



Pipeline and Transportation Pumps

For hydrocarbons and other energy resources



Experience In Motion



Superior pumping solutions for pipeline and transportation applications

Pipelines are a vital link in the global economy, transporting critical resources across countries and continents to points of use around the world. And they are safer, more efficient, and create fewer greenhouse gas (GHG) emissions than other modes of transportation. To achieve this, pipeline operators require efficient, highly reliable pumps that are easy to maintain and cost-effective to operate. They also need a partner that can keep their equipment and systems operating at peak condition and with high availability.

Flowserve is the right partner for the job. We offer innovative pumping solutions for every conceivable pipeline application, including oil, refined products, natural gas liquids (NGLs), liquefied natural gas (LNG), ethylene, carbon dioxide (CO₂) and ammonia. With more than 200 years of industrial pump experience and 100 years of pipeline pumping experience, we have earned a preeminent position in the industry through advanced design, engineered solutions, equipment re-rates and customer service excellence.

Pipeline owners and operators all over the world turn to Flowserve for creative solutions that improve:

- Safety
- Reliability
- Availability
- Lifecycle costs
- Profitability

Expertise to help you achieve your business objectives

Flowserve has the expertise to serve as the overall systems manager for pipeline operations. Working with architect and construction firms or in-house design teams, we can provide turnkey services, pump-specific diagnostics, maintenance and repair, and a full spectrum of technical services — including full-system analysis using dedicated pipeline design software — to optimize the return on pipeline investment.

Market-focused customer support

Flowserve pipeline specialists provide our customers with the technical support necessary to develop effective solutions for tough pipeline challenges. These solutions can incorporate all manner of specific market and customer preferences. We offer technical advice and assistance throughout each stage of the product lifecycle. From feasibility through pipeline design, inquiry through order fulfillment, installation through startup and pipeline re-rates, our pipeline specialists work with customers to successfully achieve their operational goals.

A complete range of transportation pumps

Flowserve offers a comprehensive portfolio of API pumps that meet the demanding requirements of transportation, transfer, storage and cargo stripping applications. These pumps are CE-compliant and manufactured to stringent criteria, often exceeding those in the current edition of API 610.

- BB5 multistage, diffuser- or volute-style, double case pumps
- BB3 multistage, axially split, between bearings pumps
- BB2 one- or two-stage, radially split, between bearings pumps
- BB1 one- or two-stage, axially split, between bearings pumps
- VS6 or VS7 volute or diffuser style, double case vertical pumps
- VS1 or VS2 volute or diffuser style, vertical turbine pumps
- Deep well submersible motor pumps
- OH3 or OH4 vertical in-line pumps
- OH2 centerline-mounted overhung pumps

Other non-API pumps may also be provided for light-duty applications.



Experience that matters

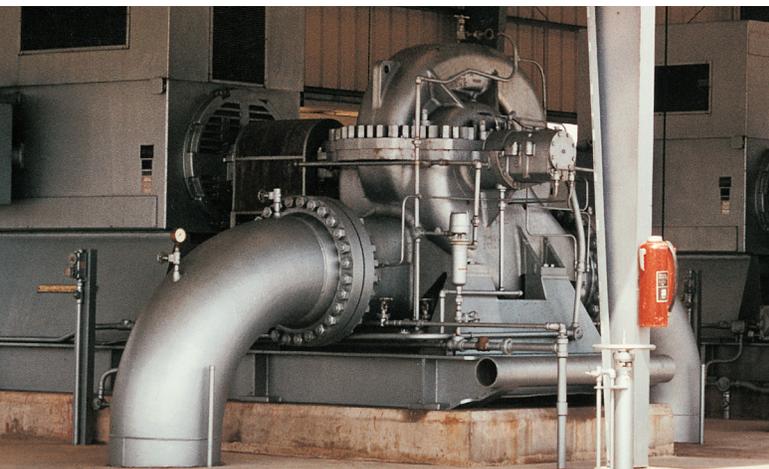
Flowserve pumping solutions have been used in numerous pipeline and transportation projects worldwide. Our engineering, service and support teams also have extensive experience improving the performance of pipeline pumping assets and systems.

A sample project list can be provided upon request. Contact your local Flowserve representative for details.

Experience: Refined products pipeline

Installation: More than 300 DVSH single-stage, double-suction, axially split pumps (sizes 24 x 27, 24 x 29, 30 x 27 and 30 x 29) with driver sizes up to 3,730 kW (5,000 hp).

Application: One of the world's largest products pipelines, 4,665 km (2,900 mi) from the Gulf Coast to northeastern United States. Pipeline diameters: 900 through 1,050 mm (36 through 42 in.).



Pumps for every transportation application

Flowserve has reliable and cost-effective solutions for the most demanding pipeline applications across the oil and gas industry and broader energy value chain. No other manufacturer offers a comparable portfolio of fluid motion and control equipment — including API 610 pumps and API 682 seals — and related services for transportation, transfer, storage and cargo stripping applications, providing the single-source reliability our end users require.

Crude oil and products supply pipeline and terminals

Flowserve takes pride in its breadth of products designed for the transportation, transfer, storage and cargo stripping of crude oil and finished products for the pipeline market. With models ranging from pipeline sampling pumps to large radially split barrel mainline pumps, Flowserve can provide a cost-effective solution for all terminal and pipeline applications.

