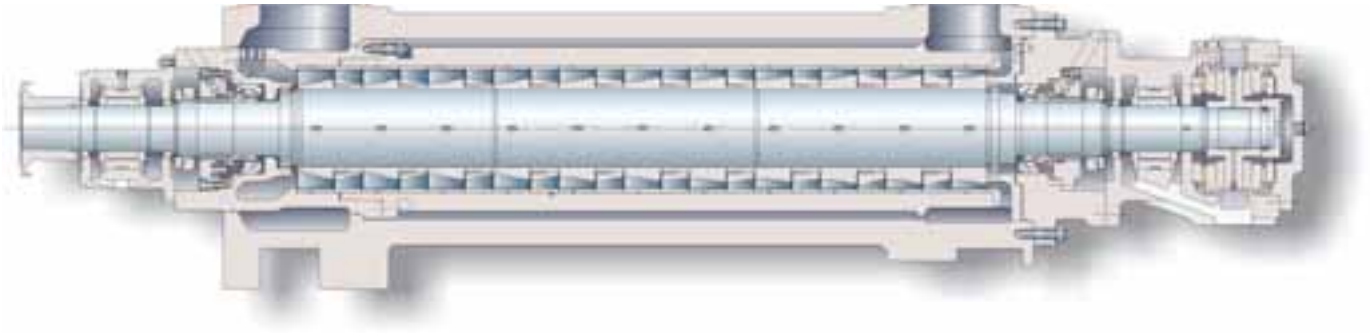
SULZER

MPP High Performance Multi-Phase Pump



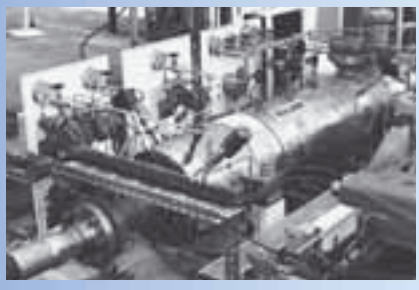
The Heart of Your Process

Sulzer Pumps

Sulzer Pumps combines more than 135 years of experience in pump development and manufacturing with a deep commitment to fully understand the needs of our customers.

Our detailed process and application knowledge has allowed us to develop innovative pumping solutions for our focus segments including tailor made systems if required. Our active research & development supports the customer-oriented approach.

Sulzer Pumps has sales and service facilities in all the major markets of the world to provide fast and flexible response and support.



The first MPP made by Sulzer.

Multiphase Pumping Solutions

Helico-axial multiphase pumping was developed from the Poseidon research programme in the eighties. The first commercial unit was designed by Sulzer in 1993. Since then Sulzer have supplied many units, with power rating from 530 HP (400 kW) up to over 8,000 HP (6'000 kW), in various parts of the world, and have accumulated a unique level of experience in the successful implementation of this technology.

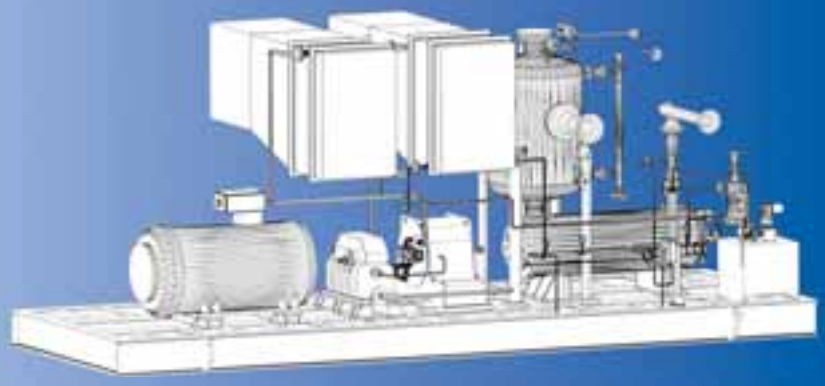
Sulzer multiphase pumps (MPP) have been successfully deployed, onshore and offshore, in a variety of environments and climates such as: Siberia, Middle East, North Africa, South East Asia and in the North Sea. These pumps cover a wide and variable range of process conditions (variable oil flows, water flows, gas volume fractions, fluid pressures and temperatures).

Several oil fields (with an oil production ranging from 60,000 up to 200,000 bopd) are relying on Sulzer Multiphase Pumping Solutions to produce them. The worlds largest offshore MPP units (4.5 MW each) as well as the worlds largest onshore MPP (6.6 MW each) operating to date have been supplied by Sulzer Pumps.

