



SERVICES AND SOLUTIONS

Technical Assessments for Pipelines



Experience In Motion

The mission of Flowserve is to help pipeline operators optimize pumping system performance and maximize profitability. This is accomplished by a team of more than 150 design and applications engineers stationed around the world. Comprehensive pipeline system assessments using advanced data collection tools and methods coupled with sophisticated modeling techniques provide the blueprint by:

- Identifying opportunities to reduce energy usage of major systems and critical equipment*
- Diagnosing the root cause(s) of underperforming systems and premature equipment failure, regardless of OEM or type*
- Identifying opportunities to improve operator safety*
- Developing economical solutions for chronically problematic equipment using life cycle cost (LCC) projections*

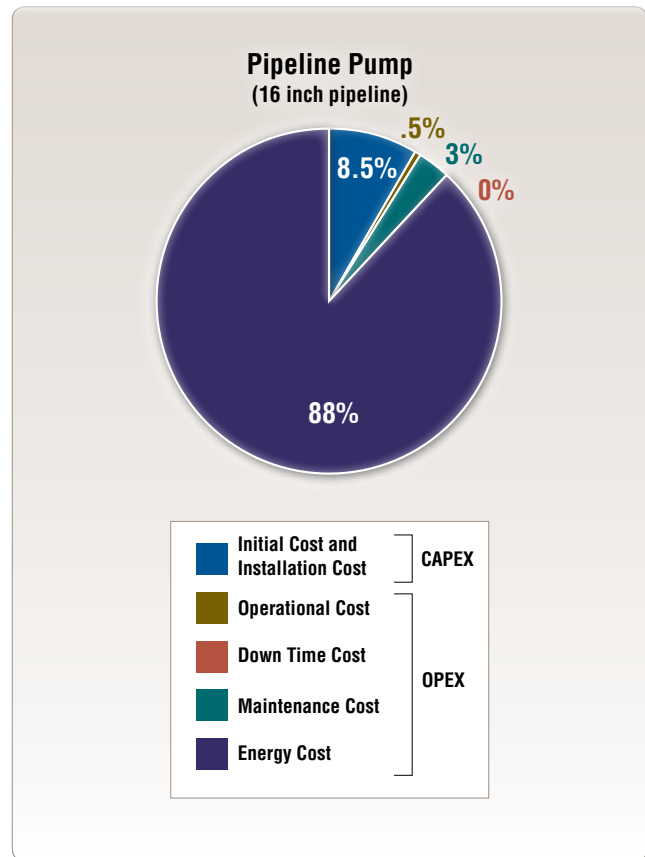


A Systems Approach

Flowserve is fully committed to maximizing pipeline profitability by reducing the life cycle costs of pumping systems. And while main-line and booster pumps are critical components of any pipeline, Flowserve recognizes that no pump operates in isolation. It is part of a system with myriad other components, all with crucial roles in achieving optimal pipeline efficiency and availability. That's why Flowserve is system driven, dedicated to looking beyond pumps. Furthermore, with nearly 90% of a typical pipeline pump's total life cycle cost apportioned to energy usage, Flowserve assessments are sharply focused on energy reduction as the most immediate way to improve pipeline profitability.

Assessments by Flowserve engineers can help pipeline operators optimize performance and reduce energy usage by identifying deficiencies in systems such as:

- Mainline system pumps and drivers
- Booster station pumps and drivers
- Piping design
- Mechanical seals and seal support systems
- Ancillary equipment



Flowserve Identifies \$3.51 Million in Savings

The Challenge: A South American pipeline company which moves over 42 000 m³/day (264 000 bpd) of crude oil was burdened with high operating expenses. Flowserve was engaged to identify opportunities to reduce operating expenses and to provide LCC justification for each.

The Assessment: Flowserve engineers performed comprehensive field testing of the entire system, consisting of 16 pump stations, to collect actual system performance data. Highly accurate torque meters were used to obtain operating efficiencies of pumps and gas turbines. In-depth mechanical and vibro-elastic reviews were also performed on two pumps known to be “bad actors.”

Using actual performance data and interactive software for designing and analyzing pipelines, Flowserve engineers created a highly accurate model of the entire pipeline system. The model and LCC methodologies were used in combination to identify and evaluate opportunities to improve system performance and reduce operating costs.

