

*PSI pipelines  
Integrated Solutions for  
Leak Detection and  
Pipeline Monitoring*

PSI 

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# Introduction

PSI*pipelines* is a field-proven suite of operational applications which are used to quickly identify critical situations, to track what is happening throughout a pipeline, to check certain conditions before execution, to maintain the integrity of pipelines and to allow operators to react instantly to all conditions.

This highly available and reliable system has been developed to guarantee

that the strict requirements for the transportation of liquids and gases are met. The liquids and gases concerned may be crude oil, natural gas, liquified gas, petrochemical products, water and other liquid or gaseous products.

PSI*pipelines* can also effectively be deployed for multi-batch pipelines to monitor the movement of different fluid compositions.



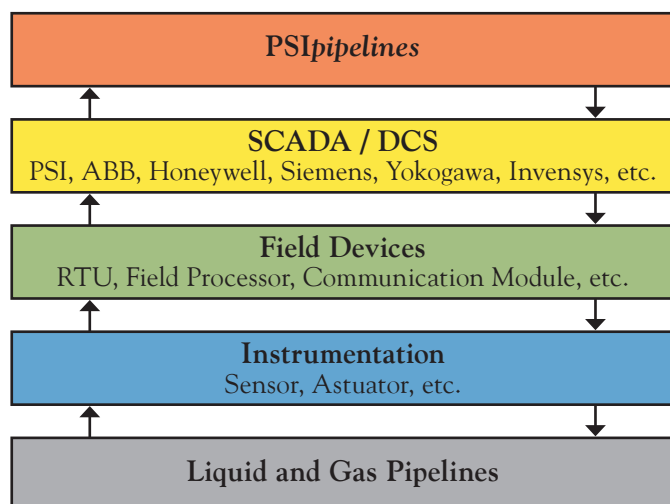
PSI*pipelines* provides a platform for

- Leak Detection and Location
- Hydraulic Profiles
- Scraper Tracking
- Batch Tracking
- Density Tracking
- Temperature Tracking
- Velocity Monitoring
- Flow Path Detection
- DRA Management
- Pipeline Stress Monitoring
- Inventory Monitoring
- Wall Roughness Monitoring
- Predictive Simulation
- What-If Simulation
- Pump Monitoring and Operation Improvement
- Pipeline Operation Analysis
- Tank Farm Management

## Integrated Solutions

Fully integrated solutions are perfectly matched applications utilising software and hardware for cost-effective implementations, high system performance, high reliability, outstanding quality, efficient engineering, safe operations and reduced costs for services and training.

PSIpipelines unique scalable architecture supports different levels of integration with SCADA systems, instrumentation and field devices. PSIpipelines can integrate easily with any third party SCADA system and other applications across diverse operation environments.



It supports multiple international standards like OPC, Modbus, IEC and other protocols with minimal configuration to transfer data to and from SCADA servers. PSIpipelines can seamlessly integrate with PSIcontrol SCADA system which has been specifically developed for the monitoring and control of pipelines. Customers benefit from a consistent

look-and-feel across products, optimal system performance, efficient implementation, shared access to all engineering tools, reduced training costs and a single point of service.

PSI provides integrated leak detection solutions for upstream and downstream oil and gas pipelines through advanced hardware combined with the PSIpipelines software platform. The hardware components of PSI integrated solutions include dedicated Leak Remote Units (LRU) equipped with GPS synchronization, high analogue-to-digital resolution (above 12 bits depending on hardware model) and buffering capabilities to overcome communication failure without field data loss. The buffering capabilities as well as data scanning and processing time are configurable. The fast scan high resolution platform allows the running of sophisticated PSIpipelines Pressure Wave Analysis and Pattern Recognition applications to resolve leak detection and location. Based on the distributed smart-processing hardware platform pipeline leaks can be detected directly by Leak Remote Units which provide various types of programmable outputs for pump shut-downs, isolation valves or local alarming purposes. The smart-processing features embedded in the hardware of PSI integrated solutions further boosts PSI leak detection capabilities in order to achieve fast response actions to line-ruptures while minimizing the communication bandwidth requirements for the applications.

# Scalability and Flexibility

Every project is different, and will vary according to the size of a pipeline system, project budget and operational requirements. *PSIpipelines* is a highly scalable system that provides all parts of a solution that are needed for the day to day operation.

