A PASSION FOR PERFECTION

PFEIFFER VACUUM

Turbo Pumps
From Theory to Practice

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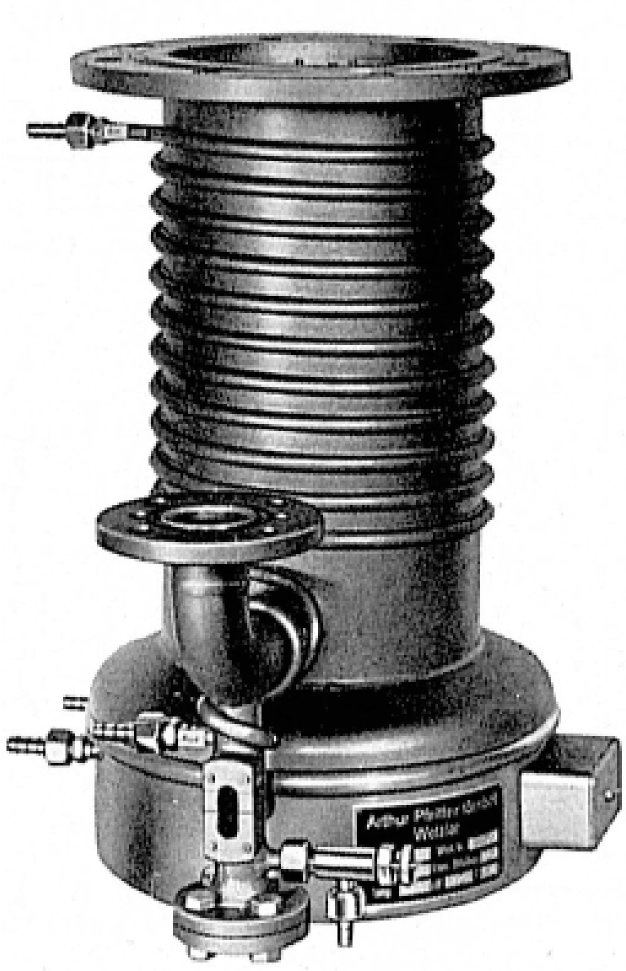
Agenda

- History of the development of Turbo Pumps
- Theory of pumping effect
- Different Design Concepts
- Bearing concepts
- Gas type depending pump performance
- Calculation of the chamber pressure
- Application: turbo pumps in radioactive environment
- Summary

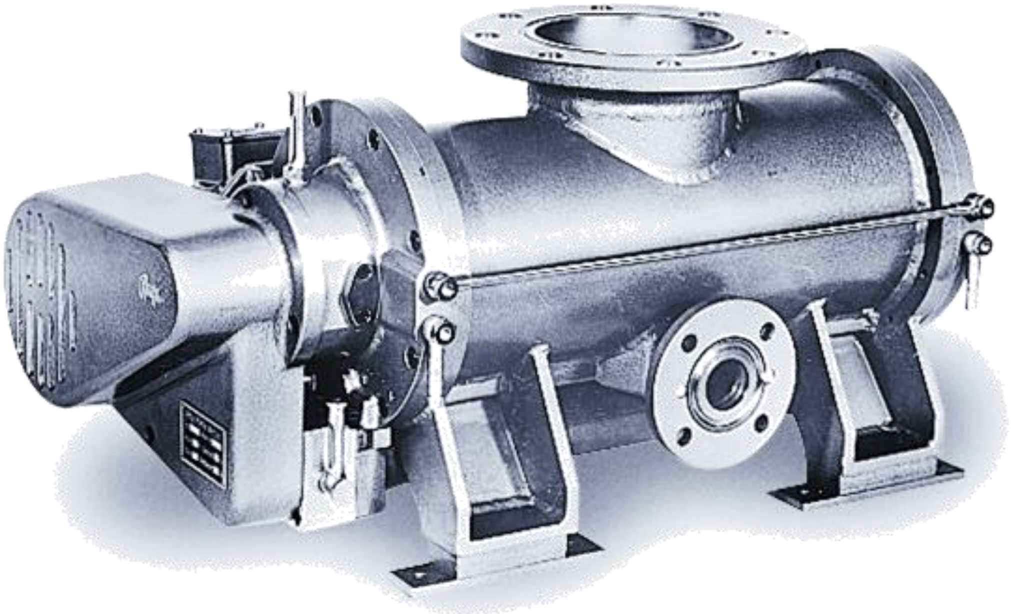
History of High Vacuum

- It was possible to create high- and ultrahigh vacuum with diffusion pumps only
- High energy consumption
- Problem of
  oil contamination of the vacuum



Invention of the Turbo Pump

- In 1958 Dr. BeckerPfeiffer Vacuum invents the worlds first Turbo Pump
- Invention was done by coincidence

