VERTICAL Insight

Guidelines, Technical Information and Tips for Selling Vertical Pumps

Second Quarter 2007

In This Issue

This issue will feature articles on Thrusters, VTP shaft sleeves and driver concerns for VTPs.

Also included is an update on Arganda VTP Center of Excellence (VCOE) and the German Geothermal Motor Development (GGMD).

Current and back issues are available in Passport under FPD -> FPD Home -> FPD News -> Technical News -> Product News -> Verticals.

Events

Water Rep Training	Taneytown	May 6-8
VTP Training	Taneytown	Jun 3-5
VTP Training	Taneytown	Sep10-12

Resources - Passport

Additional Product Management information is available on Passport, including current and back issues of Vertical Insight. Visit us at FPD -> Organizations -> Marketing

Vertical & Solids Handling Product Management Team

Director
Chuck Powers

Product Portfolio Managers
Marc Buckler – Verticals
Verónica Dolç – Verticals
Jay Sivigny – Solids Handling
Klaus Rechtenbach – Submersibles & Thrusters

Lead Product Engineers
Hans Memelink
Bob Cornman

In This Issue

Driver Concerns for VTPs

By Al Miller, Sr. Project Engineer - Upgrades

Vertical turbine pumps are driven by a wide variety of prime movers, but the most common arrangement is with an induction motor mounted on a Flowserve furnished support, usually a discharge head. On the surface, the selection of a motor to drive a pump is a simple matter of meeting the specification at a low price, but we all know better! The application of a motor to a structure involves careful consideration of the interface dimensions and the effect of mounting structure on the reed critical frequency of the combined machines. This is particularly important for motors slower than 900 RPM or greater than 350 HP.

IN THE BEGINNING

Unfortunately, the analysis of the impact of mounting a particular driver on a planned discharge head occurs after an order is received. At this point in time, the driver vendor also has a purchase order and expects to provide a machine at the quoted price without additional cost.

The driver vendor's data is used to determine the critical frequency of the combined machine and many times the result is unacceptable. Now what? – costly changes to the structure? Vibration dampening plates? An alternate driver vendor? No! These options involve more cost.

SOLUTIONS

By working with our vendors we've found that a win-win approach can be the path to success. Once the problem is defined (critical frequency in the wrong place) a team effort can result in the right answer at the right price. Examples of this team work that have produced the desired results:

- Vendor change to a smaller motor base diameter
- Flowserve change to a shorter discharge head
- Vendor addition of mass to the top of the driver
- Skip frequency added to VFD

A NEW PROBLEM TO CONSIDER

On a recent job involving large motors and pumps, a problem developed on the split mechanical seals. At startup, the seal would leak significantly until the discharge valve opened completely. Of course the pressure during this transition from shutoff head to design head was well within the design range of the seal, so why the leakage? With a simple dial indicator, it was determined that the combination of the motor and its support structure was deflecting downward approximately 2 mm on startup and ending at 1 mm displacement with the discharge valve open. Considering that the seal setting was made at zero pressure, it was high by 1 mm, no wonder the seal leaked!

VERTICAL SHAFT DISPLACEMENT?

Faced with the observations reported above, the FEA model of the motor mounting structure was analyzed and found to deflect 0.5 mm at the maximum head condition. That left 1.5 mm deflection in the motor! The motor vendor was never advised that there was a limit on shaft deflection in the vertical direction, so why is it their problem? In this case the problem was solved by setting the seal on the shaft at the position it would be at when in normal operation, not at the rest position.

NEW APPLICATIONS

Given that the motor and pump industry is a competitive place, cost reductions will continue and problems due to pressure and thrust will become more frequent. So how can we protect ourselves and our customers from unexpected problems due to motor and foundation deflections caused by thrust and pressure? The answer is communication! While a 2 mm downward deflection may be acceptable in a packed pump or even with a cartridge mechanical seal it will be an issue with a split seal. Consider an even greater issue – apply this 2 mm downward deflection on a pump with semi open impellers lifted less than 1 mm. Not a good situation at all.

Driver specifications should include the maximum allowable displacement of the shaft when split mechanical seals and/or semi open impellers are utilized.

Azimuthing Thruster for Offshore Applications

With Tilted Shaft Improves Net Thrust

The Pleuger azimuthing thruster has been designed by Flowserve Hamburg, Germany, combining decades of application experience with the latest market requirements. The rugged and versatile tilted-shaft design is positioned as the prominent choice for the offshore thruster industry.

