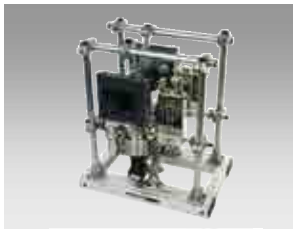
HNP Mikrosysteme



Intensified Pumps for Intensified Processes

RSC Symposium
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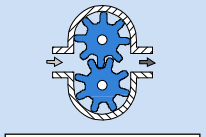
- **Introduction**
- mzr-pumps
- Characteristic properties
- R&D, materials
- Example

Pump classification

Liquid pumps

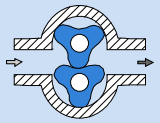
Positive displacement pumps

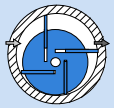
Rotary pumps

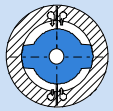

External gear pump


Internal gear pump

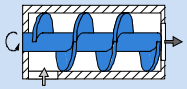

Annular gear pump

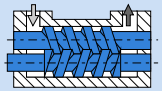

Lobe pump

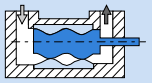

Vane pump

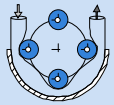

Rotary piston pump


Impeller pump

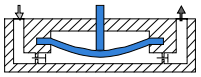

Spiral pump

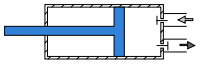

Screw pump

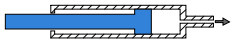

Eccentric screw pump

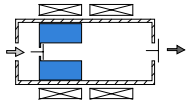

Peristaltic pump

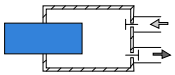
Reciprocating pumps


Diaphragm pump


Piston pump

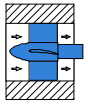

Syringe Pump

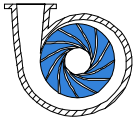

Reciprocating plunger pump


Plunger pump

Rotodynamic pumps

Rotary pumps


Axial-flow pump


Centrifugal pump

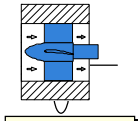

Side channel pump
Peripheral pump

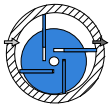
Reciprocating pumps

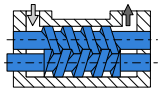
Gas pumps

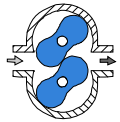
- compressor
- vacuum pump
- blower

rotary


Axial blower

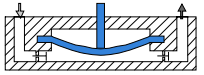

Vane pump

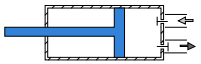

Screw compressor


Roots compressor

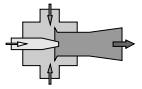

Scroll compressor

reciprocating


Diaphragm pump


Piston compressor

miscellaneous


Water jet pump

- Eductor-jet pump
- Cryogenic pump
- Sorption pump

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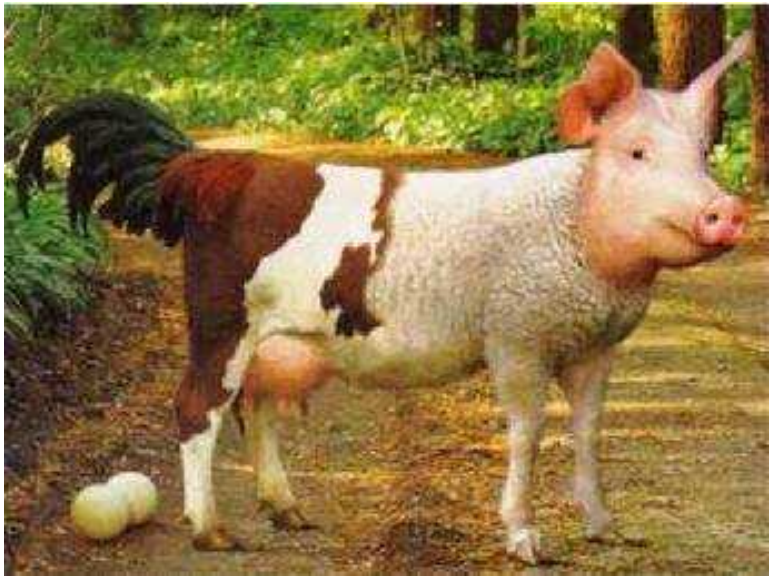
A common enquiry!