Offshore pipelines

Flowserve offers a complete line of single- or multistage pumps in either axial or radially split configurations. These pumps are perfectly suited for main oil line, transfer and tanker loading on offshore platforms. With a history of developing innovative pumping solutions that push performance limits and solve tough industry challenges, Flowserve has the proven products capable of moving crude oil directly from the platform to marine terminals or waiting tankers.

NGL pipelines

Because of their volatility and flammability, natural gas liquids can be more challenging to move than refined petroleum products. Flowserve offers numerous safe and cost-effective pumping systems that are well-suited to the demands of transporting NGLs from remote processing plants to end markets. Pump types include axially or radially split units in single- or multistage configurations.

LNG pipelines

We understand how fluid motion and control equipment should work in complete systems throughout the entire LNG value chain. Our comprehensive portfolio of API pumps includes high-pressure BB5 or BB3 units as well as vertical or overhung configurations. Along with our advanced compressor and pump sealing systems, they enable you to maximize performance and uptime while safeguarding against leakage, fugitive emissions and product loss in pipelines during LNG processing, loading, unloading and storage.

Ethylene pipelines

Ethylene is the most widely used and produced petrochemical due to its versatile physicochemical properties. Generally found in its gaseous form, it is turned into a cryogenic liquid for storage and transportation. Our multistage pumps reliably pump compressible, dense phase ethylene at normal and supercritical pressures. Used in conjunction with our pump and compressor sealing systems, these pumping solutions minimize or even eliminate fugitive emissions and product loss.

Diluent/bitumen, froth transfer and synthetic crude pipelines

Flowserve pumps are especially suited to the unique requirements of diluent/bitumen service for steam-assisted gravity drainage (SAGD). Through extensive knowledge of heat tracing, variable-speed operation and mechanical sealing solutions, Flowserve pumps are custom-designed to suit each application.

In tar sands mining, Flowserve high-pressure, hard metal slurry pumps feed a mixture of air, water and bitumen down a pipeline from the sand extraction plant at the mine to the base plant for further extraction and refining. From there, axially split single- or multistage pumps transport the synthetic crude to the refinery.

Products cavern and well storage transfer terminals

Flowserve leads the way in providing vertical wet-pit and submersible motor pump solutions for direct storage transfer pumping applications in salt dome and cavern services. Additionally, horizontal single- and multistage pumps offer excellent injection solutions for indirect storage transfer applications.

Ship, tank car and truck loading terminals

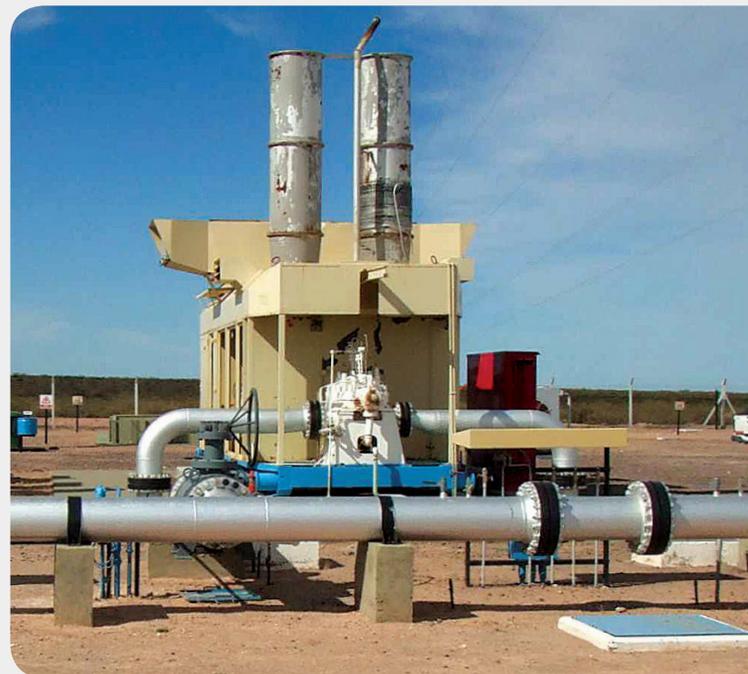
With a full line of ISO 2858/5199, ANSI B73.1, API 610, DIN and JIS compliant designs, Flowserve maintains the largest family of pumps to address any terminal application. Low-NPSH pumps in either horizontal or vertical configurations are also available for booster-station service.

