Focused on the Bottom Line
The mission of Flowserve Technical Services is to define and execute comprehensive pump systems solutions which maximize operational performance and plant profitability. It accomplishes this through exhaustive technical assessments, the application of integrated engineering technologies and unmatched process know-how. Proposed solutions are analyzed and justified economically through a thorough life cycle cost (LCC) analysis to determine the optimum cost-effective solution. Technical Services experts then implement the selected solution to achieve the lowest possible total life cycle costs.

A Systems Approach
Technical Services recognizes that no pump – no matter how critical – operates in isolation. Rather, it is part of a system with myriad components, all with crucial roles in achieving optimal plant efficiency and availability. Thus, Technical Services employs a systems approach to define and implement successful pumping solutions that:

- Significantly reduce energy usage and CO₂ emissions
- Improve reliability for longer mean time between repair (MTBR), increased equipment availability and reduced production losses
- Solve vibration, pressure pulsation and noise problems for increased (MTBR) and reliability
- Optimize pump system performance
- Improve pump corrosion and erosion resistance
- Solve problems associated with changing process conditions, debottlenecking, etc.
- Reduce safety, health and environmental (SH&E) related costs

A Global Team
Technical Services is comprised of more than 150 design and applications engineers who are deployed worldwide. This technology team includes hydraulic and mechanical design engineers, materials and mechatronics engineers along with highly experienced, expert technicians. Process and applications engineers have access to the world’s largest database of installed pumps, more than one million units across all industry segments. These combined capabilities make Technical Services particularly adept at conducting effective energy assessments, performance assessments (i.e., upgrades and re-rate projects) and reliability assessments such as root cause analyses, bad actor programs, etc.
Unrivaled Technical Expertise
Technical Services has the industry’s largest multi-dimensional team of engineers and technicians with expertise across five key technology disciplines. Equipped with state-of-the-art engineering tools and analytical resources, Flowserve leverages this team to provide solutions that optimize pump system performance, regardless of OEM or pump type.

• **Hydraulic Design**
  – Energy
  – Overall efficiency
  – Cavitation
  – Recirculation

• **Vibro-Elastics**
  – Noise
  – Vibrations
  – Pulsations

• **Mechanical Design**
  – General design
  – Reliability
  – Bearings
  – Seals
  – Seal systems
  – Warm-up
  – Internal alignments

• **Materials and Welding**
  – Erosion
  – Corrosion
  – New materials
  – Repair welding
  – Boron diffusion
  – surface treatment
  – PTA welding
  – HVOF overlay

• **Application and Process Knowledge**
  – Energy reviews
  – System analysis
  – Transients
  – Foundations
  – Driver technology

The Right Tools for the Job
Flowserve engineers use numerous analytical tools for system assessments, including:

• Hydraulic modeling validated with real-time field data
• Water steam cycle thermodynamic modeling
• Powerful "elimination schemes" (rather than "truth tables") to diagnose the root cause for vibration-pulsation problems
• A 48-channel vibro-elastic data acquisition system to allow signature analysis, ODS, field model analysis, etc.
• Acoustic analysis of pump systems to handle pressure pulsation problems
• Erosion and corrosion materials analyses
• Software to model steady state and transient pipe flow 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 eigenvalues, responses to force, etc.
Hydraulic Design

In addition to re-rating existing pumps to increase efficiency and to meet new duty parameters, Flowserve hydraulic engineers have an arsenal of tools to address a wide variety of hydraulic problems in the field. These include numerical computer programs, extensive testing capabilities including flow visualization and a massive experiential database of the company’s product lines. Other computer tools available to Technical Services engineers are hydraulic modeling, thermodynamic (entire steam-water cycle) modeling and pipeflow dynamics modeling.

A powerful means of determining improvements to pump geometry and configuration is through computational fluid dynamics, or CFD. A branch of fluid mechanics, CFD uses numerical methods and algorithms to analyze and solve fluid flow problems. Computers are used to perform the millions of calculations required to simulate the interaction of fluids, gases and particles with the complex surfaces found in pumping equipment. The objective is to optimize hydraulics for a specific application. CFD tools include programs to study potential flow and those providing full Navier-Stokes solutions for turbulent flow.