The thruster can be mounted and dismantled underwater without dry-docking for optimum maintainability. The unique, tilted-shaft propeller design assures minimum thruster-hull and thruster-thruster interaction. This results in higher net thrust.

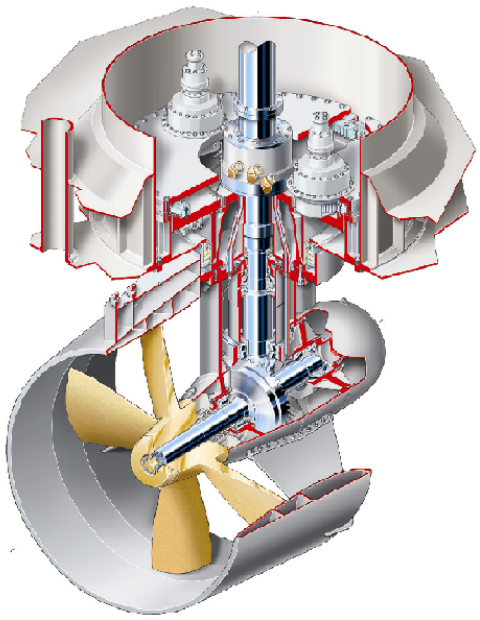
The following article focuses on the design and construction of this new innovation, as well as the application.

Introduction

The process to extract offshore oil has been an increasing challenge. Oil reserves in more remote areas and in deeper offshore reservoirs-- from tropical Brazil to the cold, stormy northern oceans of Norway. Add in market volatility and unstable global political environments and the reasons for increased offshore investments become obvious.

With the increase in oil and gas prices and a strong worldwide demand for energy, many more offshore fields are proving to be viable options for development. New technological advancements in semi-submersible drilling rigs, drill ships and FPSO (Floating Production, Storage and Offloading) vessels are either planned or are under construction.

Operating in these diverse and extreme conditions requires that offshore structures are dynamically positioned (DP) and thus require their own propulsive power. Several of the new semi-submersible technological innovations will be dynamically positioned by the Flowserve Pleuger thruster.



Thruster Assembly

Technology and Experience

For over 50 years, the Flowserve manufacturing facility in Hamburg, Germany, has led the development and production of different thruster designs under the heritage brand Pleuger®. In 1955, this operation patented the world's first electric pod-propulsion system.

Since that time, more than 2000 thrusters of different construction principles have been manufactured. Transverse tunnel thrusters, active rudder thrusters, retractable thrusters, containerized controllable- and fixed-pitch thrusters, and underwater mountable thrusters are some examples.

Besides the thrusters for standard applications, Flowserve Pleuger has developed and manufactured a great number of custom-designed auxiliary propulsion units. This was done in order to meet the extreme shock and signature requirements of navy vessels like atomic and conventional submarines and aircraft carriers.

Azimuthing Thruster for Offshore Applications

With Tilted Shaft Improves Net Thrust

New Tilted-Axis Design

By combining decades of application expertise with the latest in design principles, Flowserve Pleuger has developed an underwater-mountable, L-drive and fixed-pitch thruster line for offshore applications. The WFSD-type thruster type with tilted-axis propeller is designed for optimum net thrust output and maintainability.

Several advanced features are incorporated to deliver maximum performance, long service life and ease of installation and maintenance.

•7-degree tilted-shaft propeller to reduce thruster-hull and thruster-thruster interactions
•Easy under-water mounting and dismantling operations
•Duplex-thrust bearing allowing windmilling at any speed
•Automatic pressure compensation system for adopting differential pressure to draft during transit or operation
•Industry-leading service ratings and safety factors

The newly designed thrusters are available for custom optimized up to 5 meters in propeller diameter, and for greater than 4.000 kW input power with a fixed-pitch propeller (FPP).

Thruster Propeller

Application Potential

This thruster is especially designed for dynamically positioned vessels with significant draft variations such as semi-submersible rigs. Other applications include those for floating production storage and offloading (FPSO) vessels, drill ships, crane vessels and pipe-laying vessels.

Construction Principle

The Flowserve Pleuger thruster is a rugged, versatile and specially fabricated unit. Each thruster can be optimized for the application, with no standardized sub-assembly force provided for unwanted compromises.

