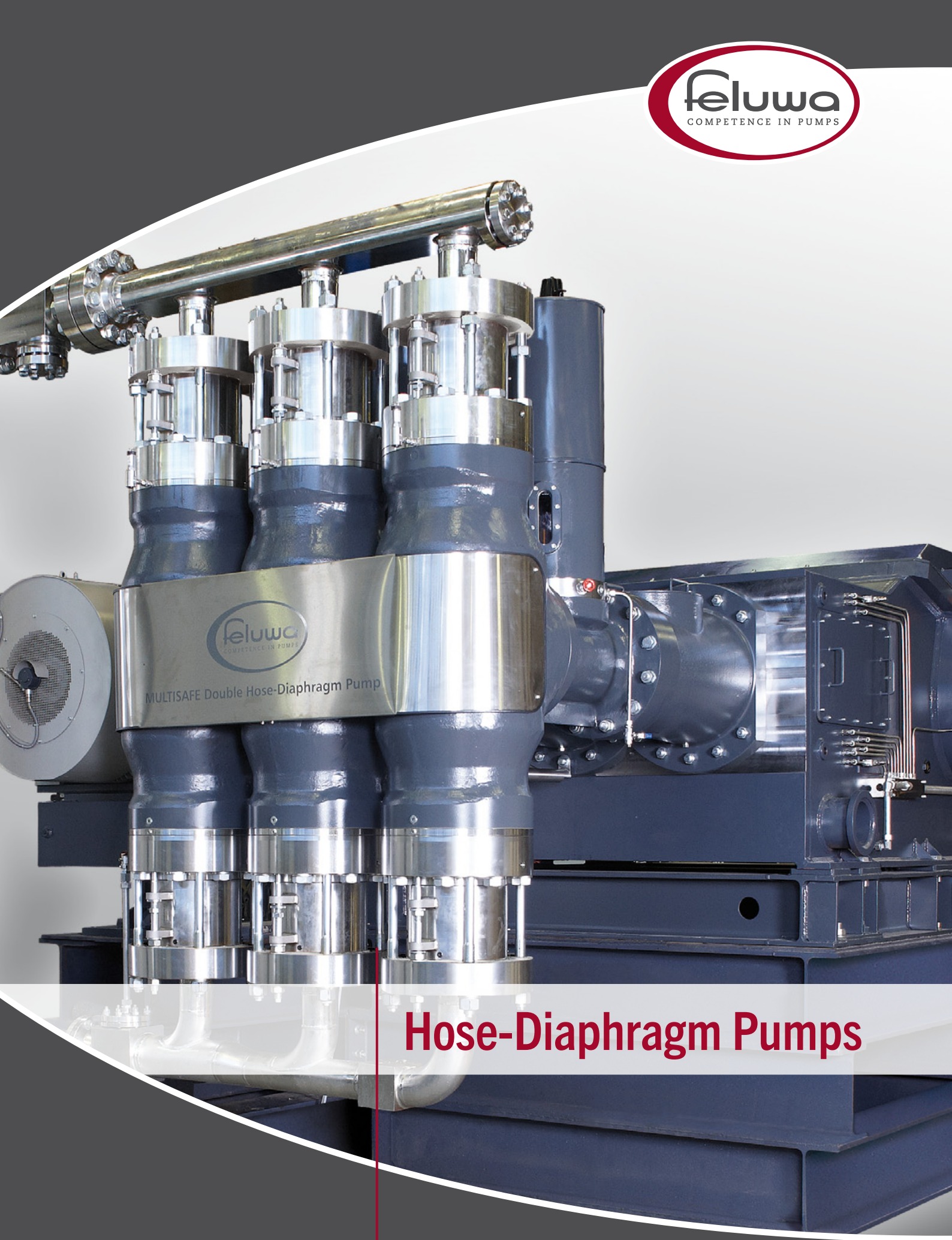


Hose-Diaphragm Pumps

Company History

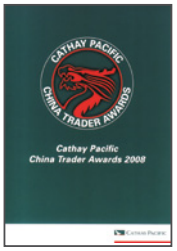
This brochure is intended to familiarise the reader with FELUWA Pumpen GmbH and its first class heavy duty process pumps MADE IN GERMANY.

FELUWA Pumpen GmbH has at its base in excess of 100 years' corporate history. In 1901, the parent company was established in Neuwerk/Mönchengladbach as a foundry and expanded in 1931 by the addition of a machine factory, based in Cologne. At that time, the company focused on the production of equipment of fire, air and water technology, such as burner equipment, compressors, fans and pumps. After a relatively short period of time, the company started concentrating on pump technology. In 1960, FELUWA moved to Mürlenbach in the Eifel area, where its headquarters are still located today. The integration of FELUWA Pumpen GmbH into the ARCA Flow Group in November 2000 has offered the opportunity of unique know-how transfer within the group, which in turn combines wide and varied engineering knowledge of the individual group members.

The continuous process of innovation and development of FELUWA pumps has been subject to multiple high-ranking recognition and awards.

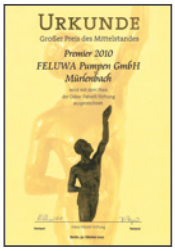
For in excess of 80 years, ARCA Regler GmbH has been one of the leading manufacturers of control valves, pneumatic actuators and positioners. With four production facilities in Germany, two in Switzerland, one in the Netherlands as well as joint venture companies in India, Korea, Mexico and China the ARCA Flow Group operates worldwide. With a diverse range of control valves, pumps and level indicators the ARCA Flow Group is firmly established in various fields of operation, such as chemical, petrochemical, oil and gas, mining, food industries, power plants and synthesis gas plants.

Innovative Medium-Sized Enterprises



China Trader Award


Holkenbrink Award



Premier – Grand Prix of Medium-Sized Enterprises

Plaque of Honour

Members of the ARCA Flow Group:

feluwa
COMPETENCE IN PUMPS

- MULTISAFE® double hose-diaphragm pumps
- Hose diaphragm piston pumps
- Sludge dewatering units for underground mining
- Municipal pumping stations
- Sewage pumping stations with cutter
- Wastewater pumping stations with solids diversion
- Homogenising centrifugal pumps

www.feluwa.com

ARCA VALVES

- ECOTROL® Control valves (Works 2)
- Control valves
- Actuators
- Positioners
- Steam Conditioning Valves

www.arca-valve.com

von Rohr Armaturen AG

- Diaphragm valves
- Floor outlet control valves
- Food industry valves
- Sterile control valves
- Single seat control valves
- Corrosion-resistant control valves
- Pneumatic actuators
- Electric actuators

www.von-rohr.ch

ARTES VALVE & SERVICE

- Control ball valves
- Desuperheaters
- Steam atomising desuperheaters
- Steam conditioning valves
- Differential pressure transmitters

www.artes-valve.de

WEKA®

- Visual level indicators
- Tank level instruments
- Cryogenic components
- Stainless steel valves
- Micro flow valves

www.weka-ag.ch

Welcome to FELUWA

FELUWA Pumpen GmbH is situated in Mürlenbach, the scenic valley of the river Kyll (province Rhineland Palatinate) in the south-western part of Germany, close to Belgium and Luxemburg. Mürlenbach lies at the heart of the "Vulkaneifel", where it is possible to study 400 million years of evolutionary history.

The company name FELUWA is derived from the German words for the former business operating areas "fire" (**FE**UER), "air" (**LU**FT) and "water" (**WA**SSER) and thus represents three out of the four basic elements.

The total company land area exceeds 100,000 m^2, including more than 9,350 m^2 of building area for production and office facilities. FELUWA is continuously expanding and investing in new machinery and production halls in order to ensure constant and optimum quality standards.

Quality assurance

Fabrication of FELUWA process and transportation pumps, air vessels and pulsation dampeners is subject to a comprehensive and efficient quality programme that is adapted to actual requirements. The quality and environmental management system is in accordance with DIN EN ISO 9001:2008 and 14001:2004 standard.

Pump testing facilities

In the course of mechanical fabrication and testing on FELUWA's state-of-the-art performance test rig, all important pump characteristics and components are determined and documented by test reports. Before shipment, all pumps are subject to a rigorous test regime. The implemented quality management system ISO 9001 ensures that a uniform and constant design and fabrication level is maintained.

Test procedures – Pump test rig

- Measurement of displacement pumps according to VDMA 24284
- Pressure test according to AD 2000-Merkblatt HP30
- Flow measurement at specified pressure and number of strokes according to ISO 5168 and VDI/VDE 3513
- Determination of sound power and sound energy levels acc. to DIN EN ISO 3744
- Absorbed power

Test procedures – Fabrication

- Dimensional check against fabrication drawings
- Spring and hardness test
- Brinell measurement system
- Coating thickness according to DIN EN ISO 2178

Measuring facility

- Actual-theoretical comparison with an accuracy of +/- 0.016 mm

Diaphragm Pumps – Evolution

Why hose-diaphragm pumps?

For a long time, diaphragm pumps or diaphragm piston pumps have been used for the handling of media in industrial applications. Internal parts of such pumps (diaphragm housing and pump cover for example) are in direct contact with the conveyed fluid so that in many cases (especially when handling corrosive slurries) expensive construction materials are required that are chemically resistant to the conveyed fluid. In addition, failure of single diaphragms results in damage to the hydraulic end of the pump (pistons, cylinder liners, etc.) and high cost for wear parts and downtime. Diaphragm condition monitoring requires elaborate and sensitive conductivity measurement systems in the hydraulic chamber.

Hose diaphragm piston pumps

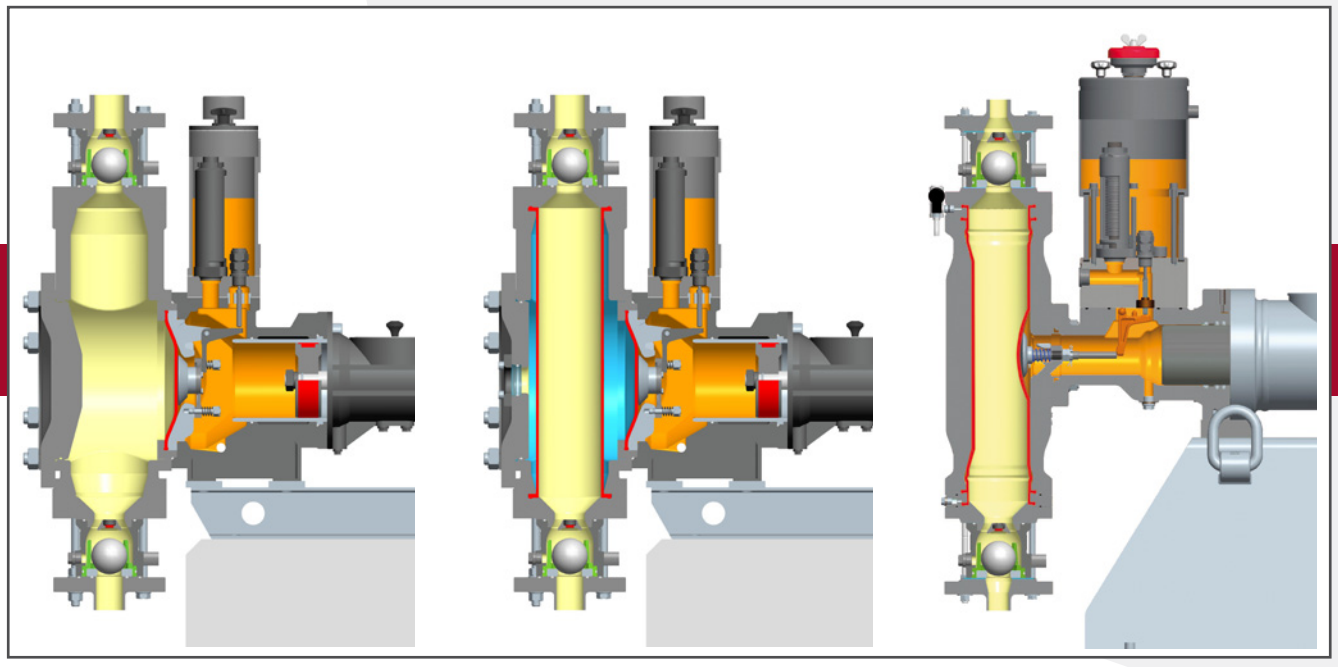
In order to avoid the disadvantages of traditional diaphragm pumps, FELUWA has developed its hermetically sealed, leak-proof, reciprocating displacement pump, the aptly named Hose Diaphragm Piston Pump. This pump has been successfully operated in worldwide applications for 40 years. It is characterised by an extraordinarily high technical and economic value. With the FELUWA hose diaphragm piston pump, the commonly utilised principle of a flat diaphragm has been extended by the additional provision of a flexible hose-diaphragm so that the conveyed fluid is in direct contact with the inside of the hose-diaphragm and check valves only. Wet end and drive end of the pump are separated by a flat diaphragm and a hose-diaphragm. The second actuation fluid between flat and hose-diaphragm serves as hydraulic coupling and safety aid for leak detection. A mechanical valve system in the hydraulic chamber ensures automatic control and compensation of the actuation fluid volume without additional oil pump and control unit.

Even in the event of a hose-diaphragm failure, the secondary diaphragm ensures that the slurry will not enter the hydraulic drive end so that operation can be maintained. This contributes to low costs for wear parts and high availability.

Double hose-diaphragm pumps

Although hose diaphragm piston pumps already represent significant advantages over diaphragm pumps with several thousand units being well proven, consistent further development has been pursued with the MULTISAFE® double hose-diaphragm process and transportation pump. Basically, it is a hermetically sealed, leak-proof, oscillating displacement pump with double sealing of the wet end from the hydraulic drive end and the environment by means of two hose-diaphragms which are arranged one inside the other. The flat diaphragm is fully abandoned.

MULTISAFE® pumps utilise an overall diagnostic system for permanent condition monitoring of primary and secondary hose-diaphragms (by means of pressure sensors), check valves (FELUWA Valve Performance Monitoring System – FVPMS), suction pressure as well as hydraulic and gearbox oil temperature. Double hose-diaphragm pumps are characterised by unique design features and advantages, which are described in detail in this brochure and put this pump ahead of any other diaphragm pump design.

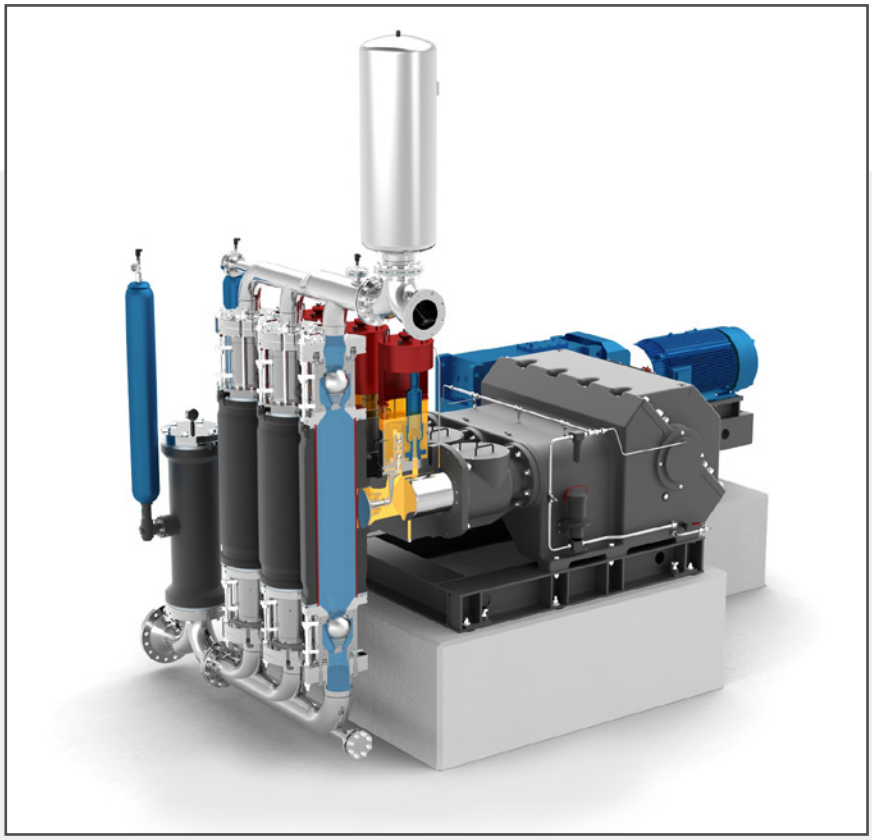


Diaphragm Piston Pump (developed in 1960)

Hose Diaphragm Piston Pump (developed in 1970)

MULTISAFE® Double Hose-Diaphragm Pump (developed in 2002)

Working Principle and Safety



MULTISAFE® double hose-diaphragm process and transportation pump. Triplex design – Downflow configuration.