Flow rate range
1 µl/h – 1 l/min

Viscosity range
0.2 – 1,000,000 mPas

Liquids
liquid butane … nitric acid



Differential pressure
Vacuum, 0 – 200 bar

Dosage
2 µl-droplets, 100 per minute

Dosage precision
< 1 %

Flow
pulseless

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– Introduction

– **mzr-pumps**

– Characteristic properties

– R&D, materials

– Example

Micro annular gear technology
Milestones R & D

1996
hydraulic motor diameter 10 mm

1997
micro annular gear pump
outer diameter 2,5 mm

1998
high performance series
mzr-2900, mzr-4600

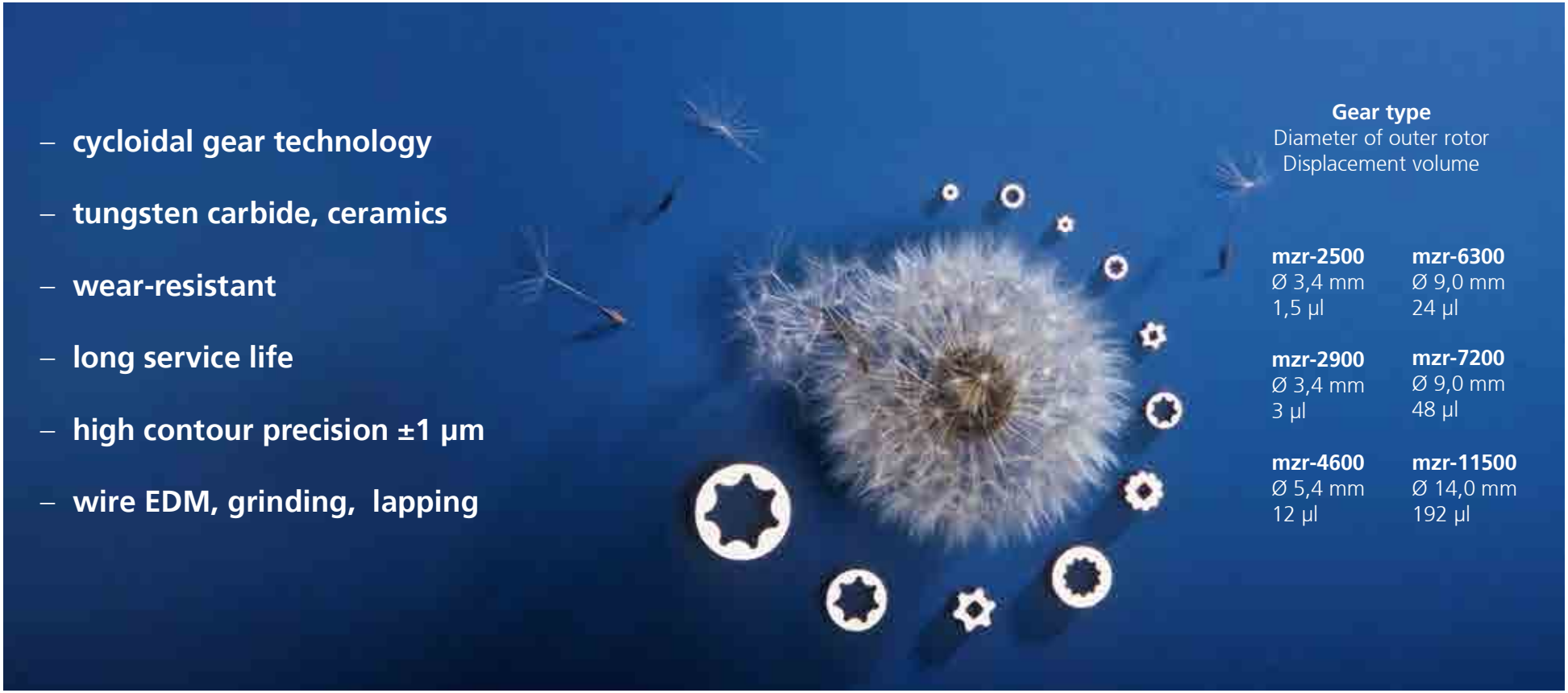
1999
integrated mzr-pump

2000
mzr-pump with universal actuator

2001
low pressure pump mzr-2921

Source: HNP Mikrosysteme, Fraunhofer IPA

mzr®-Pumps
Rotors



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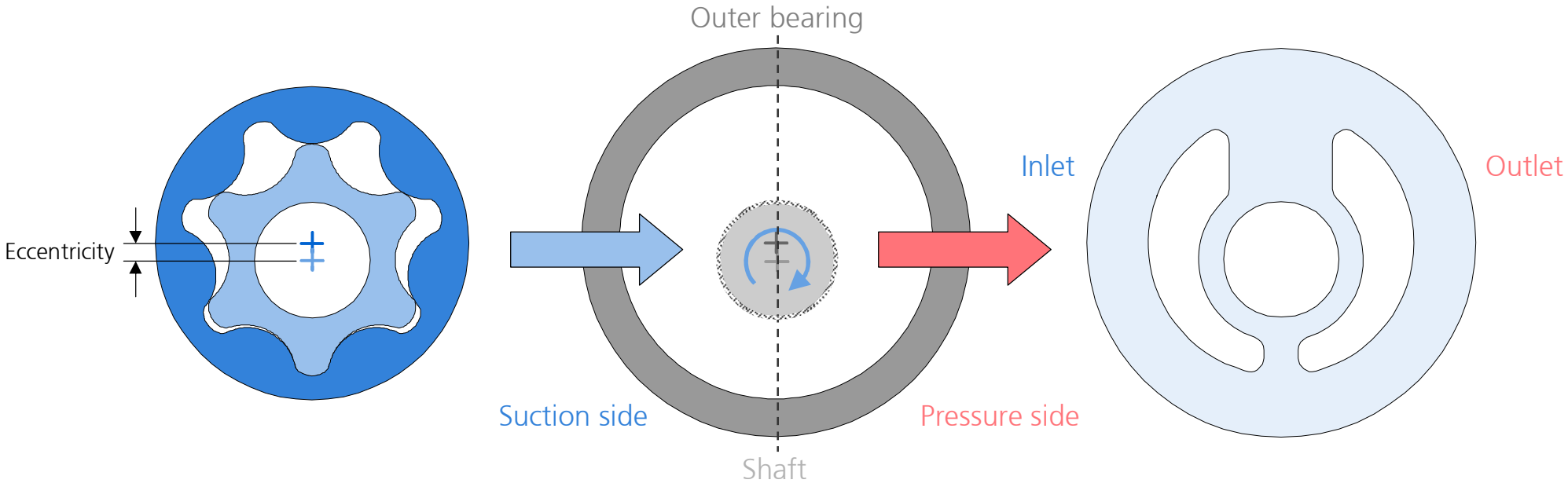
Design and basic principle
Micro annular gear pump