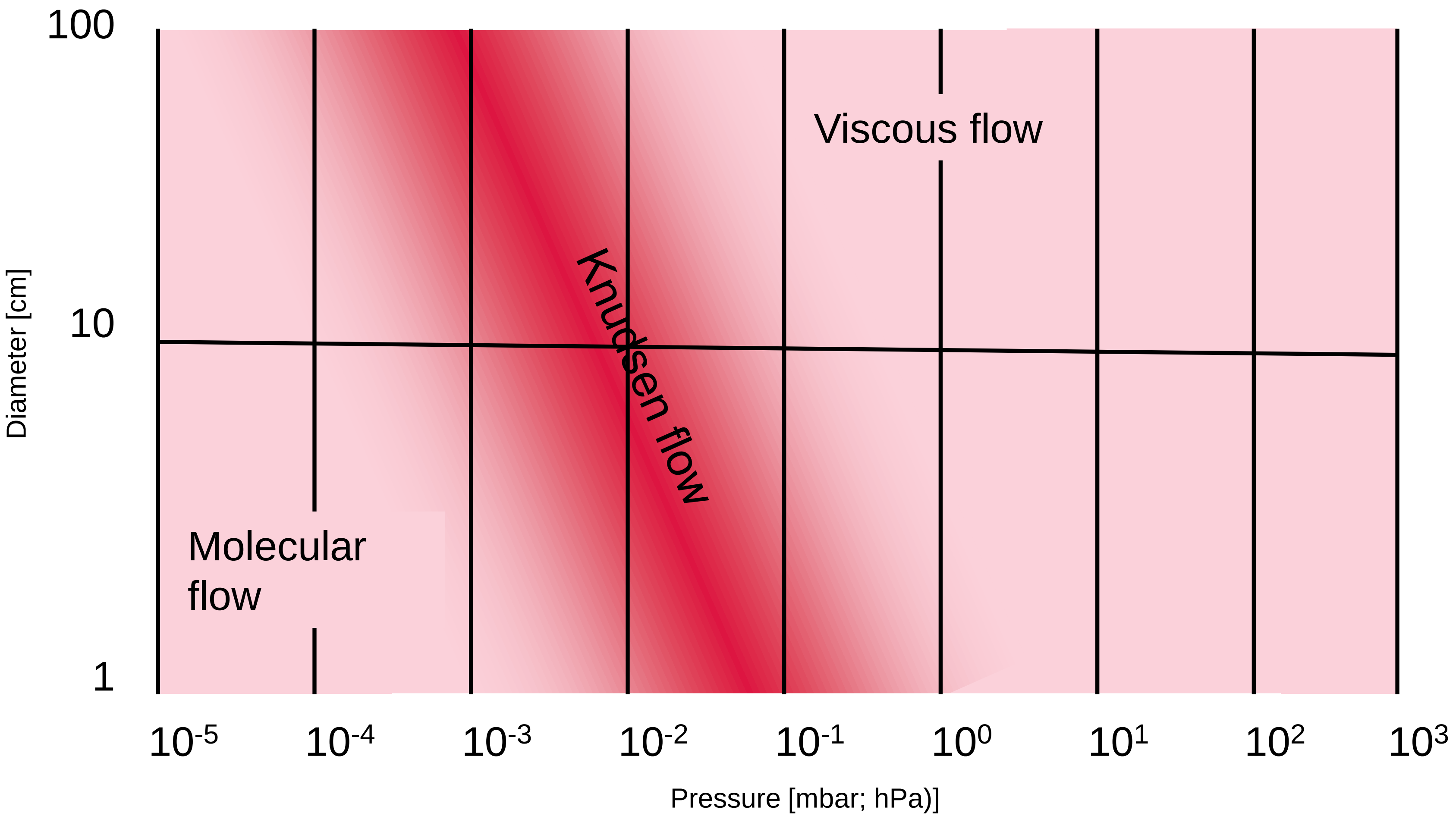


TVF 400

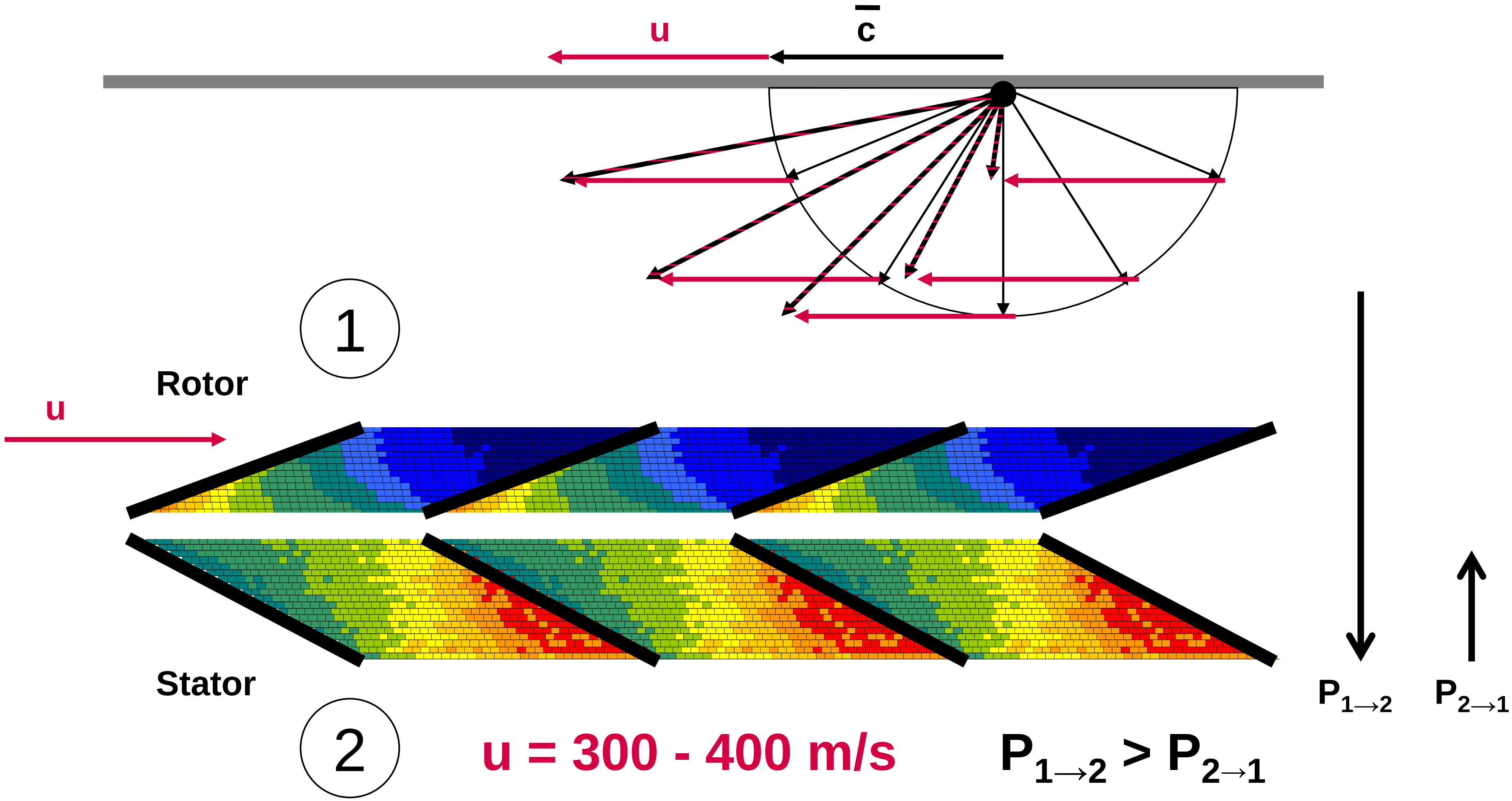
Pumping speed
140 l/s for N_2