CO₂ pipelines

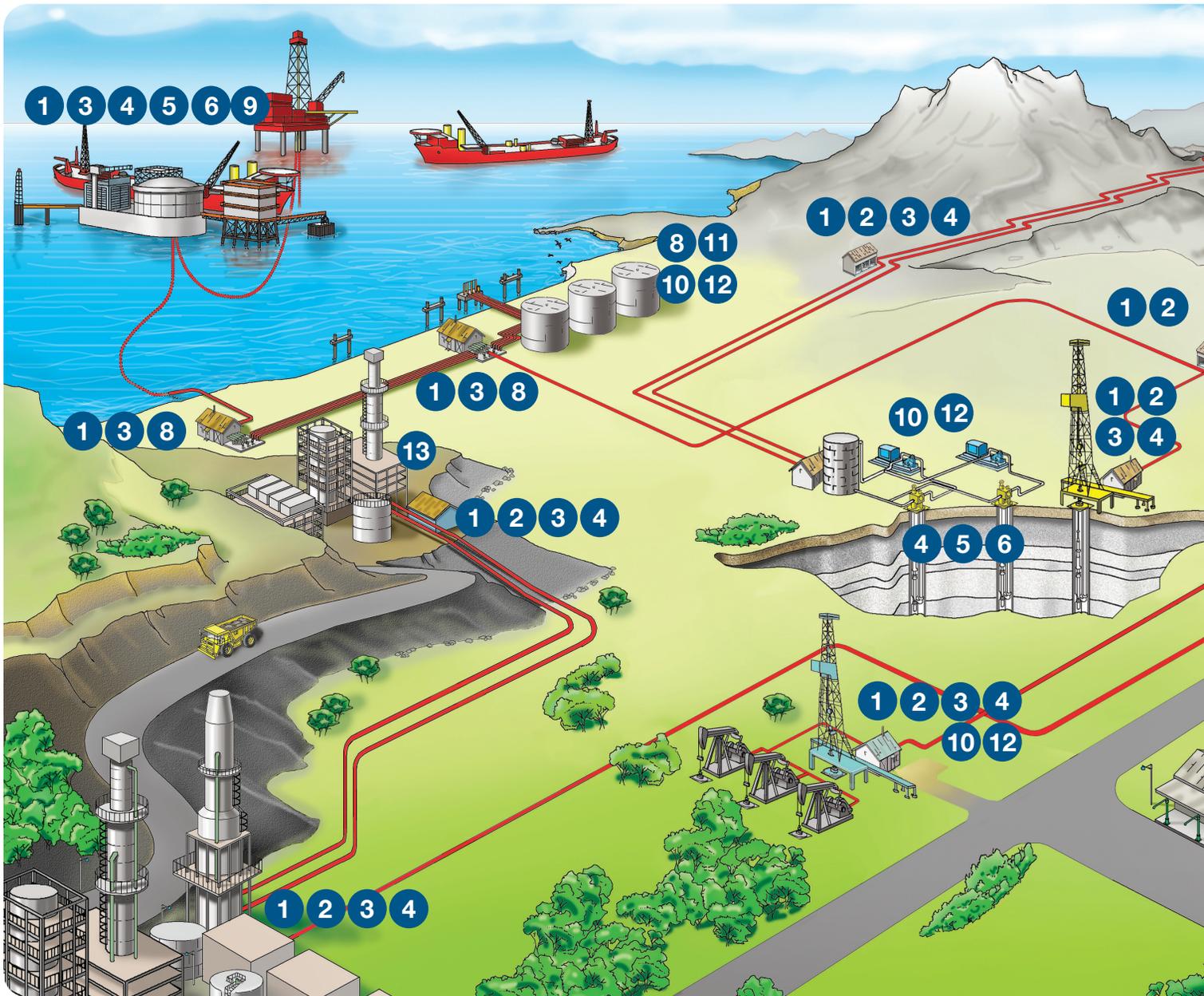
Flowserve has a significant amount of experience in the design and application of pump and sealing solutions for the transportation, injection and re-injection of CO₂. We pioneered the use of centrifugal pumps for transportation of supercritical dense phase CO₂ in pipelines and injection for enhanced oil recovery and underground sequestration. We also were the first to use dry gas seals in dense phase CO₂ pumps. Pumps typically used in this application include high-pressure axially split or radially split multistage pumps as well as specially designed high-pressure, single-stage pumps.

Ammonia pipelines

As power generation and industrial uses of hydrogen expand, ammonia is being utilized to efficiently transport the clean, sustainable fuel in pipelines. It's easier to liquefy and contains more hydrogen per cubic meter than liquefied hydrogen itself. Ammonia liquefies at -33°C (-27°F), so pumping systems must operate reliably and eliminate fugitive emissions under extreme temperatures and pressures. Our multistage, axially split pumps are up to the challenge.



