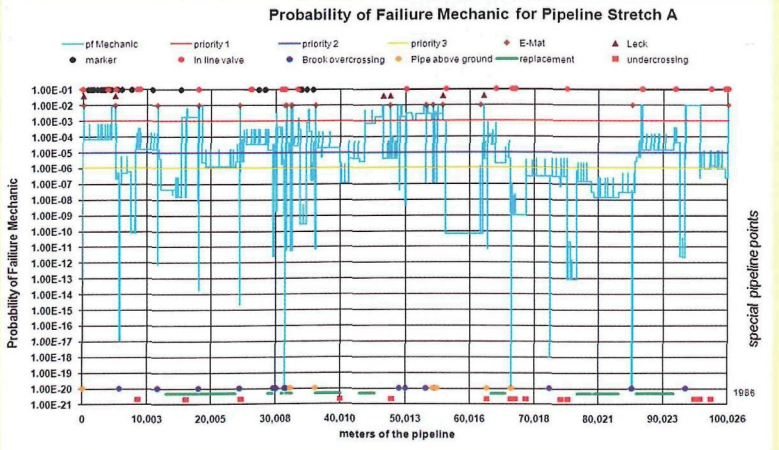

***Figure 3**. Graphic with the result of "Probability of Mechanical Failure" calculation.*

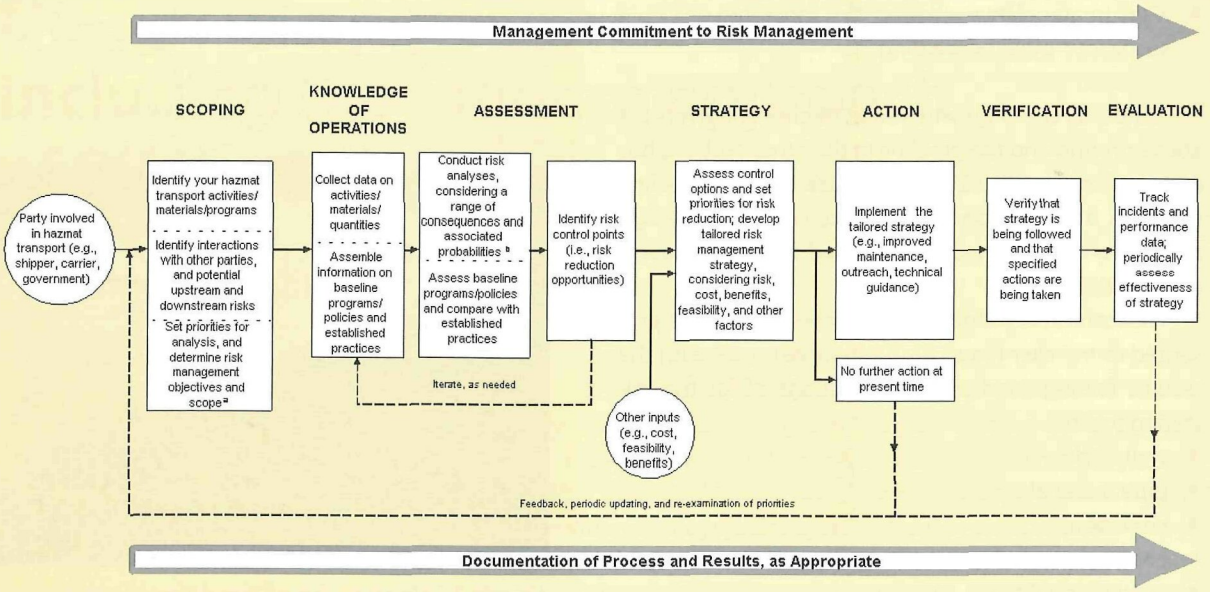

Figure 4. *Setup according to the US Department of Transportation*

We also advised the client to setup a PIMS (Pipeline Integrity Management System), training program for pipeline operators and pipeline inspectors to make them a part of the PIMS. This will stimulate a professional dedication to their job and a sense of job responsibility.

3. Time has changed within the world of pipeline operations

The major mission of a pipeline organization was to transport products from A to B in a most economical and effective manner. If there was a leak they repaired it without any involvement or supervision of authorities. In some operational manuals of pipeline operators you can still find the strategy "Maintenance on Leakage". In the modern time this will probably cost you your license to operate and a bad "Public Relation" documented and published by the national or even international media.

The Pipline operation philosophy is changed into risk control and risk management. Many pipeline companies are puzzled and uncertain about what system to use and what management system to build for safeguarding the integrity of their pipelines and to secure the compliance with the local or international legislation and/or standards. There are so many abbreviations going round and many tools are offered by study bureau's or software suppliers that want to have a piece of this new market.

