



# *Pumps for CO<sub>2</sub> Capture, Transportation and Storage*

Pre-Combustion • Post-Combustion • Pipeline • Injection



*Experience In Motion*



## **Pump Supplier to a Carbon Constrained World**

*Flowserve is the driving force in the global pump marketplace with unparalleled expertise in the successful application of pre-engineered, engineered and special purpose pumps and systems.*

### **Pump Supplier of Choice for Carbon Capture and Storage (CCS)**

Flowserve boasts unrivaled expertise in developing and implementing pumping technologies and systems for capturing, transporting and storing carbon dioxide (CO<sub>2</sub>). In 1984, Flowserve pioneered the use of pumps for high-pressure CO<sub>2</sub> pipeline and injection service and later became the first to use dry gas seals in dense phase CO<sub>2</sub> pumps. Flowserve also possesses unsurpassed experience in pumping the many solvents used to capture CO<sub>2</sub>. Flowserve is uniquely qualified to be the primary pump partner for customers endeavoring to reduce their carbon emissions.



### **Pump Designs**

Flowserve offers a wide range of pump types to meet the varied and numerous applications in CCS. These include:

- Single stage process
- Single and multistage between bearings, axially split
- Single and multistage between bearings, radially split
- Double case
- Vertical
- Slurry

### **Available Standards**

Flowserve pumps comply with the most stringent industry standards, including:

- ISO 13709/API 610
- ASME (ANSI) B73.1
- ISO 2858
- ISO 5199
- Hydraulic Institute



## Advanced Solutions to Reduce Carbon Footprints

*FlowsERVE combines technical expertise with cutting edge technology to reduce the carbon footprint of industry through reduced emissions, lower energy use and greater mechanical and process reliability.*

### **Technical Services**

FlowsERVE Technical Services works with plant operators to maximize productivity and minimize greenhouse gas (GHG) intensity. Nearly 200 design and application engineers stationed on six continents help to proactively identify and implement equipment and system modifications that reduce energy usage and improve reliability while lowering safety, health and environmental (SH&E) costs.

### **Technology Advantage™**

Technology Advantage combines state-of-the-art data collection and analytical technologies with advanced equipment diagnostic solutions to identify and implement proactive maintenance, upgrades and system modifications that reduce equipment shutdowns and process flaring.

### **Committed to the Complete Life Cycle of the CCS System**

For more than two centuries, FlowsERVE has served industries requiring solutions that add value and reduce costs throughout the life cycle of a pumping system.

- Oil and gas processing
- Power generation
- Chemical processing
- Cement manufacturing
- Steel manufacturing



Through its incomparable experience, FlowsERVE provides its CCS partners with know-how to respond to their business conditions. FlowsERVE works with customers to improve efficiency, maximize throughput and control process quality. Whether customer needs involve equipment upgrades, on-site technical assistance or broader project planning capabilities with full turnkey responsibility, FlowsERVE delivers professional, reliable results.

*Flowserve has been in the forefront of the development of process pump technologies to capture, transport and inject CO<sub>2</sub> and other acid gases.*



## CO<sub>2</sub> Capture Technologies

The process technologies to capture CO<sub>2</sub> have been well proven in the gas processing, chemical and petroleum industries for more than 50 years and Flowserve has been there every step of the way.

With the growing worldwide emphasis on curtailing and regulating GHG, CO<sub>2</sub> capture technologies may soon be applied on a much larger scale to fossil fuel power stations, oil and gas processing plants and general industrial manufacturing such as steel mills and cement plants. To comply with GHG limits, the industries will need to install CO<sub>2</sub> capture absorption trains with reliable pumping solutions.

### ***Experience, Technology and Support You Can Trust For Your Carbon Capture Needs***

With one of the largest installed bases of CO<sub>2</sub> solvent process pumps in the world, Flowserve has proven experience meeting highly challenging applications. From initial pump selection or design to aftermarket support, Flowserve is a name you can trust for your carbon capture needs:

- The most complete line of process pumps, including high-efficiency units for virtually every CO<sub>2</sub> service
- Customized diagnostics that improve efficiency, reduce downtime and optimize life cycle costs
- Unmatched expertise in a broad range of materials of construction and advanced surfacing technologies, including through hardening, HVOF and DLD overlays and ceramic coatings
- The largest global service network with unrivaled experience performing hydraulic re-rates and upgrades, regardless of OEM