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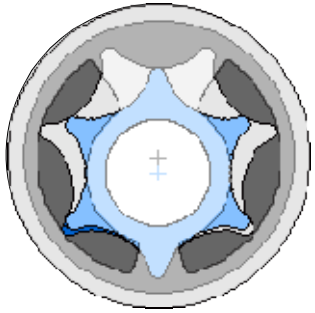
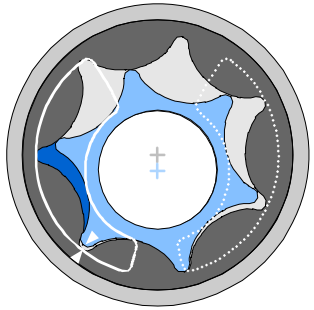
Basic principle

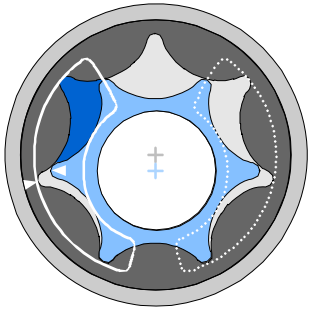
Micro annular gear pump



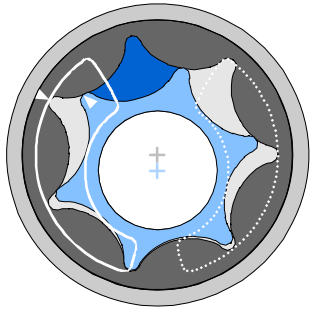
0°, 309°
0°, 360°



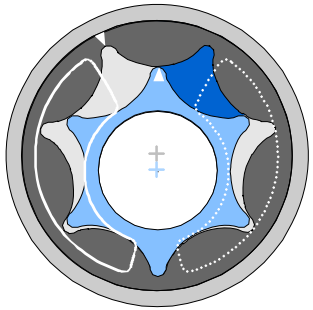
39°
45°



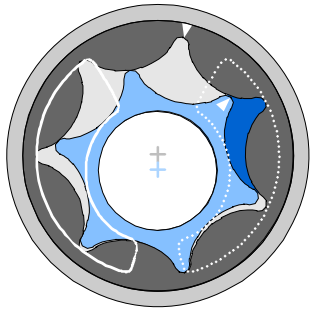
77°
90°



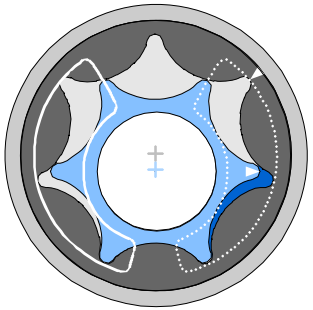
116°
135°



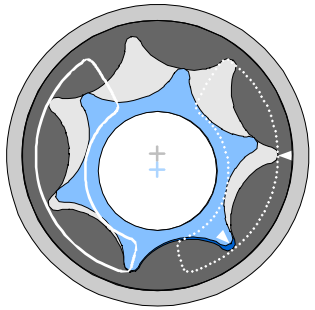
154°
180°



193°
225°



231°
270°



270°
315°

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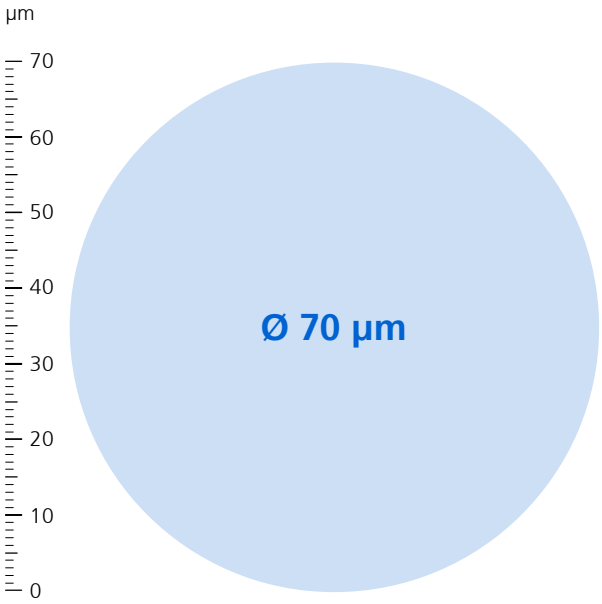
Clearance Space
Comparison of dimensions