Weight: approx. 60 Kg

Different Flow Regimes

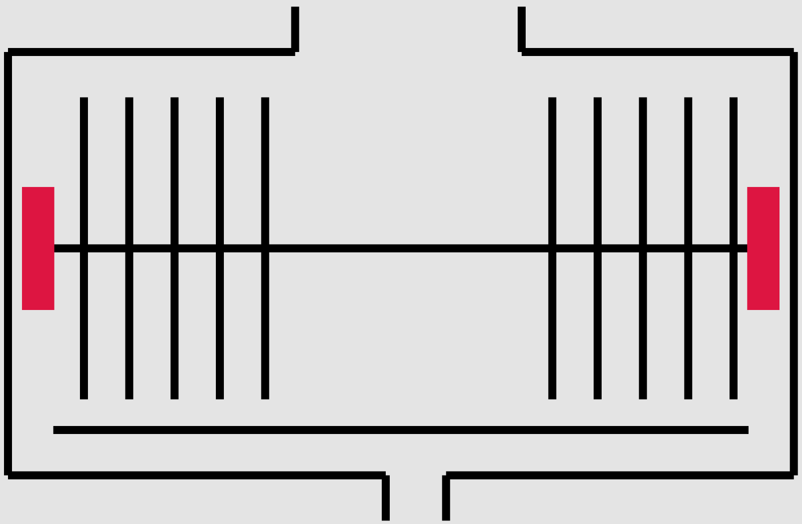
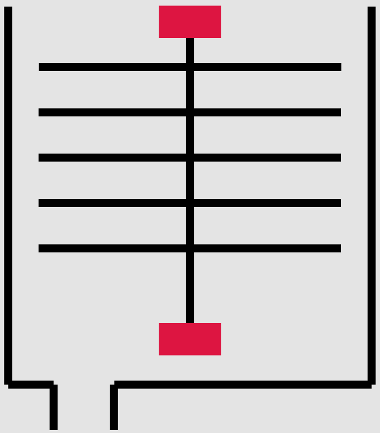