The design focuses on ensuring reliability and durability, both of which are important in ensuring availability of the system. Life cycle expectancy as well as legendary performance are key attributes.

The special downward tilt of the propeller axis is achieved by utilizing a special gear. This avoids the boundary attachment (Coanda Effect), thus avoiding severe thrust deductions resulting in higher net thrust.

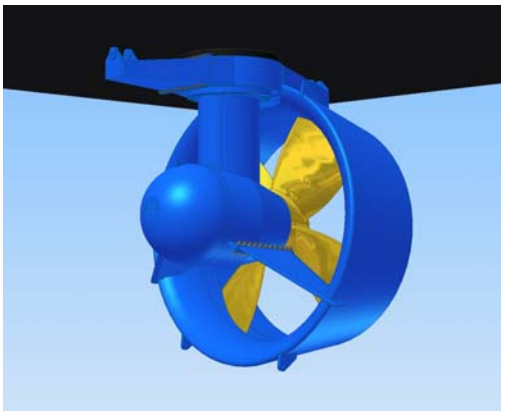
An industry-leading 97-degree cyclo-palloid spiral bevel gear is incorporated in this unique design. This gear type has a uniform tooth depth over the entire tooth width, and such a tooth curvature that follows the path of the epicycloids.

Within the Flowserve Pleuger thruster design, the gearwheel is in between the propeller and pinion placement. This ensures optimum contact pattern, especially with increasing thrust.
Gears are produced with the HPG method. The pinion and gear are rough machined, case hardened and then finished with carbide tooling.

All transmission parts (i.e. gearwheels and bearings) are designed with industry-leading service ratings and safety factors. The design loading is based on continuous running in dynamic position conditions.

Azimuthing Thruster for Offshore Applications

With Tilted Shaft Improves Net Thrust



Latest solid modeling design tools are used

Hydrodynamics

The reputation of Flowserve as the global leader in innovative pumping and propulsion solutions is based upon decades of experience in designing equipment with optimum hydrodynamic performance. Every propeller has an individually optimized profile geometry, as in-house experts have applied proven computer calculation methods that have been gleaned from years of field and test data analysis.

In principle, Flowserve recommends specific low loads for the propeller. This design philosophy secures optimum efficiency, maintains minimum fuel consumption and reduces lifetime operation costs for the user. Based on customer specifications, specific loads for other industry standards can be offered.

The nozzle is based on approved types that are optimized for maximizing the net thrust in bollard conditions. The nozzle and thruster are identically tilted and co-axial, allowing for reduced clearance. This results in better performance in comparison to combining the tilted nozzle with the horizontal propeller axis.

The propeller wash is directed away from the hull by the tilted-axis, avoiding boundary attachment (Coanda Effect). The result is a higher net thrust. Thrust deduction in DP-capability calculations may be assumed to be zero. The additional thrust results in an improved station-keeping capability plot within higher operational limits.

With the slightly downward-directed propeller wash, the thruster- to-thruster interaction can be reduced significantly. Forbidden angles are minimized and the vessel concept may be optimized with different constraints.

Flowserve's Pleuger Thruster technical leadership continues to be the industry choice.

Seal System

A reliable seal system is the backbone of trouble free operation. Flowserve uses as a standard a four lip, viton-on-ceramic seal arrangement on the propeller shaft. The differential pressure is maintained as constant by an automatic pressure compensating system, ensuring maximum life on the seal lips.

The seal is on the outside, protected by a Flowserve Pleuger specially designed rope guard and net cutter. All aspects of secondary backup are also considered.

The multi-lip sealing at the azimuthing coulomb is bolted to the foundation in the azimuth gear. Each chamber between the sealing rings is accessible by two check lines that check the seal status.

Lubrication System

The propeller gearbox of the Pleuger thruster is completely flooded with oil. For optimum operating condition of the seal system, the gear oil pressure is kept above the outside water pressure by an automatic differential pressure compensating system at all drafts. In the vertical high oil pipe the outside pressure at each thruster is measured, and the oil level is kept at corresponding levels to secure a constant static differential pressure.

As another design quality consideration, the gear housing suction pipe is located at the lowest point of the housing. This will help directly identify an unlikely increase in water content. With such an arrangement, water content in the gear oil may be measured during operation, and the oil may be separated from the water with an optional separator.