Working principle of FELUWA MULTISAFE® pumps

The rotary driving motion of the pump gearbox is converted into a reciprocating action of the crosshead by means of the crank drive. The crosshead is connected to the piston or plunger, respectively. By means of hydraulic fluid the piston actuates a pair of redundant hose-diaphragms, which are arranged one inside the other. They not only enclose the conveyed fluid in a linear flow path, but also provide double hermetic sealing from the hydraulic drive end. The conveyed fluid will neither come in contact with the pump head nor with the hydraulic area. For general process engineering applications, the hydraulic fluid normally consists of hydraulic oil. As an alternative option, non-compressible fluids with physiologically harmless lubricants are applied, which are compatible with the conveyed fluid. Pumping action is effected by displacement of the inside volume resulting from contraction of the hose-diaphragms. Unlike so-called peristaltic hose pumps with mechanical drive, the hose-diaphragms of the MULTISAFE® pump are not squeezed. In step with the piston stroke, they are only subject to pulsating action, comparable with that of a human vein. Elastic distortion of the hose-diaphragms is path-controlled and effected in a concentric manner due to their inherent construction. As a result of hydraulic support, the hose-diaphragms are subject to little load even under high working pressures. The service life of hose-diaphragms is considerably extended beyond that of traditional flat diaphragms which reflects in very good MTBF (Mean Time Between Failure) and MTBR (Mean Time Between Repair) values.

High operating safety

One of the distinct advantages of the MULTISAFE® pump is its linear flow path without deviation, so that it is especially conducive to the handling of shear-sensitive, aggressive, abrasive and solids carrying fluids and slurries, even at high viscosity. Unlike traditional diaphragm pumps, hose-diaphragms do not require a clamping ring that allows for settling of solids which results in early diaphragm failure.

The pump offers unique operating reliability. Even in the event that one of the hose-diaphragms leaks or fails, the second hose-diaphragm will ensure that pump operation can be maintained until the next planned shutdown of the unit. Any internal loss of hydraulic fluid is automatically compensated by the incorporated leakage compensation valve. External compensation systems are not required.

Quintuplex Design

of MULTISAFE®
Double Hose-Diaphragm Pumps

Worldwide unique configuration

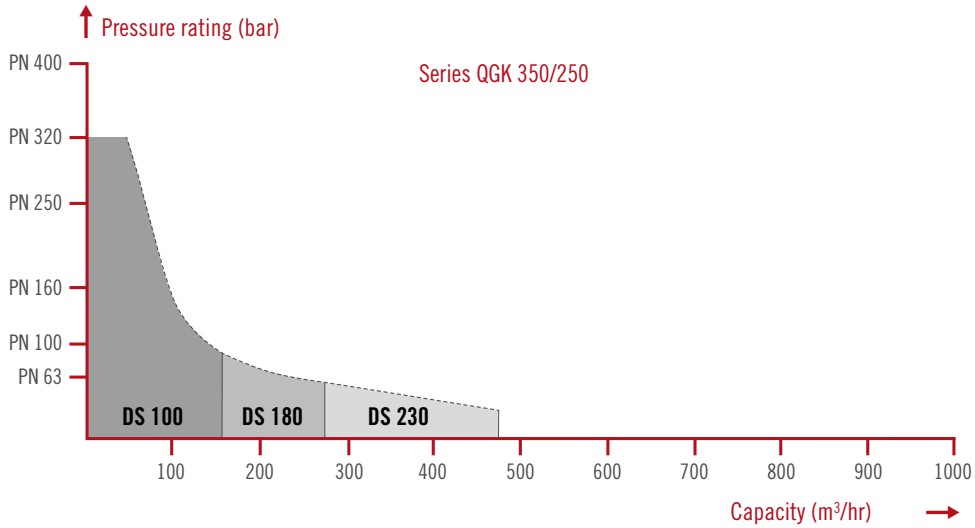
MULTISAFE® double hose-diaphragm pumps are designed with relatively narrow cylindrically shaped pump heads when compared to standard diaphragm piston pumps and therefore allow for the arrangement of five pump heads in parallel. When considering high flow and pressure rates, quintuplex design would not be economical for traditional diaphragm piston pumps because circular flat diaphragms would require a gearbox design that would be excessively wide to accommodate the size of the heads in parallel.

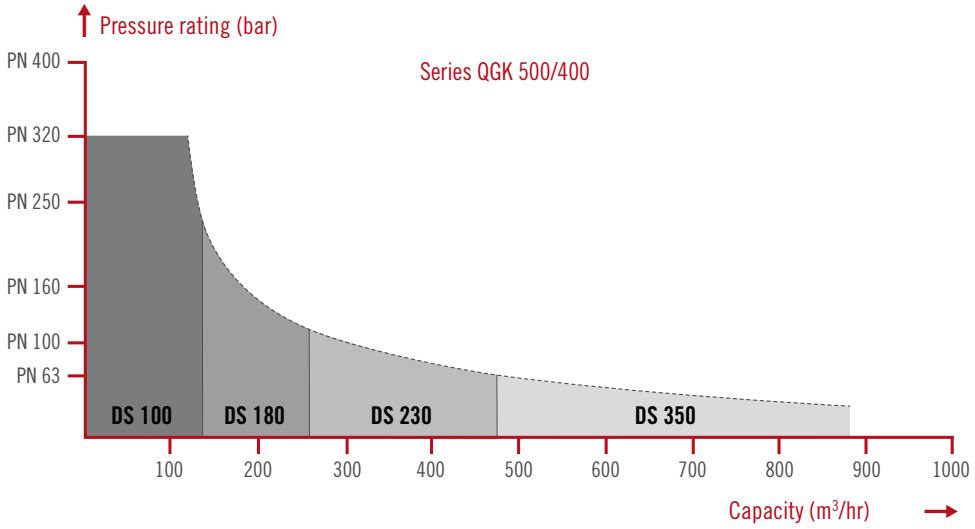
Quintuplex configuration of FELUWA MULTISAFE® pumps offers unprecedented uniformity. Even without provision of pulsation dampeners, residual pulsation is reduced to 5.1 % p to p.

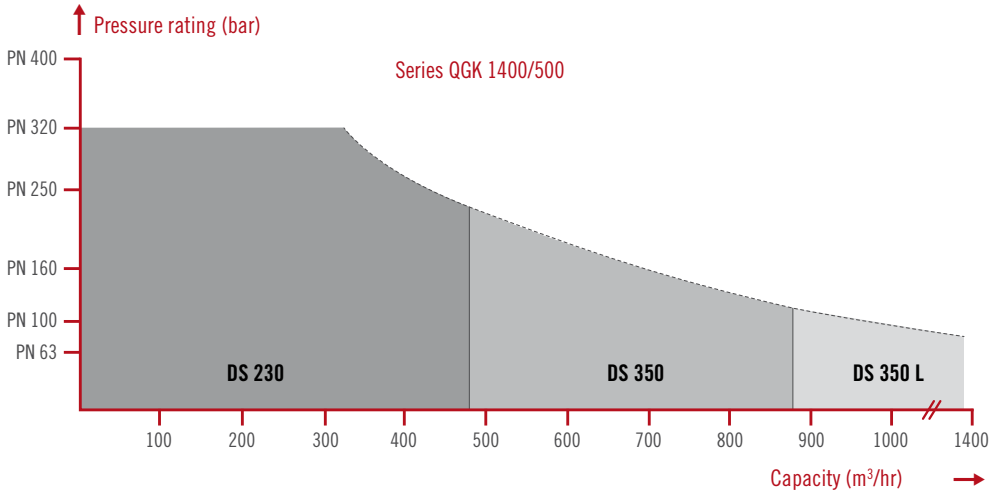
Quintuplex pumps are available with three different crank drive options and allow for flow rates of up to 1,400 m^3/h and pressures of up to 320 bar.

Capacity

of Quintuplex MULTISAFE®
Double Hose-Diaphragm Pumps Series QGK







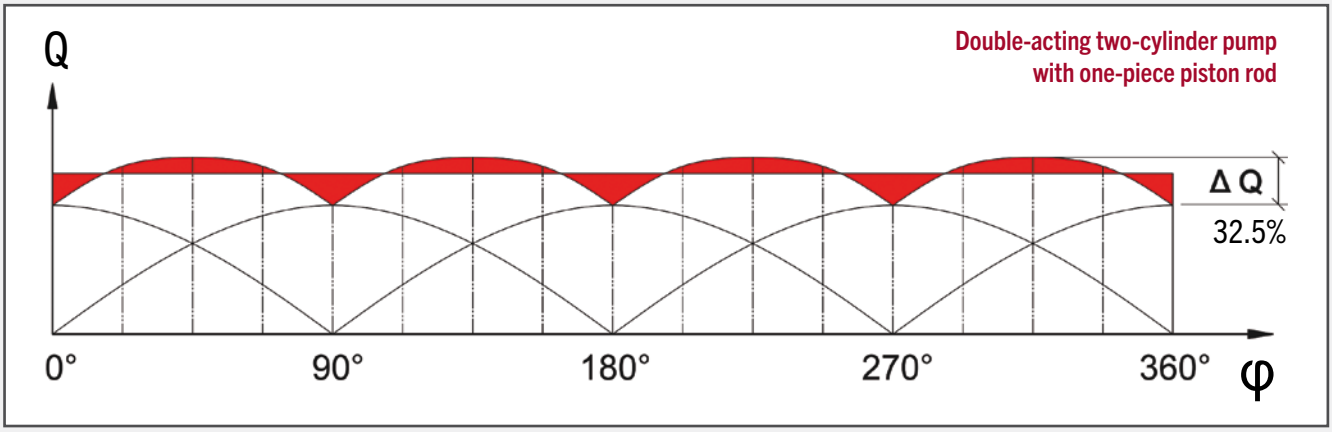
All series are available both in upflow (from the bottom to the top of the pump) and downflow (from the top to the bottom of the pump) configuration.

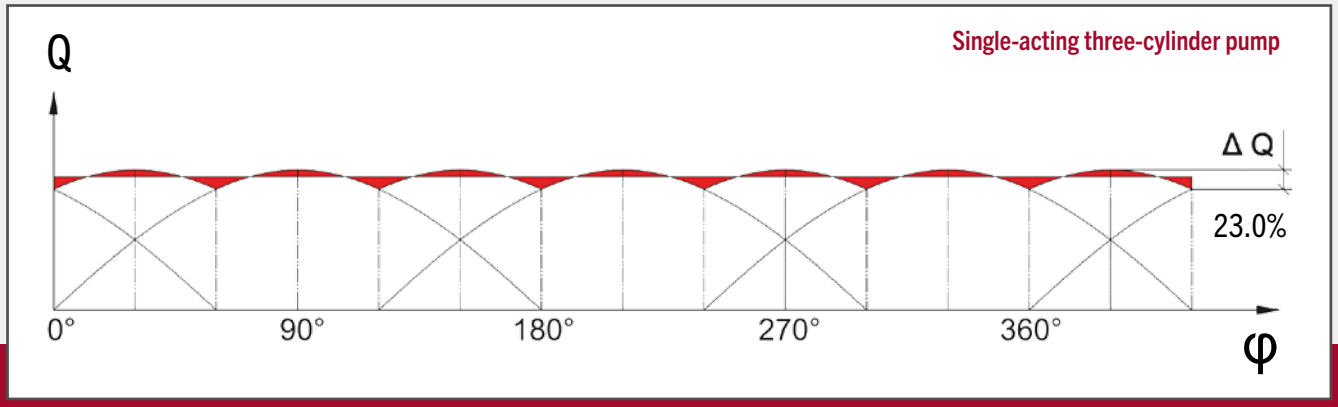
Unique Uniformity

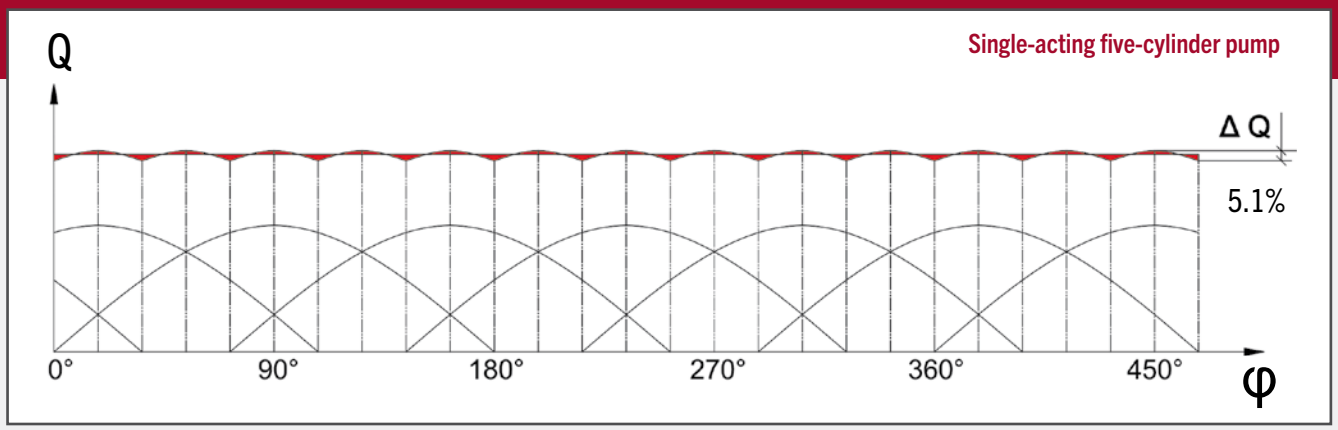
of Quintuplex MULTISAFE® Double Hose-Diaphragm Pumps

Redundancy of pulsation dampening equipment is all the more advantageous since the negating of manually or automatically operated dampening devices is a great benefit as they are usually mandatorily employed when operating at variable discharge pressures.

For high flow rates, by far the highest efficiency and lowest irregularity is achieved by means of single-acting five-cylinder pumps. Quintuplex configuration not only allows for uniformities comparable with those of centrifugal pumps, but also contributes to a reduction of valve wear to an extent that has not been feasible thus far. Even without pulsation dampening, the irregularity of single-acting quintuplex reciprocating pumps is reduced to 5.1 % (vs. 23.0 % of single-acting three-cylinder pumps and 32.5 % of single-acting four-cylinder pumps). The irregularity of 5.1 % is to be considered as a theoretical value, which does not yet make allowance for additional compensation as a result of gas content included in the hydraulic oil and the medium.





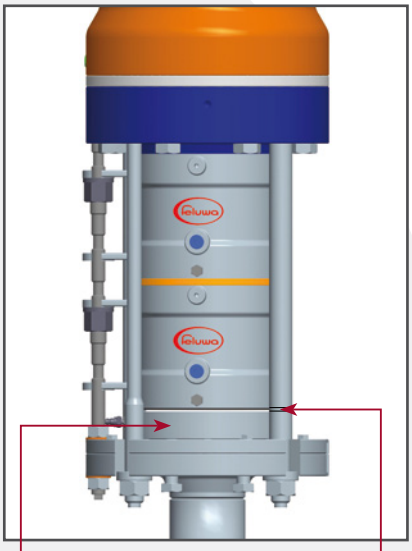


Quick Change Device for Check Valves

MULTISAFE® double hose-diaphragm pumps are typically characterised by easily removable check valves of wafer design. This valve design not only ensures linear flow path throughout the pump and valves, but also allows for easy withdrawal of the complete valve assembly without prior removal of adjacent elements. Bigger valves with a unit weight exceeding 10 kg are designed with a swivelling style holder type. Dependent on the pump duty, check valves are either specified as single or double ball, cone or plate valves. Big size double check valves of high pressure pumps are additionally provided with the patented FELUWA Quick Change system, which allows for replacement of individual valves in less than 30 minutes. Prior to fixing the check valves by locking screws, the hydraulically activated clamping mechanism is subject to axial pretension by means of a hand pump. Simple valve dismantling is achieved in reversed order.