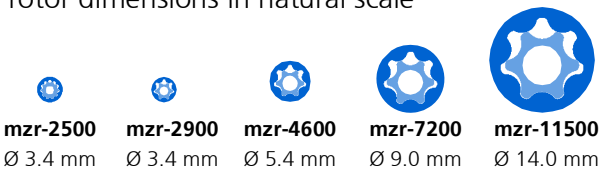


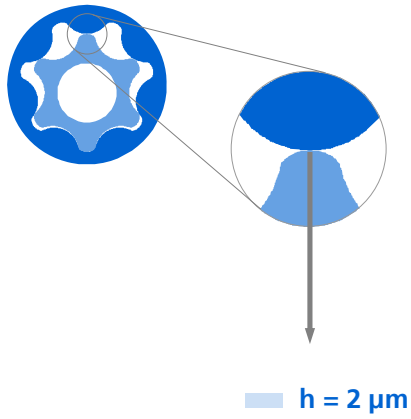
human hair

fog droplet

red blood corpuscle

rotor dimensions in natural scale





clearance space
micro annular gear pumps

RSC_SympChemspec_2013-06-06

– Introduction

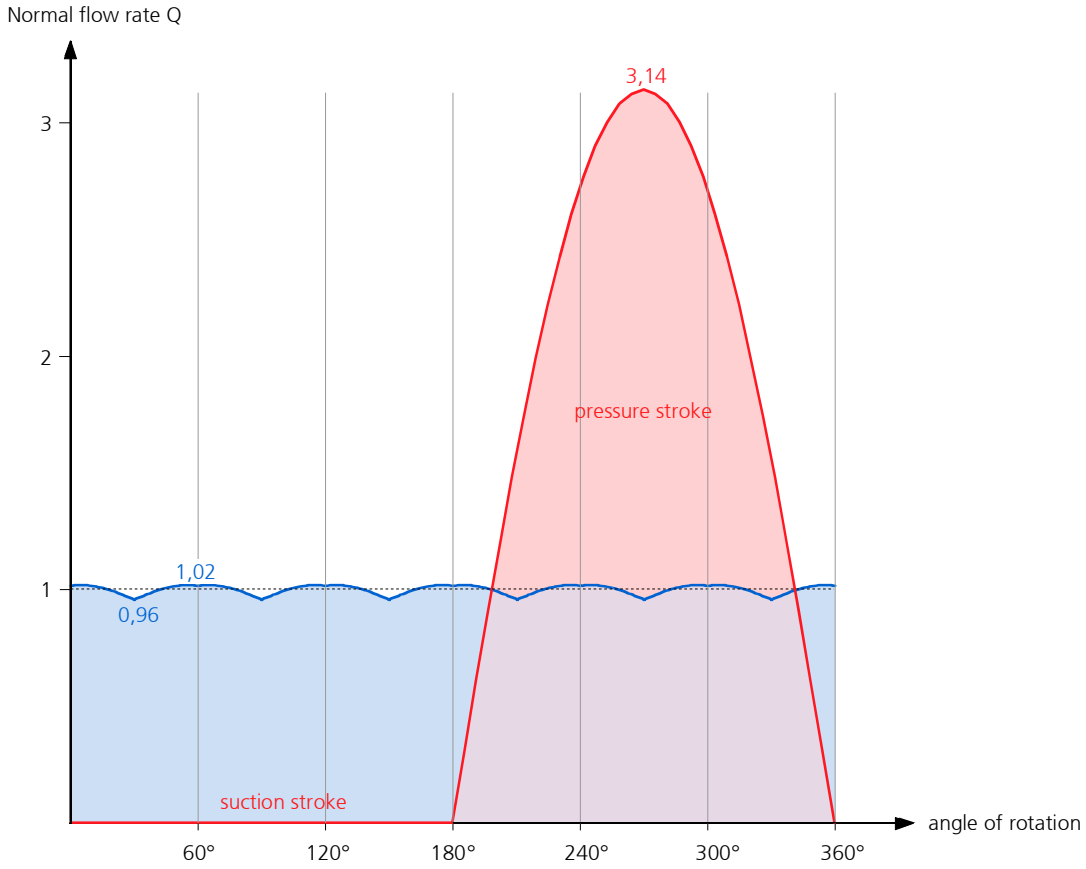
– mzr-pumps

– **Characteristic properties**

– R&D, materials

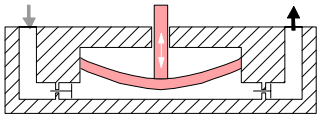
– Example

Comparison of pulsation



Pulsation of flow: $\delta_Q = \frac{Q_{max} - Q_{min}}{\overline{Q}}$

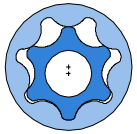
Diaphragm Pump



$\delta_Q = \frac{3{,}14 - 0}{1} = \mathbf{314\ \%}$

Factor 50

Micro annular gear pump



mzr-2921
6/7 indenting

$\delta_Q = \frac{1{,}02 - 0{,}96}{1} = \mathbf{6{,}3\ \%}$

mzr-2521
10/11 indenting

$= \mathbf{1{,}5\ \%}$

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Comparison of pulsation – experimental