Pumps for the entire transportation value chain



1 DVSH or LPN (BB1)
Axially split, single-stage

2 UZDL (BB1)
Axially split, two-stage
BFD (BB1)
Double-suction

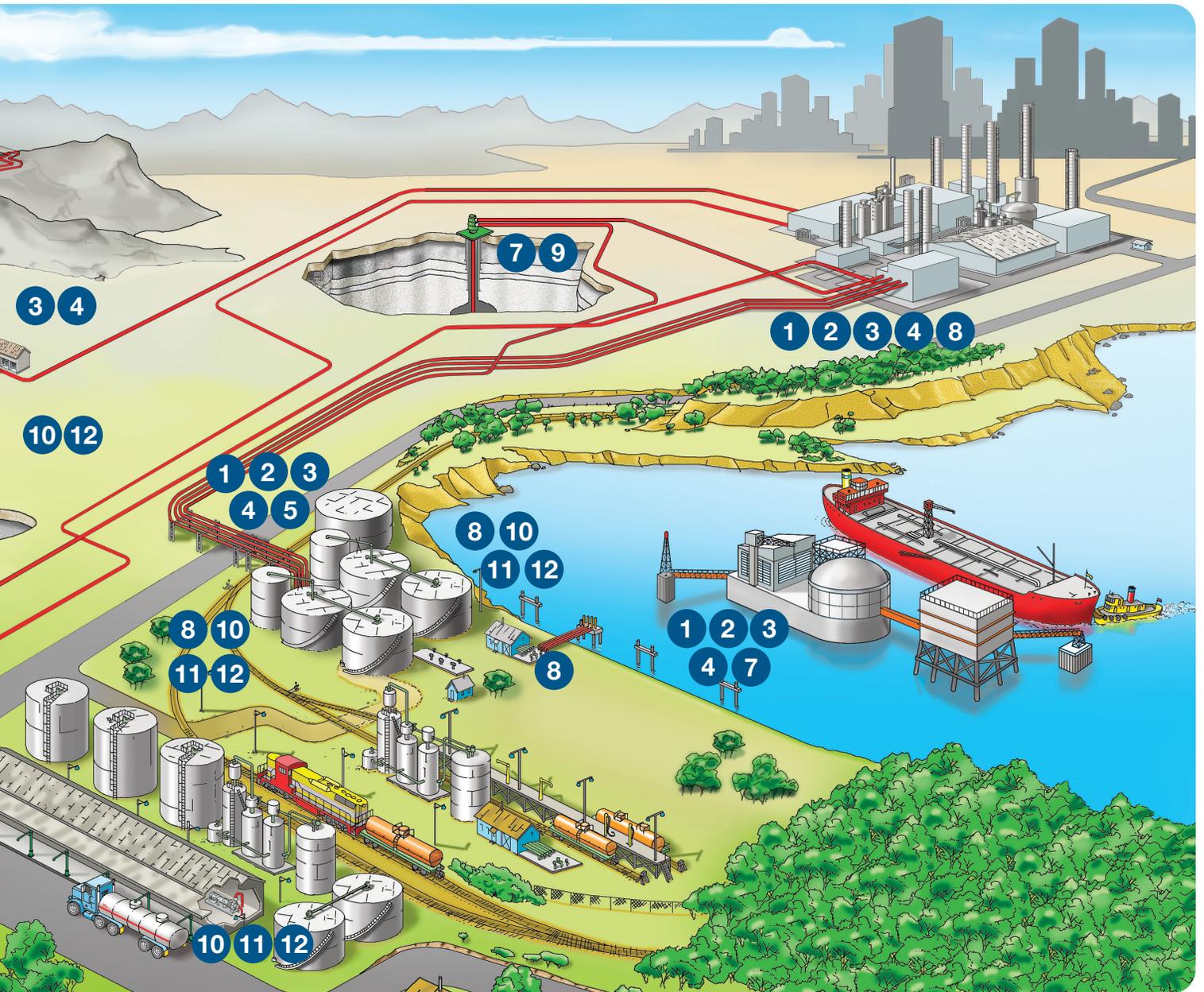
3 HDX (BB2)
Radially split, double-suction, single-stage
HED (BB2)
Radially split, two-stage

4 DMX (BB3)
Axially split, multistage

5 WCC or WIK (BB5)
Multistage, diffuser collector, barrel casing

6 HDO or HSO (BB5)
Multistage, volute casing, process barrel

7 WUJ or VTP (VS1)
Vertical, wet-pit, diffuser
QL and QLQ (VS2)
Vertical, wet-pit, volute



- 8 VPC or WUC (VS6)**
Vertical, double-case, diffuser
QLC and QLQC (VS7)
Vertical, double-case, volute



- 9 Byron Jackson® SUBM**
Deep-well submersible pump with
OIL oil-filled motor



- 10 HPX (OH2)**
Centerline-mounted, overhung



- 11 HPX-V (OH3)**
Vertical in-line
DSVP (OH4)
Double-suction vertical in-line

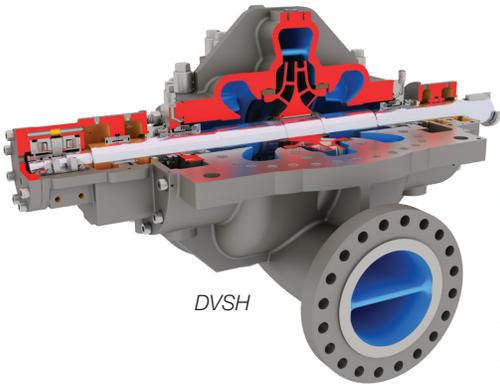


- 12 Durco® Mark 3™
and Mark 3 ISO**
ASME B73.1 or ISO 2858
frame-mounted, overhung



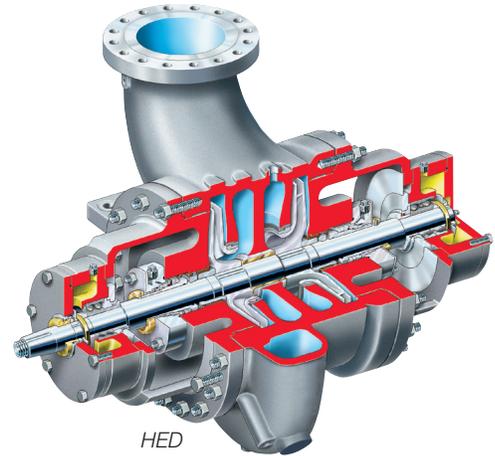
- 13 Type M**
Hard metal slurry

Mainline and booster pumps



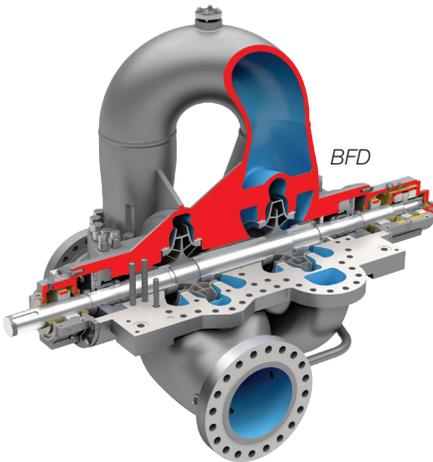
DVSH and LPN (BB1) axially split, single-stage