Azimuthing Thruster for Offshore Applications

With Tilted Shaft Improves Net Thrust

Underwater Mountable Thruster

This construction principle allows for the installing and removing of the outboard part of the thruster without dry-docking the vessel. For maintenance and repair purposes, the thruster can be replaced even when the vessel is in the open ocean.

The Flowserve Pleuger Thruster is delivered with an outer- and inner-cover for the underwater installation. The outer-cover seals the outboard part and the inner-cover seals the installation opening of the vessel.

With two extended rope fixings, the outboard thruster part can be pulled into position and hydraulically locked. No mounting force is required from the ropes. The inner and outer covers are then removed, and the thruster is mechanically fixed and the drive shaft is installed.

As an additional safety and design consideration, a buoyancy neutral cover is supplied for maintenance work in the wet part of the thruster base structure.

FAT

At specially designed facilities, Flowserve tests each thruster to a higher standard than classification requires. The Flowserve Pleuger Thruster group leads the industry in policy and procedures.

Torque and thrust are simultaneously applied to each thruster unit and the gear is tested. This is done in order to attain detailed knowledge of reaction to the operating condition.

Service

Flowserve is a reliable service partner for the offshore industry for the Flowserve Pleuger thruster. A team of dedicated experts supports system operators globally and local Flowserve service facilities are well positioned to provide optimum response. The on-site repair and overhaul of all variations of these thrusters has been successfully performed over the decades.

All ship yards, engineering contractors and key portals are very familiar with Pleuger thruster teams and service capabilities.

FAT 97 degree gear

Azimuthing Thruster for Offshore Applications

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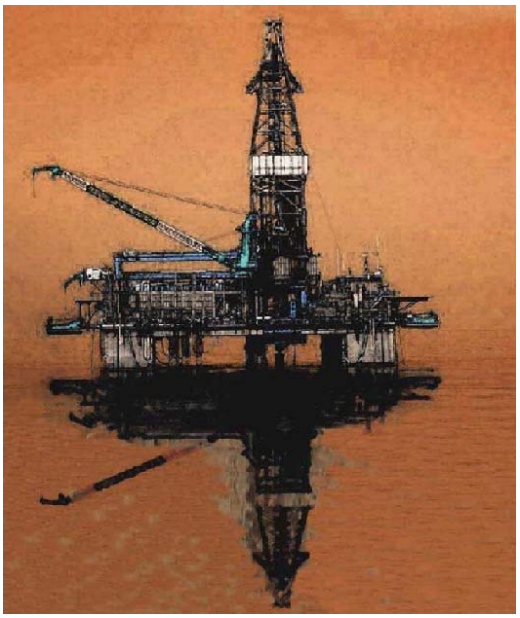
Application Example

US drilling rig operator ENSCO selected for its new design of the ENSCO 8500 a Flowserve Pleuger thruster. The current construction of the ENCSO 8500 at Keppel Fels in Singapore utilizes eight Pleuger WFSD 340 azimuthing, detachable, L-type thrusters with fixed-pitch propeller.

The DP class 2 ENSCO type 8500 rig is designed for an operational water depth of 8500 feet and a drilling depth of 35 000 feet. At operational draft of 55 feet, the rig has a displacement of 8500 tons and an air gap of 34 feet.
Two more similar ENSCO rigs are also under construction, and Flowserve Hamburg will supply 16 more thrusters for these units.

Also, the DSS 38 for Brazilian operator QGP is under construction at the same shipyard in Singapore is a further example of the utilization of the Flowserve Pleuger propelled semi-submersible rig.



Artist impression of ENSCO 8500

Photo courtesy of ENSCO

End-User Options

Flowserve´s global team can supply complete propulsion packages. These packages include diesel engines, generators, power management, e-motors and thrusters for offshore applications.

Further, the DP-system may be included. Pleuger has the technical experience and historical leadership to accommodate such an option.

Conclusion

Flowserve heavy-duty thrusters for offshore applications are the prominent choice for reliable DP-propulsion.

Torsten Moltrecht
Senior Application Engineer - Thrusters

VTP Shaft Sleeves

Alternate Installation Process

Application

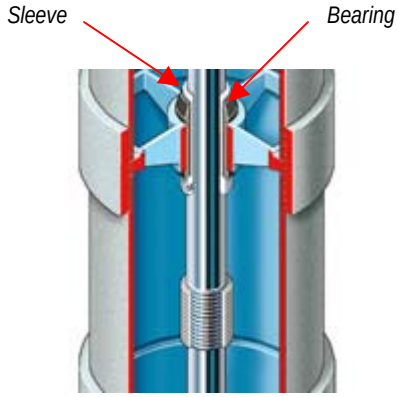
Line shafts for product lubricated VTPs. Primarily for the Agricultural market.