MPP Package

A typical multiphase pump unit is a fully tested self-contained package to minimize hook-up and start-up time. It is a turnkey solution comprising pump, variable speed driver, flow distributor, seal & lube oil systems, coolers, piping and cabling up to junction boxes.

Two executions are available, using either a horizontal or vertical pump arrangement.



Boosting of Unprocessed Well Stream

Interest in multiphase pumping which leads to simpler and smaller in-field installations is primarily influenced by the need for more cost-effective production systems.
This is especially the case with marginal or declining fields, both onshore and offshore, often in hostile and remote or deep-water environments.

Multiphase pumps are essentially a means of adding energy to the unprocessed well stream, which enables liquid/gas mixtures to be transported over longer distances without the need for prior phase separation.

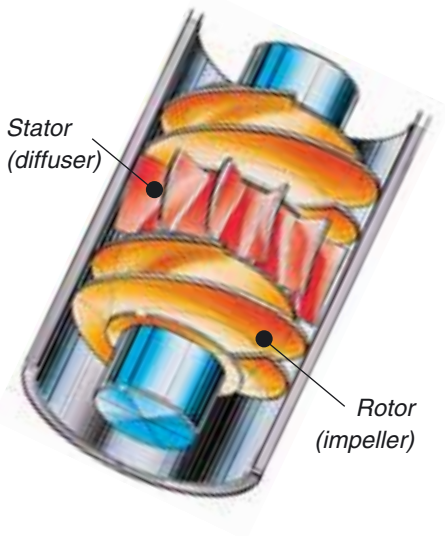
MPP stations do not require permanent manning and are suitable for remote control.

Multiphase transportation over long distances has been made possible by predicting both stationary and transient multiphase flow phenomena in pipelines and by the capability of the helico-axial multiphase pumps (Poseidon license). These pumps are capable of handling Gas Volume Fractions (GVF) between 0 (100% liquid) and 1 (100% gas).

The Sulzer range of MPP's is designed to accommodate a variety of variable suction pressures. This is a major advantage over a conventional separation system featuring a compressor which is designed to operate solely at a predetermined fixed inlet pressure level.

Main MPP applications

- Increase capacity (debottleneck) of existing flowlines by maximizing throughput
- Produce low & medium pressure wells into a high pressure manifold/ separator
- Produce marginal fields or remote tiebacks to existing facilities
- Segregate production scheme of medium and low pressure wells by using dedicated MPPs
- Restore production of dead wells by reduction of well backpressure
- Maximise utilization of existing production facilities on a declining field by adding production from remote wells
- Eliminate flaring and recover gas by boosting the unprocessed wellstream to a separation plant
- Reduce unstable flow regimes in multiphase pipelines due to higher superficial velocities



R&D Commitment

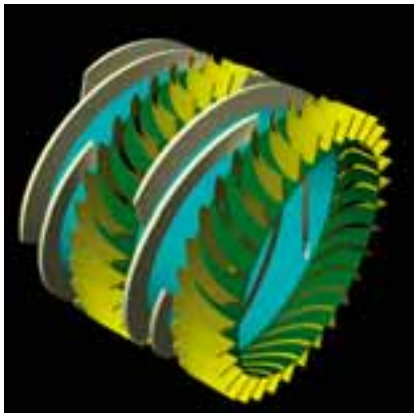
Todays technical achievements result from yesterdays Research and Development (R&D) investments. The role of R&D is to ensure that tomorrow's technical challenges are met and opportunities grasped. It aims at developing the technologies which will give our customers a commercial advantage by developing better, more efficient processes and products.

Sulzer have a long history as a technology leader, and have a successful track record of improving our customers' profitability by setting new standards in efficiency and reliability.

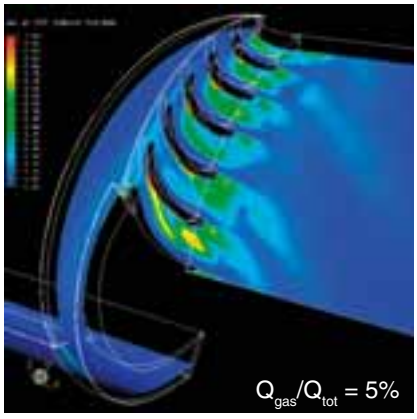
Basic research focuses on hydraulics, cavitation, erosion, corrosion and mechanical design (particularly rotordynamics), which is then applied to advance product development.