Recommended solutions can be confirmed using model components in a flow visualization test stand where cavitation, stall and recirculation issues can be observed.

Improving Efficiency and Performance

The goal of hydraulic re-rates and upgrades is to reduce energy costs and improve equipment performance. Common hydraulic field issues addressed by Technical Services engineers include:

- Efficiency upgrades
- Hydraulic re-rating for changed duty conditions
- Suction eye and impeller discharge recirculation problems
- Rotating and stationary stall effects
- Diffuser/casing flow-induced erosion
- Minimum flow rate problems
- Two-phase flow problems
- Vertical pump intake flow problems
- Particle flow erosion problems
- Cavitation problems

After implementing a re-rate, Flowserve Technical Services technicians work with customers to assess the performance of equipment in the field. This is done to confirm the intended hydraulic and mechanical results have been achieved and to establish the new performance baseline.
**Vibro-Elastics Engineering**

Vibro-elastics is a branch of engineering concerned with vibration, pressure, pulsation and noise problems. An industry leader in this field, Flowserve has conducted state-of-the-art research that has resulted in the development of numerous computer analysis tools and field acquisition systems that are currently being deployed to rapidly and accurately identify the root causes of equipment failure. These tools include:

- Pump rotor dynamic analysis including all fluid force effects to calculate eigenvalues, responses to forces, etc.
- Structural dynamic analysis to verify rotor-structure interactions and foundation and pump structure dynamics
- Acoustic analysis of pumps and pump systems to identify pressure pulsation problems

In addition, field data acquisition systems with up to 48 channels of special measurements capabilities permit highly accurate:

- Vibration and pressure pulsation signature analysis
- Running mode analysis
- Experimental modal analysis
- Transient run-up/coast-down analysis
- Noise intensity measurements and other related operating characteristics

The combination of these advanced computer analysis tools and field data acquisition systems has resulted in the development of a powerful and effective elimination scheme for determining the root cause(s) of equipment failure due to vibration and pressure pulsation problems. As a diagnostic tool, this elimination scheme has proven much quicker and more reliable than the traditional trial-and-error truth table techniques. Root causes are identified in weeks rather than months, allowing Technical Services to promptly deliver accurate solutions to pump efficiency and availability issues.
Mechanical Design

Improving pumping system reliability is the chief priority for Flowserve mechanical design engineers. Their main mission is to convert mechanical root-cause failure problems into practical solutions that will reduce maintenance, repair and inventory costs, eliminate bad actor pumps and increase operating uptime. Additionally, these engineers are highly skilled in adapting hydraulic modifications within fixed geometries to address hydraulic efficiency and erosion, corrosion and wear issues.

Like their counterparts in vibro-elastics and hydraulic engineering, Technical Services mechanical designers utilize the industry’s most sophisticated computerized technology available, including:

- Laser-assisted component technology
- CAD-3D solid modeling coupled to rapid prototyping
- Finite element analysis (FEA) software
- Tribology to study metallic and non-metallic surfaces in relative motion, like bearings and mechanical seals

Much of their work to improve MTBR and reliability is focused on upgrading and retrofitting components pertaining to:

- Mechanical seals
- Axial and radial bearings and bearing housings
- Seal chambers
- Leakage of pressure containment components
- Running clearances
- Axial balancing devices
- Increased rotor stiffness
- VOC reduction

This, however, is not their only mission. Technical Services mechanical engineers also offer API latest edition upgrade programs, ANSI/ISO power end exchange programs and inventory standardization programs. The goal is to improve reliability and availability with pumps built to the industry’s contemporary performance standards while simultaneously reducing spare parts inventory complexity and cost.
Materials and Welding Engineering

This technology discipline handles a wide variety of wear, erosion and corrosion problems which may impact pump performance. Materials engineers focus upon these issues:

- Increasing corrosion and erosion resistance
- Improving resistance to wear and galling
- Maintaining critical pump clearances

Technical Services may also apply advanced coatings, claddings and surface conversions to extend the life of pump wet end components by increasing resistance to wear, corrosion and erosion. These include:

- High velocity oxygen flame (HVOF) spray, typically tungsten carbide coatings
- Plasma transfer arc (PTA) welding, typically Stellite® and Colmonoy® hard-face overlay materials
- Direct laser disposition (DLD), powder-based welding process (powder 420 SS, Stellite, Ultimet®, tungsten carbide, etc.)
- Boron diffusion surface treatment
- Laser hardening

An Interdisciplinary Approach

The best way to minimize wear and extend pump operating life is to eliminate or reduce the causes of wear. Erosive wear is typically prevalent in those areas where flow is turbulent as a result of mismatched hydraulic and/or mechanical design.