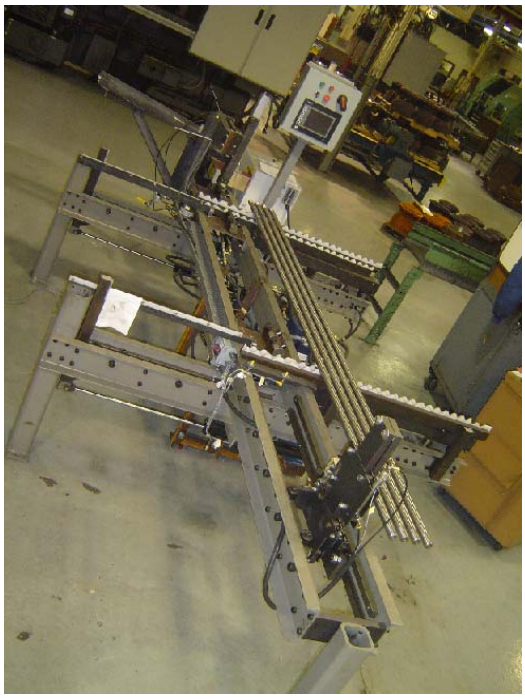
Background

Most line shafts for product lubricated pumps have a stainless steel sleeve installed on the shaft that runs in a rubber bearing. The previous design standard was to use a slip on sleeve that was retained with Loctite and set screws. There were a significant number of warranty claims due to the sleeve breaking loose and sliding down the shaft causing failure of the pump.

Solution

The best solution for the problem was to use sleeve with an inside diameter slightly smaller then the shaft. This requires the sleeve to be heated to expand the diameter enough so that the sleeve will fit over the shaft. Once the sleeve cools, they can be very difficult to move. The traditional method was to heat a batch of sleeves in an oven to a very high temperature. Then reach into the oven with a gloved hand to retrieve a sleeve and slide into position on the shaft. However, there were several issues with this assembly operation process. Most notable is the safety issue of handling hot sleeves. Another major concern was that the sleeves were often heated above the material's critical temperature during the process. Also, the cycle time to heat a batch of sleeves was also over two hours, causing significant delays in the production process. It was determined that this would not be an acceptable process.





Automated Assembly Machine

The final solution was to design and build an automated assembly machine with an induction heater to heat the sleeves. The automation eliminated the need for the operator to handle hot sleeves. And the induction heater provided the required cycle time reduction, bringing the shaft to shaft cycle time to less then 84 seconds. The operator only has to complete the material handling functions, including loading the sleeves and shafts into the machine and removing the finished assemblies. The sleeves cool to a safe temperature at the unloading point. The next step is to complete the "Box Loader" part of the machine, which will automatically take the shaft assembly from the end of the cooling rack and load it into the shipping container. This will eliminate half of the material handling operations.

VTP Shaft Sleeves

Alternate Installation Process

Cooling Rack

Machine Cycle

- Move one sleeve from magazine to induction heater coil
- Start heater timer
- Move next shaft in position to be assembled, this also moves the previously assembled shaft to the cooling rack
- Push shaft through the sleeve with a hydraulic cylinder

An adjustable stop is used to properly position the sleeve on the shaft

- Pull the shaft and sleeve assembly out of the coil using the same hydraulic cylinder as above
- Repeat cycle

Machine Features

- Touch screen control panel
- Self contained hydraulic unit built into the frame of the machine to make it easier to move the machine
- Two-axis pick and place arm to automatically move sleeves into the induction heater coil
- Gravity feed on both sleeve and shaft in-feed magazines to allow continuous loading of materials without stopping the machine
- V-notches in the cooling rack to prevent the finished shafts from touching

Design and Manufacturing Team:

Arlen Seeman - Manufacturing Engineering Manager
Tim Godtel - Manufacturing Engineer
Greg Peters - Tool Room

Arganda VTP Center of Excellence (VCOE)

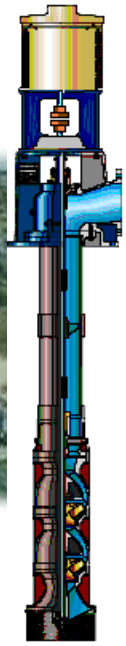
VTP Globalization

The Vertical Team is pleased to announce the upcoming release of the Arganda VCOE program.