- Flows to 15,000 m³/h (65,000 gpm)
- Heads to 565 m (1,854 ft)
- Pressures to 150 bar (2,175 psi)
- Speeds to 6,000 rpm



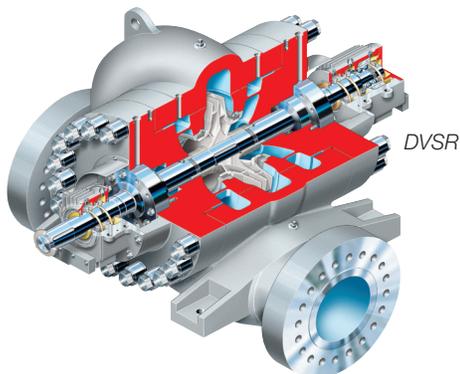
HED (BB2) radially split, two-stage

- Flows to 2,000 m³/h (8,800 gpm)
- Heads to 650 m (2,100 ft)
- Pressures to 150 bar (2,176 psi)



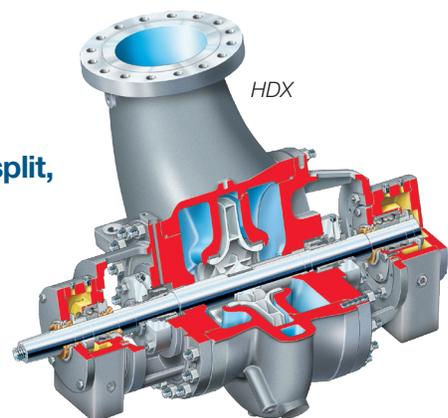
UZDL and BFD (BB1) axially split, two-stage

- Flows to 4,300 m³/h (18,800 gpm)
- Heads to 2,130 m (6,000 ft)
- Pressures to 230 bar (3,335 psi)

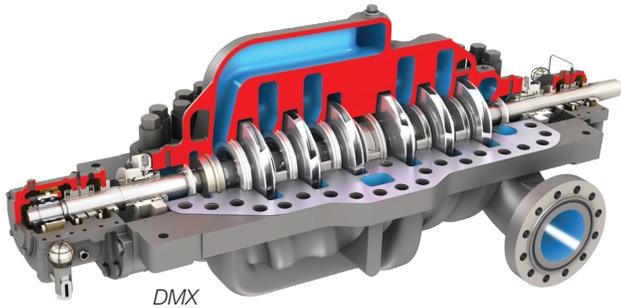


HDX or DVSR (BB2) radially split, double-suction, single-stage

- Flows to 6,585 m³/h (29,000 gpm)
- Heads to 450 m (1,500 ft)
- Pressures to 260 bar (3,750 psi)

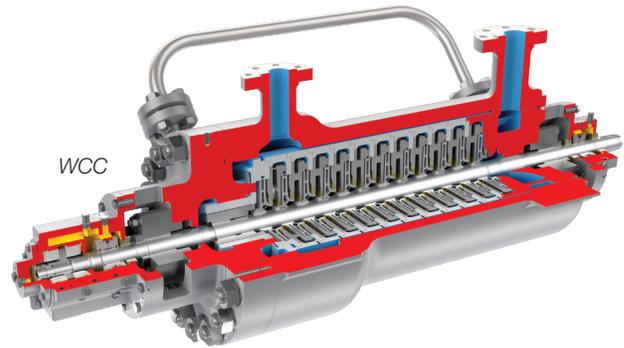


Note: The above values indicate the typical performance envelope for the models listed. Flowserve has significant experience beyond these limits. Consult your Flowserve representative with your specific performance requirements.



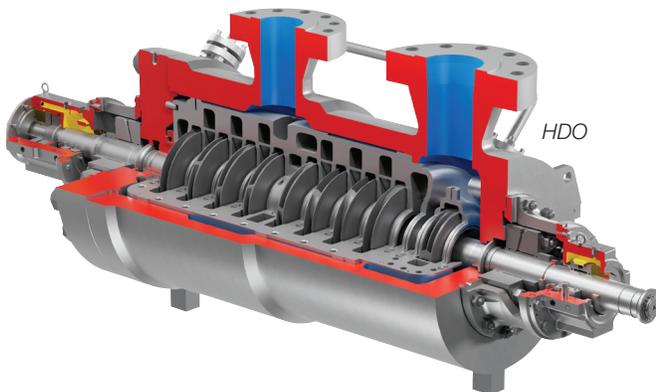
DMX (BB3) axially split, multistage

- Flows to 5,678 m³/h (25,000 gpm)
- Heads to 2,712 m (8,900 ft)
- Pressures to 275 bar (4,000 psi)
- Speeds to 6,000 rpm