### **Flowserve Improves Benfield\* Plant Reliability**

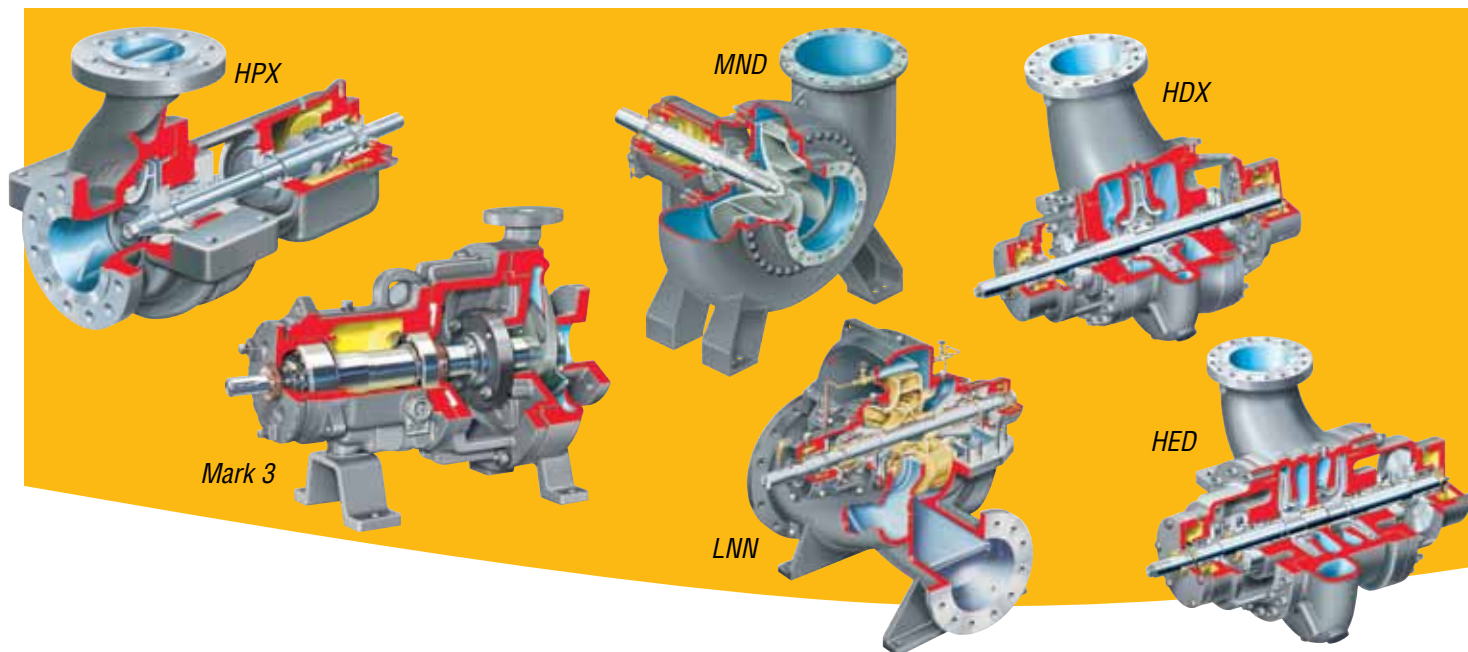
An ammonia/urea facility had recurring failures on its lean Benfield solution pumps which are used to remove CO<sub>2</sub> from the process gas. Shaft failures were occurring every 6-9 months, costing the plant hundreds of thousands of (U.S.) dollars in maintenance and downtime costs. A study by Flowserve confirmed that gas breakout was inducing vibration and causing the shafts to fail due to fatigue.

Working in partnership with the customer, Flowserve installed an intelligent diagnostics and optimization system consisting of two IPS APEX™ units and a local convergence unit with visualization and communication capabilities. The system utilized software developed by Flowserve which included an application-specific aeration detection algorithm.

The IPS APEX units continuously monitor key operating parameters of the Benfield pumps to detect the onset of aeration. They also transmit the data to an on-site control room, alerting operators to take corrective action.

This system has had a significant impact on the life cycle cost of the Benfield solution pumps; MTBF has increased to more than 3 years.

\*The Benfield™ Process is licensed by UOP, a Honeywell company



## Pumps for Capturing CO<sub>2</sub>

Whether utilizing pre-combustion or post-combustion technologies with amines, ammonia or other solvents, Flowserve can provide proven pumps in numerous metallurgies for all CO<sub>2</sub> capture applications.