Flowserve historically has had low-medium activity on projects involving VTPs in EMA other than Spanish market as served locally in Arganda. With this program, the current role of Arganda will be expanded to VTP Centre of Excellence for EMA. Arganda will manufacture the 6"-20" VTP active line to serve EMA market, with the necessary modifications to meet EMA market requirements, such as thrust bearing on pump, DIN/EN discharge flange, IEC motors with solid motor shaft design or CE marking.

A team formed by a mixed group of associates in Coslada, Arganda, Taneytown and Bangalore is working on the program, which will be launched in the 4th Quarter 2007

TAKE ADVANTAGE OF THIS PROGRAM SOON.

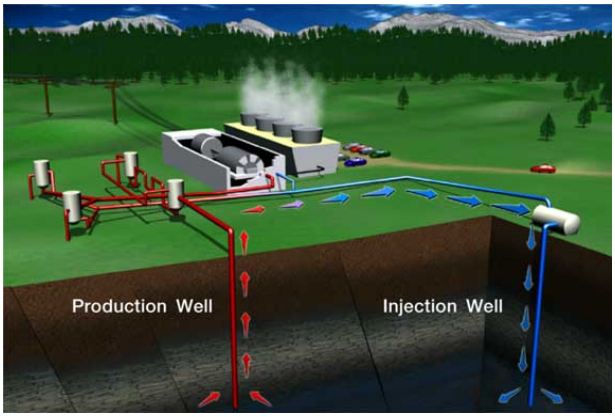


Arganda Facility

German Geothermal Motor Development (GGMD)

High Temperature SUBM

Flowserve Hamburg is currently designing new Byron Jackson submersible oil filled motors and submersible pumps for high ambient water temperatures, 180°C (350 °F). The submersible pump units will be used for pumping hot water out of deep wells. This hot water will be used for heating cities or for generating energy. Applications differ depending on existing water temperature. At certain ambient water temperatures, it is an efficient use for heating cities. But at higher ambient water temperatures, it is more efficient to generate energy. Flowserve Hamburg is currently manufacturing a test pump and motor for research and development.



Geothermal Process

Geothermal Well

Product Photos

200VLT (VPC Product Family)
Mendoza Operations
Astra Capsa
Yacimiento Vizcacheras- Argentina

40QL38 (QL Product Family)
Coslada Operations
Snamprogretti-Gasco (Ruwais)
United Arab Emirates

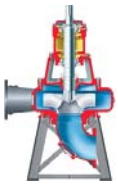
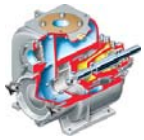
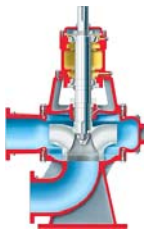
Global Vertical Product Guide