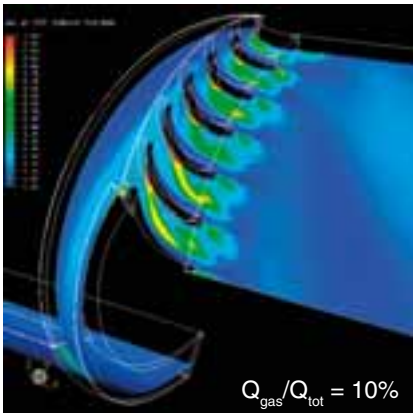
To develop multiphase pump solutions, Sulzer gathered scientific specialists who conduct fundamental research, experienced design engineers and technicians with practical field knowledge.

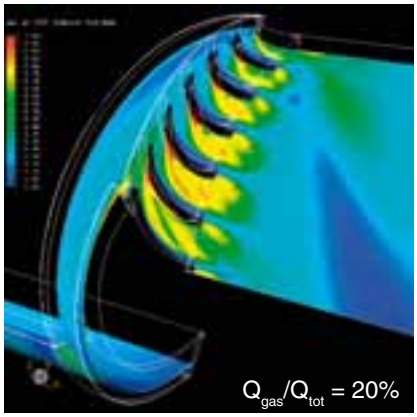
Successful research and development activities require continuous investment, which benefits our customers by ensuring that they have a stable business partner at the leading edge of pumping technology.

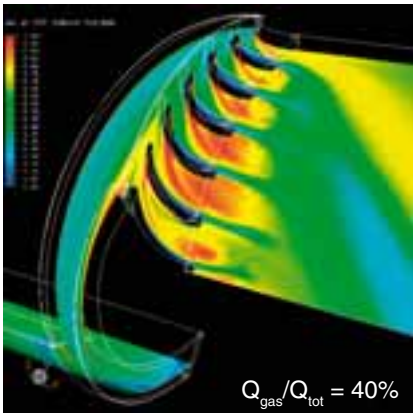


Two successive MPP stages.







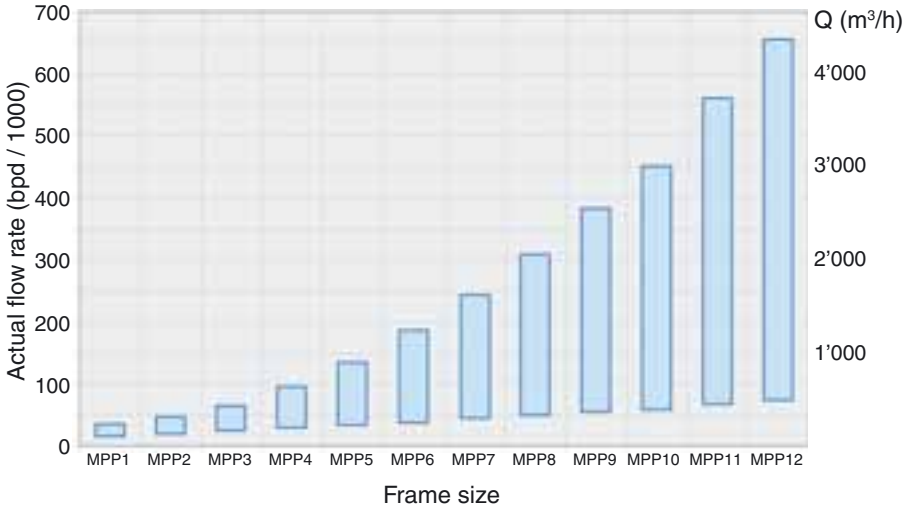


Two phase Navier-Stokes flow calculations with four different gas volume fractions.

MPP Performance Range

The Sulzer MPP modular range consists of 12 standardised frame sizes with a total nominal capacity of up to 650,000 bpd (4'300 m³/h) at pump inlet conditions.