Tightened valve

Hydraulic connection

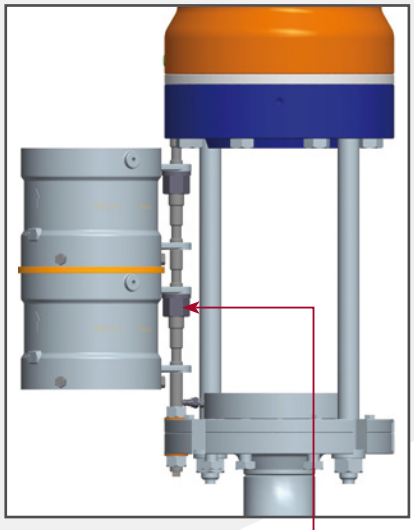


Hydraulic pressure released for opening

Clamping cylinder is pulled down automatically

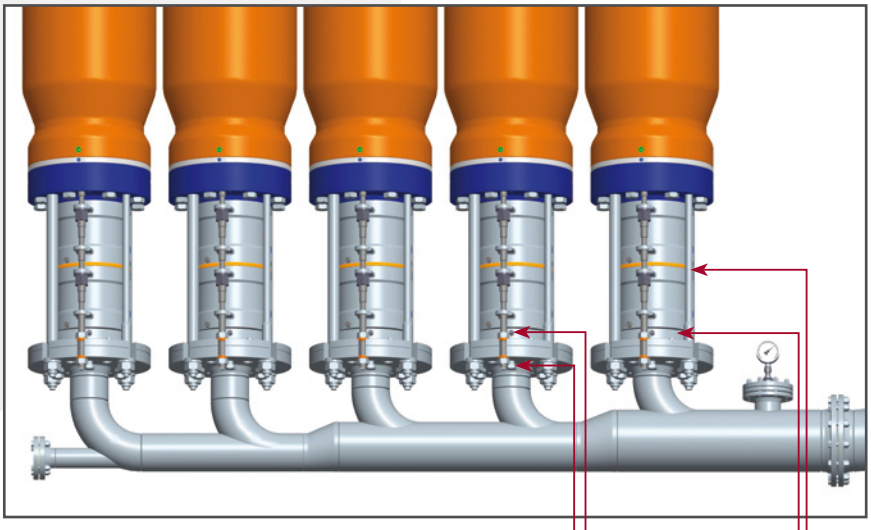
Installation gap

Hydraulic pressure released and left support tube removed for opening



Swivelled double valve assembly

Lifting and swivelling by means of jacking bolt



Hydraulic pressure released for opening

Clamping bolt

Hydraulic connection

Hydraulic cylinder

Support tube

Key Applications

FELUWA process and transportation pumps are specified for a great variety of industries, such as power, metallurgical, mining, chemical, petrochemical, pharmaceutical, cement, ceramic and process engineering.

1. Ash disposal

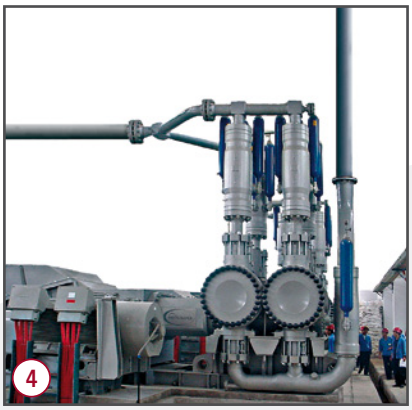
In coal-fired power stations, large volumes of fly and bottom ash are generated as a result of the incineration process. Disposal of this dense ash to the relating ash ponds is effected by pipeline transportation. FELUWA pumps are capable of handling large solids so that even bottom ash slurry can be reliably pumped over long distances.

2. Autoclave feeding

In metallurgical process plants, FELUWA pumps are used to feed autoclaves at high pressure in order to dissolve the concentrate from the ore. With a maximised linear flow path without deviation, FELUWA pumps are especially conducive to the handling of mining slurries and tailings with minimum wear, be they highly viscous, corrosive and/or erosive.

3. Coal gasification

In the coal gasification process, coal is pulverised and mixed with water. The resulting coal slurry is then processed by both partial oxidation and gasification. FELUWA process pumps are not only specified for high pressure feeding of the coal slurry into the gasifier, but equally profitable to convey the slurry at low pressure from the mill discharge tank into the coal slurry tank.



4. Digester feeding

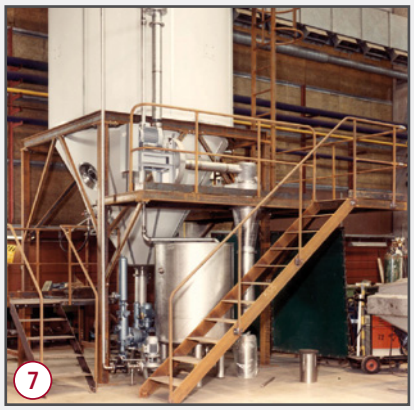
In alumina production processes, highly caustic bauxite slurries are pumped at high pressure into tubes or autoclaves for digestion at high temperature. With FELUWA pumps the slurry is in contact with the inside of the hose-diaphragm and the check valves only, so that the heavy pump casings can be made from standard materials.

5. Mine dewatering

MULTISAFE® double hose-diaphragm pumps allow for economical pumping of dirty mine water or sludge from underground mines to surface in a single stage. They ensure highest reliability for example by means of downflow configuration, but likewise contribute to a considerable reduction of excavation costs as a result of the small footprint.

6. Pipeline transfer

Pumping of ore concentrates (copper, nickel, iron, etc.) at high solids concentration through pipelines is a profitable alternative to transportation by means of conveyor belts, rail or truck. Slurry pipelines can even run through inaccessible areas (mountains, forests, deserts), where other means of transportation would not be feasible.



7. Spray dryer feeding

Spray drying units are most convenient for the conversion of liquid based products into dry materials with a defined powder or granule form. In this process, precise product characteristics of solutions or suspensions can be achieved, i.e. particle size, powder weight, moisture content, pourability and re-dispersability. FELUWA pump technology is ideal for spray dryer feeding due to its intrinsically high operating safety, its easy, economical variation options for flow rate and pressure and its ability to handle suspensions with dry solid contents of up to 80 %.

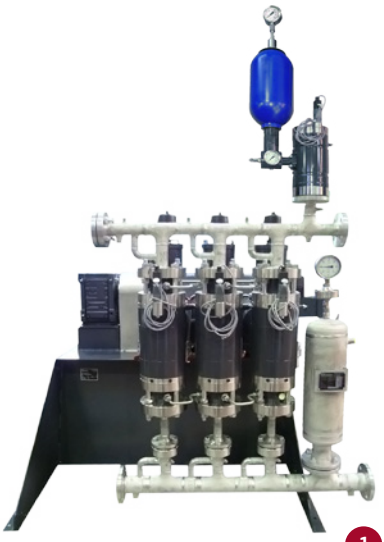
8. Tailings transfer

Disposal of tailings is required in a great variety of facilities, such as in metallurgical processes, where highly concentrated red mud has to be pumped to tailings ponds.

9. Wet oxidation – Reactor feeding

Wet oxidation is applied for the destruction of organics in wastewater and sludge. The process involves feeding of thickened sludge into an oxidation reactor at high pressure and temperature. FELUWA hose-diaphragm process pumps offer unique benefits for this duty and are typically characterised by double check valves.

FELUWA
Hose-Diaphragm Pumps



1

2

3

4

1. *MULTISAFE® Double Hose-Diaphragm Pump*
   Type TG 70 – 3 DS 1
   Q = 0.5 m³/h p = 100 bar P = 2.2 kW
   Application: Coal gasification

2. *MULTISAFE® Double Hose-Diaphragm Pump*
   Type TG 100 – 3 DS 4
   Q = 3 m³/h p = 100 bar P = 15 kW
   Application: Spray dryer feeding – Tannin dyestuff

3. *MULTISAFE® Double Hose-Diaphragm Pump*
   Type TG 40 – 4 DS 1
   Q = 4 x 0.131 m³/h p = 25 bar P = 1.5 kW
   Application: Spray dryer feeding – Calcined titanium dioxide

4. *3 sets of Hose Diaphragm Piston Pumps*
   Quadruplex design
   Type DG 250 – 4 SM 460
   Q = 53 m³/h p = 96 bar P = 200 kW
   Application: Coal gasification

5. *MULTISAFE® Double Hose-Diaphragm Pump*
   Triplex design with PTFE diaphragm
   Type TG 200 – 3 DS 35 - P
   Q = 10 m³/h p = 100 bar P = 45 kW
   Application: Chemical industry

6. *3 sets of MULTISAFE® Double Hose-Diaphragm Pumps*
   Triplex design
   Type TGK 400 – 3 DS 230
   Q = 95 m³/h p = 120 bar P = 450 kW
   Application: Aluminium industry – Red mud

7. *MULTISAFE® Double Hose-Diaphragm Pump*
   Triplex design
   Type TGK 400 – 3 DS 230
   Q = 150 m³/h p = 105 bar P = 450 kW
   Application: Chemical industry

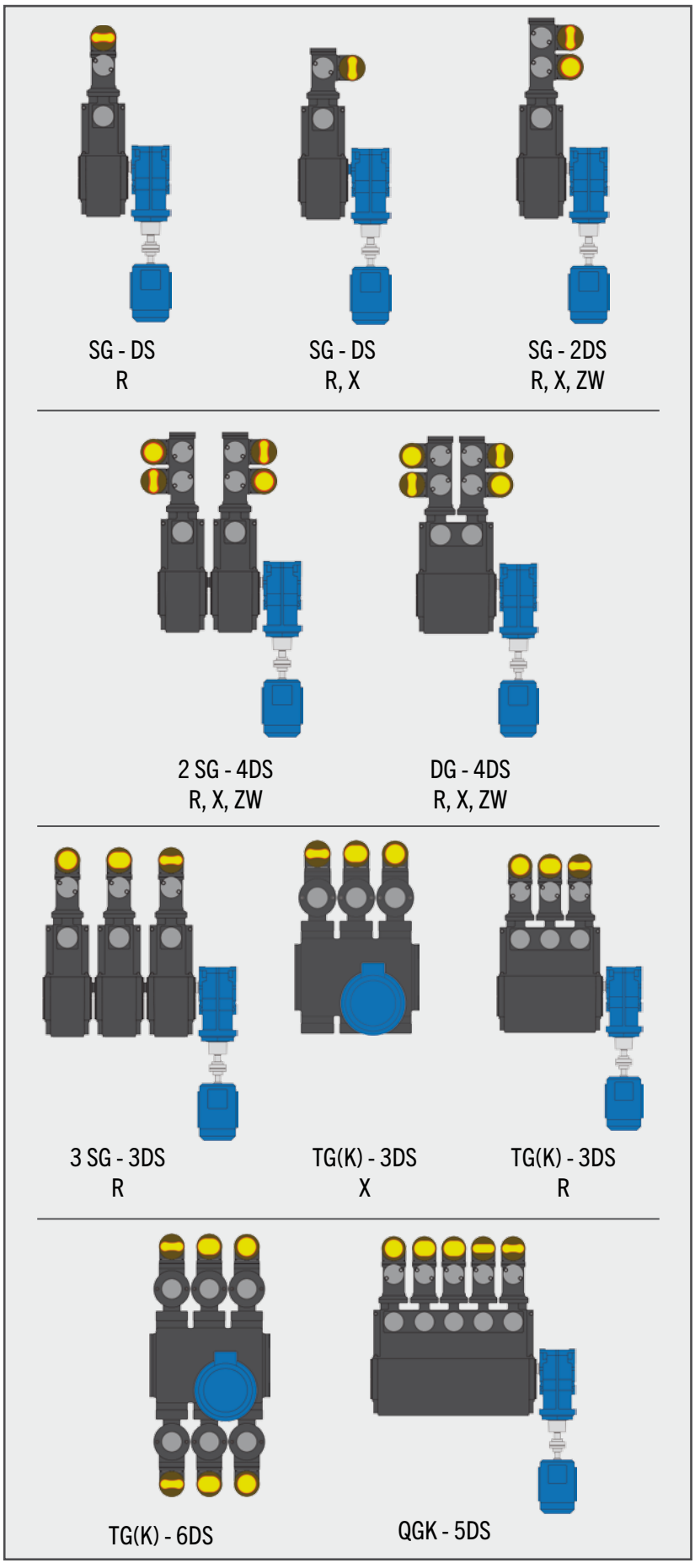
8. *3 sets of Hose Diaphragm Piston Pumps*
   Quadruplex design
   Type DG 250 – 4 SM 460
   Q = 55 m³/h p = 100 bar P = 250 kW
   Application: Coal gasification

9. *4 sets of MULTISAFE® Double Hose-Diaphragm Pumps*
   Triplex design
   Type TG 200 – 3 DS 100
   Q = 40 m³/h p = 80 bar P = 132 kW
   Application: Coal gasification

Modular Design

	Gearbox Type	Max. Driving Power* (kW)
SIMPLEX	SG 124/40	4.5
	SG 224/40	4.5
	SG 132/40	4.5
	SG 232/40	4.5
	SG 70	7.5
	SGK 70	10
	SG 100	15
	SG 130	30
	SG 135	50
	SG 200	100
	SG 250	150
DUPLEX	DG 130	60
	DG 135	70
	DG 200	155
	DG 250	350
	DG 400	600
TRIPLEX	TG 40	3
	TG 70	15
	TG 100	17
	TG 130	26
	TG 135	48
	TG 200	100
	TGK 300	355
	TGK 400	650
	TGK 500	2800
QUINTUPLEX	QGK 250	450
	QGK 400	1100
	QGK 500	3500

** guide value at medium stroke rate*



SG *Simplex gearbox*
SGK *Simplex crank drive*
DG *Duplex gearbox*
TG *Triplex gearbox*
TGK *Triplex crank drive*
QGK *Quintuplex crank drive*
K *Piston*
DS *Double hose-diaphragm*
R *Vee belt drive*
ZW *Duplex pump design*
X *Available with in-built FELUWA piston compressor*

FELUWA Stroke and Reduction Gearboxes and Crank Drives

The conversion of the rotary motion of the motor output shaft into a reduced axial reciprocating action of the pump piston or plunger is achieved by powerful combined **FELUWA stroke and reduction gearboxes** or by a combination of **FELUWA crank drives** with separate gear units. Both drives are available in various ratings for a maximum power transmission of 3,500 kW. Design and development of these units are based on high reliability and long service life.

Fabrication, assembly and factory performance tests are carried out by a well educated and trained expert team. Innovative fabrication and machining methods, proven material qualities and calculation systems for component and design strength ensure that customers may rely on high availability even under the most arduous of conditions. In order to offer maximum safety, finite element method (FEM) is applied for dimensioning and design. All bearings of driving and crank shafts are designed as large antifriction bearings with an expected service life of 100,000 hours plus.

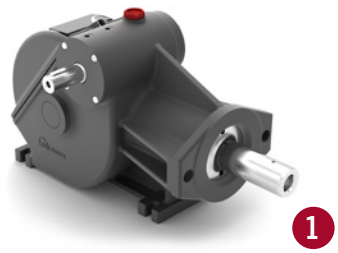
Drive options

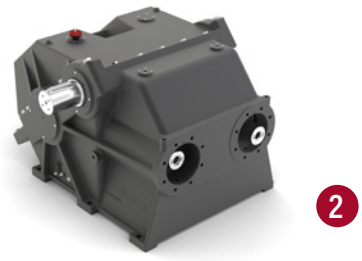
Electric motors
for stationary operation
- Mainly asynchronous three-phase current motors
- Standard enclosure
- Flameproof enclosure (Ex) acc. to ATEX
- Low or medium voltage

Variable frequency drives
- Low or medium voltage

Internal combustion engines
for mobile applications
- Diesel engines
- Petrol engines

Static displacement drives
for existing hydraulic systems
- Stationary and mobile application
- Fluid power motors





1. *FELUWA simplex stroke and reduction gearbox*
   Type SG 70
   Max. power output 7.5 kW

2. *FELUWA duplex stroke and reduction gearbox with additional oil lube pump for operation at low stroke rate*
   Type DG 250
   Max. power output 315 kW

3. *FELUWA triplex crank drive*
   Type TGK 400
   Max. power output 650 kW

4. *FELUWA quintuplex crank drive*
   Type QGK 500
   Max. power output 3,500 kW

Special Designs of MULTISAFE®
Double Hose-Diaphragm Process Pumps

DownFlow Technology (DFT)

Pumping of heterogeneous mixtures and fluids containing coarse contaminations calls for custom-tailored solutions to ensure permanently trouble-free operation.

With traditional diaphragm pumps there is the risk of excessive stretching of the diaphragm in the pump head or suction valve so that it may even be pressed into the discharge check valve, which inevitably results in diaphragm failure. Such a case of breakdown cannot be avoided by the use of double flat diaphragms, because both diaphragms are subject to almost identical stress and will, therefore, rupture simultaneously.

In order to avoid disadvantageous sedimentation, MULTISAFE® double hose-diaphragm pumps literally turn the traditional pumping principle upside down, which means a flow from the top to the bottom (see Fig. 3). The cylindrical shape of the diaphragm with maximum linear flow lines panders to the flow behaviour and avoids the settling of solids.