All *PSIpipelines* applications are built on top of a common set of subsystems including real-time database, data historian, real-time transient model, tracking system, alarm and warning subsystem, data acquisition, data processing and data validation, network communication and data exchange, SCADA integration, redundancy management with automatic fail-over functionality, user permission management and a graphical user interface with a familiar Windows look and feel and multi-language support.

The inherent flexibility of the system ensures that an existing solution can expand as the pipeline system expands up to large scale hydrocarbon transporting and distribution networks without project-specific code changes. In order to support maximum flexibility, scalability and efficient project implementation *PSIpipelines* provides all engineering tools for database and pipeline system configuration, graphical screen design, pipeline modelling, user management and other configuration tools.

The utilisation of the modular *PSIpipelines* platform and engineering, development and service expertise enables PSI to be a strategic partner for many customers to implement tailor-made solutions if standard solutions are not adequate.

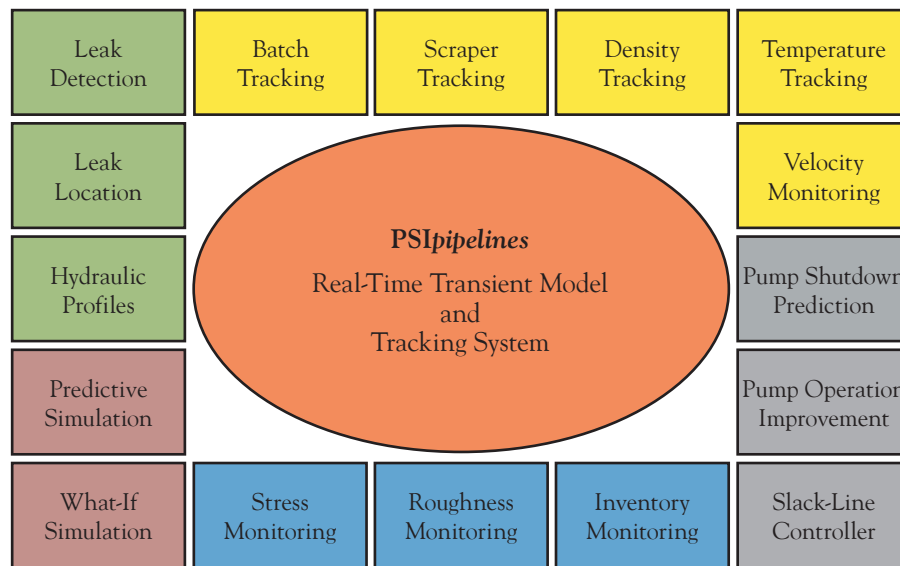


# Fundamental Components

## Real-Time Transient Model

The PSI Real-Time Transient Model (RTTM) is the fundamental component of PSIpipelines. It simulates the hydraulic behaviour and thermodynamics of the flow at each point of the pipeline and compares in real-time the calculated

vides accurate information to the operator and associated applications. The model is also capable to take wax and drag reduction agents into account. The PSIpipelines RTTM is very robust in handling bad or inconsistent data and



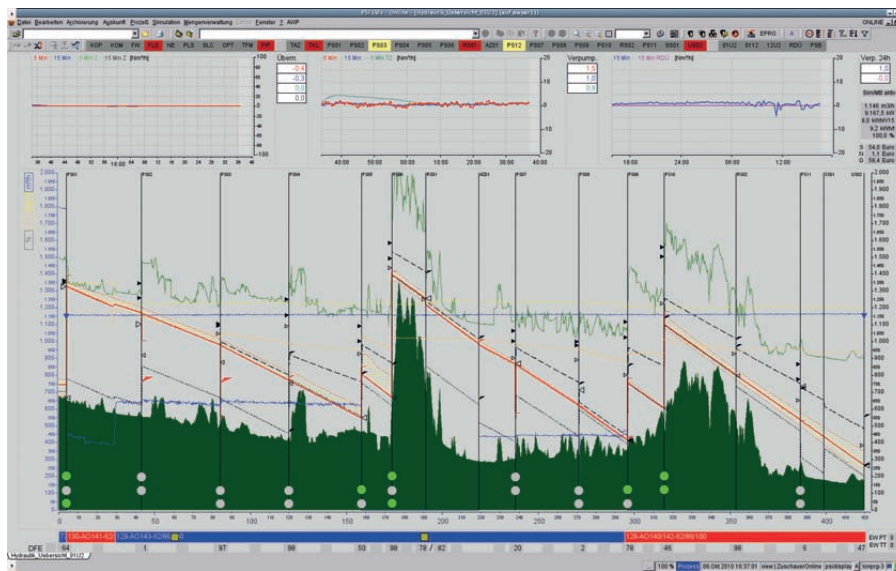
values with the actual data. The system receives measurements from instrumentation (e.g. flow, pressure, temperature, density, etc.) and updates the model on a fixed cycle basis. The calculations include regular solving of hydraulic, thermodynamic and state equations taking into account the properties of the pipeline and fluid, instrumentation and equipment, state variations and the heat exchange with the surroundings. Based on a complete and accurate mathematical representation the PSIpipelines RTTM represents the pipeline state under any operating condition and pro-