Upon completion of their analysis, Flowserve found:

- Several pumps were oversized, operating at $\leq 60\%$ BEP due to reductions in original hydraulic requirements
- Low-efficiency gas turbines were limiting pump availability and driving up operating costs due to increasing fuel prices
- Valve throttling to compensate for reduced flow requirements was amplifying vibration which in turn decreased mean time between repair (MTBR) and increased the related maintenance costs
- Improperly sized suction filters increased friction losses and reduced efficiency while escalating maintenance costs

The Solution: Flowserve recommended:

- Hydraulically re-rating the two bad actors as well as eight other pumps to restore BEP performance and improve energy efficiency
- Replace inefficient gas turbine drivers with high-efficiency electric motors equipped with VFDs to eliminate fuel-related problems and improve net efficiency
- Eliminate valve throttling and vibration issues with VFDs for more efficient flow control, resulting in lower energy usage and maintenance costs while extending MTBR
- Upgrade suction strainers to reduce friction losses, energy use and maintenance costs

The recommendations represent an estimated annual savings of \$3.51 million (U.S.) – \$3.06 million (U.S.) in energy and \$450 000 (U.S.) in maintenance costs – on an investment of \$2.58 million (U.S.), \$2.44 million (U.S.) of which is capital.

Pump Station Assessments

Station monitoring and control are critical to reliable pipeline system operation. Flowserve engineers collect data to diagnose pump reliability and efficiency issues. Excessive vibration, high temperature, low flow, high pressure, high lube oil temperature or other abnormal conditions are all important evidence in pinpointing poor pump performance.

Flowserve employs sophisticated hydraulic system modeling and piping design software to determine energy optimization solutions. These tools allow Flowserve engineers to systematically and comprehensively address:

- Changes in elevation and friction issues
- Fluid characteristics including specific gravity, temperature, vapor pressure and the presence of corrosives
- Desired pumping rate and expected future changes in volume requirements
- Pressure conditions including: suction and discharge pressure, NPSHa, expected future pressure conditions and the effects of operating pumps in series or in parallel
- Special metallurgy and/or surface finishing to handle high temperatures, corrosive fluids or other severe conditions
- Impact of driver selection and flow throttling



Looking Beyond the Pumps

Pumps and drivers are crucial elements in any pipeline performance evaluation but they do not tell the whole story. System piping is also important, especially where piping pressure losses and NPSH are critical. Besides increasing energy costs, unexpected pressure losses contribute to decreased pump MTBR. Furthermore, maintaining proper NPSHa is essential to preventing cavitation which can severely damage equipment and lead to premature pump failure.

System efficiency is also impacted by ancillary equipment such as:

- Storage vessels
- Metering devices
- Scraper traps



The Evaluation Process

Well-engineered pipeline pumps have an expected life-time service of 40 years. Over time, however, changing product characteristics and gradual equipment degradation can have negative effects upon pump reliability and efficiency. Maintaining hydraulic balance between high-speed mainline pumps and low-speed, low-suction pressure booster pumps can become increasingly problematic.

While sound pipeline pumps will have eight to 12 years MTBR, those with design weaknesses will require significant maintenance within three years or less. These bad actors sharply increase maintenance costs and should be analyzed for root cause failure and modified to achieve average or better MTBR.

The Flowserve five-step assessment process has proved highly successful in optimizing pipeline system performance.

1. Evaluate symptoms of deficient equipment or under-performing systems by forensically auditing current process parameters, maintenance history and operational demands.
2. Implement a testing methodology utilizing proprietary and non-proprietary data collection hardware or software tools to generate actionable data.
3. Analyze data, technical documentation and interviews to delineate root cause solutions.
4. Generate a comprehensive report with recommendations supported by life cycle cost analysis that enables the customer to achieve operational and reliability goals.
5. Provide continued technical and commercial support to secure sustainable and measurable results.

Knowledgeable People With Powerful Tools

In addition to their pump expertise, Flowserve engineers have extensive experience with pipeline systems and applications. These credentials are supported by state-of-the-art monitoring, diagnostic and modeling technologies, including proprietary Flowserve engineering software and evaluation methods. The result is actionable information that pipeline operators can use to optimize system performance.



Acquiring the Data

Performing an in-depth analysis of pipeline hydraulics requires the collection of a large amount of historical information and actual performance data.