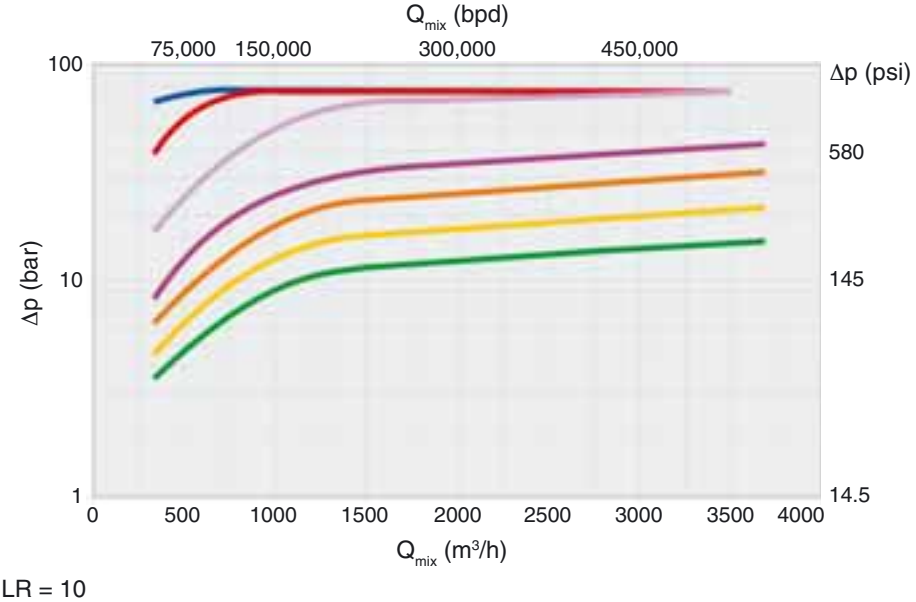
The standard range is designed for pressure boost up to 90 bar. As for any centrifugal pump the pressure boosting capability depends on the density of the fluids being pumped, pump speed, impeller diameter and number of stages.



Pressure capabilities of the Sulzer MPPs can be estimated knowing the following parameters at pump inlet: Gas Liquid Ratio (GLR), total flow rate, and suction pressure.

Gas Liquid Ratio is defined as the gas flow rate divided by the liquid flow rate expressed in the same units. It can also be derived from the Gas Volume Fraction (GVF) which is the volume of gas over the total fluid volume.