Handling of fluids carrying large solids moreover requires special and custom-tailored check valves. Various design options, which assist the passage of coarse solids carried by the fluid, are available for downflow configuration, such as spring-loaded ball valves (see Fig. 3), spherical cap ball valves (see Fig. 2) or special floating ball valves with hollow steel balls (see Fig. 1). In case of critical process conditions, in which the continuous flow must by no means be interrupted, double valves in cassette design avoid backflow leaks resulting from jammed solids (see Fig. 2 and page 22).

Fig. 1

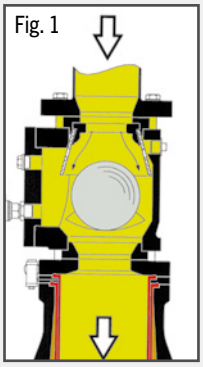
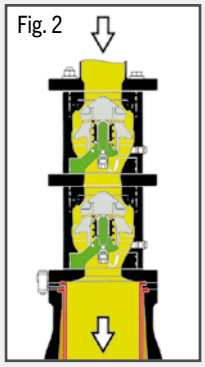
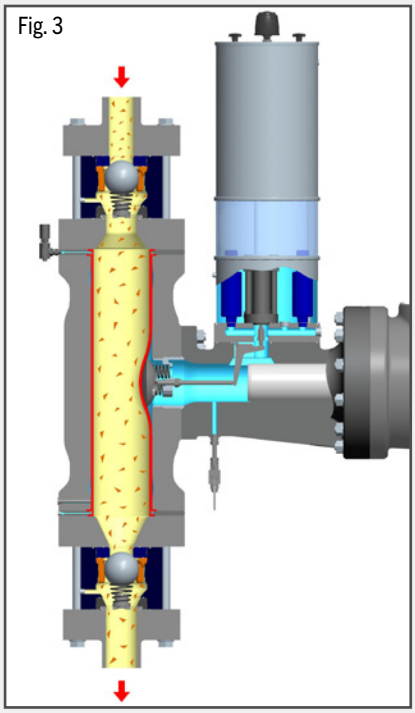


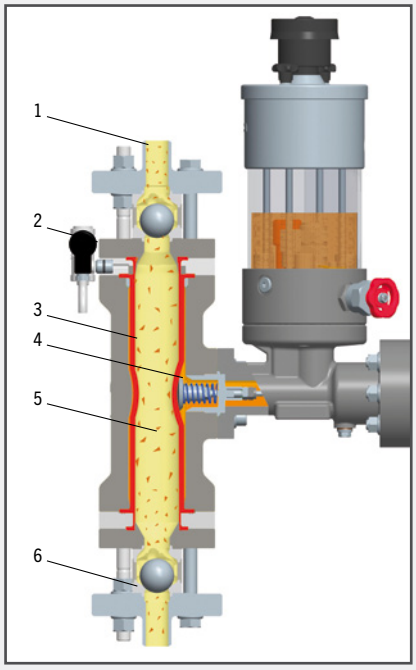
Fig. 2



Reverse pumping with the MULTISAFE® double hose-diaphragm pump (Downflow configuration).

Fig. 3





Hygienic design

Pumps in aseptic process technology have to provide maximum cleanliness and biological safety. FELUWA MULTISAFE® double hose-diaphragm process pumps in aseptic design meet the necessary purity criteria and FDA regulations in terms of fluid wetted materials. Designs with EHEDG, 3A conformity are available upon request.

Typical applications

- Pharmaceutical industry
- Cosmetics industry
- Biotechnology

1. Inlet pipe
2. Diaphragm condition monitoring
3. Hose-diaphragms
4. Hydraulic oil
5. Conveyed fluid
6. Check valve

... for extreme pumping temperatures

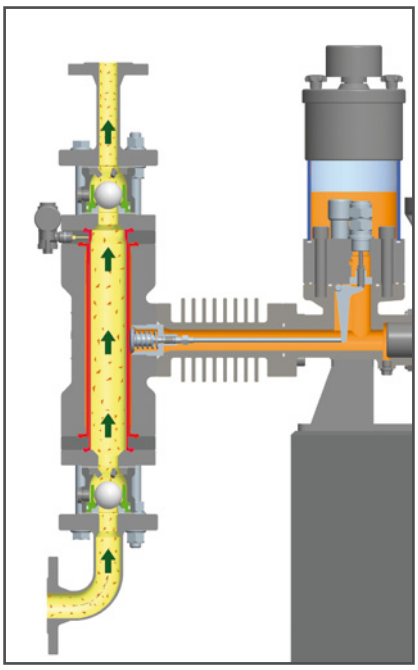
High efficiency at extreme pumping temperatures

Also in terms of pumping temperature the modular system of double hose-diaphragm pumps includes a great variety of options, such as

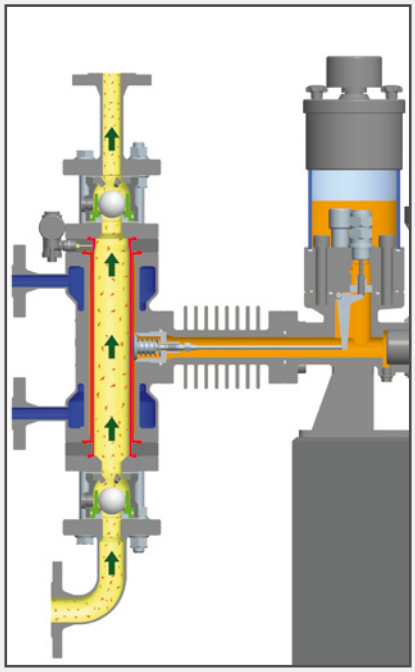
- Designs with ribbed casing area (convector)
- Designs with cooling or heating jacket
- Designs with double hose-diaphragms and additional flat diaphragm

Elastomer hose-diaphragms are generally employed up to 130 °C. PTFE components, specially developed for hose-diaphragm pumps, have proven their effectiveness for higher temperatures up to 200 °C. These can also be employed if the pumped medium is characterised by extremely aggressive chemical properties.

The pumps are equipped with ribbed surfaces between the wet and drive ends to master extreme temperatures ≥ 200 °C. These also ensure effective heat dissipation.



MULTISAFE® double hose-diaphragm pump with ribbed casing area (convector).



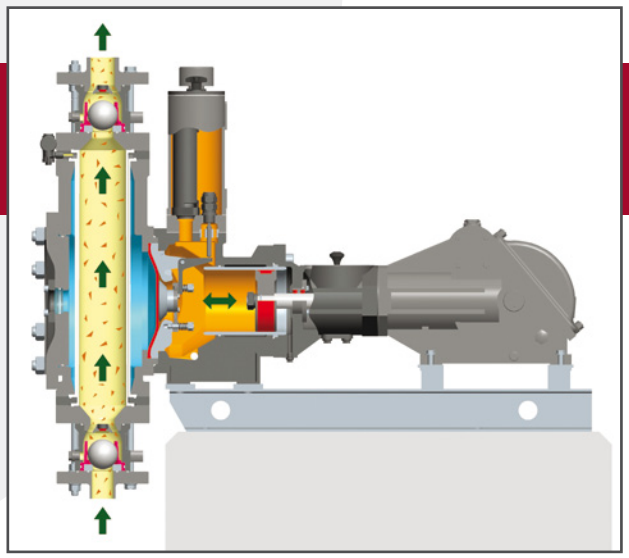
Pump with cooling or heating jacket (optional for check valves)

Some media require a minimum temperature if they are to retain their positive flow characteristics. In the event of a temperature drop, they will become very viscous, solidify or crystallise. Hose-diaphragm housing and, where necessary, valve casing and connection flange are fitted with a heating jacket to ensure pumpability of the product.

MULTISAFE® double hose-diaphragm pump with cooling/heating jacket (convector).

Variants with double redundant diaphragms

The combination of a double hose-diaphragm and flat diaphragm represents a further option for extreme pumping temperatures and/or high suction pressures.



Double redundant MULTISAFE® pump with double hose-diaphragms made of special PTFE and additional flat diaphragm for extreme pumping temperatures and/or high suction pressure.

... for toxic or explosive fluids

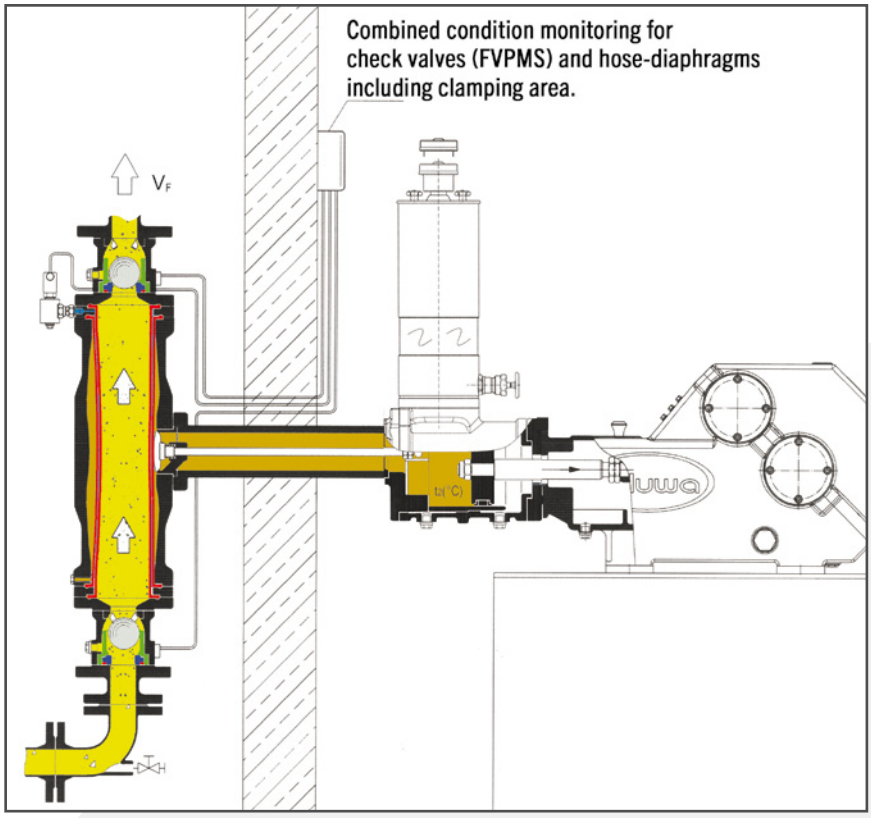
When pumping aggressive and toxic fluids, the utilisation of hermetically sealed and low-maintenance pumps is vital.

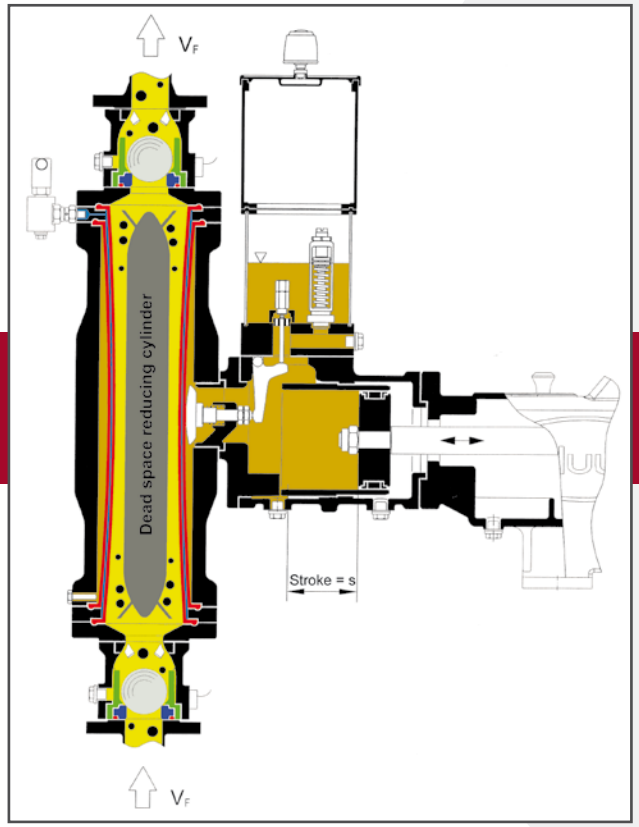
Unique operating safety

Wet and drive end of MULTISAFE® hose-diaphragm pumps are not separated by the traditional flat diaphragm, but by means of a pair of redundant double hose-diaphragms. With maximum linear flow lines the pump is therefore also capable of handling toxic, explosive, corrosive and erosive chemicals at minimum wear. For extremely critical fluids the use of the remote head design with separation of wet end and dry end is recommendable.

Even in the event that one of the two hose-diaphragms leaks, the conveyed fluid will neither come into contact with the pump casing nor with the dynamic seals. The second hose-diaphragm ensures that pump operation can be maintained until the next planned shut-down of the unit.

Remote head design with diagnostic systems for delivery valves and hose-diaphragms.





Design with dead space reducing cylinder for the handling of fluids with rather high entrained gases.

... with dead space reducing cylinder

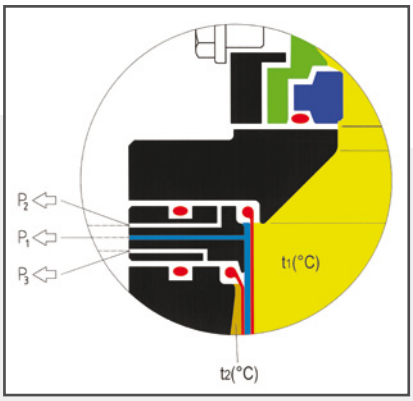
Gas or air, entrained in the conveyed fluid, must be compressed during the pumping action in order to avoid a loss in flow rate. By means of a so-called dead space reducing cylinder in the hose-diaphragm, the volume of the fluid chamber is reduced to minimum. Thus, entrapped gas bubbles are automatically compressed and the hydraulic efficiency of the pump is optimised.

Control Systems

of MULTISAFE® Double Hose-Diaphragm Pumps and Hose Diaphragm Piston Pumps

Condition monitoring of hose-diaphragm clamping

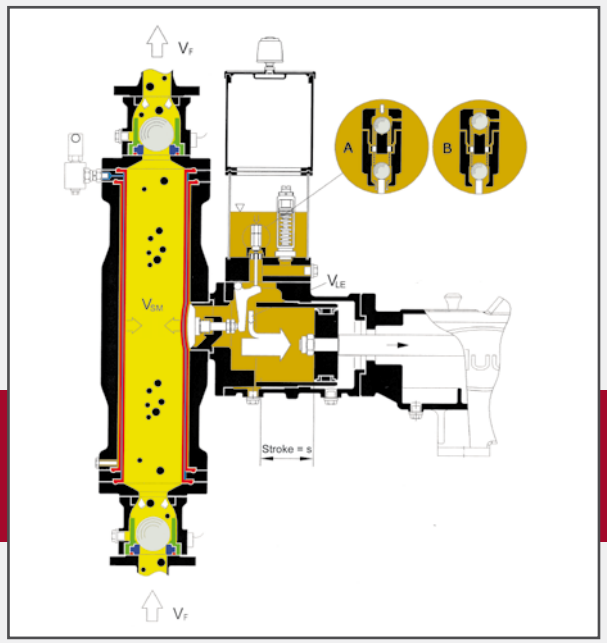
Particularly when it comes to the handling of toxic or other fluids that are harmful to the environment or to aseptic process engineering applications, condition monitoring of diaphragms has to be extended to the clamping area. For this reason, a unique and redundant diaphragm clamping system has been developed for MULTISAFE® double hose-diaphragm process pumps. It allows for permanent monitoring of the clamping area and reliable prevention of leaks. The monitoring provides for triple differentiation in order to cover different leak possibilities. Elastic distortion of hose-diaphragms is path-controlled and effected in a concentric manner due to their inherent construction. The space between both hose-diaphragms is unpressurised and ends in a central transfer point. In the event that one of the hose-diaphragms leaks or fails, either product or hydraulic fluid will penetrate into the unpressurised intermediate space. The resulting build-up of pressure is automatically fed to the hose-diaphragm condition monitoring system (measuring point P1) and activates the respective electrical contact or pressure sensor (signal transmitter). Measuring point P2 checks the sealing towards the wet end and the clamping of the primary (inner) hose-diaphragm. Measuring point P3 is allocated to the sealing of the hydraulic end and clamping of the secondary (outer) hose-diaphragm.