### ANSI, ISO and API Process Pumps

Many designs available: low flow/high head, self-priming, dynamic sealing, recessed impeller, in-line and centerline mounted (HPX, Mark 3, CPX3 and PVML)

#### Operating Parameters

- Flows to 2000 m<sup>3</sup>/h (9000 gpm)
- Heads to 350 m (1100 ft)
- Pressures to 80 bar (1160 psi)
- Temperatures to 450°C (840°F)

### Slurry and Solids-Handling Pumps

Overhung horizontal and vertical configurations; back end pullout design (MND and FRBH)

#### Operating Parameters

- Flows to 17 500 m<sup>3</sup>/h (77 000 gpm)
- Heads to 100 m (325 ft)
- Pressures to 14 bar (203 psi)
- Temperatures to 150°C (302°F)

### Heavy-Duty, Axially Split Between Bearings Pumps

Double volute casing; hydraulically balanced, double-suction impeller (LNN, UZDL and LPN)

#### Operating Parameters

- Flows to 51 000 m<sup>3</sup>/h (225 000 gpm)
- Heads to 685 m (2250 ft)
- Pressures to 64 bar (910 psi)
- Temperatures to 200°C (400°F)

### Heavy-Duty, Radially Split, Double-Suction Process Pumps

API 610/ISO 13709 (BB2), latest edition; double volute, centerline supported, self-venting casing (HDX and HED)

#### Operating Parameters

- Flows to 4100 m<sup>3</sup>/h (18 000 gpm)
- Heads to 700 m (2310 ft)
- Pressures to 100 bar (1500 psi)
- Temperatures to 450°C (850°F)

*Flowserve pioneered the use of centrifugal pumps for dense phase CO<sub>2</sub> in pipeline and injection for enhanced oil recovery.*



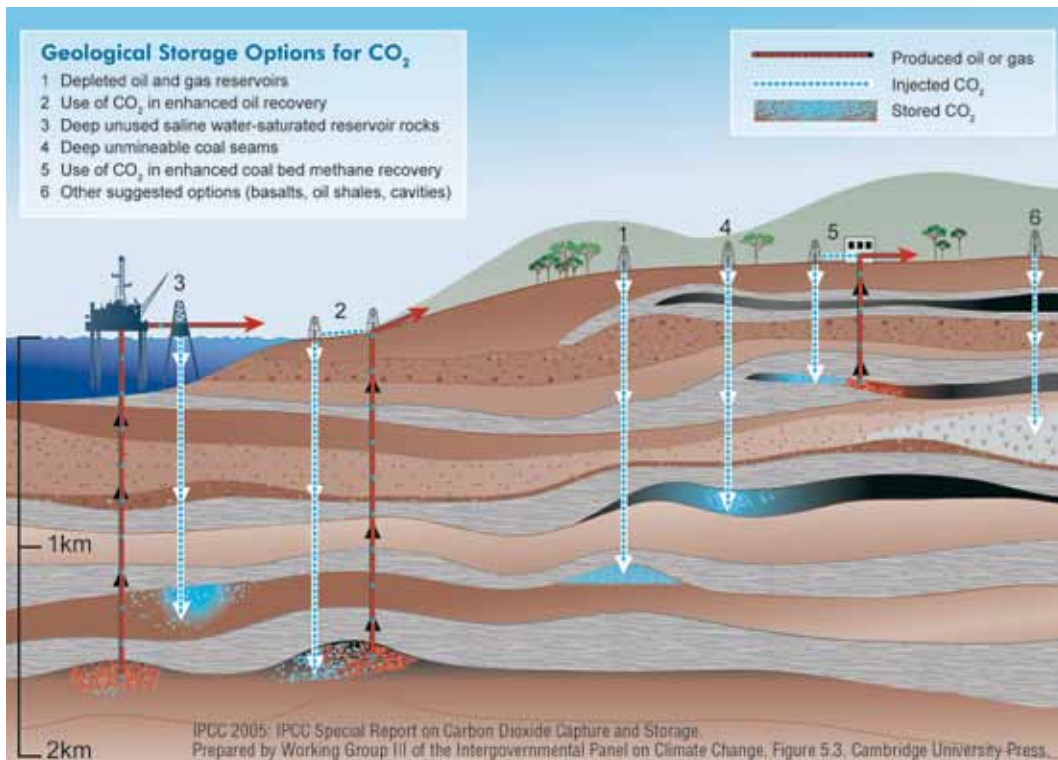
## CO<sub>2</sub> Transportation and Storage