WCC and WIK (BB5) multistage, double case, diffuser

- Flows to 1,600 m³/h (7,000 gpm)
- Heads to 7,000 m (23,000 ft)
- Discharge pressures to 650 bar (9,425 psi)
- Speeds to 8,600 rpm

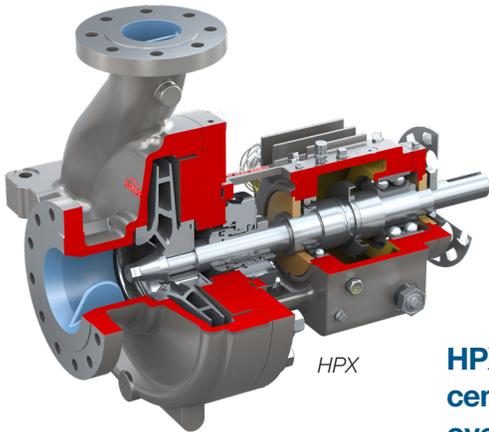


HDO and HSO (BB5) multistage, double case, volute

- Flows to 4,000 m³/h (17,610 gpm)
- Heads to 5,500 m (18,000 ft)
- Discharge pressures to 450 bar (6,525 psi)
- Speeds to 9,000 rpm



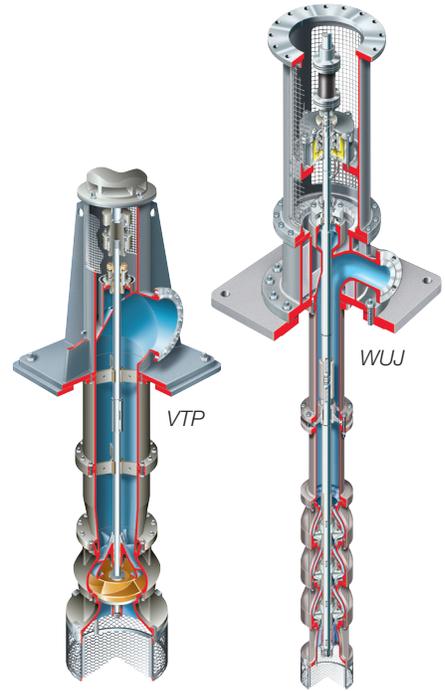
Auxiliary services pumps



HPX

HPX (OH2) centerline-mounted, overhung

- Flows to 5,000 m³/h (22,014 gpm)
- Heads to 350 m (1,148 ft)
- Pressures in accordance with API limits



VTP

WUJ

WUJ and VTP (VS1) vertical, wet-pit, diffuser

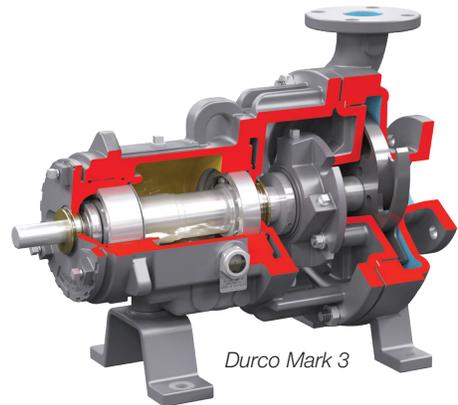
- Flows to 13,600 m³/h (60,000 gpm)
- Heads to 2,000 m (6,560 ft)
- Pressures to 200 bar (2,900 psi)



HPX-V

HPX-V (OH3) and DSVP (OH4) vertical in-line

- Flows to 1,200 m³/h (5,200 gpm)
- Heads to 325 m (1,070 ft)
- Pressures to 42 bar (600 psi)

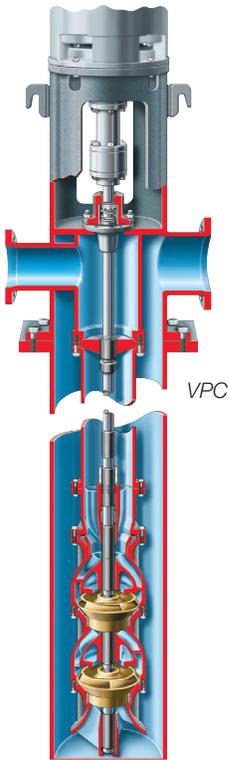


Durco Mark 3

Durco Mark 3 (ASME) and Mark 3 ISO frame-mounted, overhung

- Flows to 4,540 m³/h (20,000 gpm)
- Heads to 220 m (720 ft)
- Pressures to 27 bar (400 psi)

Note: The above values indicate the typical performance envelope for the models listed. Flowserve has significant experience beyond these limits. Consult your Flowserve representative with your specific performance requirements.