Theory of Turbo Pumping Effect

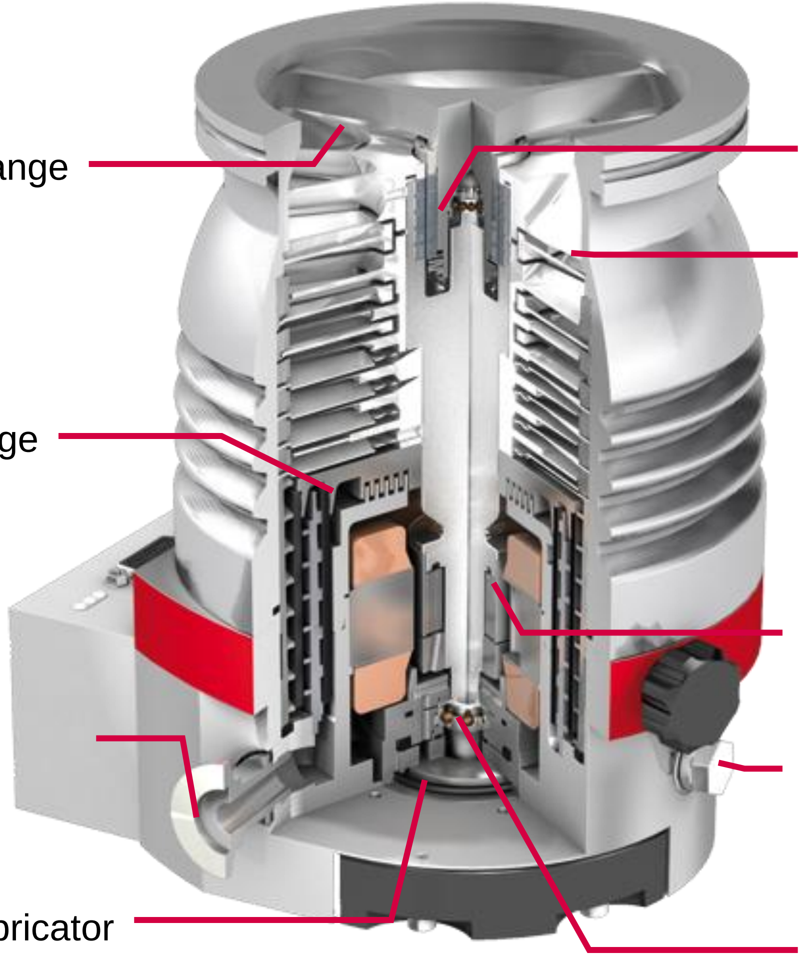


u = 300 - 400 m/s $P_{1\rightarrow2} > P_{2\rightarrow1}$

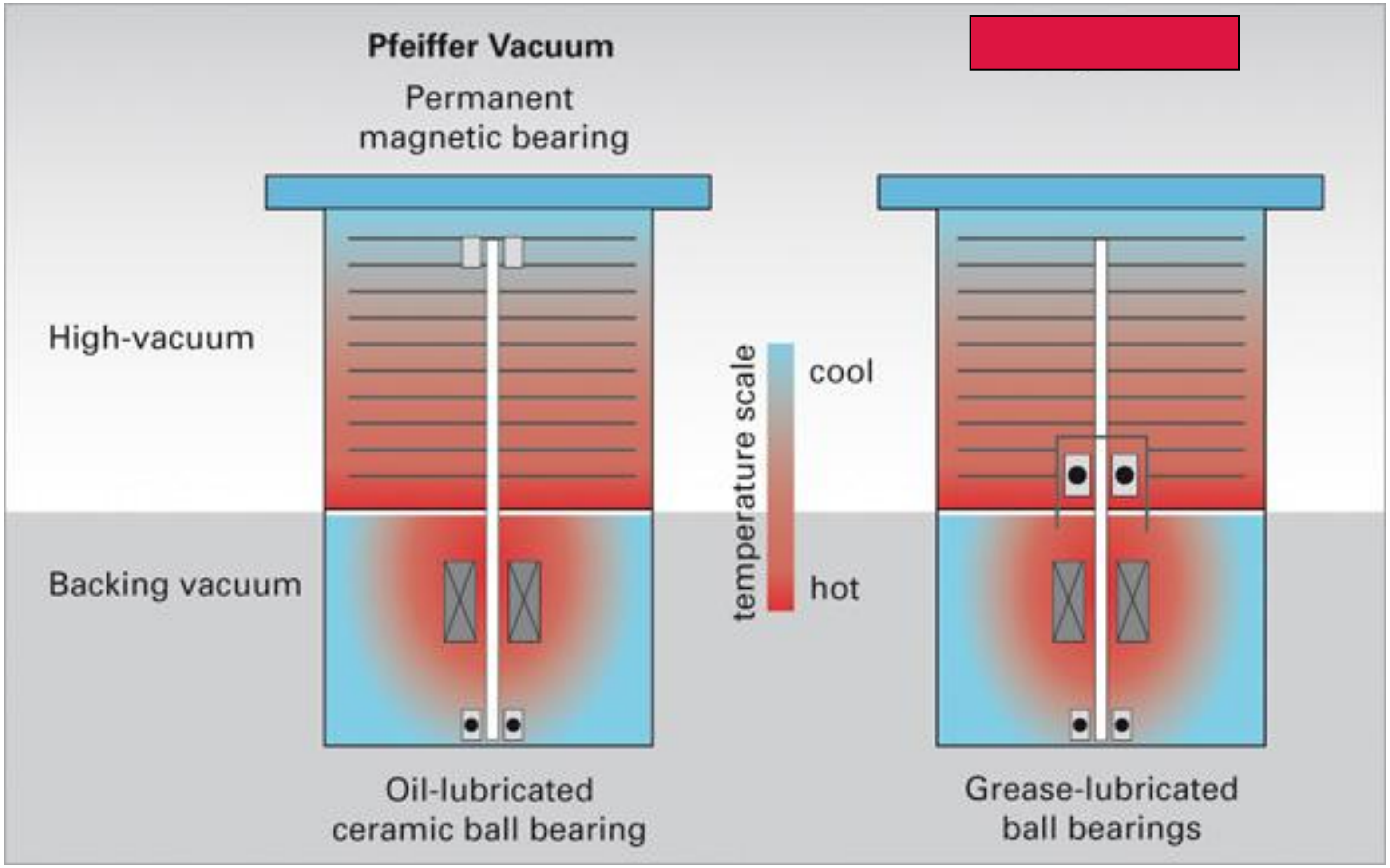
Turbo Pump Design

Classical Design	Modern Design
	
Double flow design	Single flow design

Turbo Pump Design



Bearing Types and Rotor Design