V_F = *volumetric displacement*
V_K = *volumetric piston displacement*
V_L = *continuous bleed volume*
V_{LE} = *leakage compensation volume (via make-up device)*
V_{SM} = *volumetric hose-diaphragm displacement*
$V_Ü$ = *volume diverted into the oil storage tank via the pressure relief valve*

Mechanical leakage control

Loss of hydraulic fluid (V_L, $V_Ü$, V_B) is automatically compensated by FELUWA pumps. For these situations the pumps are provided with a unique mechanical leakage control and compensation device within the hydraulic chamber. This system operates fully automatically, neither requires a separate oil pump nor a control system and is moreover easy to maintain.

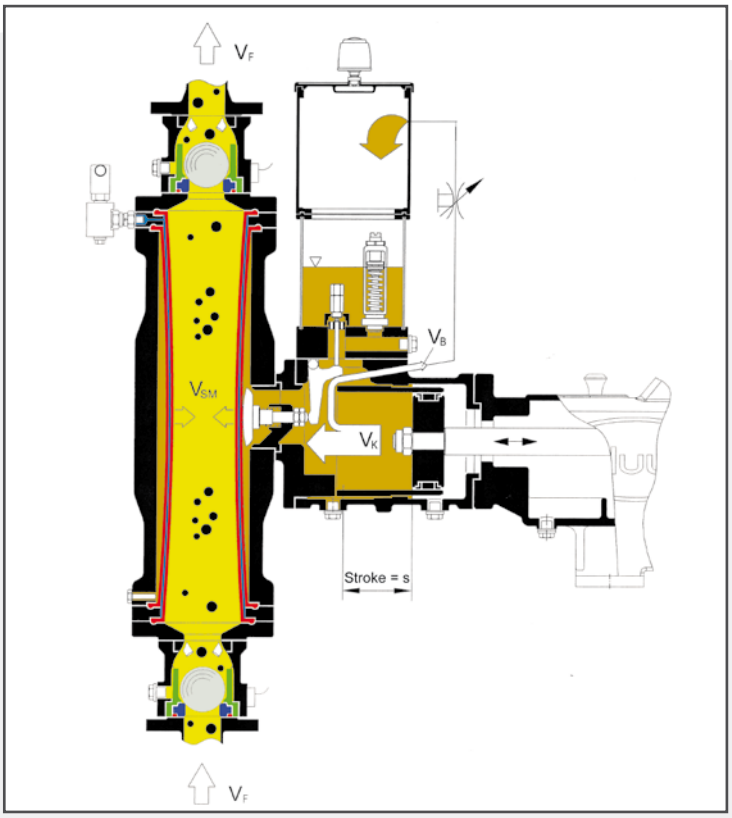


During the suction stroke, the diaphragm (either hose-diaphragm or flat diaphragm, depending on the pump type) is drawn towards the hydraulic chamber of the piston or plunger. If the hydraulic oil volume decreases due to leakage, the diaphragm will actuate a control disc, which in turn opens the compensation valve via a lever. Further backward movement of the piston/plunger causes a vacuum in the actuation chamber, since the diaphragm cannot move any further. As soon as the vacuum exceeds the setting range of the compensating valve (make-up valve), the valve opens. The actuation fluid (V_L, $V_Ü$, V_B) that had been displaced into the oil reservoir during the delivery stroke is replenished during the increased suction stroke. By this means, the missing volume of hydraulic fluid (V_{LE}) is replaced in the hydraulic chamber. Since the compensating valve cannot open unless the leakage control valve is mechanically opened by a lever, it is ensured that the diaphragms cannot be overstretched.

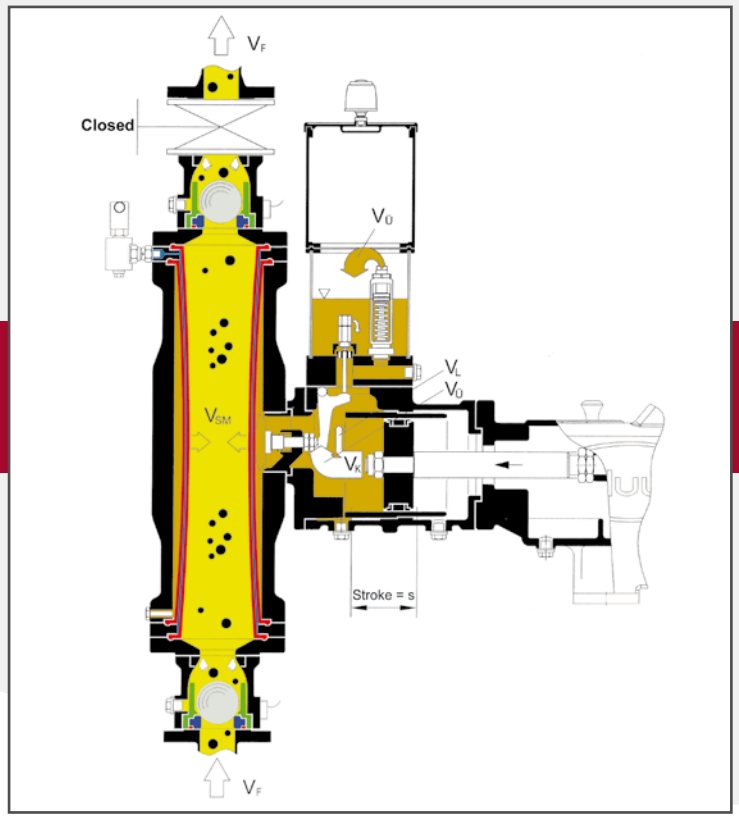
Bypass flow control

A bypass system which functions in the same manner as the pressure relief valve is fitted to the pump as an option for short-term flow control. Essentially, with each delivery stroke of the pump, an infinitely adjustable portion of the hydraulic oil (V_B) displaced by the piston/plunger is diverted into the hydraulic oil reservoir. Since the volume being displaced by the piston/plunger onto the diaphragm (either hose-diaphragm or flat diaphragm, depending on the pump type) is reduced by the volume being diverted into the hydraulic oil reservoir, the output of the pump decreases accordingly.

The bypass control is only designed for a relatively low driving power up to 5.5 kW or for short-term control (e.g. during system startup). Alternatively, brief opening of the bypass valve during pump startup generally enables relatively rapid bleeding and diaphragm positioning in line with the design.



V_F = volumetric displacement
V_K = volumetric piston displacement
V_L = continuous bleed volume
V_{LE} = leakage compensation volume (via make-up device)
V_{SM} = volumetric hose-diaphragm displacement
$V_Ü$ = volume diverted into the oil storage tank via the pressure relief valve



Pressure relief valve

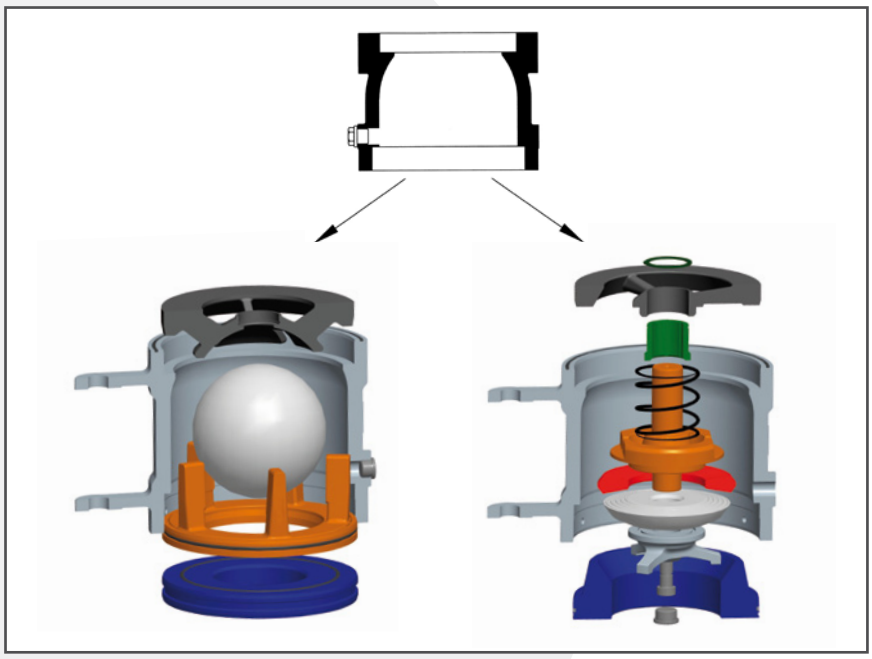
Each pump head is provided with an individual, easily accessible pressure relief valve in the hydraulic fluid. This valve is set to the exact nominal pressure required during the works test run of the pump. If an over-pressure situation becomes evident in the hydraulic fluid, i.e. due to a closed discharge sluice valve, the pressure relief valve will open, thus relieving hydraulic fluid ($V_Ü$) into the hydraulic oil reservoir. From this reservoir the oil is automatically returned into the pump chamber via the leakage compensating valve. The relief valve protects the pump as well as the gearbox from overload which may arise from an erroneously closed isolating valve or from a blocked discharge pipe etc.

Pressure relief valves are also available with type approval and with lead seal.

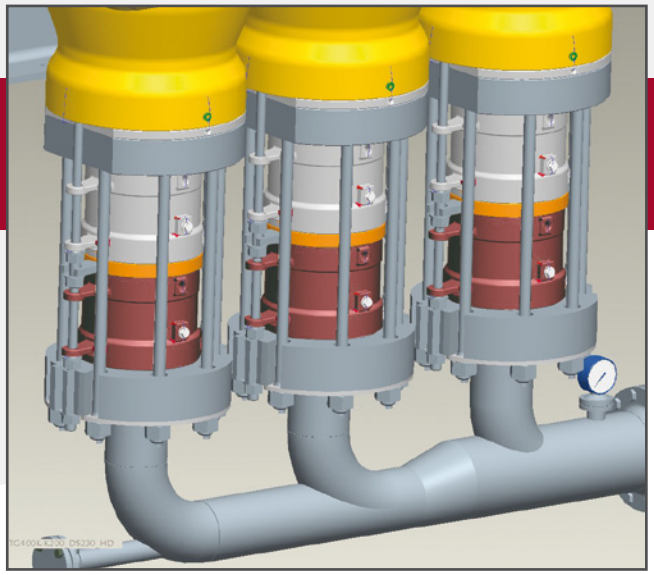
FELUWA Check Valves in Cassette Design

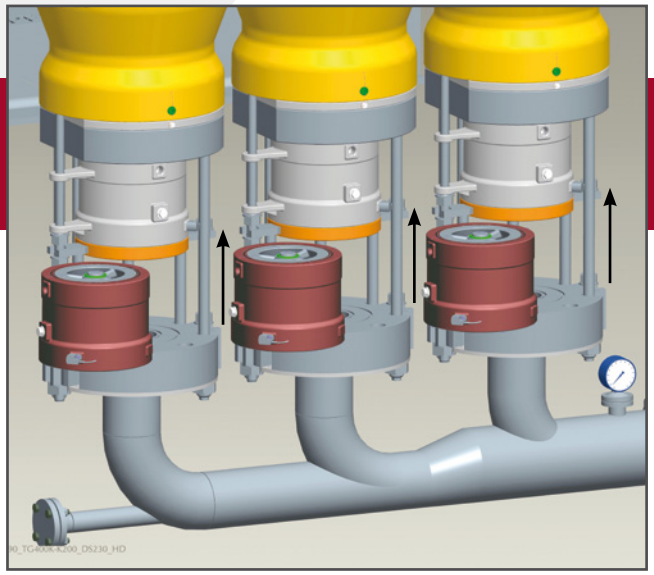
Check valves rank among the key components of positive displacement pumps. With FELUWA MULTISAFE® double hose-diaphragm pumps and hose diaphragm piston pumps, the suction and discharge check valves are to be considered as the sole real wearing parts. For this reason, the achievement of utmost lifetime is paramount when designing the valves. FELUWA check valves are individually adapted to the application, both with regard to flow velocity and the selection of material and flow geometry. They are of modular cassette design, which allows for the utilisation of ball or cone valve trims with the same valve casing. The cassettes are hinge-mounted between the pump head and suction or discharge manifold, respectively. For maintenance purposes, the complete valve assembly is easily removable like a cassette by means of jacking bolts, without prior dismantling of adjacent elements or piping. Removal neither requires skilled personnel nor special tools. This allows for minimum downtime for service and maximum availability.

FELUWA valve casings are suitable for a great variety of valve trims. Ball valve trims are characterised by a considerably smaller number of parts than cone valves (3 vs. 7).



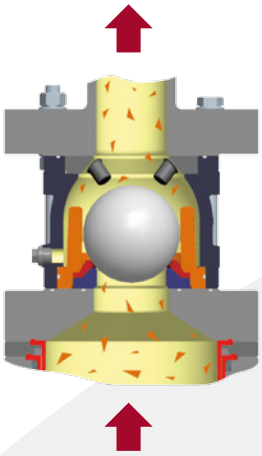
Swiveling of double valves without pipe removal.



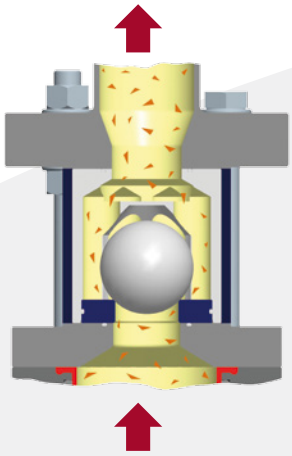


FELUWA Check Valve Design Options

FELUWA has at its base in excess of 60 years experience in the design and fabrication of check valves for positive displacement pumps. Suction and discharge valves are available as ball, cone or plate valves with a great variety of different designs, such as:

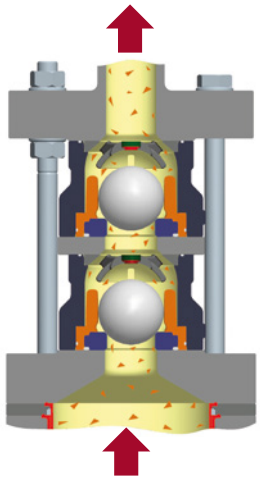


Ball valve with metal and additional soft seal

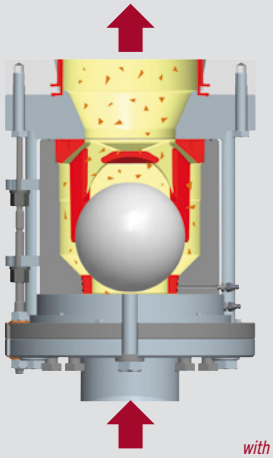


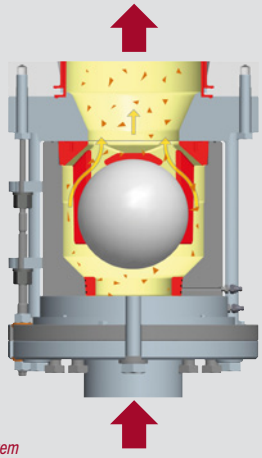
Ball valve made of polypropylene with steel reinforcement

Double ball valves are specified for media with high levels of impurities and applications which require a particularly high continuous flow (e.g. gasifier feed pumps in coal gasification systems). If, in the short term, a particle is jammed in one valve, the second valve ensures effective sealing, thus preventing medium backflow and a resulting flow loss.