WUC and VPC (VS6) vertical, double case, diffuser

- Flows to 13,600 m³/h (60,000 gpm)
- Heads to 2,000 m (6,560 ft)
- Pressures to 200 bar (2,900 psi)

Specialty designs

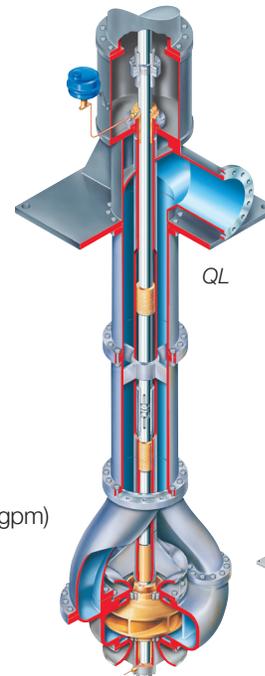
- In-line, double-suction
- Multistage, axially split, double-suction
- Abrasive slurry pump



Byron Jackson SUBM deep-well submersible pump with OIL oil-filled motor

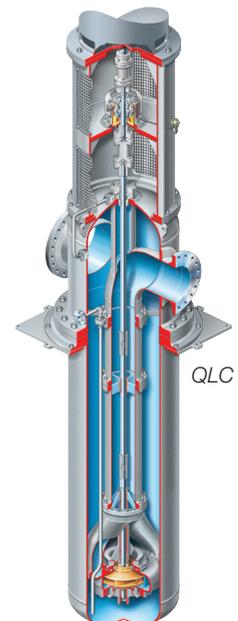
- Flows to 6,000 m³/h (26,415 gpm)
- Heads to 800 m (2,625 ft)
- Motor sizes to 1,500 kW (2,000 hp)
- Speeds from 1,000 to 3,600 rpm

Byron Jackson SUBM



QL and QLQ (VS2) vertical, wet-pit, volute

- Flows to 25,000 m³/h (110,000 gpm)
- Heads to 500 m (1,640 ft)
- Pressures to 70 bar (1,015 psi)

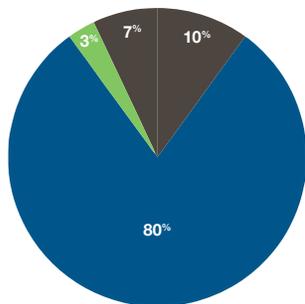


QLC and QLQC (VS7) vertical, double case, volute

- Flows to 25,000 m³/h (110,000 gpm)
- Heads to 500 m (1,640 ft)
- Pressures to 70 bar (1,015 psi)



Typical lifecycle costs of a pipeline pump



- CAPEX
- OPEX energy
- OPEX inventory HSE disposal
- OPEX maintenance repair costs

Engineering and support services that drive profitability

Energy represents the vast majority of the total lifecycle costs of a mainline pump on a crude oil pipeline — about 80%. Maximizing pump efficiency, availability and service life is critical to pipeline profitability.

Flowserve has extensive experience improving the performance of pipeline pumping assets. We offer a comprehensive suite of engineering and support services designed to improve the efficiency, availability and reliability of equipment and systems while controlling total lifecycle costs. And, our worldwide network of manufacturing facilities, engineering centers and strategically located Quick Response Centers means you never have to look far for help with:

Continued on p. 13



Case study: South American pipeline

Application: 760 km (472 mi) pipeline in Argentina that transports crude oil from Neuquen Patagonia to Puerto Rosales on the Pacific coast. Pipeline diameters: 356 and 406 mm (14 and 16 in.).

Installation: BB1 and BB3 type pumps driven by 92,000 kW (123,400 hp) of gas turbines and 13,825 kW (18,500 hp) of electric motors. Maximum throughput is 42,600 m³/h (187,500 gpm) of crude oil per day.

Challenge: Reduce energy, as well as maintenance and operating costs.

Solution: Conduct a technical assessment of the existing pipeline. Develop an accurate computer model of the entire pipeline and validate it with actual operating data. Use the model and field performance test data to identify and evaluate equipment and system improvements.

Result: Several operational and equipment issues were identified, including pumps operating well below BEP and vibration issues that were significantly reducing MTBR and preventing operation at certain flow rates.

Six solutions that reduced energy use and increased MTBR were proposed and implemented. Estimated savings include:

- 26.3% reduction in total pipeline energy costs
- Up to US\$3.5 million in OPEX costs savings

- **Energy optimization** of the entire pipeline using special pipeline design tools and hydraulic gradients to conduct a complete system energy review
- **Re-rating pipeline pumps** to ensure efficient operation at new duty conditions, preventing the expensive implementation of completely new pipeline pumps
- **Repairing or upgrading pipeline pumps** for improved MTBR (mechanical upgrade)
- **Noise identification and reduction** of pipeline pumps and pump stations
- **Improving mechanical seal performance** in pipeline pumps
- **Root-cause analysis (RCA) of vibration** in pipeline pumps using state-of-the-art, vibro-elastic data acquisition tools and analysis methods
- **Analyzing water hammer and pressure pulsations** in pipelines using specialized engineering analysis tools
- **Damping devices** to reduce the effects of high-pressure pulsations
- **Monitoring and predictive analytics** of pipeline pumps to increase availability and decrease unexpected downtime (see page 15 for more information)
- **Modernization** of pipeline pump stations, including remote control
- **Lifetime extension** of pump assets, including extra qualifications such as ATEX, CE, etc.
- **Turnaround management services** that ensure needed repairs and are performed on time and within budget
- **Streamlining spare parts** inventory and management programs to reduce costs
- **LifeCycle Advantage agreements** that tailor equipment maintenance plans around particular objectives
- **Education and training programs** to enhance your team's understanding of fluid motion and control equipment operation, maintenance and repair

Case study: U.S. pipeline

Installation: DVSH single-stage, double-suction axially split pumps on a 645 km (400 mi) pipeline in northwest United States to transport gasoline, diesel and jet fuel. Pipeline diameters: 300 through 500 mm (12 through 20 in.).