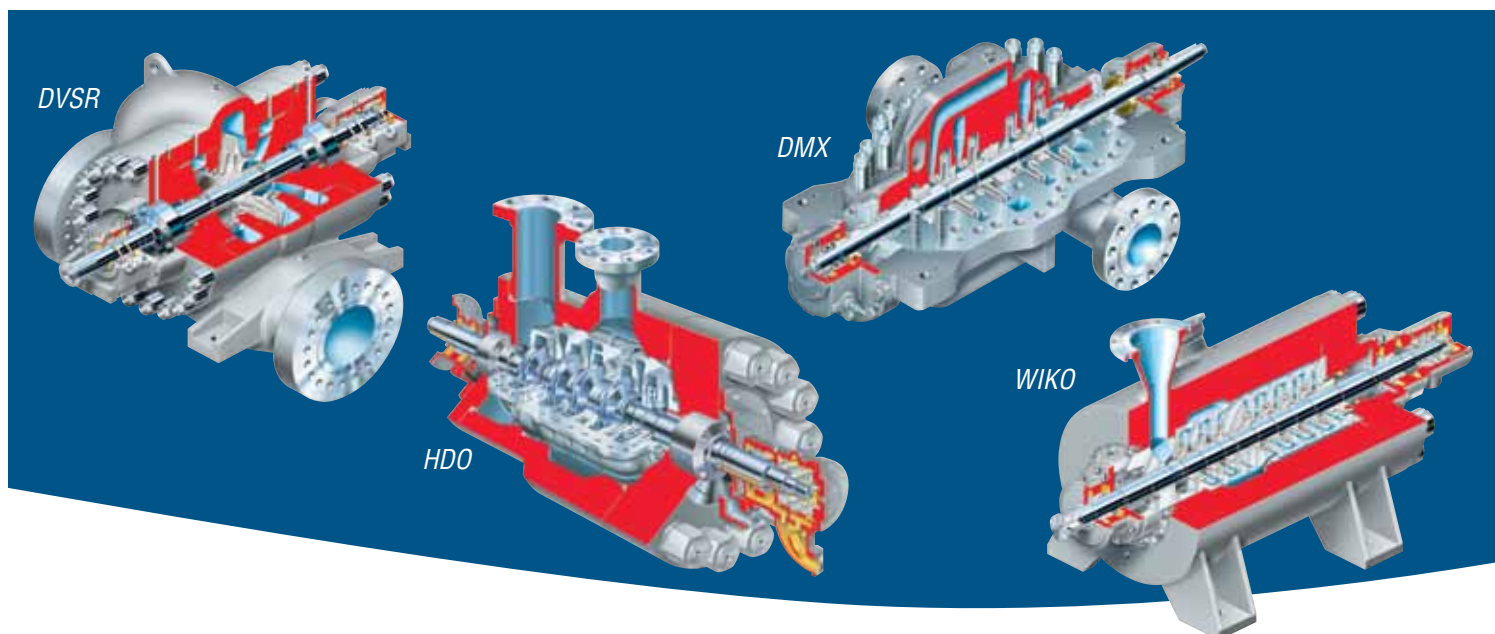
### Pipeline

Once captured, the CO<sub>2</sub> must be transported to a permanent storage site. Currently, the most economical method for transporting large volumes of CO<sub>2</sub> is via pipeline. To make this possible, the CO<sub>2</sub> is converted into a high-pressure, super-critical fluid called dense phase. In this phase the CO<sub>2</sub> behaves more like a liquid than a gas, allowing it to be pumped. Flowserve offers several radially and axially split pumps that are ideal for dense phase CO<sub>2</sub> transportation.

### Injection

While several methods of CO<sub>2</sub> sequestration have been proposed, leading methods involve injection into geological reservoirs. The most economically viable of these is enhanced oil recovery (EOR), where CO<sub>2</sub> is injected into active oil fields to increase production. The gas can also be injected into unusable saline aquifers and depleted oil and natural gas reservoirs. Regardless of the method, Flowserve offers high-pressure, axially split pumps and highly engineered, high-energy double-case pumps for injection.





## Pumps for CO<sub>2</sub> Transportation and Storage

As the world's leading supplier of CO<sub>2</sub> pipeline and injection pumps, Flowserve offers several pump models that have demonstrated proven reliability in these critical applications:

- Single and multistage pipeline and injection pumps
- High and ultra-high pressure barrel pumps for injection services
- Sealing solutions using liquid or dry gas seals

### Heavy-Duty, Radially Split, Double-Suction, Single-Stage Process Pumps

API 610/ISO 13709 (BB2), latest edition; between bearings, double volute casing (DVSR)

#### Operating Parameters

- Flows to 3635 m<sup>3</sup>/h (16 000 gpm)
- Heads to 250 m (820 ft)
- Pressures to 260 bar (3750 psi)
- Temperatures to 200°C (400°F)