For every pipeline environmental and operational risk, someone developed a tool, methodology, matrix or calculation sheet being on the basis of quantitative or qualitative data. In essence all these tools are evaluating or calculating the probabilities of failure that might lead to a loss of containment or the installation being out of service because of equipment that fails.

4. RMS (Risk Management System) and PIMS (Pipeline Integrity Management system)

As for all systems and processes you should start with a clear plan that will lead you and support you through the process and will keep the attention, awareness and dedication mandatory for all parties involved.

The following steps for a RMS are to be considered (US Department of Transportation **Figure 4**)

A. Define the scope and write a project plan as guidance
B. Document the operation knowledge and experiences
C. Assess all identified risks
D. Strategy/Planning: prioritize and create SMART targets
E. Action: actions change something, plans don't
F. Verification: check the actions and processes
G. Evaluation: review the targets and set results

The asset owner should evaluate all risks, describe the evaluation process and prescribe the way they are detecting or measuring the defects. Following this, the evaluation of causes and possible results, the mitigation measurements and the way of documentation and evaluation on effectiveness has to be checked. In other words the continuous improvements circle also known as Deming circle or PDCA (Plan, Do, Check, Act) methodology has to be implemented.

Not many companies know how to implement systems like this or don't even know where to start.

PIMS looks at and safeguards the integrity of the pipeline to preserve the asset utilization and capability and the actions in mitigation are prioritized on "Fit for Purpose" which are usually influenced by the factor of costs.

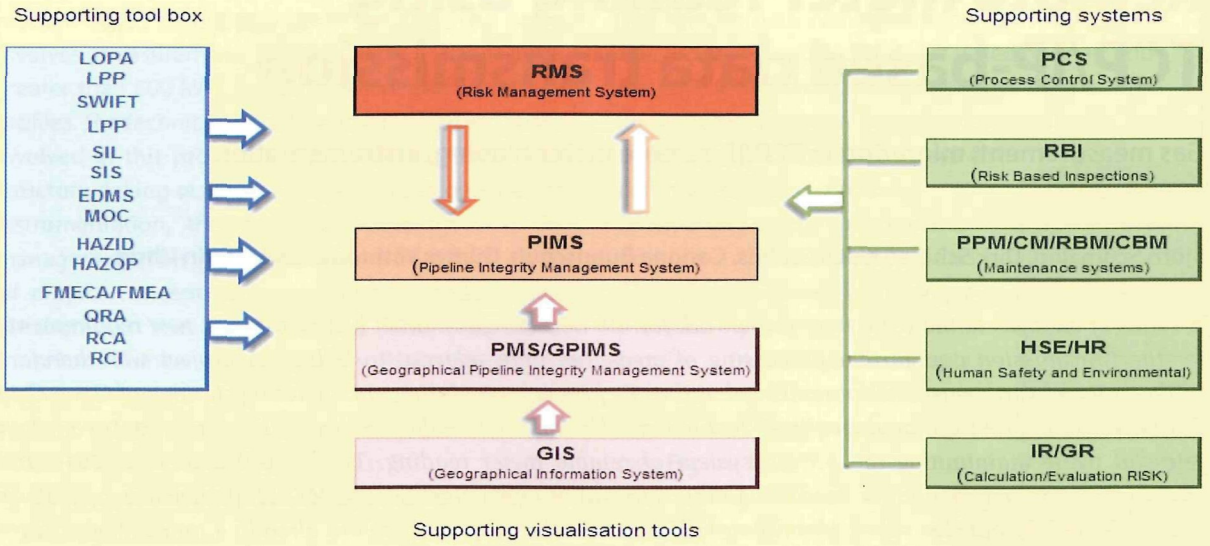

Figure 5. *Position of a PIMS (Pipeline Integrity Management System) in a corporate risk management organization.*

RMS looks at the PIMS, which assesses the integrity of the pipeline installation itself, but also looks at the possible consequences of all pipeline external threats that might cause risks. These risks are not only related to the loss of containment and the costs of repairs or downtime of the pipeline system itself, but are also related to the consequences of an incident to the environment and public safety which could seriously damage the corporate reputation.

Many operators are mixing the RMS and PIMS systems up (see **Figure 5**) and when a problem/incident or threat occurs they will start looking for a solution instead of investigating the real root of the problem.

ILF Consulting Engineers can assist and/or provide the pipeline operating companies the knowledge that will allow them to manage the complex tasks, planning and mitigation processes that are required to control, reduce and mitigate the risks of pipeline operation.

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