Challenge: Improve pump efficiencies at low flows and eliminate vibration issues that are increasing maintenance and operating costs.

Solution: Hydraulic re-rate to match lower current rated duty.

- Replace impeller with lower flow design
- Reduce volute area to pull back BEP
- Increase volute cutwater diameter ("B" gap)

Benefits:

- Normal flow rate at 96% BEP
- Energy savings >1,182 MW annually
- Increased mean time between repair (MTBR), resulting in maintenance savings



Case study: Middle East pipeline

Application: 1,200 km (750 mi) pipeline across rugged terrain in the Middle East. Pipeline diameter of 1,400 mm (56 in.).

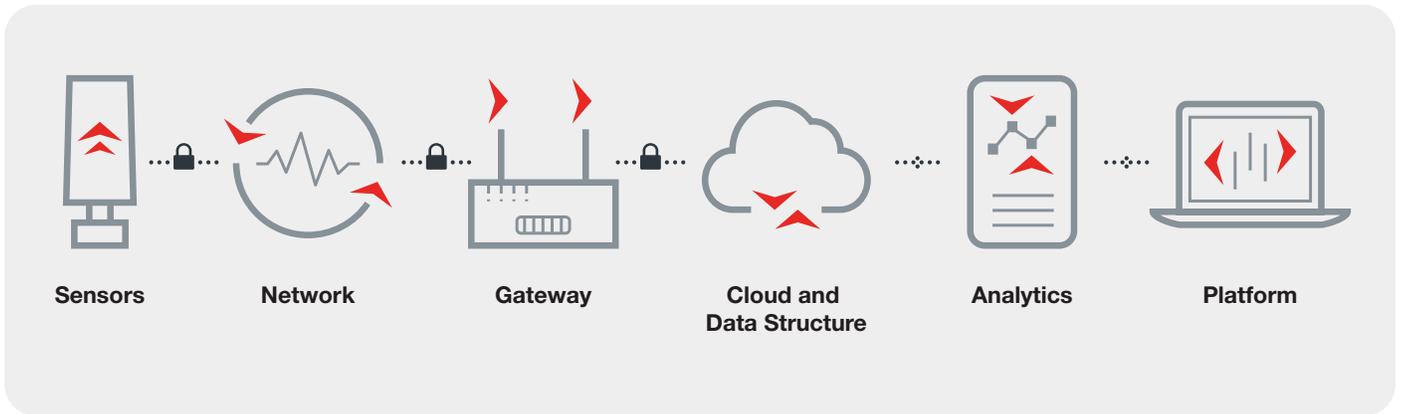
Installation: 22 DMX axially split, two-stage pumps (24 x 28) with driver sizes to 16,780 kW (22,500 hp) delivering 1.6 million bbl/d at heads to 625 m (2,050 ft). Casing weights in total equal 13,610 kg (30,000 lb).

Challenge: Maintain problem-free operation across all flow range requirements.

Solution: Employ computational fluid dynamics (CFD) to analyze and optimize impeller blade geometry.

Result: New impeller design demonstrated no cavitation, far exceeding previous industry acceptance criteria for high-energy impellers.





Increase uptime with predictive maintenance

Most pumps from Flowserve are RedRaven Ready. RedRaven is a predictive maintenance service from Flowserve that improves plant performance by detecting anomalies in pumps, valves and seals. It enables you to predict when and why your critical assets may experience issues so you can take preventive action.

RedRaven is a complete end-to-end proactive maintenance solution. It enables you to leverage the IoT for a connected platform of smart products, software and services. It gives you the tools you need to monitor, analyze and predict the performance of your pumps, seals and valves, as well as the insights you need to make more informed decisions for improving your plant's efficiency, productivity and bottom line.



A ready-to-deploy, scalable solution

What does it mean that a Flowserve pump, valve or seal is RedRaven Ready? That means it's designed and built to accept RedRaven wired or wireless sensors using cloud architecture for condition monitoring and predictive analytics services.

Equipment featuring the RedRaven Ready symbol can provide clear insights that improve your plant's efficiency, productivity and reliability. RedRaven Ready pumps, seals and valves securely connect to an IoT platform that includes hazardous area-certified equipment sensors, secure communication, performance analytics and trend reporting tools — all tailored to your plant's unique needs.

Options include:

- **Condition monitoring:** Enables you to capture asset performance data for analysis
- **Predictive analytics:** Applies data analysis software and algorithms to help you identify and diagnose equipment problems



For more information on RedRaven, contact your Flowserve representative or visit <https://www.flowserve.com/redraven>



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Flowserve Corporation has established industry leadership in the design and manufacture of its products. When properly selected, this Flowserve product is designed to perform its intended function safely during its useful life. However, the purchaser or user of Flowserve products should be aware that Flowserve products might be used in numerous applications under a wide variety of industrial service conditions. Although Flowserve can provide general guidelines, it cannot provide specific data and warnings for all possible applications. The purchaser/user must therefore assume the ultimate responsibility for the proper sizing and selection, installation, operation, and maintenance of Flowserve products. The purchaser/user should read and understand the Installation Instructions included with the product, and train its employees and contractors in the safe use of Flowserve products in connection with the specific application.

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