### Axially Split, Multistage API Pumps

API 610/ISO 13709 (BB3), latest edition; between bearings, near centerline-mounted, double volute casing (DMX)

#### Operating Parameters

- Flows to 2950 m<sup>3</sup>/h (13 000 gpm)
- Heads to 2130 m (7000 ft)
- Pressures to 275 bar (4000 psi)
- Temperatures to 200°C (400°F)

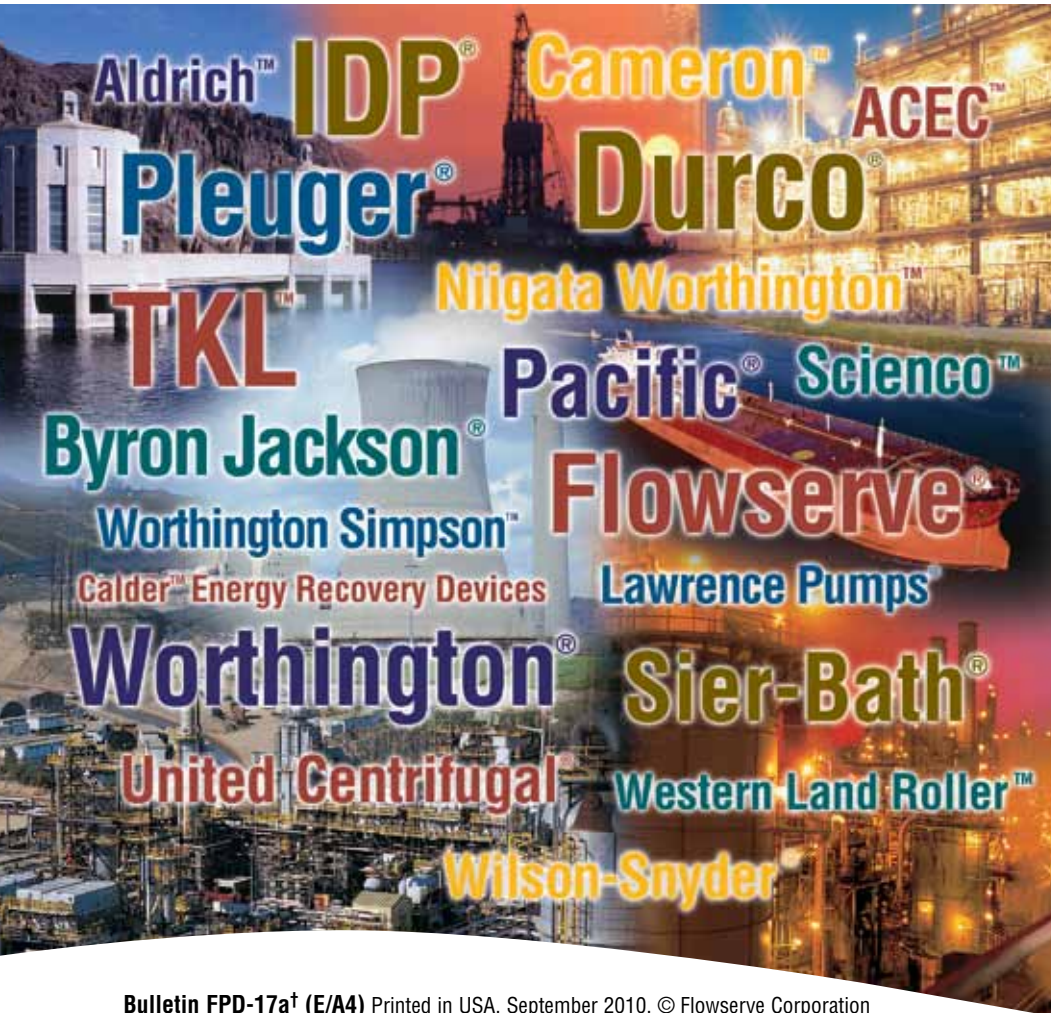
### Extra Heavy-Duty, High-Pressure Multistage Barrel Pumps

API 610/ISO 13709 (BB5), latest edition; tandem and opposed impeller configurations; diffuser or volute design; single-diameter balance drum (WCC, WIK, HDO and WIKO)

#### Typical Operating Parameters

- Flows to 2730 m<sup>3</sup>/h (12 000 gpm)
- Differential pressures to 650 bar (9500 psi); higher pressures available
- Temperatures to 450°C (840°F)





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***To find your local Flowserve representative:***

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