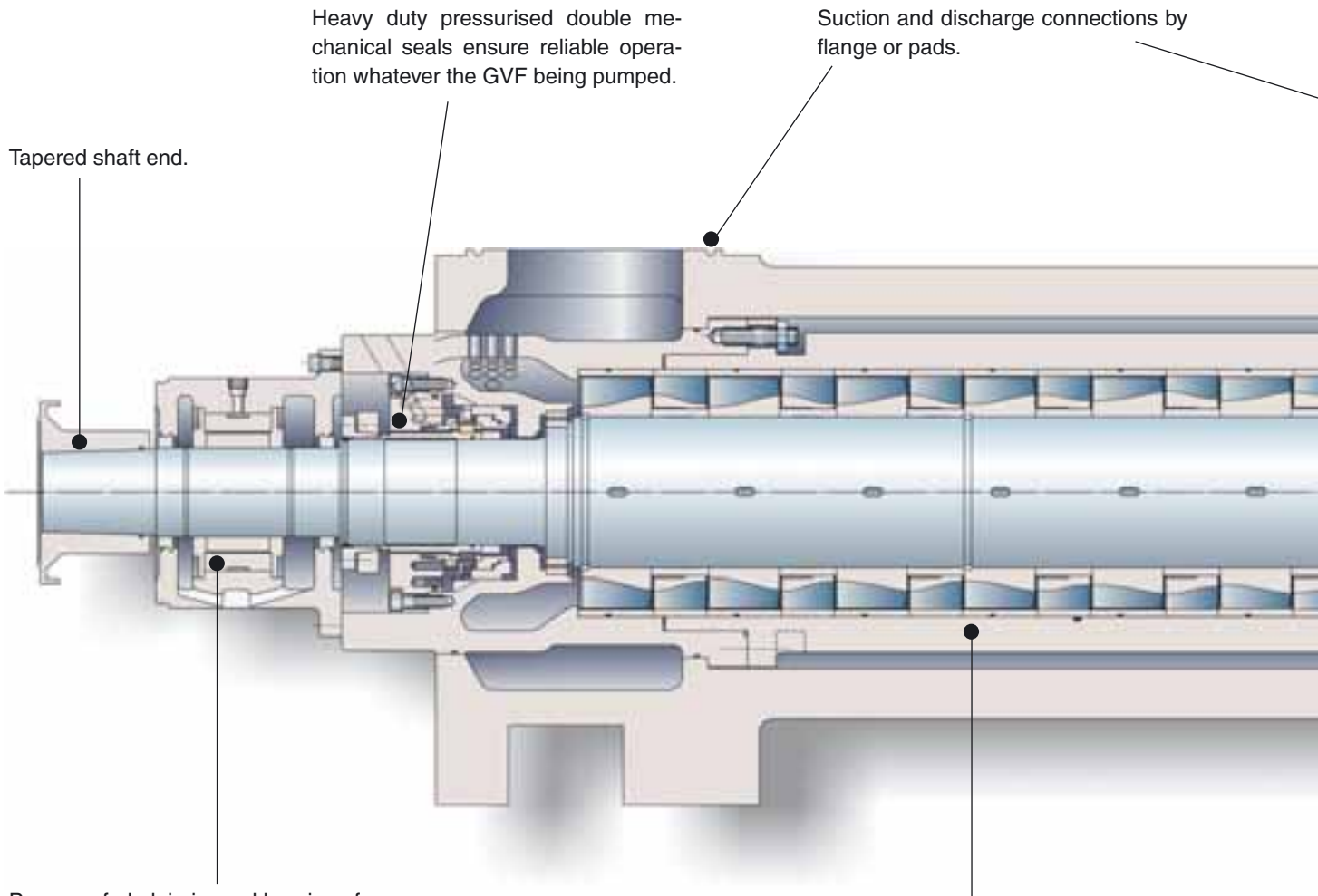
$$GLR = \frac{GVF}{1 - GVF}$$



GLR = 1
GLR = 2
GLR = 4
GLR = 7.5
GLR = 10
GLR = 15
GLR = 25

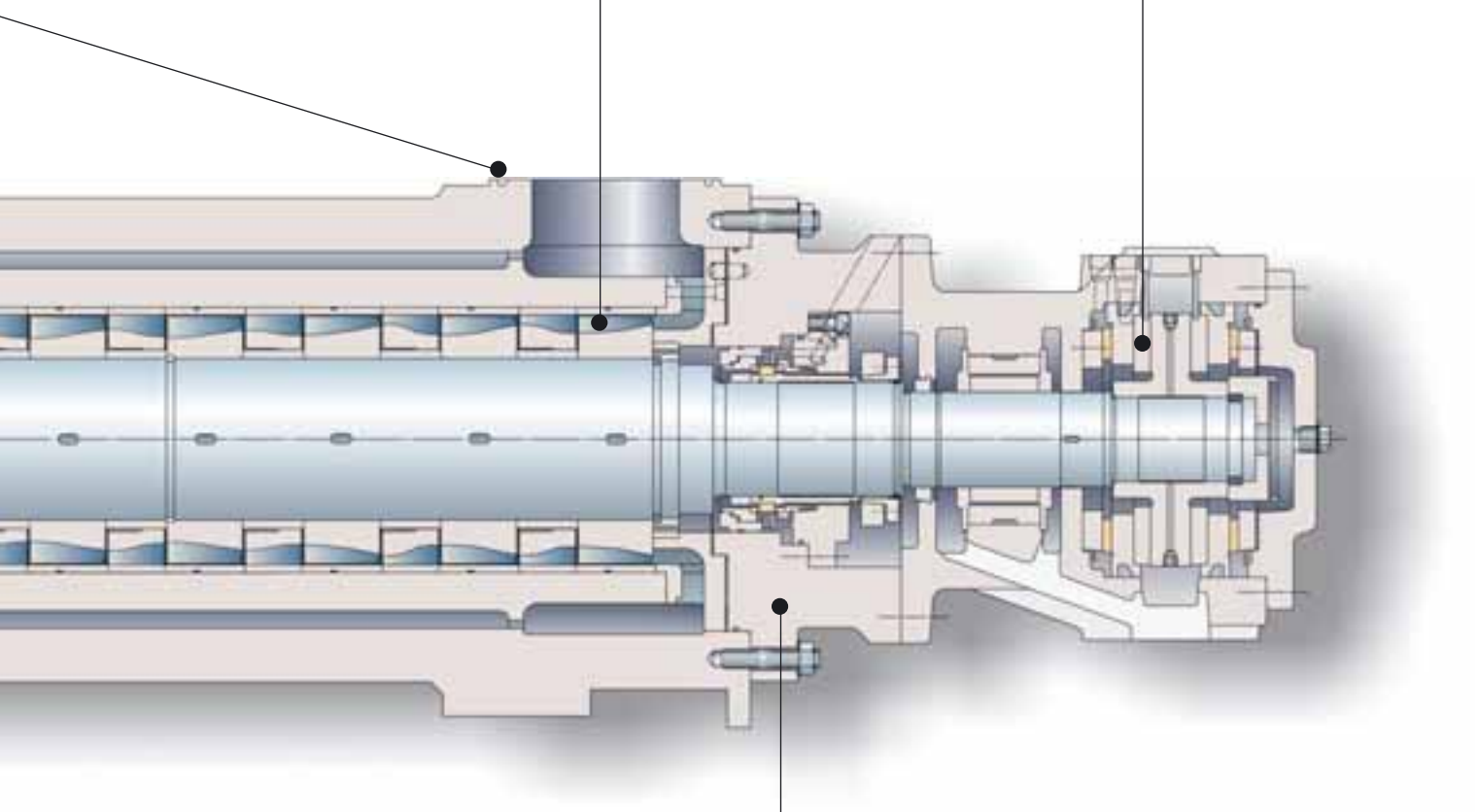
Pump Features and Benefits

- Pump design according to API 610
- High pressure capability and axial thrust balancing with balance drum (option)
- Flexible cartridge design allows for higher pressure or higher flow capabilities (by re-staging, dummy stages, higher flow hydraulics)



Helico-axial hydraulic allows high volumes to be pumped, sand tolerant design due to large clearances and abrasion resistant material/coatings.

Tilting pad thrust bearing to absorb fluctuating loads caused by different GVF changes.



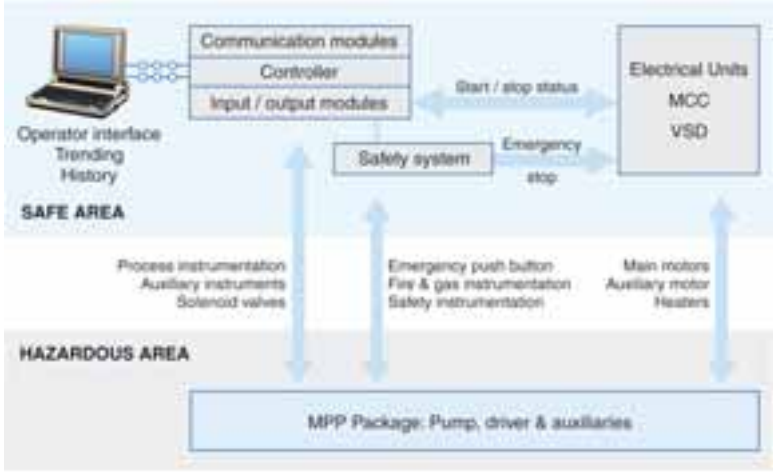
Full cartridge pull-out with bolted cover closure.

Monitoring and Control

Helico-axial MPPs have a self regulating capability to adapt to gas volume changes under normal operating conditions. They have a wide operating envelope with a large turndown capability.

The pump and its auxiliaries are controlled by a PLC via an operator interface (local and/or remote and allowing for unmanned operation). Trending and history functions are provided.

MPP's are normally operated at a constant speed selected by the operator (to achieve the desired output). The operating process control can be effected by changing the speed set point (using a process parameter for control). Variable speed drive (mechanical or electrical) provides a high degree of operational flexibility and suits process changes due to field evolution over time.



Equipment Testing

Every multiphase pump package with its driver and auxillary equipment is submitted to a complete string test on Sulzer's high performance multiphase testbed.

Prior to this each multiphase pump undergoes complete mechanical and hydraulic performance testing to demonstrate full compliance with the specifications. Mechanical seals are tested on supplier's test rig simulating actual conditions.

The Sulzer testbed is fully automated to ensure accurate results considering all multiphase flow variables to be measured. Actual operating conditions can be simulated.

Testbed main characteristics

Total flow:	up to 3'600 m^3/h (550,000 bbld)
Power:	up to 12'500 kVA
Lifting capacity:	500 kN (50 tons)

Pumps are tested on Sulzer's testbed simulating actual conditions.

Applications

Production Enhancement Onshore Saudi Arabia

Reactivate and boost dead wells into HP manifold/separator. Outdoors installation suitable for desert climate, high well stream temperature (up to 120°C or 250°F), separate electrical control room, remote control.