Sectional	Specific Speed	Family Name	Description	Hydraulic Range	Typical Models	Key Manufacturing Locations
	0.2 - 1.4 (500 - 3900)	WUC API 610 VS6 (Vertical, Double Casing, Multistage)	The Flowserve WUC vertical turbine is a radial flow or axial flow type, multistage, heavy-duty double casing pump. It is designed for continuous unspared duty in a variety of high pressure services, operating at extremes of temperature, marginal NPSHA and	Flows to 3,000 m^3/h (13,000 gpm) Heads to 2000 m (6500 ft) Pressures to 200 bar (3000 psi) Temperatures from -200°C (-325°F) to 350°C (660°F)	WUC	Brunn, Austria
	0.2 - 1.4 (500 - 3900)	WUJ API 610 VS1 (Vertical Wet Pit)	The Flowserve WUJ vertical turbine is a radial flow or axial flow type, multistage, heavy-duty single casing pump. It is designed for wet pit or deep well applications.	Flows to 3,000 m^3/h (13,000 gpm) Heads to 2000 m (6500 ft) Pressures to 200 bar (3000 psi) Temperatures from -200°C (-325°F) to 350°C (660°F)	WUJ	Brunn, Austria
	0.3 - 1.0 (800 - 2800)	QL and APKD (Vertical, Double Suction, Twin Volute, Wet Pit or Double Casing, Single or Multistage)	The Flowserve QL vertical, double-suction pump has a single impeller and true twin-volute design that produces more head and can operate at higher speeds than conventional, multistaged vertical turbine models. It can be used in all wet pit applications an	Flows to 20,000 m^3/h (90,000 gpm) Heads to 610 m (2000 ft) Pressures to 70 bar (1000 psi) Temperatures from -45°C (-50°F) to 200°C (400°F) Column sizes 100 mm (4 in) to 1200 mm (48 in)	QL, QLC, QLQ, QLQC, APKD, APKC	Desio, Italy Taneytown, USA Coslada, Spain Rio, Brazil
	0.5 - 1.7 (1500 - 4700)	VTP (Vertical Turbine, Wet Pit)	Flowserve's VTP vertical turbine pump is a diffuser type, single or multiple stage design for continuous service in wet pit and deep well applications. With more than 300 bowl and impeller designs, the VTP provides unsurpassed hydraulic coverage to ensure	Flows to 13,600 m^3/h (60,000 gpm) Heads to 700 m (2300 ft) Pressures to 150 bar (2175 psi) Temperatures from -200°C (-325°F) to 300°C (570°F) Sizes to 1375 mm (55 in) Settings to 365 m (1200 ft)	EL, EJ, EM, EK/SK, EG, EH, EN/SN, EP/SP, EB, ETM	Taneytown, USA Hastings, USA Arganda, Spain
	0.5 - 1.7 (1500 - 4700)	VPC "VTP-Can" (Vertical Turbine, Double Casing)	Flowserve's VPC vertical turbine, double casing pump is a diffuser type, single or multistage design for services with limited NPSH available.	Flows to 13,600 m^3/h (60,000 gpm) Heads to 700 m (2300 ft) Pressures to 150 bar (2175 psi) Temperatures from -200°C (-330°F) to 300°C (570°F)	EL, EJ, EM, EK/SK, EG, EH, EN, EP/SP, EB	Taneytown, USA Brunn, Austria Hastings, USA Santa Clara, Mexico Coslada, Spain

Global Vertical Product Guide

Sectional	Specific Speed	Family Name	Description	Hydraulic Range	Typical Models	Key Manufacturing Locations
	0.5 - 1.7 (1500 - 4700)	Byron Jackson SUBM (Vertical, Deep-Well Submersible "DWS", Oil-Filled Design)	The Flowserve Byron Jackson SUBM submersible motor pump is an oil filled unit built for the most demanding deep well services. Rugged, reliable and long lasting, these units offer significant total life cycle cost savings.	Flows to 4,500 m^3/h (19,800 gpm) Heads to 800 m (2600 ft) Motor sizes to 1500 kW (2000 hp)	LQ, MQ, HQ	Hamburg, Germany Taneytown, USA
	0.5 - 1.7 (1500 - 4700)	Pleuger SUBM (Vertical, Deep-Well Submersible "DWS", Water Filled Design)	The Flowserve Pleuger SUBM submersible motor pump uses water filled, wet wound motors. This design is environmentally friendly, provides high efficiency and offers great reliability.	Flows to 4,500 m^3/h (19,800 gpm) Heads to 800 m (2600 ft) Motor sizes to 5000 kW (6700 hp)	EL, EJ, EM, EK, EG, EH, EN, EP, EB, EQ, NN, PN, QN, KN, QT, SN	Hamburg, Germany Taneytown, USA Arganda, Spain Orleans, France
	1.0 - 2.9 (2600 - 8000)	VCT (Vertical, Mixed Flow, Wet-Pit)	Flowserve's VCT is a vertical mixed flow pump designed for extended operation on condenser cooling water service, flood control or where large capacities at relatively low pressures are required and installation requirements are best suited to a vertical	Flows to 113,550 m^3/h (500,000 gpm) Heads to 110 m (350 ft) Sizes from 500 mm (20 in) to 3000 mm (120 in)	KX, RX, VX, PMR, VOA	Santa Clara, Mexico Hengelo, Netherlands Coslada, Spain
	1.6 - 2.4 (4300 - 6600)	BSV/BCV (Concrete Volute "CVP")	The Flowserve BSV and BCV concrete volute pumps are a vertical, wet pit design used for large flow applications requiring continuous operation. The massive concrete volute substantially reduces noise and vibration, offers high corrosion and erosion resist	Flows to 115,000 m^3/h (500,000 gpm) Heads to 22 m (72 ft)	BSV, BCV	Hengelo, Netherlands
	3.3 - 5.5 (9000 - 15000)	AFV (Axial Flow Vertical)	The Flowserve AFV axial flow suspended shaft vertical pump is a single stage propeller type design. This family of pumps is specifically designed for low head movement of water for a multitude of municipal, agricultural and industrial services.	Flows to 180,000 m3/h (800,000 gpm) Heads to 11 m (35 ft) Speeds to 1770 rpm Sizes from 200 mm (8 in) to 3.1 m (123 in) Settings to 8 m (25 ft)	HSPR, PMR, VOP, APS, D	Santa Clara, Mexico Coslada, Spain Hengelo, Netherlands Orland, USA