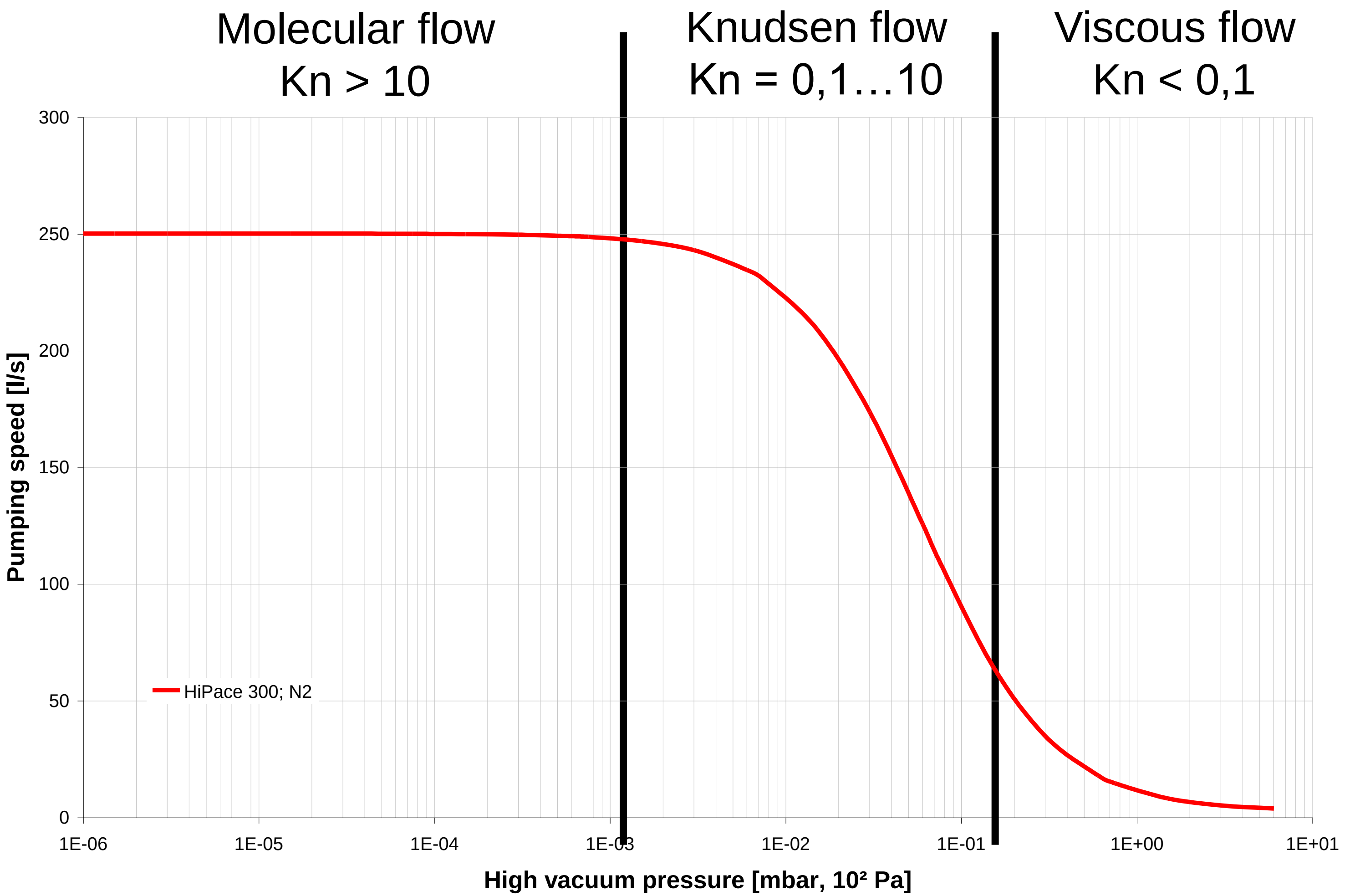
Turbo Pumps today

HiPace 300

Pumping speed
260 l/s for N_2

Weight: 6.2 Kg

Pumping Speed vs. Regimes

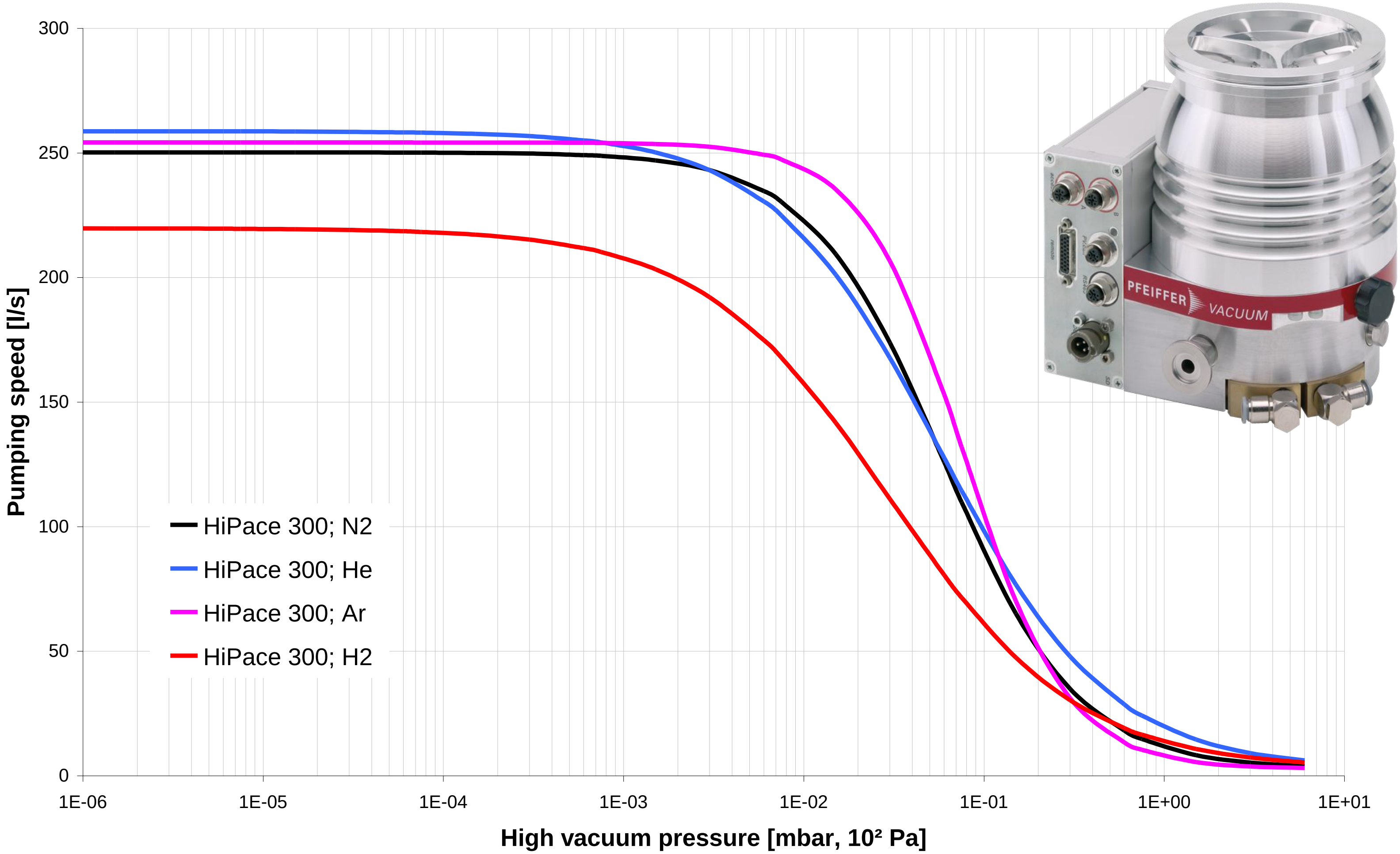


Important Technical Data

- Pumping speed — S [l/s]
- Compression ratio (Q=0) : — $K_0 = p_{FV} / p_{HV}$