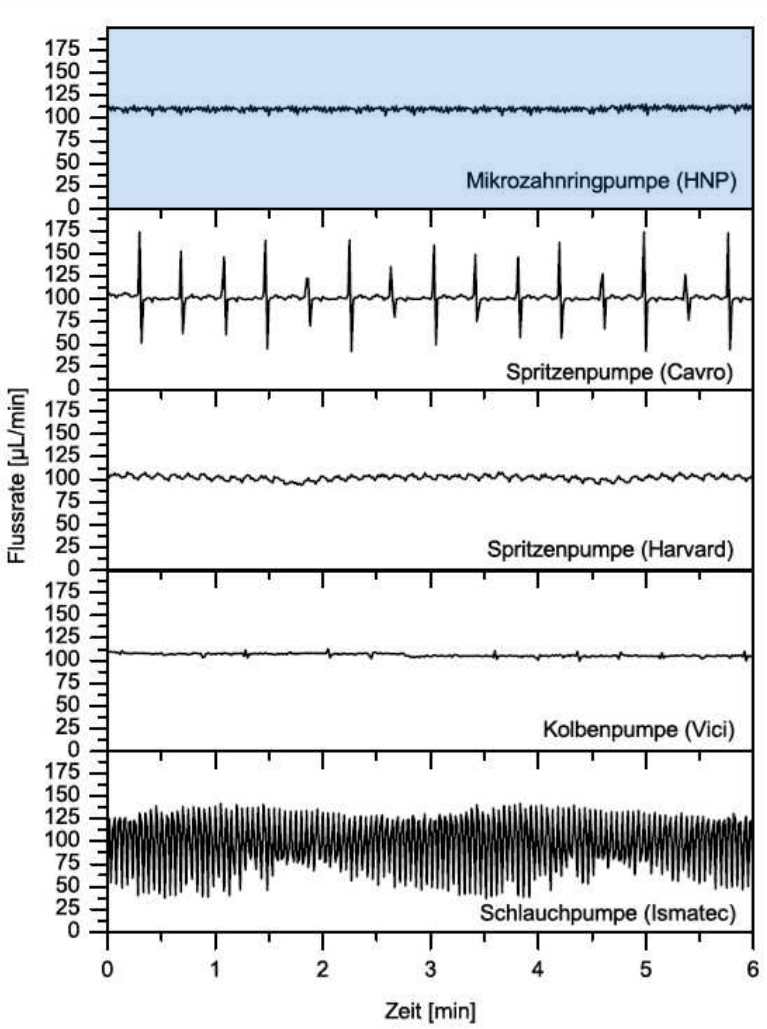


Tabelle 5.2: Übersicht der Messungen der Flussratengenauigkeit von verschiedenen Pumpenmodellen.