Global Solids Handling Product Guide

Sectional	Specific Speed	Family Name	Description	Hydraulic Range	Typical Models	Key Manufacturing Locations
	0.5 - 1.2 (1400 - 3300)	MF (Overhung, Solids Handling Pump)	The Flowserve MF is an end-suction, side discharge, mixed flow, non-clog pump. This pump is designed specifically for reliability, low cost and long life in demanding sewage handling services or where solids in suspension are of particular concern.	Flows to 2275 m3/h (10,000 gpm) Heads to 90 m (300 ft) Sizes to 400 mm (16 in)	MF, MFV, MFC	Taneytown, USA Rio, Brazil
	0.6 - 0.8 (1600 - 2200)	MPT "Primo-Titan" (Self-Priming, Solids Handling Pump)	The Flowserve MPT "Primo-Titan" self-priming, solids-handling pump is engineered for reliability, low cost and long life in demanding services containing solids in suspension.	Flows to 600 m3/h (2650 gpm) Heads to 35 m (115 ft) Pressures to 3.7 bar (54 psi) Solids size to 75 mm (3.0 in)	PTP	Castlemaine, Australia
	0.6 - 1.3 (1600 - 3700)	MSX (Overhung, Solids Handling, Sewage Pump)	The Flowserve MSX family of solids handling, submersible pumps is engineered to perform efficiently in the most challenging environments, from pumping raw sewage to moving industrial wastewater and solids-laden liquids.	Flows to 4550 m3/h (20,000 gpm) Heads to 90 m (300 ft) Sizes to 500 mm (20 in)	MSX Dry Pit, MSX Wet Pit	Taneytown, USA
	0.8 - 1.6 (2300 - 4300)	MN (Solids Handling, Large Capacity, Overhung Impeller)	The Flowserve MN is an end-suction, side discharge, mixed flow, non-clog pump. This large capacity pump is designed specifically for reliability, low cost and long life in demanding sewage handling services or where solids in suspension are of particular	Flows to 45,500 m3/h (200,000 gpm) Heads to 90 m (300 ft) Sizes to 1800 mm (72 in)	MN, MNV, MNC, MNZ, MNF	Taneytown, USA Rio, Brazil
	1.6 - 1.9 (4400 - 5300)	QMN (Solids Handling, Wet Pit Pump)	The Flowserve QMN is a rugged wet-pit pump designed to pump sewage or for use in other wet-pit services where solids and stringy materials are present.	Flows to 17,000 m3/h (75,000 gpm) Heads to 40 m (130 ft) Solids up to 150 mm (6 in) Sizes 250 mm (10 in) to 1200 mm (48 in) Drivers to 950 kW (1250 hp)	QMN	Taneytown, USA

USA and Canada
Flowserve Corporation
Pump Division
5215 North O'Connor Blvd.
Suite 2300
Irving, Texas 75039-5421 USA
Telephone: 1 972 443 6500
Telefax: 1 972 443 6800

Europe, Middle East, Africa
Flowserve Corporation
Pump Division
Via Rossini 90/92
20033 Desio (Milan), Italy
Telephone: 39 0362 6121
Telefax: 39 0362 303396

Latin America and Caribbean
Flowserve Corporation
Pump Division
6840 Wynnwood Lane
Houston, Texas 77008 USA
Telephone: 1 713 803 4434
Telefax: 1 713 803 4497

Asia Pacific
Flowserve Pte. Ltd.
Pump Division
200 Pandan Loop #06-03/04
Pantech 21
Singapore 128388
Telephone: 65 6775 3003
Telefax: 65 6779 4607

To find the Flowserve associate or representative with the expertise you need, visit www.flowserve.com/pumps/contacts

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