ensures that faulty input data will not cause instability or shut-down of the complete system. It contains auto-tuning and self-adaption functions to improve results during pipeline operation and to detect negative drifts that may occur. Even though the capability of the modelling software is determined by pipeline design and instrumentation, the software itself imposes no limitations on the performance of the overall system. In environments with many different pipelines that transport different fluids and gases, the model is able to handle all pipelines at the same time.

## Tracking System

The PSIpipelines Tracking System is another fundamental component and closely integrated with the PSIpipelines Real-Time Transient Model. The Tracking System provides complete linefill information for all associated applica-

calculates and provides the exact arrival time and velocity of all linefill elements. Operators are informed in good time before a batch arrives at a pump station or pipeline branch.



tions and keeps all data reliable even if a pipeline topology has been changed. With its powerful and proven methods the tracking system covers all requirements for accurate tracking of scrapers, batches, products, densities and temperatures. The tracking system is able to handle any mixing and splitting point. It uses scraper signals in order to correct automatically their position and generates warnings whenever valve stations are approached. The Tracking System

## Hydraulic Profiles

The PSIpipelines Real-Time Transient Model provides high-resolution real-time hydraulic profiles. These profiles help the operator to identify pressure excursions, liquid dropout, gas breakout or drifts of instrument performance. The system displays various profile plots with both actual and simulated data on the screen including Pipeline Elevation, Pressure, Flow, Temperature, Density, Velocity, Maximum and Minimum Operating Pressure.

# Leak Detection and Location

Leaks can be caused by third-party intervention, ground movement or corrosion, but also by improper operating procedures and material failure. PSIpipelines provides several methods for leak detection and location.

The selection of appropriate methodology depends upon instrument availability, field devices, communication infrastructure, transported fluids and gases and performance criteria. PSIpipelines Leak Detection System does not depend on special instrumentation and field devices, but the overall system performance improves if integrated with ultra-fast scanning sensors and dedicated Leak Remote Units with sufficient processing power.

PSIpipelines Leak Detection System is the most accurate solution for long

Detection System is compliant to international and industry standards including API 1155 / 1130 and TRFL – German Regulations for Pipelines. PSIpipelines Leak Detection System is also certified by all TÜV organisations.

In combination with statistical analysis PSIpipelines Leak Detection System provides model-based methods (Model Compensated Mass Balance, Transient Model, Pressure-Temperature Method and Gradient Evaluation) and methods that utilise the signature of a leak (Pressure Wave Analysis, Pattern Recognition).

Methods are optimised to detect and to locate leaks accurately during steady state, shut-in and transients operations for onshore and offshore pipelines of all sizes. The different methods can be deployed in parallel in order to ensure the highest possible reliability. PSIpipelines Leak Detection System has been designed to handle many pipelines as well as pipeline segments for different fluids and gases in one single solution. The system takes available data from composition analysis and density measurements also into account if the conditions of transported products change.

Any invalid measurements or field device malfunctions will not cause a shutdown of the PSIpipelines Leak Detection System. All leaks are clearly indicated and presented graphically via the PSIpipelines graphical user interface. This interface is highly customisable and provides significant information to the operator. Leak warnings and alarms are also sent to the SCADA system.



distance pipelines with intermediate pumps, extreme elevations and slack line flow conditions. PSIpipelines Leak

# *Real-Time and Offline Simulations*

## **Predictive Simulation**

During steady-state operations the hydraulic conditions may change. If a pipeline transports different products of different compositions the conditions will change slowly so that a previously chosen optimal mode of operation might become more and more inconvenient. The *PSIpipelines* Predictive Simulation module identifies in advance any negative drift to undesirable hydraulic conditions. The system detects the process element that is going to reach a certain threshold and calculates the exact time at which the event will occur. The operator then can adjust pump switches or modify set points. A predictive simulation runs on a cyclical basis. It can be started either manually by the operator or it runs permanently in the background. The resulting simulation values for flow, pressure, density, etc. are stored in the same database as any real-time measurements and thus can be applied by any other module and subsystem.