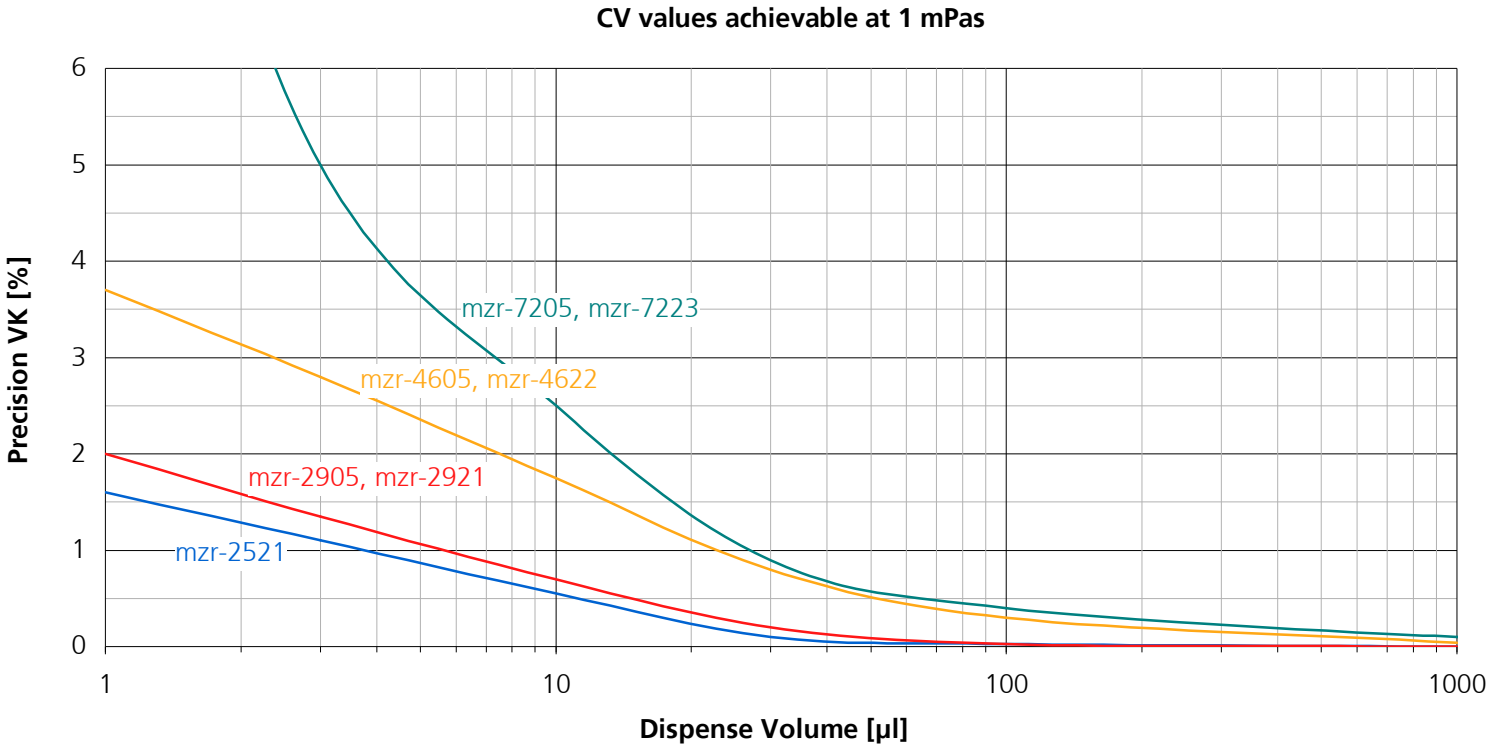
	MZR	Cavro	Cavro (Pendel-betrieb)	Harvard	Vici	Schlauch
mittlere Flussrate [μL/min]	110.2	100.8	101.8	101.0	106.3	98.3
Standard-abweichung [%]	2.5	1.5	14.1	2.7	1.7	33.6
F_{min} [μL/min]	102.5	97.8	41.7	93.5	99.3	35.4
ΔF_{min} [%]	7.0	3.0	58.8	7.5	6.6	64.0
F_{max} [μL/min]	115.6	102.9	174.0	107.9	113.1	141.8
ΔF_{max} [%]	4.9	2.1	72.1	6.8	6.4	44.2

Abb. 5.2: Mit einem Flusssensor wurde die Pulsation verschiedener Pumpentypen bei einer Flussrate von ~100 μL/min mit 1.5625 Hz aufgezeichnet. Die höchste Pulsation zeigte erwartungsgemäß die Schlauchpumpe. Einen nahezu pulsationsfreien Fluss generierte die Kolbenpumpe der Firma Vici. Die hohen Ausschläge der Spritzenpumpe von Cavro sind auf den Pendelbetrieb zurückzuführen.

Source: Fabel, Susanne; PhD thesis, Munich 2007, p. 97

Dosage Precision

Dispensing with mzr-pumps



Definition
The coefficient of variation (CV) expressed in % is defined as a standard deviation from the average value.

$$CV\,[\%] = \frac{s \cdot 100}{\overline{V}}$$

CV .... Coefficient of variation [%]
s .... Standard deviation [µl]
V .... Average volume value [µl]