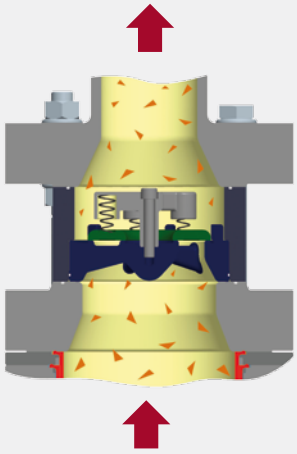


Double ball valve with reversible valve seat

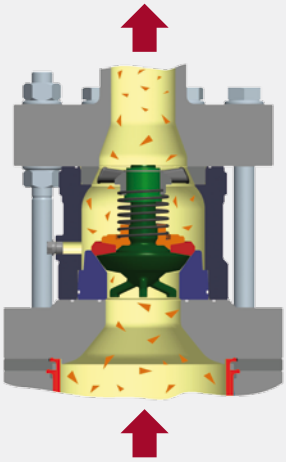




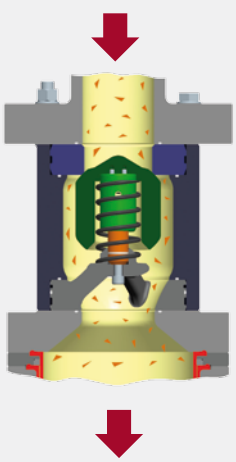
TopEntry valve design with FELUWA Quick Change System



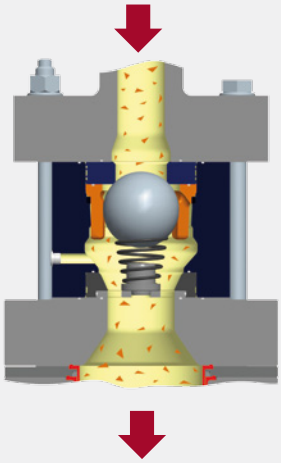
Spring-loaded plate valve



Spring-loaded cone valve



Spring-loaded downflow cone valve

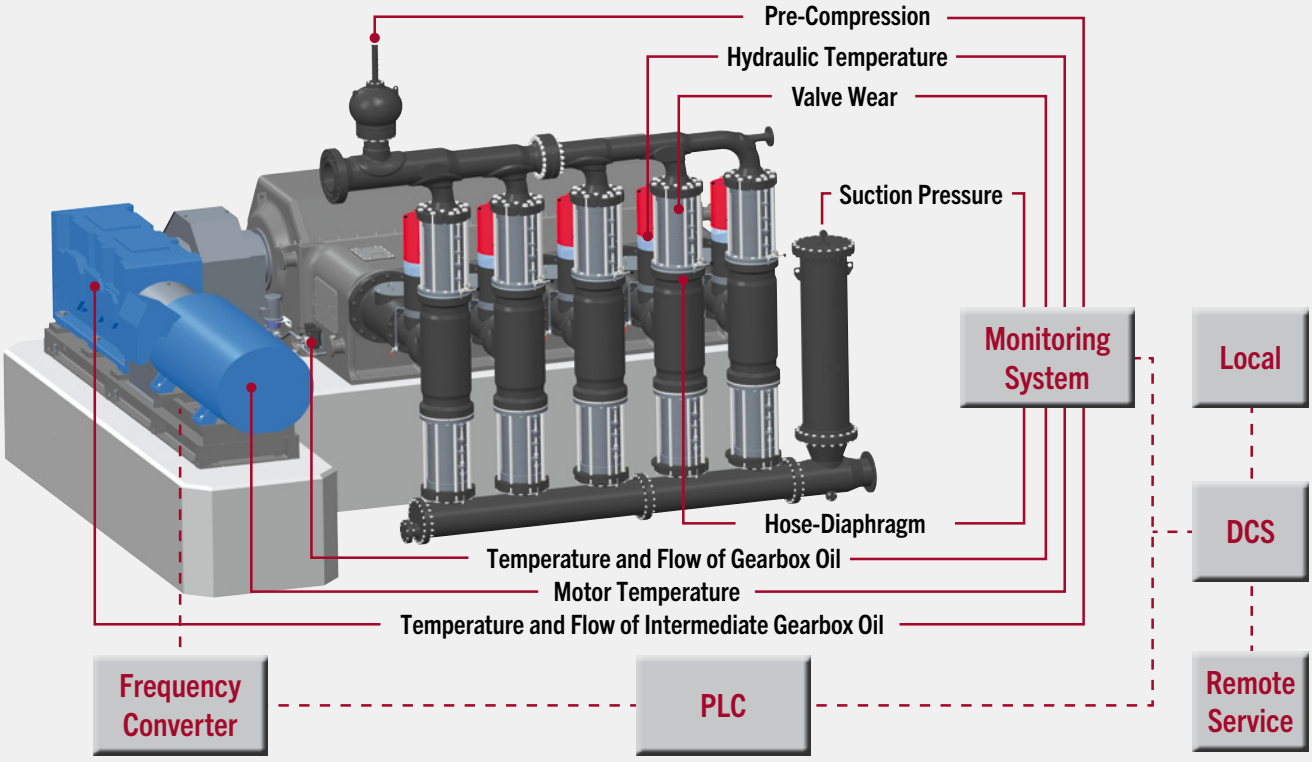


Spring-loaded downflow ball valve

Online Diagnostic Systems

Pump Condition Guard (PCG)

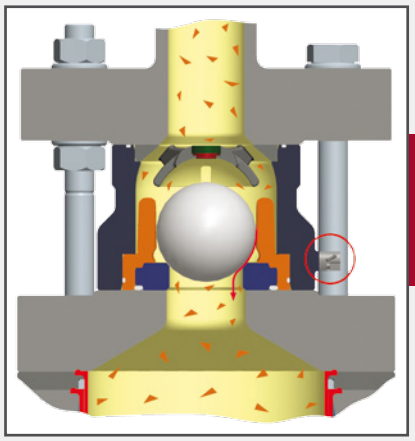
MULTISAFE® double hose-diaphragm pumps are designed to avoid sudden deviation from admissible working conditions and unplanned downtime. For additional back-up of failsafe characteristics, MULTISAFE® pumps utilise an overall diagnostic system for permanent condition monitoring of essential components and parameters. The readings are saved with trend and allow for complete backtracking of the history over several weeks.

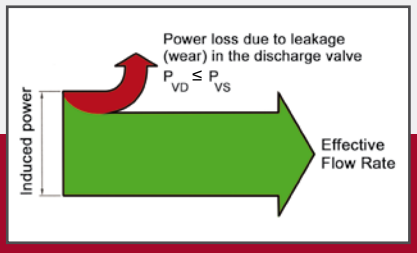


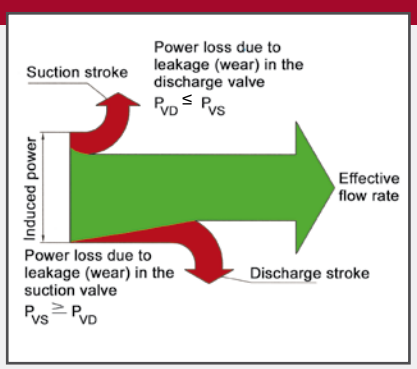
Acoustic valve diagnostics for early recognition of wear in delivery valves

FELUWA Valve Performance Monitoring System (FVPMS)

For early recognition of wear in delivery valves, FELUWA has developed specific diagnostic equipment. The measuring principle is capable of detecting leaks, even if the loss of output is still less than 1.5 %. By means of the FVPMS diagnostic system, the operational safety and availability of pumps is significantly increased, since wear is precisely localised and detected at an early stage which allows for specific forward planning of service and repair.



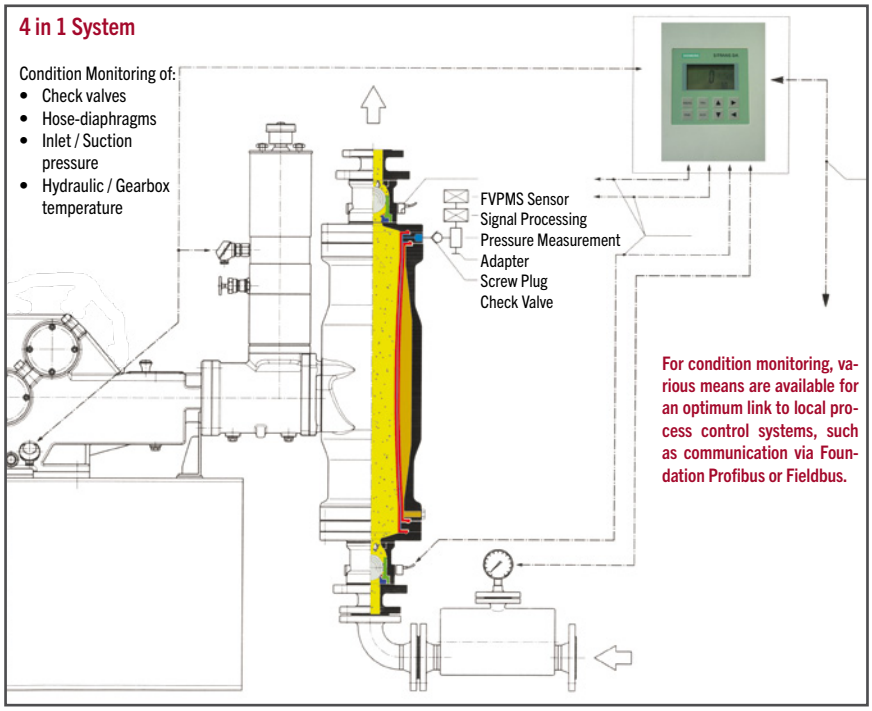




P_{VD} Power loss caused by valve leakage (due to wear) during the discharge stroke

P_{VS} Power loss caused by valve leakage (due to wear) during the suction stroke

4 in 1 Diagnostics



Efficient diagnostics for mechanical and plant engineering

Condition monitoring of the most essential pump components and parameters enables preventive maintenance, increases pump availability and reduces cost of ownership. For this reason FELUWA has developed a unique “4 in 1” diagnostics system which allows operators to monitor four of the most important parameters.

Diagnostics for hose-diaphragms: Hose-Diaphragm Guard (HDG)

Whereas traditional diaphragm piston pumps require conductivity measurement systems, permanent condition monitoring of MULTI-SAFE® hose-diaphragms is ensured by means of pressure sensors, pressure gauges or contact pressure gauges. In the event that one of the hose-diaphragms leaks or fails, either product or actuation fluid will penetrate into the unpressurised intermediate space. The resulting build-up of pressure is led to the condition monitoring system, which in turn provides a signal with manifold processing options. Nevertheless, operation can be maintained with a single hose-diaphragm until the system allows for shutdown and repair.

Diagnostics for check valves: FELUWA Valve Performance Monitoring System (FVPMS)

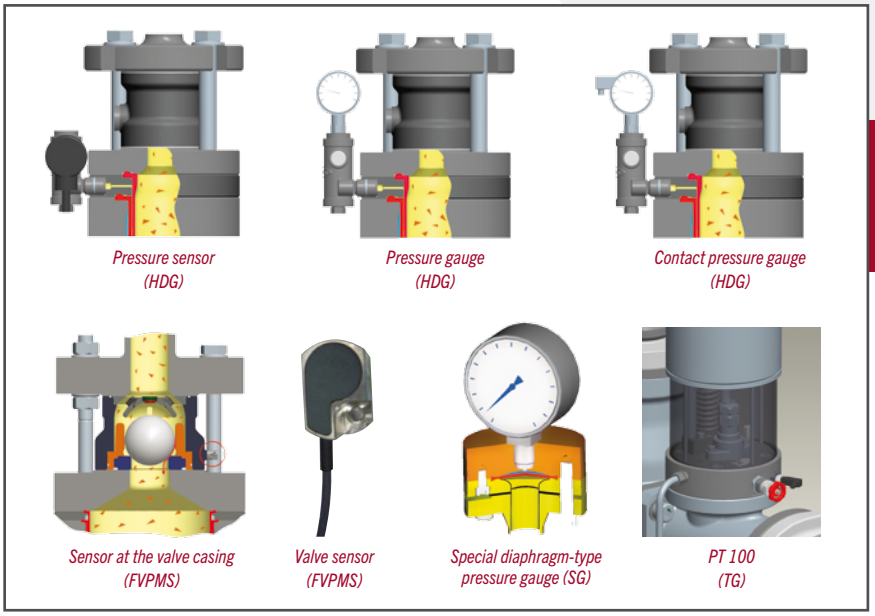
Permanent condition monitoring of individual check valves is effected by means of acoustic sensors which are fixed to the outside of the valve casing. They are not in contact with the product and easily retrofittable. The sensor is capable of detecting leaks, even if the loss of output is still less than 1.5 %. By means of the FVPMS (FELUWA Valve Performance Monitoring System) diagnostic system, the operational safety and availability of pumps is significantly increased, since wear is precisely localised and detected at an early stage which allows for specific forward planning of service and repair. For details see page 23.

Diagnostics for suction pressure: Suction Guard (SG)

Unrestricted inflow at an appropriate inlet pressure is essential for trouble-free operation. For reliable supervision of suction pressure, diaphragm-type pressure gauges are applied which have especially been designed by FELUWA for slurry handling applications.

Diagnostics for hydraulic and gearbox temperature: TempGuard (TG)

Supervision of hydraulic and gearbox oil temperature is carried out by means of PT 100 temperature sensors.



FelWebGuard

The Internet has developed into a comprehensive medium for the transfer of all kinds of data. In times of “Industry 4.0” FELUWA increasingly focuses on wireless data communication and benefits from the new prospects resulting thereof.

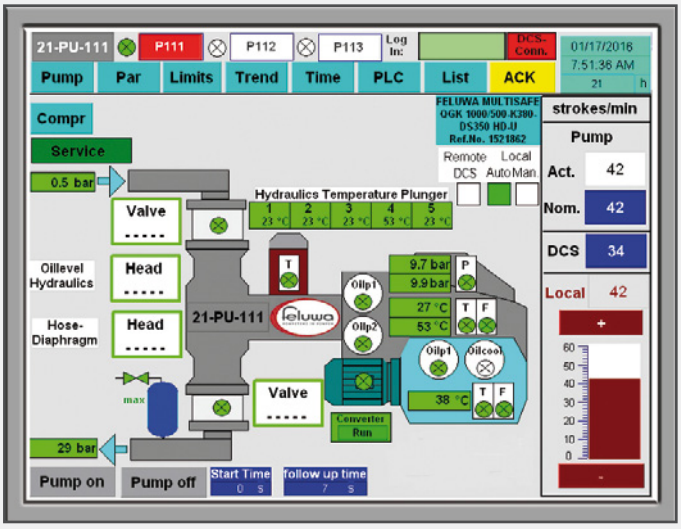
Touch panels

For early detection of faults and with the objective of ensuring maximum availability FELUWA supports the redundant nature of MULTISAFE® double hose-diaphragm pumps by means of an overall diagnostic system. Touch panels, which are integrated into the control cabinet, give the pump a transparent character and provide the operator with information on current operating parameters and the condition of fundamental parts. Bus systems link the touch panel to local process control, whereby PROFIBUS (Process Field Bus) provides best conditions for communication and control of system frequency converters, PLC, touch panels and the FVPMS (FELUWA Valve Performance Monitoring System).

The pump can either be controlled via the frequency converter panel, the FELUWA touch panel of the local control or via client’s DCS system with setpoint setting (via analogue input 4 to 20 mA). Touch panels provide time-related recording and direct or remote insight into check valves (via FVPMS), primary and secondary hose-diaphragms, suction and discharge pressure, hydraulic and gearbox oil temperature, stroke rate, pre-compression of accumulators to pulsation dampeners, oil lube systems of crank drive and intermediate gear (including temperature, pressure and flow), motor (including measurement of torque, absorbed power and FELUWA pump speed), transformer and frequency converter (variable frequency drive).

FelWebGuard (FWG): Working principle

The system is linked to the Internet. In the event that actual values differ from the programmed nominal values, the system will email an according notification to a FELUWA service technician. In addition, a safe, bidirectional VPN conduit can be set up, which allows for remote access to the control unit of the pump. The system not only allows for higher availability and productivity, but also for a reduction in service costs.



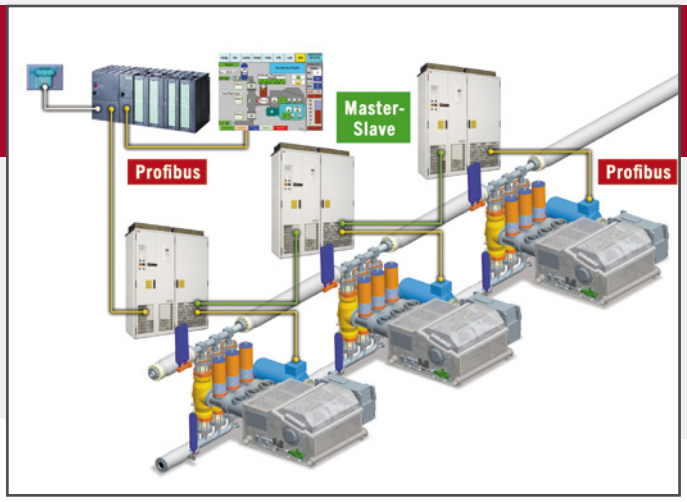
FELUWA touch panel

Display of all critical parameters by means of traffic light logic.