MPP7

Actual flow:	48,850 bpd (324 m^3/h)
Actual GVF:	59%
Inlet pressure:	434 to 734 psia (30 to 51 bar abs)
Outlet pressure:	up to 734 psia (51 bar abs)
Power:	750 HP (560 kW)
Variable speed:	frequency converter

Multiphase Transport Onshore Siberia

Boost flow to production centre, recover gas. 2 x 50% MPPs. Outdoors installation suitable for temperature range from -40°C (-40°F) up to +35°C (+95°F), 300 ppm solids content, pump sets supplied in heated/ventilated shelters, separate electrical/control room.

MPP7

Actual flow:	83,000 bpd (550 m^3/h)
Actual GVF:	40 to 88%
Inlet pressure:	75 to 150 psia (5 to 10 bar abs)
Outlet pressure:	up to 260 psia (18 bar abs)
Power:	530 HP (400 kW)
Variable speed:	turbo coupling

Production Enhancement Onshore Sumatra

Reduce wells backpressure, boost to existing gathering center. Outdoors installation suitable for tropical climate, very high well stream temperature (up to 150°C or 300°F), very high solids content (2,000 ppm), separate electrical/control room.

MPP7

Actual flow:	150,000 bpd (1'000 m^3/h)
Actual GVF:	40 to 95%
Inlet pressure:	35 to 190 psia (2,5 to 13 bar abs)
Outlet pressure:	up to 260 psia (18 bar abs)
Power:	740 HP (550 kW)
Variable speed:	frequency converter

Pumping station in Western Siberia: three MPPs operating in parallel.

Applications

Full Field Production Enhancement: 2nd Development Stage Offshore North Sea

Reduce wells backpressure, boost LP wells (at pressure below export pressure) into a 16" multiphase subsea flowline to a processing platform located 22 km away.

Platform installation suitable for unsheltered North Sea conditions, largest power concentration in a single vertical multiphase pump offshore, very high suction and differential pressure, separate electrical/control room. Two units supplied. Remote control.

MPP8 (vertical arrangement)

Actual flow:	180,000 bpd (1'200 m^3/h)
Actual GVF:	30 to 90%
Inlet pressure:	725 to 1,830 psia (50 to 126 bar abs)
Outlet pressure:	up to 1,830 psia (126 bar abs)
Power:	6,000 HP (4,500 kW)
Variable speed:	frequency converter

MPP module added to side of existing platform.

200'000 bopd Full Field Development: Multiphase Transport Onshore Siberia

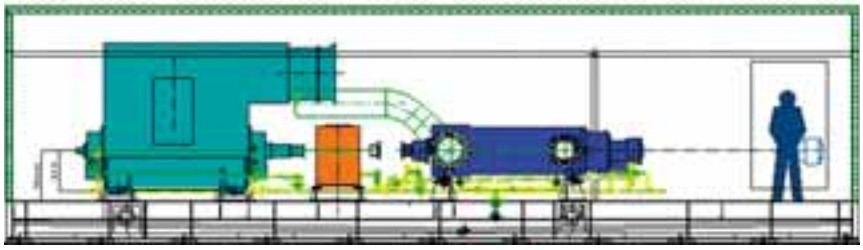
Boost flow to production centre, eliminate gas flaring.

World highest power concentration in a single MPP driven by a 6.6 MW electric motor. Outdoors installation suitable for temperature range from -55°C (-67°F) up to +35°C (+95°F), four pump sets (3 operating, 1 stand-by) supplied in heated/ventilated shelters, with separate electrical/control room, transformers, and switchgear room.

MPP11

Actual flow:	560,000 bpd (3,700 m^3/h)
Actual GVF:	up to 91 %
Inlet pressure:	87 to 360 psia (6 to 25 bar abs)
Outlet pressure:	up to 900 psia (62 bar abs)
Power:	8,800 HP (6'600 kW)
Variable speed:	frequency converter

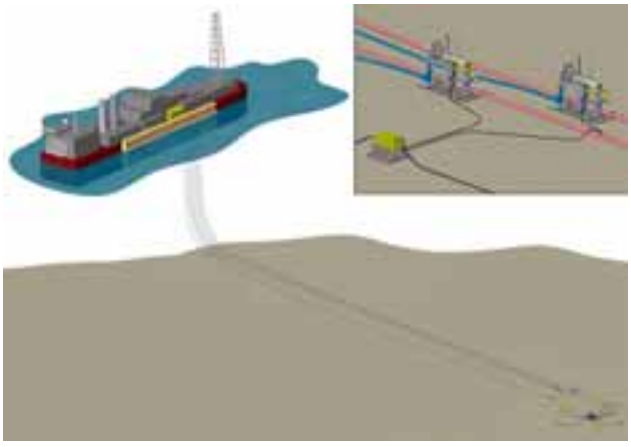
Phased installation: two MPP sets installed.