- Max. backing pressure: — $p_{FV\ max.}$ [mbar]
- Max. gasload: — $Q_{max.}$ [mbar l / s]

(according to ISO 5302: Vacuum Technology TMP-Measurement and Performance)

Gas Type dependant Pumping Speed



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Technical Data
Example HiPace 300

- Pumping speed

S_{N2} = 260 l/s

S_{H2} = 220 l/s

- Compression ratio (Q=0) :

$K_{0\ N2}$ => 1 E 11

$K_{0\ H2}$ = 9 E 5

- Max. backing pressure:

$p_{FV\ max.}$ = 20 mbar l/s

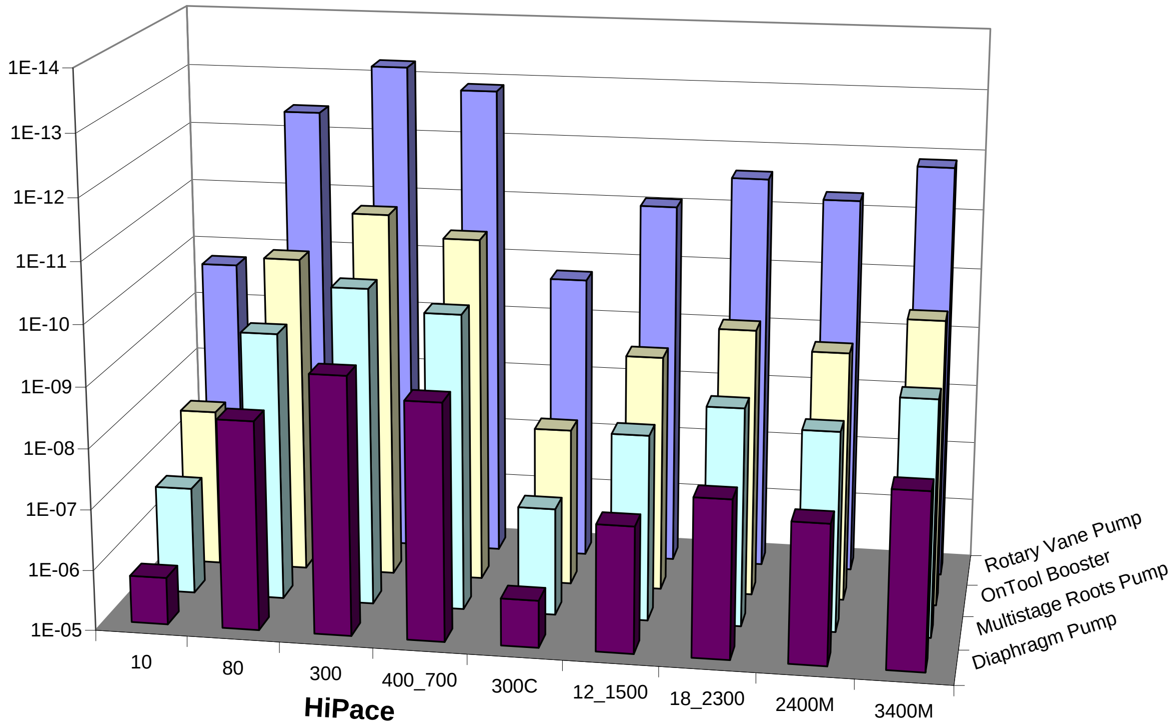
- Max. gas load:

$Q_{max.}$ = 14 mbar l/s

(according to ISO 5302: Vacuum Technology
TMP-Measurement and Performance)