## **What-If Simulation**

In multi-batch pipeline operations it is essential to know in advance the consequences of operator-initiated actions. Based on Real-Time Transient Model data, pump switch settings, modified set points, flow path variations and other information the *PSIpipelines* What-If Simulation calculates the corresponding process values.

## **Training System**

The *PSIpipelines* Offline Simulation contains a transient model of the pipeline system along with a facility simulation kit for pump control, valve control and for the emulation of control loops. The offline simulation system is the basis for *PSIpipelines* Training System.

The Training System exactly replicates the real process and provides all functions for leak detection and pipeline monitoring simulation. The hydraulic offline simulation replaces the complete pipeline process as modelled in a real solution. The virtual control system converts operator commands into process information and emulates control loops.



# Improved Pump Operations

## Energy Efficient Pump Operations

The reduction of pumping costs and energy consumption is a major objective for all pipeline operating companies. Optimal pumping is essential to keep the lifetime of pipelines. In order to obtain the required flow within a pipeline the Pump Optimisation module utilises the pressure and flow characteristics and pump efficiency curves as well. Based on the Real-Time Transient

## Pump Shutdown Monitoring

Pipelines are equipped for safety reasons with special shutdown and controlling devices. PSI*pipelines* Shutdown Monitor follows the same logic as for emergency control and shutdown, but permits the setup of different thresholds. The system triggers warnings before any action in the field is automatically started.



Model and actual hydraulic conditions like linefill, pipe friction factor, etc. the system determines the most efficient pump operations and provides the results to the operator.

# *Pipeline Integrity and more*

## **Pipeline Stress Monitoring**

The total lifetime of a pipeline segment is limited and depends on operational procedures. In order to predict material fatigue it is important to monitor the stress that is caused by pipeline pressures. If most pump operations are performed during steady state with only a few interruptions, the impact on the total lifetime is much less than during transient conditions.

Based on actual pressure values for monitored pipeline segments which are stored continuously in the database, the *PSIpipelines* Stress Monitor analyses permanently pressure trend curves, determines maximum and minimum possible thresholds and calculates the impacts of pressure changes. When the pipeline approaches the end of its lifetime the system generates appropriate messages for further actions that should be initiated by the operator. The system executes calculations in accordance to TÜV AD S1 and S2 technical rules (Analysis for cyclic loading).

## **Pipeline Wall Roughness Monitoring**

Pipeline configuration, wall roughness and pipe friction factor are usually defined as standard values during design stage. Any changes of these values will be compensated by the Real-Time Transient Model tuning methods. Tuning factors which are calculated for each

pipeline segment are also monitored against thresholds. The *PSIpipelines* Wall Roughness Monitor triggers alarms to indicate new scraper runs.

## **Pipeline Inventory Monitoring**

During operation days a pipeline contains different amounts of products, which is caused by temperature and pressure variations. *PSIpipelines* Inventory Monitor stores the quantities of all pipeline segments in the real-time database and compares each quantity to all threshold levels. The system determines the quantities for each pipeline segment and also for every product in multi-product pipelines.

## **Density Monitoring**

If batches of different products are transported through the same pipeline the operator needs precise information about the moment when the flow path shall be changed. The *PSIpipelines* Density Monitor identifies the expected density trend and presents all batches and mixing zones fully graphically on the screen. Based on this information the operator decides at which part of the mixing zone the flow path shall be changed in order to avoid any contamination at the delivery point.

# Engineering, Training and Support

## Engineering

System Design, Project Management, Engineering, Test and Commissioning include:

- Project organisation and resources management,
- Preparation and execution of reviews and meetings,
- Project schedule supervision,
- Quality control,



- Preparation of System Design Documents,
- Hardware setup and configuration,
- Software setup and configuration,
- Real-Time Transient Model design and engineering,
- System integration with SCADA,
- Tests and Model tuning,
- Preparation and execution of commissioning and tests,
- Preparation of user manuals.

## Training

Training courses for operators, system administrators and maintenance personnel include:

- Basics of the Real-Time Transient Model and Tracking System,
- PSI*pipelines* data visualisation and human machine interface,
- Leak detection and location methods,
- PSI*pipelines* modules,
- System and engineering tools.