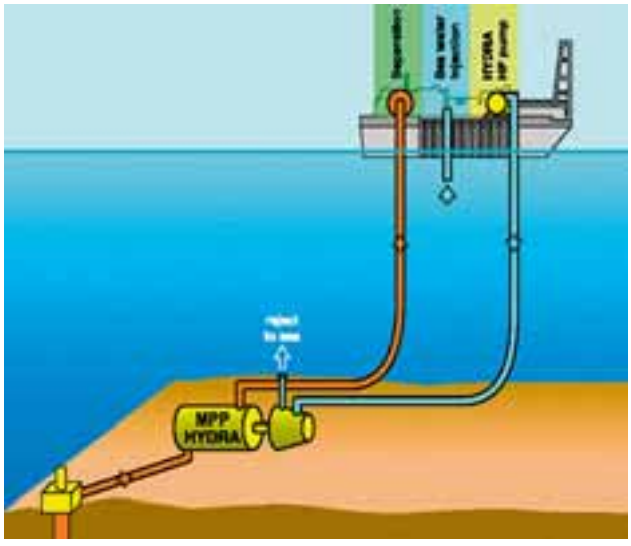


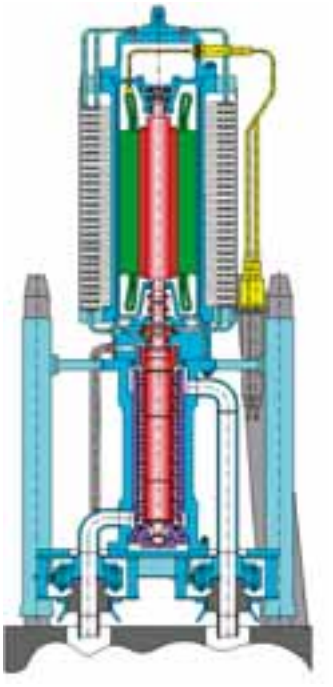
Subsea Boosting

Flowrates up to 650,000 bpd (4'300 m^3/h) and differential pressure up to 1300 psi (90 bar). Two alternative configurations, depending on the preferred type of driver, are proposed:

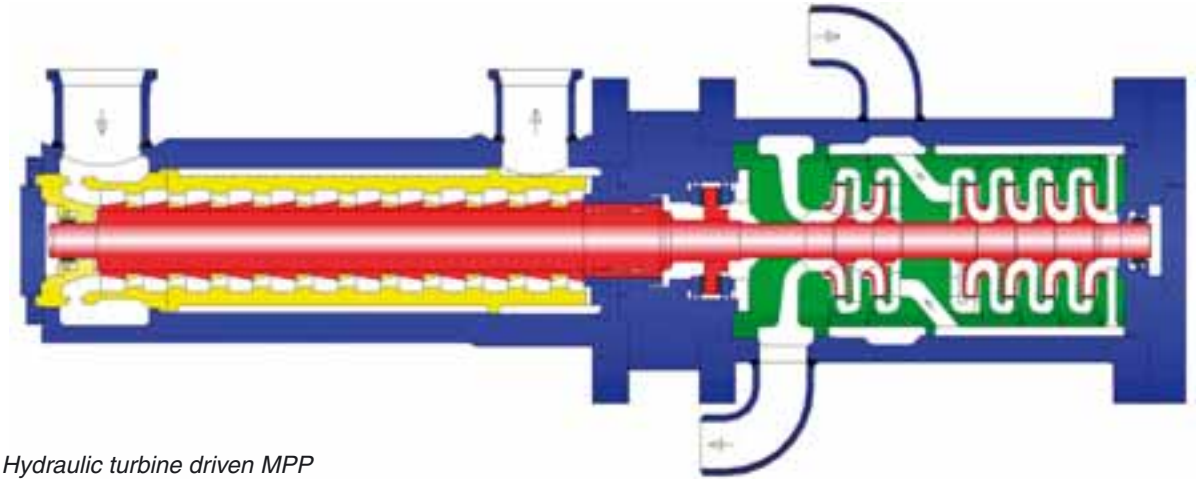
- electric drive
- hydraulic turbine drive







Electric driven MPP (≤2,500 kW)



Hydraulic turbine driven MPP

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