Experienced Flowserve engineers perform extensive on-site audits to define pump reliability issues and maintenance history, operating issues and possible system and component design weaknesses. This is accomplished in part by interviewing pipeline staff and by collecting historical data like maintenance files, design and construction data.

Flowserve engineers also conduct comprehensive field testing to establish actual performance data. This testing may include the company's proprietary IPS Wireless monitoring and diagnostics hardware and software. Data including pressure, temperature, flow, etc., is recorded in real time. This data is used to validate high-fidelity hydraulic models of the system which are used to identify system deficiencies and predict changes in system performance.

A Reliable Partner

With more than 100 years of pipeline pumping experience, Flowserve is globally recognized as the industry leader in advanced design, engineered solutions and equipment re-rates. Flowserve has successfully completed hundreds of pipeline evaluation projects which include:

- Energy optimization through complete system review
- Hydraulic re-rates to meet new duty conditions
- Mechanical upgrades for improved MTBR
- Mechanical seal asset management for improved reliability and reduced emissions
- Station modernization, including remote control and monitoring of all pump stations
- Tailored inventory programs
- Full maintenance contracts with routine/required equipment upgrades

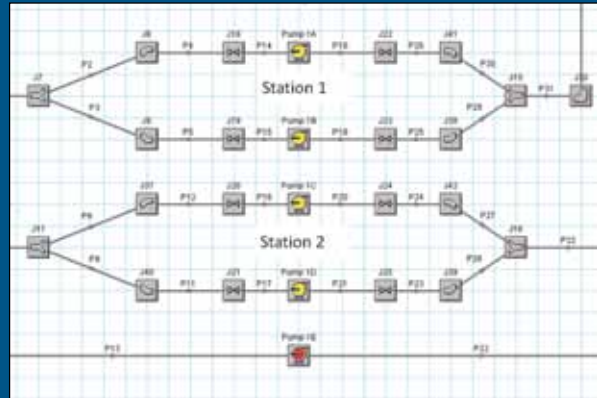
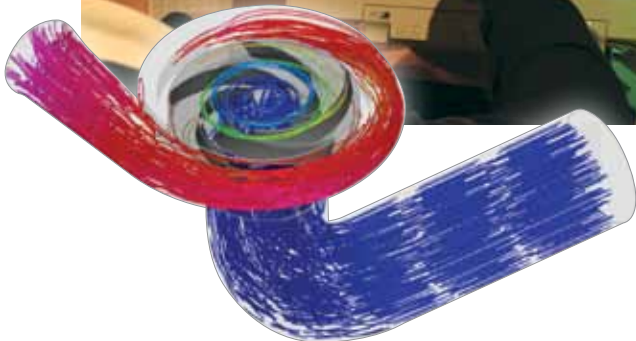


Hydraulic Modeling Removes Guesswork

Flowserve uses sophisticated software and techniques to develop highly accurate hydraulic models of plant systems. Validated with real-time field data, these models enable Flowserve engineers to analyze actual system performance, determine the impact of modifications and develop cost-effective corrective actions for system and equipment optimization.

Using hydraulic models, Flowserve engineers are able to:

- Perform real-time analysis of the dynamic behavior of system piping, pumps and controls
- Run “what if” scenarios to determine the optimum solution
- Develop system head loss curves and illustrate areas of excessive pressure drop, low NPSHa, etc., for any mode of operation
- Determine any process variable, e.g., flow, head, velocity, pressure drop, etc., at any location within the system



The Right Tools for the Job

Flowserve engineers use numerous analytical tools for system assessments, including:

- Powerful “elimination schemes” (rather than “truth tables”) to diagnose root-cause for vibration-pulsation problems
- A 48-channel vibro-elastic data acquisition system to allow signature analysis, ODS, field model analysis, etc.
- Erosion and corrosion materials analyses with specialized overlay and surface-coating technologies and hard-facing technologies
- Software to model steady state and transient pipeflow in complex pump systems
- Hydraulic design CFD analysis, flow visualization, energy optimization, erosion modeling, etc.
- Rotor dynamic analysis including all fluid force effects to calculate natural frequencies, forced responses, dynamic stresses, etc.
- Structural dynamic analysis to verify rotor-structure interactions and foundation-pump structure dynamics
- Acoustic analysis of pump systems to handle pressure pulsation problems



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