Using CFD software, hydraulics and materials experts perform three-dimensional, two-phase flow analyses to calculate particle tracks through the pump as well as the fluid path itself. Through validation of these results with actual damage found, these analyses can accurately predict erosion patterns and allow evaluation of alternative upgrade options. In addition to a hydraulic review, the geometry of the pump is also studied to minimize abrasive particle entry into zones between impeller shrouds and casing/cover walls where they will collect to cause wear damage.

In some applications, specialized materials may be required to address erosion and corrosion problems. For example, X-Cavalloy, a proprietary Flowserve material, was developed specifically to combat cavitation damage caused by marginal or inadequate NPSH conditions.

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Process and Applications Knowledge

With more than two centuries of pump innovation, an installed base exceeding one million units and a global footprint, Flowserve stands alone in process knowledge and applications experience. Technical Services engineers have performed assessments and successfully implemented projects in virtually every industry in every corner of the world. They have collaborated with plant operators, process licensors and A&E firms to solve virtually every conceivable system reliability and plant availability problem.

A sampling of the challenges and the solutions Flowserve provides to the global infrastructure, broad process and general industrial markets includes:

- Re-rating oil production and pipeline pumps
- Upgrading refinery charge pumps
- Designing new pump hydraulics for advanced hydrocracking process technology
- Upgrading boiler feed, condensate, cooling and auxiliary systems to satisfy new turbine generating capacity
- Modifying potable water treatment and distribution pumps for a growing population
- Recommissioning an idle hydrocarbon processing plant

Turnkey Engineering

Customers are under increasing pressure to complete projects cheaper, smarter and faster. Technical Services can provide the resources to manage even the most complex project from start to finish. Flowserve is unique in its capability to offer comprehensive turnkey engineering services, including:

- System reviews
- Hydraulic design
- Mechanical design (including vibro-elastics)
- Material design
- Electrical and instrumentation engineering (DCS, P&ID, wireless monitoring and diagnostics, etc.)
- Piping design and installation
- Foundation design (civil engineering along with installation and commissioning)
- Auxiliary systems (lube-oil systems, sealing systems, VFD and steam turbine drivers, etc.)
- Field testing
Technical Assessments

Technical Services engineers perform comprehensive pump systems audits to identify design weaknesses and reliability-availability issues. Operating and historical data are analyzed. Modeling and technology-sided tools pinpoint problems. Solutions, recommendations and economic justifications are offered based upon LCC calculations. Metrics goals are established and the project is implemented.

In summary, the five-step technical assessment process includes:

1. Evaluate symptoms of deficient equipment or underperforming 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 and 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.

Flowserve Identifies Root Cause of 30 MW Derate

The Challenge: While running on a single train, a large power station in the U.S. experienced an unexplained 30 MW derate in its 800 MW unit. The associated loss in revenue is conservatively estimated at $470,000 per month.

The Assessment: Flowserve Technical Services engineers performed a study of the feed water and LP heater drain systems. Wireless technology was employed to obtain performance data under varying unit loads, producing a high-resolution profile capable of capturing transient conditions. This data was utilized to validate a hydraulic model which was then used to evaluate the system's response to multiple variables.

Analysis of the model revealed:
• The heater drip pump was underperforming the OEM curve by 15% due to reduced system demand.
• Level instability in the undersized heater drip tank caused excessive dump valves cycling to maintain the desired level.
• Hot water from the heater drip system was being dumped into the condenser instead of the feed water system, reducing the thermal efficiency of the unit.

The Solution: Flowserve engineers recommended replacing the heater drip pump with a smaller, vertical inline model fitted with a variable frequency drive (VFD). The VFD will allow the pump to operate even at low flows, stabilizing the heater drip tank level and restoring the thermal efficiency of the unit.