OK	Warning	Alarm

Configuration

- Parameterisation
- Access to service intervals
- Access to specific documentation
- Setup of a bidirectional VPN conduit for web-based service by a FELUWA service technician

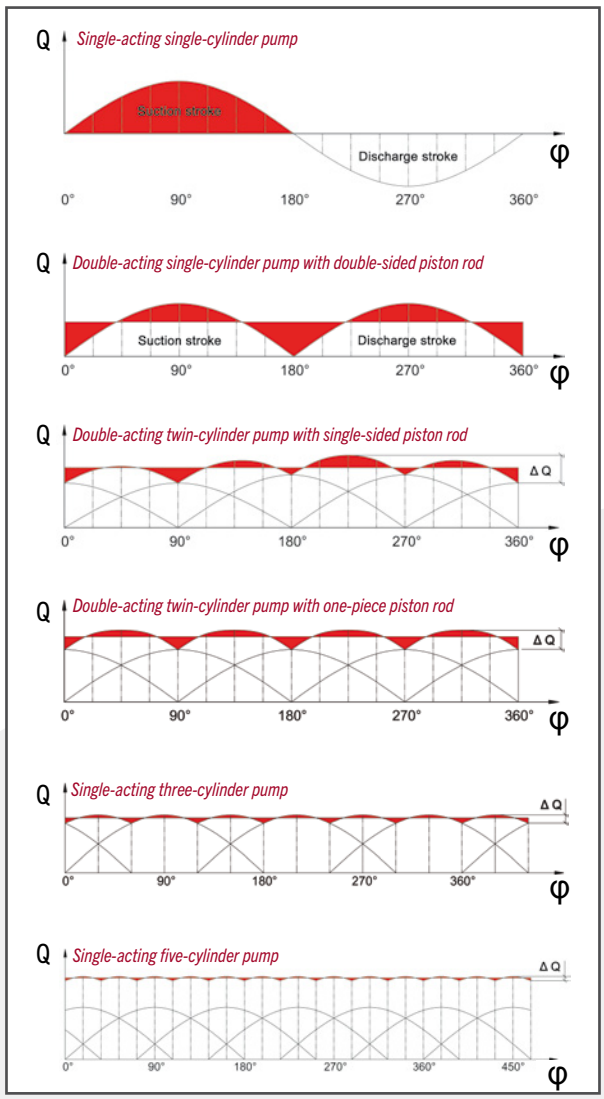


Three triplex sets of FELUWA MULTISAFE® pumps discharging into a common main. FELUWA pump synchronisation controls phase shift and eliminates excitation of resonances significantly.

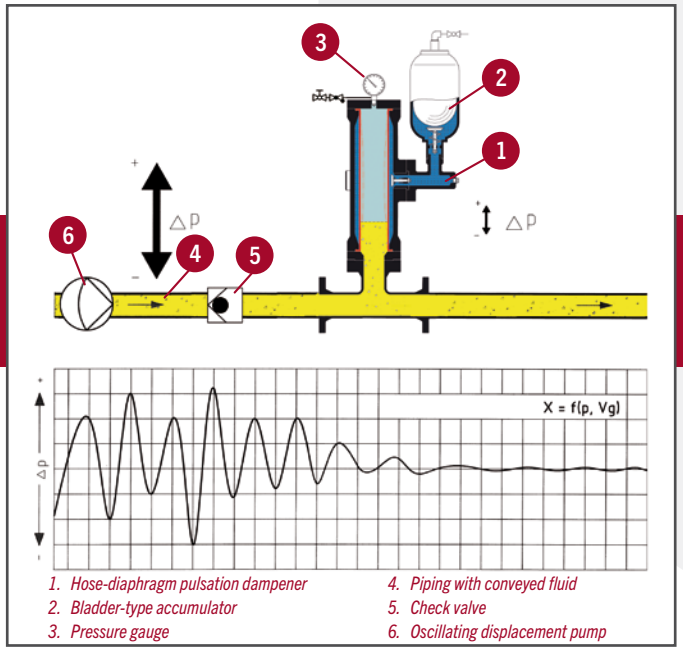
Pulsation Dampening

A typical characteristic of oscillating displacement pumps is the hydro-dynamic independency of the delivery flow from the pressure and vice versa. The reason for this feature is due to the mechanics of pressure generation by means of a displacement piston which prevents backflow and thus an escape of the displaced volume into the pipework. This principle allows for the achievement of extraordinarily high hydraulic efficiencies of up to 96%.

Conversely, the oscillating movement causes undesirable flow fluctuations and pressure pulsations. To avoid such pressure pulsations, an array of different pulsation dampeners is employed. Dependent on the actual working conditions, traditional pulsation dampeners (pressure air vessels) with air or gas cushion or so-called hose-diaphragm pulsation dampeners (PULSORBER) with nitrogen-filled accumulators are applied.

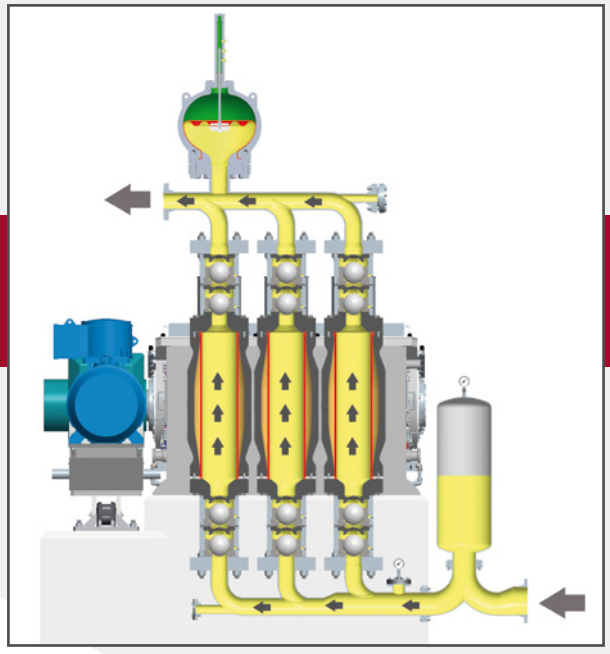


Delivery flow characteristics



1. Hose-diaphragm pulsation dampener
2. Bladder-type accumulator
3. Pressure gauge
4. Piping with conveyed fluid
5. Check valve
6. Oscillating displacement pump

Pulsation dampening by means of FELUWA hose-diaphragm pulsation dampener with additional air vessel effect.

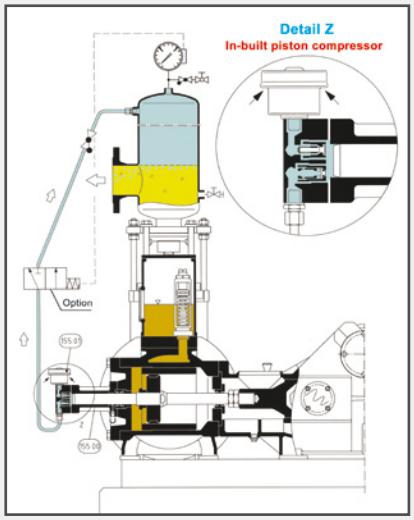


MULTISAFE® double hose-diaphragm pump with standard suction air vessel and discharge roller diaphragm pulsation dampener PULSORBER 900.

Air Vessels and In-Built Piston Compressors

In-built FELUWA piston compressor

When using standard air vessels or hose-diaphragm pulsation dampeners, the attainable residual pulsation depends on the compressed gas volume above the liquid column within the pressure vessel. However, there is a constant loss (solution) of gas at the contact surface of the conveyed fluid which reduces the dampening volume accordingly. The compensation of this loss within the air vessel requires periodic refilling by means of costly monitoring and filling devices equipped with shut-off and control units. For this purpose, FELUWA has developed an ingenious and most effective "in-built piston compressor". With each piston stroke, it feeds a small quantity of gas or atmospheric air into the discharge air vessels. The attainable pressure of the pump piston compressor is always considerably higher than the maximum pump pressure. This ensures that the conveyed fluid cannot flow back to the pump piston compressor under normal working conditions.



Working principle

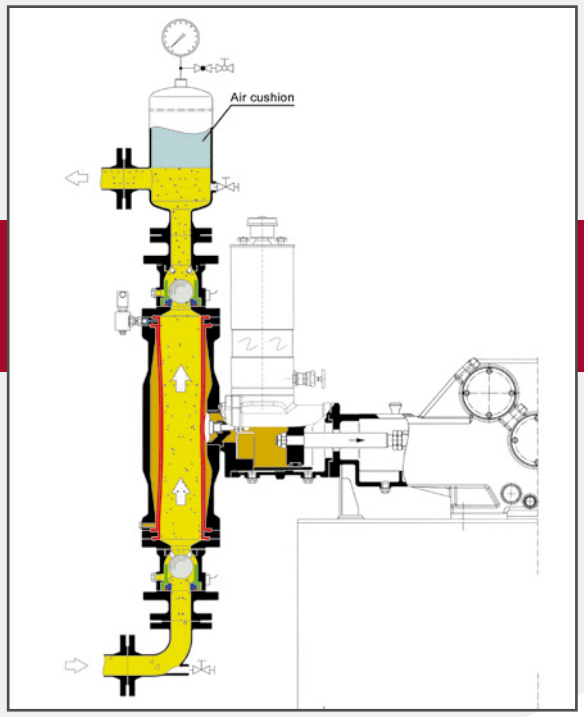
With each return stroke of the piston rod, a small volume of filtered air (or gas) is sucked into the compressor chamber via a valve. With the forward stroke of the piston rod this air volume is fed via the non-return valve into the air vessels. This procedure is repeated with each stroke of the pump and is only active when the pump is operating.

By this means, costly starting and stopping of air injection devices is fully eliminated and the available air volume within the air vessels is always maintained at an optimum level. The attainable residual pulsation is reduced to a minimum. At high pressure and/or applications which require frequent and fast filling of the air vessels, the suction end of the in-built piston compressor may additionally be fed by compressed air.

Hose diaphragm piston pump with discharge air vessel and in-built piston compressor.

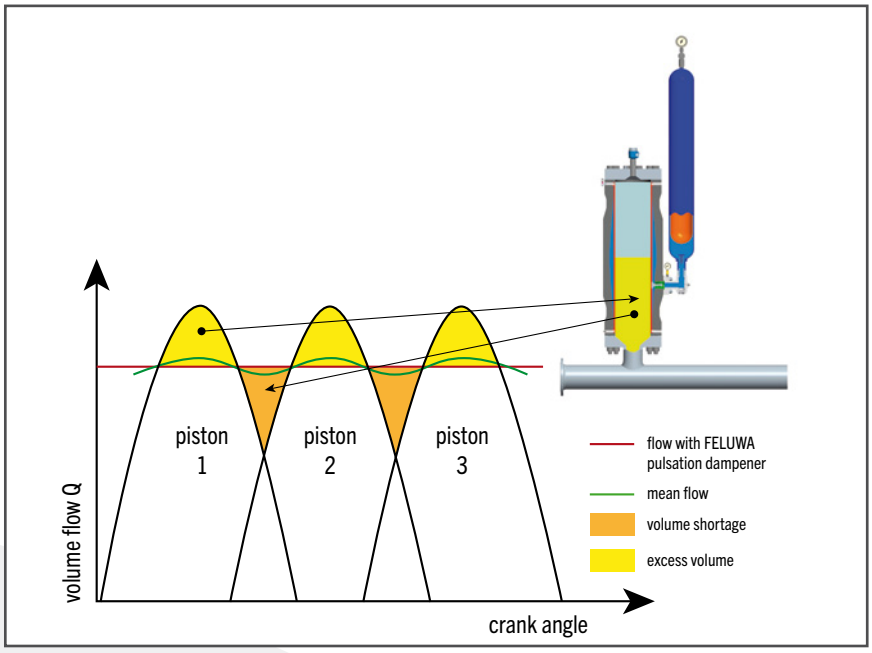
Pressure air vessels

In order to ensure high effectiveness of pulsation dampening, liquid columns should be kept as low as practicable. For this reason, air vessels are mounted as close as possible to the pump heads, which means directly above the discharge and below the suction valves. The dampening behaviour depends on the different pulsation dampener designs. With traditional pressure air vessels, the gas cushion is held directly above the conveyed fluid. Under peak pressures and/or excessive flow, this cushion is compressed above the fluid level and released during the suction stroke of the pump. The fluid is then displaced into the discharge pipe and minimises pulsations accordingly.



MULTISAFE® double hose-diaphragm pump with pressure air vessel.

PULSATROL



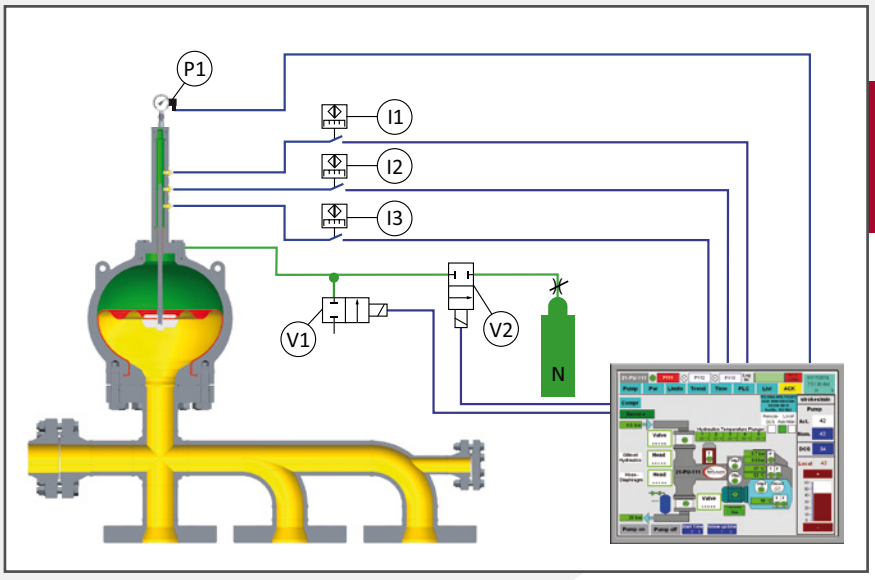
Optimum pulsation reduction by means of FELUWA PULSORBER.

For working pressures in a range of ≥ 40 bar and such products that do not allow for contact with air or gas, considerably more efficient hose-diaphragm pulsation dampeners are applied. The FELUWA PULSORBER consists of a hose-diaphragm pulsation dampener and bladder accumulator. The system offers all the advantages of a conventional pressure air vessel. It is designed to store the pumped volume over and above the average, produced during every delivery stroke, in the hermetically sealed nitrogen accumulator. This volume is then released again during the piston suction stroke, thus compensating for unavoidable delivery fluctuations.

The accumulator is pre-charged to approx. 80 % of the working pressure in order to ensure maximum efficiency. When operating at different discharge pressures, pre-compression has to be adapted accordingly. In comparison to typical bladder-type accumulators, the FELUWA PULSATROL with roller diaphragm accumulator offers a unique advantage in that the nitrogen cushion can be individually adapted to the operating conditions by means of an automatic filling unit. The position of the roller diaphragm is detected by utilisation of inductive transmitters. Based on this position, a co-efficient of operating pressure and pre-compression can be calculated. By means of this co-efficient, the control unit determines whether pre-compression has to be increased or decreased and nitrogen has to be added (V2) or drained (V1), respectively.

The FELUWA PULSATROL is, therefore, not sensitive to operating conditions which deviate from the design layout and allows for a reduction of the uniformity coefficient to less than 0.5 % (p to p).

FELUWA PULSATROL pulsation dampener with roller diaphragm accumulator and automatic adaptation of the pre-compression to varying working pressures.



Conversion Tables and Materials

60 years of experience in materials selection

Appropriate material selection is one of the keys for successful installations. FELUWA can rely on more than 60 years' experience in material selection for even the most critical duties. All materials are individually determined with respect to chemical and mechanical resistance of the conveyed product. Apart from standard casting materials and steels, a great variety of stainless steels are applied, such as martensitic, ferritic, semi-austenitic, austenitic, ferritic-austenitic (duplex and super duplex) steels, nickel or copper-based special alloys or titanium. Typical materials of flat diaphragms and hose-diaphragms are NBR (nitrile rubber), CR (chloroprene rubber), FPM (fluororubber), HNBR (hydrogenated nitrile rubber), IIR (butyl rubber), EPDM (ethylene propylene diene caoutchouc), silicon rubber, AU (polyurethane) and special mixtures of PTFE (polytetrafluor ethylene). Metal diaphragms are available upon request.