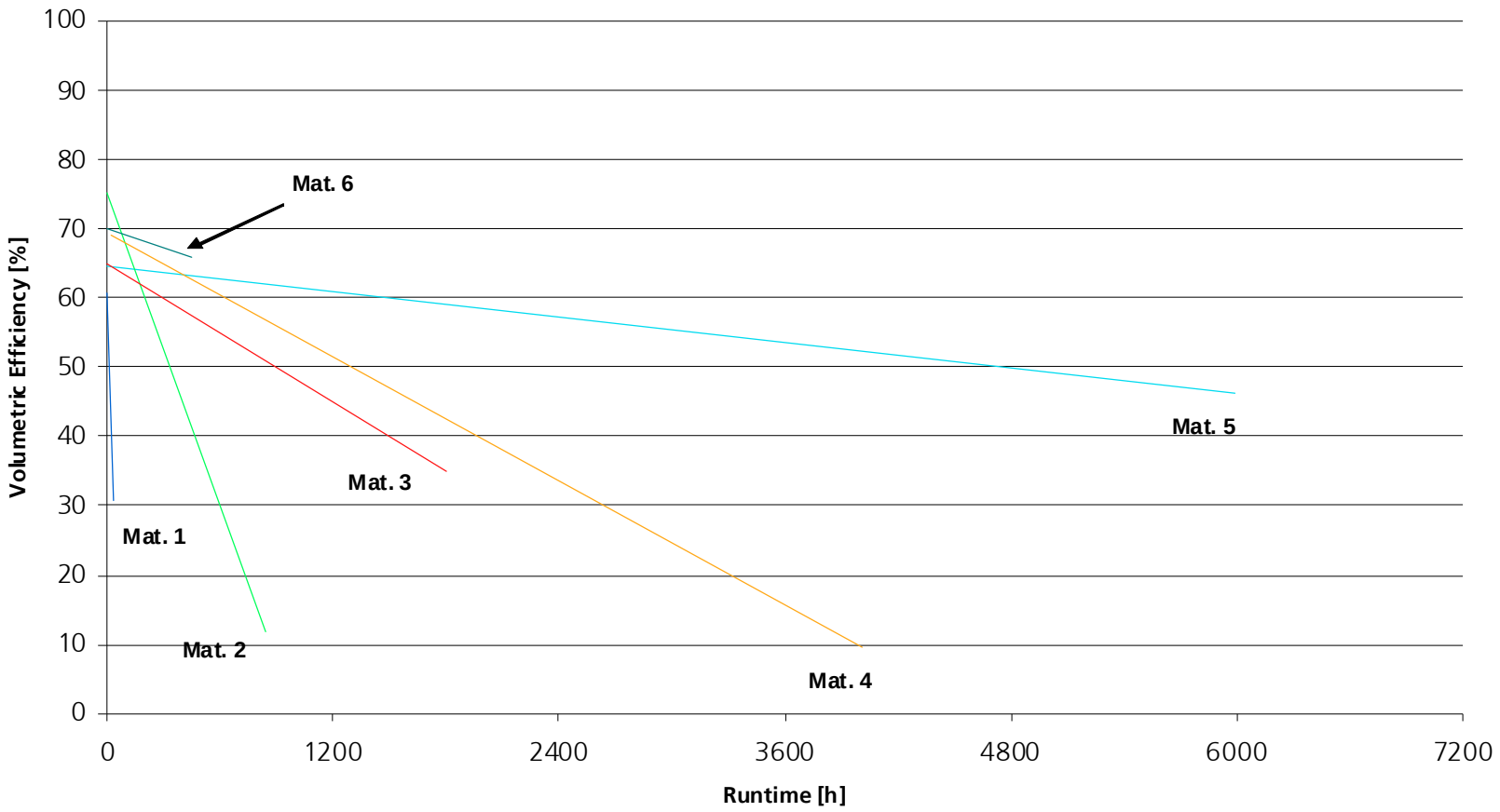
Remarks
- The CV values have been established for water (1 mPas) by using an analytical scale with 0,01 mg resolution
- Characteristics curves show values obtained at optimal conditions for each individual pump size
- Precision improves with increasing viscosity and decreasing differential pressure

Requirements for optimal precision
- Degassed liquid
- Absence of air bubbles in the system
- Constant pressure conditions
- Return valves preventing free flow
- Well adapted dosing nozzle

- Introduction
- mzr-pumps
- Characteristic properties
- **R&D, materials**
- Example

Testing of novel materials

Long term wear test



Test condition
- difficult liquid
- delta p: 20 bar
- 20 °C
- 3000 rpm

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- Introduction
- mzr-pumps
- Characteristic properties
- R&D, materials
- **Example**

mzr® micro annular gear pumps
Product summary

Ex-Pumps
- for pump heads of high performance series and hermetic inert series
- Ex-certification ATEX, EU directive 94/9/EEC
- CE Ex II 2 G c T4 X, CE Ex II 2 G c T5 X

Hermetic inert series
- chemically inert materials
- Al_2O_3, ZrO_2 ceramics, alloy C22, SSiC, Kalrez®
- hermetic magnetic coupling
- DC-servomotor with integrated controller

High performance series
- industrial equipment
- tungsten carbide Ni-based, stainless steel 316L seals: PTFE, FKM, optional: EPDM, FFKM
- differential pressure range 40 bar (max. 150 bar)
- wide viscosity range (0.3-1,000,000 mPas)
- DC-servomotor with integrated controller
- modular system: fluidic seal module, heat insulation module, electrical heating, double shell heating and cooling module, reduction gear

Modular Series
- chemically inert, compact dimensions
- configurable materials: ceramics, alloy C276/C22, optional stainless steel 316L, optional PEEK™; seals: PTFE, FKM, optional: EPDM, FFKM.
- DC-motor with graphite brushes

Low pressure series
- compact dimensions
- low pressure range (0-5 bar)
- tungsten carbide Ni-based, stainless steel 316L seals: PTFE, FKM, optional: EPDM, FFKM
- low viscosity liquids (0-100 mPas)
- DC-motor with graphite brushes

Customized pumps
- specific liquids
- specific motor
- specific design
- ...