In addition to the revenue made on the restored 30 MW, Technical Services estimates the plant will realize energy cost savings of $1.3 million (U.S.) per year due to this change.

The Maintenance and Modifications Supervisor at the plant said: “Flowserve’s system review has enabled us to make maintenance and operations decisions based on real data and analysis, rather than assumptions and history.”
Programs Putting LCC Into Practice

Performance Optimization Programs
It's all about improving reliability through mechanical upgrades and reducing energy costs through hydraulic re-rates.

Regardless of OEM or pump type, Technical Services personnel can diagnose the root cause(s) of system failure and recommend solutions to improve reliability, reduce emissions and increase plant uptime.

In many cases, pump upgrades and re-rates are attractive economic alternatives to new equipment. Technical Services has developed and implemented countless hydraulic, mechanical and metallurgical upgrades. These upgrades utilize advanced and proprietary design and diagnostic technologies to provide solutions and optimize performance.

Energy Reduction Program
Of total equipment life cycle costs, pump energy usage is almost always the single largest cost. As such, it offers the opportunity for significant and immediate cost reduction. Technical Services’ energy reduction programs include evaluations of hydraulic and mechanical design, driver and operating controls, auxiliary services and sealing systems. They are especially valuable in plants where process parameters have changed or where systems degradation has occurred.

Bad Actor Program
Regardless of size, empirical evidence reveals that 5 to 10 percent of a plant’s installed pumps are or will become bad actors, i.e., chronically problematic. A disciplined, methodical program to eliminate bad acting pumps will result in significant and rapid savings.

Technical Services can conduct an audit to identify those pumps most negatively affecting LCC and plant availability. From this audit:

- A list of bad actor pumps and seals is generated
- The highest energy usage pumps are identified
- Pumps causing the highest incidences of unscheduled outages are identified
- Maintenance methodologies (i.e., run-to-failure, preventative, predictive, etc.) are reviewed
- Other items such as LCC database, parts inventory, operational issues, etc., are analyzed

Upon approval of recommendations, remedial actions are implemented to remove the bad actor from the list. Once improved performance is confirmed, the next bad actor asset is addressed and so on, until all are restored to expected performance.
Life Cycle Cost (LCC) Principles
The initial purchase and installation cost (CAPEX) of a new pumping system is typically a small part of the total cost to operate the system (OPEX) over its life, which can be more than 15 to 20 years or even 40 years in the case of many high-energy pump systems. It is the routine OPEX costs of energy, maintenance and other recurring expenses that are the largest components of total life cycle costs.

Flowserve has played a defining role in creating the LCC analysis model through the joint efforts of the Hydraulic Institute and Europump. Quickly becoming the global procedure for evaluating pumps and determining effective courses of action to improve performance and reduce total costs, the LCC is defined as follows:

Informed Decision Making
LCC analysis is a powerful tool to help key decision makers understand the components that make up the total cost of owning and operating a particular piece of equipment or an entire system. Every pump system is unique in some way and its idiosyncrasies can impact its total life cycle costs. Recognition of the potential opportunities to reduce energy, operating and maintenance costs provide any improvement project a solid basis for success.

In applying the model, Technical Services engineers perform a thorough assessment of each application to establish the critical elements and ensure the most effective course of action is implemented.

LCC Makeup Variability
Numerous factors impact the life cycle cost makeup of a given pump system and the proportions of these components can vary greatly, as illustrated by the examples below. A thorough evaluation is required to determine the relative impact of the various components of CAPEX and OPEX.
To Learn More

The resources and capabilities of Flowserve Technical Services are the result of a hydraulic heritage that now spans three centuries. More than one million Flowserve pre-engineered, engineered and special purpose pumps and systems are installed around the world. Whether for oil and gas processing, power generation, chemical processing or water resources, Flowserve pumps can be found virtually anywhere liquids must be moved and controlled.

To learn more about Technical Services' capabilities and services, visit www.flowserve.com/isg. A video is available for download that details Technical Services' engineering, diagnostic and analytical technologies, and its research, laboratory and testing capabilities. An LCC-related white paper, feasibility studies and project stories may also be reviewed.