Metric pressure units

Unit	bar	mbar	kbar	Pa	kPa	Mpa
1 bar	1	1000	0.001	10^5	100	0.1
1 mbar	0.001	1	10^{-6}	100	0.1	10^{-4}
1 kbar	1000	10^6	1	10^8	10^5	100
1 Pa	10^5	0.01	10^{-8}	1	0.001	10^{-6}
1 kPa	0.01	10	10^{-5}	1000	1	0.001
1 Mpa	10	10^4	0.01	10^6	1000	1
1 Pa = 1 N/m²		**1 kPa = 1kN/m²**			**1MPa = 1MN/m²**	

Pressure (p)

1 in water	=	0.03613 lb/in²
1 ft water	=	0.4335 lb/in²
1 ft water	=	0.88265" Hg
1 in Hg	=	0.49116 lb/in²
1 in Hg	=	1.13299 ft water
1 atmosphere	=	14.696 lb/in²
1 atmosphere	=	760 mm Hg
1 atmosphere	=	33.899 ft water
1 psi	=	27.70" water
1 psi	=	2.036" Hg
1 psi	=	0.0703066 kg/cm²
1 psi	=	6895 Pa
1 kg/cm²	=	14.223 lb/in²
1 MPa	=	145 lb/in²
1 bar	=	0.1 MPa
1 bar	=	14.50377 psi

Weight

1 oz	=	28.35 g
1 g	=	0.03527 oz.
1 lb	=	453.59 g
1 g	=	0.0022046 lb
1 lb	=	0.4535924 kg
1 kg	=	2.205 lb
1 USgal water	=	8.33 lb
1 in³ water	=	0.0361 lb
1 Imp.gal water	=	10.04 lb

Volume (V)

1 in³	=	16.387 cm³
1 ft³	=	28316 cm³
1 ft³	=	6.229 Imp.gal
1 ft³	=	7.4805 USgal
1 ft³	=	28.317 litre
1 USgal	=	0.1337 ft³
1 USgal	=	231 in³
1 USgal	=	3.785 litre
1 Imp.gal	=	1.20094 USgal
1 Imp.gal	=	277.3 in³
1 Imp.gal	=	4.546 litre
1 litre	=	61.023 in³
1 litre	=	0.03531 ft³
1 litre	=	0.2642 USgal

Energy (E)

1 kW h	=	2.655 x 10^6 ft lbs
1 kW h	=	1.3410 PS h
1 kg cal	=	3.968 B.T.U.

Length (L)

1 in	=	25.4 mm
1 mm	=	0.03937 in
1 ft	=	30.48 cm
1 metre	=	3.28083 ft
1 micron	=	0.001 mm

Flow (Q) Volume

1 ft³/sec	=	448.83 USGPM
1 ft³/sec	=	1699.3 l/min
1 USGPM	=	0.002228 ft³/sec
1 USGPM	=	0.06308 l/sec
1 cm³/sec	=	0.0021186 ft³/min

Density (ρ)

1 lb/ft³	=	16.018 kg/m³
1 lb/ft³	=	0.0005787 lb/in³
1 kg/m³	=	0.06243 lb/ft³
1 g/cm³	=	0.03613 lb/in³

Temperature (T)

To / from	Kelvin scale (K)	Celcius scale (°C)	Fahrenheit scale (°F)
T_{Kelvin}	T_K	$T_K + 273.15$	$(T_F + 459.67) \cdot 5/9$
$T_{Celsius}$	$T_K - 273.15$	T_C	$(T_F - 32) \cdot 5/9$
$T_{Fahrenheit}$	$T_K \cdot 1.8 - 459.67$	$T_C \cdot 1.8 + 32$	T_F
$T_{Rankine}$	$T_K \cdot 1.8$	$T_C \cdot 1.8 + 491.67$	$T_F + 459.67$

Performance (F)

1 PS	=	33 000 ft lb/min
1 PS	=	550 ft lb/sec
1 PS	=	2 546.5 B.T.U./hr
1 PS	=	745.7 Watt
1 Watt	=	0.00134 PS
1 Watt	=	44.254 ft lb/min

Area (A)

1 in²	=	6.4516 cm²
1 ft²	=	929.03 cm²
1 cm²	=	0.155 in²
1 cm²	=	0.0010764 ft²
1 m²	=	10.764 ft²
1 ft²	=	0.09290304 m²

Viscosity (η and ν)

1 centipoise = 0.000672 lb/ft²

1 centistoke = 0.00001076 ft²/sec

Velocity (v)

1 ft/sec	=	30.48 cm/sec
1 cm/sec	=	0.032808 ft/sec

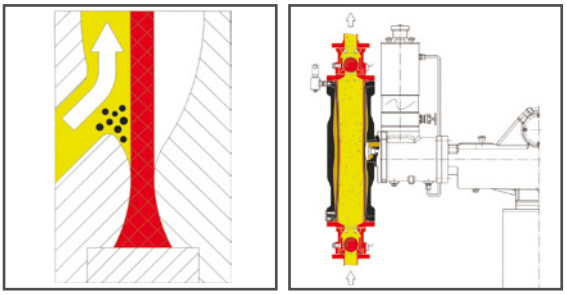
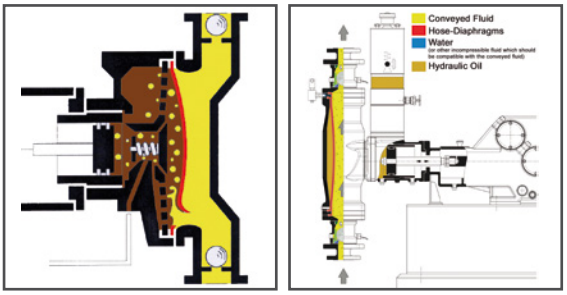
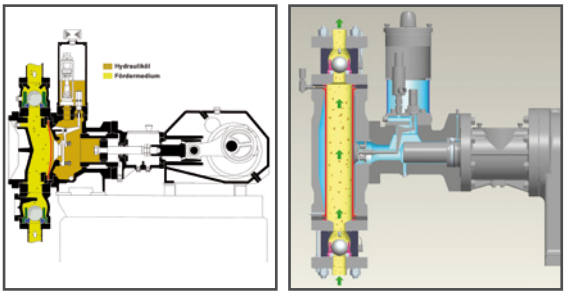
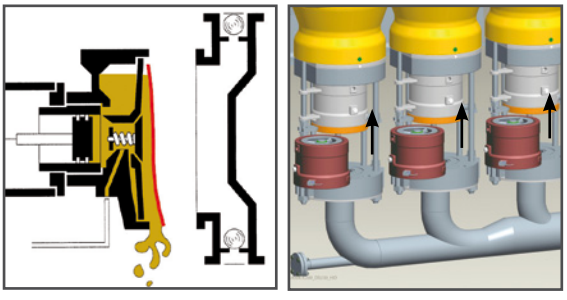
Thermal transfer (Q)

1 g cal/cm²	=	3.687 B.T.U./ft²
1 kg cal/hr/m²/°C	=	0.205 B.T.U./hr/ft²/°F

Flow (Q) Mass

1 lb/h	=	0.4536 kg/h
1 kg/h	=	2.205 lb/h

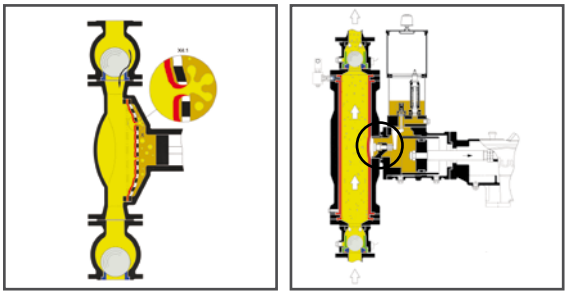
Comparison with conventional Piston Diaphragm Pumps

Conventional		FELUWA Technology
The product is retained by the diaphragm chamber and deviated several times. The design includes many areas for solids to settle in the diaphragm casing, around the clamping ring for example. The material of the diaphragm chamber has to be resistant to the product.	**Fluid transport within the pump** 	The product is retained by the hose-diaphragms, which provide for linear flow throughout the pump chamber. No risk of settling. The conveyed fluid is in contact with the inside of the hose-diaphragm and the check valves only. The material of the hose-diaphragm chamber has no need to be resistant to the product.
The diaphragm forms the sole partition between conveyed fluid and hydraulic chamber. If the diaphragm fails, damage to piston seal, cylinder and control system is inevitable. Immediate shut-down is required. High costs and long downtime for cleaning and repair.	**Safety** 	Double partition between conveyed fluid and hydraulic chamber by means of two hose-diaphragms which are arranged one inside the other. If one of the hose-diaphragms fails, operation is maintained with the second one until the process allows for shutdown. No damage to seals and/or to the hydraulic system after failure of a hose-diaphragm. Low costs and downtime.
The hydraulic fluid transferred by the piston onto the diaphragm causes the displacement of the conveyed fluid, which is in contact with the flat diaphragm and the pump casing. Solids may settle along the diaphragm clamping ring and lead to early diaphragm failure.	**Working principle** 	At the heart of this pump are two hose-diaphragms which fully enclose the linear flow path of the conveyed fluid. Simultaneously, they create double hermetic sealing from the hydraulic drive end of the unit. Both hose-diaphragms are hydraulically actuated by the piston. In step with the piston stroke they are subject to pulsating action, comparable with that of a human vein.
The diaphragm is retained by the pump cover. Diaphragm replacement requires opening of the pump cover and removal of many bolts. Opening of the cover moreover causes escape of hydraulic oil.	**Maintenance** 	Easy to maintain. No cover required for the cylindrically shaped pump heads. Every individual part that is theoretically subject to wear can be separately removed without prior dismantling of adjacent elements. Predictive maintenance is possible.

Conventional	FELUWA Technology

Diaphragm protection system

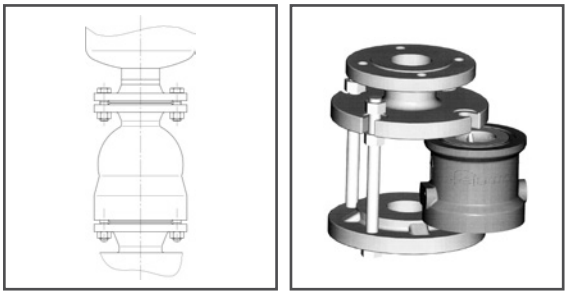
As a result of damaged delivery valves, shutdown of the pump may result in the full system pressure being transferred onto the diaphragm, which causes the diaphragm to be pressed against the diaphragm support disc. Higher pressures may even cause perforation and early diaphragm failure.



In the event that the hose-diaphragm is loaded by the system pressure as a result of a leaking discharge valve, it is gently supported by the support disc and not damaged, even if the maximum delivery pressure is applied to one side.

Delivery valve assembly

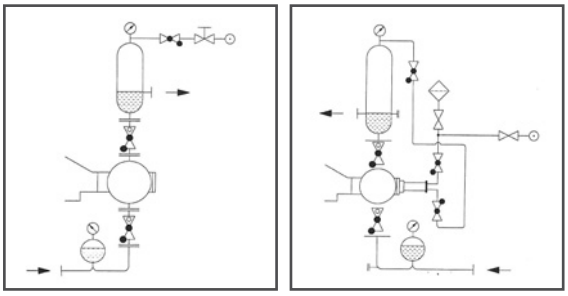
Disassembly of suction and discharge pipe and of suction/discharge pulsation dampeners is required. For bigger units a crane is necessary. All fastening bolts need to be removed. High downtime.



Suction and discharge pulsation dampeners remain in position and are lifted by means of two jacking bolts. The complete valve assembly can be withdrawn similar to a cassette without removal of pipework and/or adjacent elements. Long lifetime. Minimum downtime.

Pulsation dampening

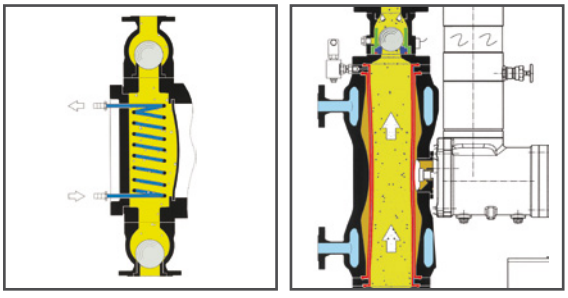
Ventilation of pressure air vessels requires external compressed air supply. Permanent supervision is required. Caution: In case of a leaky check valve and open air supply valve, conveyed fluid may stream into the compressed air supply pipe.



Special FELUWA hose-diaphragm pressure air vessel with accumulator which is pre-charged at approx. 80 % of actual working pressure guarantees optimum dampening of pulsations in valves and discharge pipes and ensures most uniform output. Standard pressure air vessels are automatically ventilated during pump operation via in-built piston compressor (see illustration).

Cooling and heating of wet end

Since the conveyed fluid is in contact with the pump casing, cooling/heating is effected by double-walled casings or within the fluid chamber. The latter, however, increases the risk of settling along the cooling or heating spirals. Moreover, the cooling or heating fluid is gradually absorbed by the conveyed fluid. Therefore, regular compensation is required.



The product is not in contact with the pump casing. The cooling or heating agent is separated from the conveyed fluid by the hose-diaphragms only. With each stroke of the piston/plunger, the hose-diaphragm makes a pulsating movement so that sedimentation, which might restrict the heating/cooling efficiency, cannot occur.

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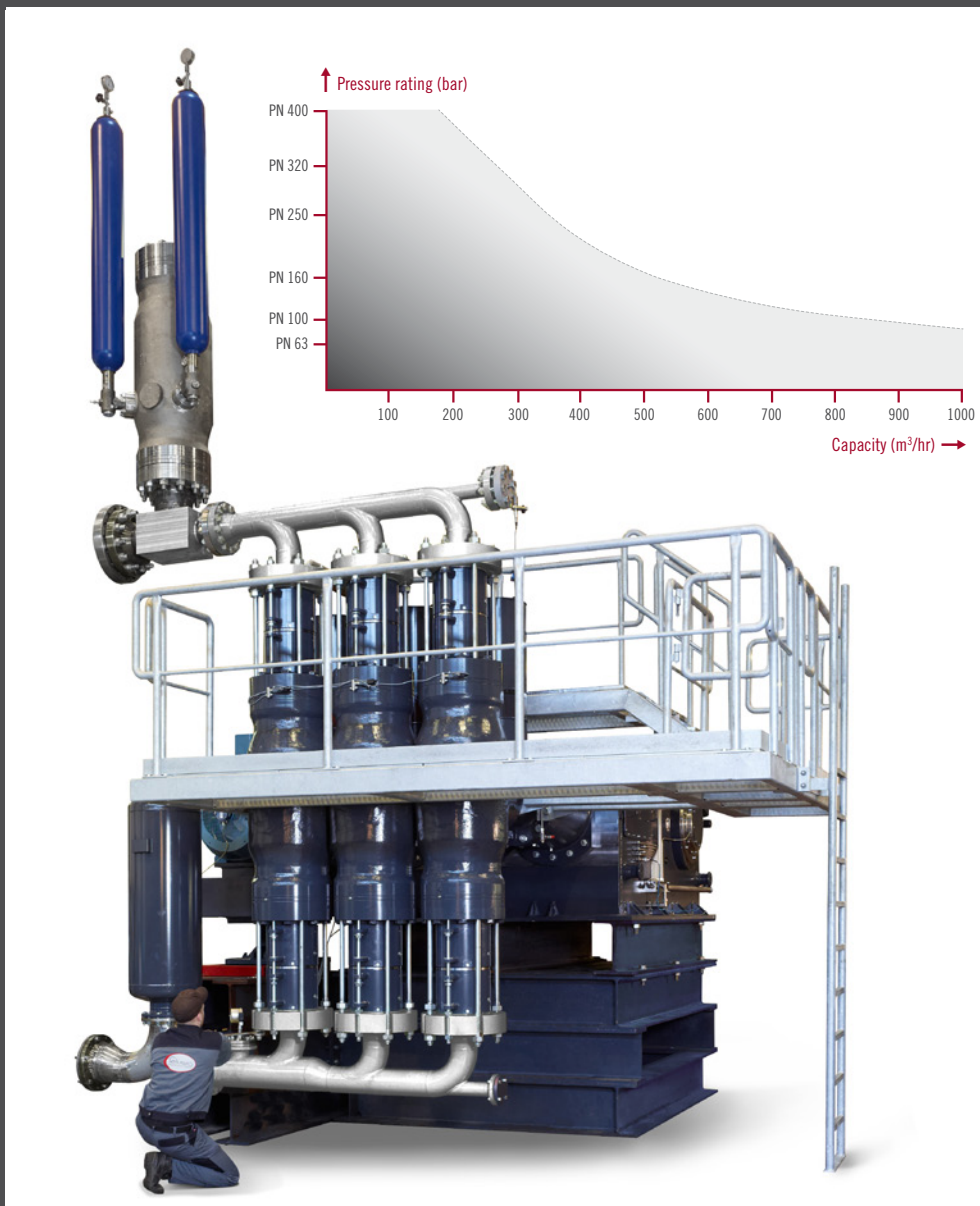

Engineered and Made in Germany

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