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Micro annular gear pumps
Hermetic inert series

Note:
Optional double shell heating module for mzr-1155x available

- **High chemical resistance**
  against oxidizing and reducing media, acids and bases
- **Hermetically sealed**
  magnetic coupling (NdFeB)
- **Long service life**
  wear-resistant, ultra-hard materials
- **Compact, chemically inert pump head**
  alloy C22, SSiC, Al_2O_3 and ZrO_2 ceramics, option: tantalum
- **Precision motor and user-friendly control**
  dynamic DC-servomotor with encoder and microcontroller, RS-232 or CAN-Bus, analog input 0-10 V, I/O
- **Precise dosage – low pulsation**
  rotary micro annular gear technology, no valves

			mzr-6355	mzr-7255	mzr-1155x
Displacement volume		µl	24	48	192
Smallest dosage volume		µl	15	30	100
Flow rate		ml/min	0.024 – 144	0.048 – 288	0.192 – 1152
Max. operation pressure *		bar	80	80	60 (max. 190)
Differential pressure range	(water, 1 mPas)	bar	0 – 15	0 – 20	30
	(oil, 16 mPas)	bar	0 – 40	40	0 – 60
Viscosity range		mPas	0.3 – 1000		
Speed range		rpm	1 – 6000		

* operation pressure = inlet pressure + differential pressure

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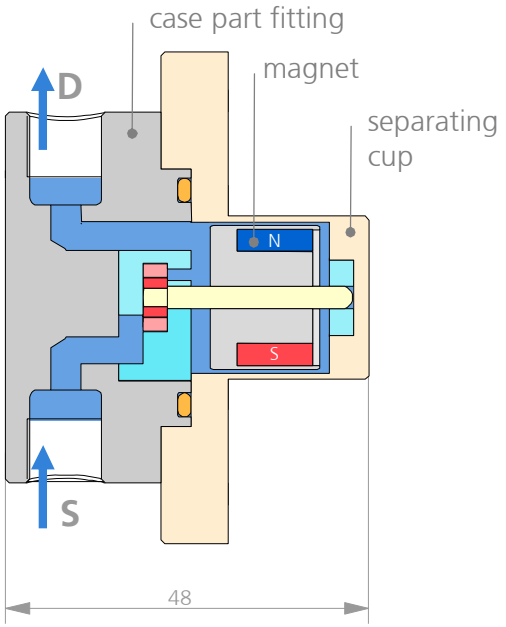
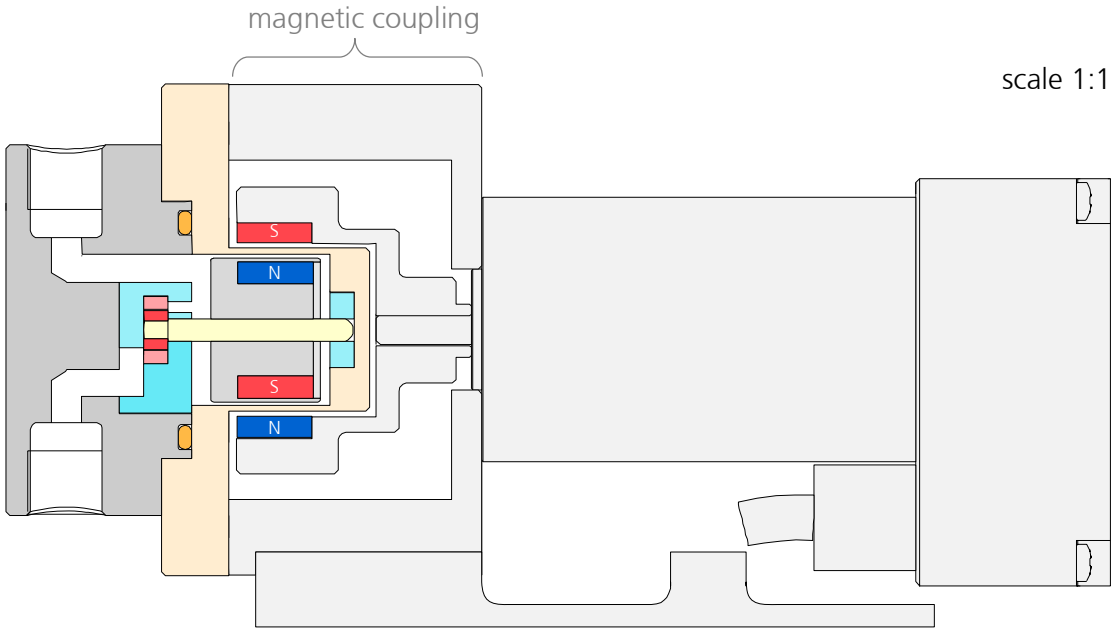
Micro annular gear pump mzr®-7255

Hermetic inert series

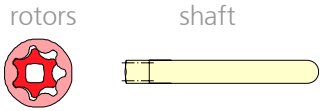


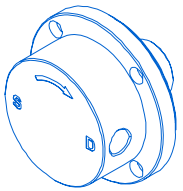


scale 1:1

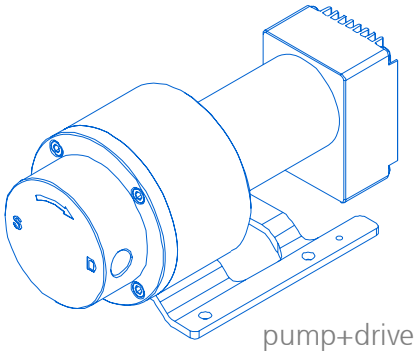
pump head twisted 90°

total length: 146 mm





pump head



pump+drive

Note: All cross sections and views are schematic!

liquid

RSC_SympChemspec_2013-06-06

Thank you for your attention





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