## Support

PSI provides maintenance services for PSI*pipelines* software after project acceptance. Depending on customer and operational requirements the following services are provided:

- 24/7 support and operational services,
- Mirror installation in PSI facilities,
- Services to correct detected faults and application support,
- Preventive maintenance and system management,
- Services at the client's request (e.g. changes and adaptations to software and configuration)
- Individual customer services and developments.

# About PSI

## Company

PSI develops and integrates software solutions and complete systems for liquid and gas pipelines, electricity networks, manufacturing plants and public transportation.

From the very beginning PSI's business focus has been clearly-defined: Close cooperation with its customers. The key to success lies in a comprehensive understanding of customers' core business processes. This enables PSI to deliver intelligent, high-tech solutions today whilst developing technical innovations that will shape the future. The company was founded in 1969 and currently employs more than 1,450 individuals in eleven German and eighteen international locations in Europe, Middle East, Asia and North America. In financial year 2010 the Group achieved revenues of 158 million Euros. The PSI AG is listed in the Prime Standard of the German stock exchange.

## Quality Management

PSI has a policy of constant development and improvement of its products and has a formal quality management system that was first certified to be in compliance with ISO9001 in 1994. The quality management system is re-certified every three years.



## References

Company	Project	Scope of Supply
Kuwait Oil Company	Gas and Condensate Pipeline Network	Pipeline Leak Detection System Scraper Tracking Predictive Simulation Detection of instrument malfunctions Pipeline Roughness Monitoring (SCADA: ABB)
Kuwait Oil Company	40" Gas Pipeline	Pipeline Leak Detection System (SCADA: ABB) Extension to Gas and Condensate Pipeline Network
Kuwait Oil Company	BS160 Gas and Condensate Pipelines	Pipeline Leak Detection System (SCADA: ABB) Extension to Gas and Condensate Pipeline Network
Kuwait Oil Company	BS171 Gas and Condensate Pipelines	Pipeline Leak Detection System (SCADA: ABB) Extension to Gas and Condensate Pipeline Network
OMV	Product Pipeline	Pipeline Leak Detection System Batch Tracking Scraper Tracking Pipeline Stress Monitoring Density Monitoring (SCADA: ABB)
Adria-Wien Pipeline	Crude Oil Pipeline	Pipeline Leak Detection System Scraper Tracking Batch Tracking Pipeline Stress Monitoring Tank Farm Dispatching DRA Management (SCADA: PSIcontrol)
Transalpine Pipeline	Crude Oil Pipelines	Pipeline Leak Detection System Scraper Tracking Batch Tracking and Batch Planning System Predictive Simulation Pipeline Stress Monitoring Tank Farm Dispatching (SCADA: PSIcontrol)
RMR	Product Pipelines	Pipeline Leak Detection System Scraper Tracking Batch Tracking (SCADA: PSIcontrol)

Company	Project	Scope of Supply
Saudi Aramco	Karan Offshore Gas Pipelines	Pipeline Leak Detection System (SCADA: Siemens)
Dow Chemical	Product and Gas Pipelines	Pipeline Leak Detection System Scraper Tracking Batch Tracking Pipeline Stress Monitoring Post Mortem Analysis (SCADA: Honeywell)
MVL	Crude Oil Pipelines	Pipeline Leak Detection System Scraper Tracking Batch Tracking Pipeline Stress Monitoring (SCADA: PSIcontrol)
PCK	Crude Oil Pipeline	Pipeline Leak Detection System Scraper Tracking Batch Tracking (SCADA: PSIcontrol)
PKN Orlen	Product Pipeline	Pipeline Leak Detection System Scraper Tracking Batch Tracking (SCADA: PSIcontrol)
OMV	Crude Oil and Product Pipelines	Pipeline Leak Detection System Pipeline Stress Monitoring (SCADA: HIMA)
LUKOIL	Product Pipeline	Pipeline Leak Detection System Pipeline Stress Monitoring (SCADA: Honeywell)
BayernOil	Product Pipelines	Pipeline Leak Detection System Pipeline Stress Monitoring (SCADA: Invensys)
Celanese	Product Pipeline	Pipeline Leak Detection System Scraper Tracking (SCADA: Yokogawa)
Tatneft	Crude Oil Pipeline	Pipeline Leak Detection System
Transneft	Crude Oil Pipeline	Pipeline Real-Time Simulation System



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