Backing Pump Selection for UHV

(U)HV - partial pressure H_2 in mbar



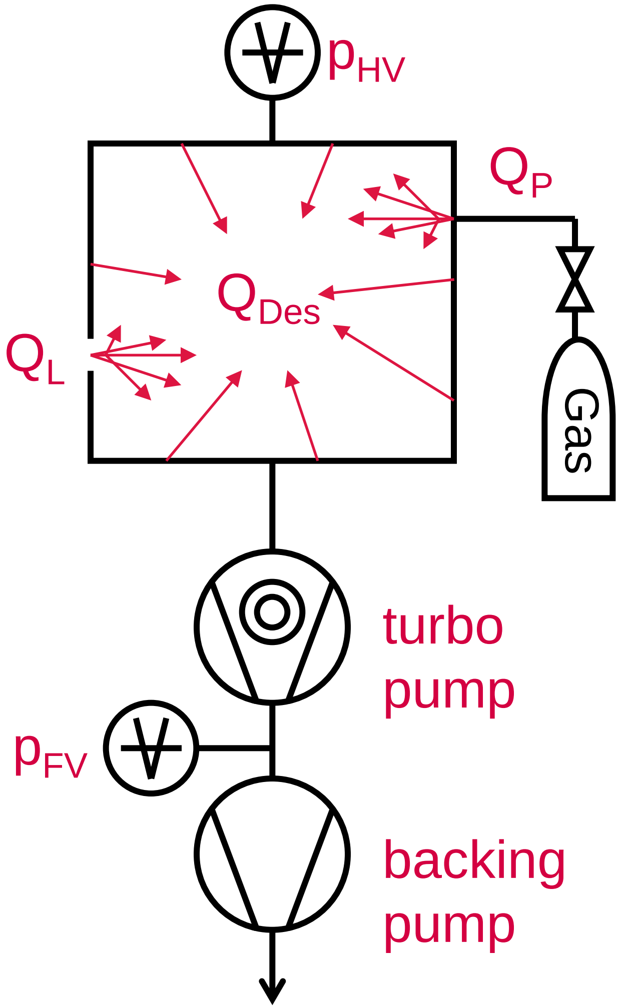
$$p_{HV\,i} = \frac{p_{Atm\,i}}{k_{oi\,BP} \cdot k_{oi\,TMP}}$$

$$p_{HV\,H_2} = \frac{5 \cdot 10^{-3}\,mbar_{\,H_2}}{1 \cdot 10^{6}{}_{RVP} * 1 \cdot 10^{4}{}_{TMP}}$$

$$p_{HV\,H_2} = 5 \cdot 10^{-13}\,mbar_{\,H_2}$$

(w/o desorption effects)

Chamber Pressure Calculation

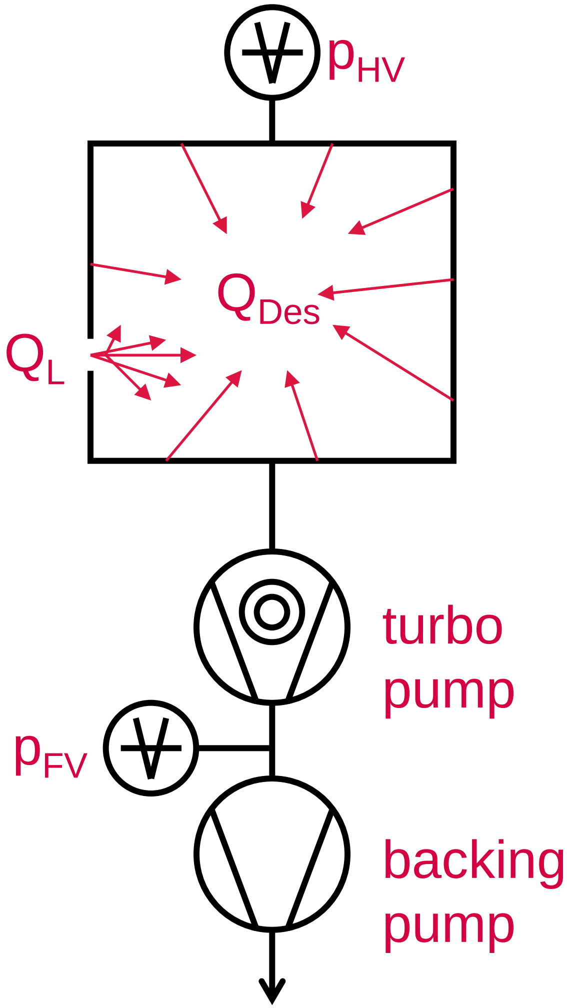


Gas Load Applications

$$p_{HV} = \frac{Q_P + Q_{Des} + Q_L}{S_{TMP,eff}} + \frac{p_{FVH_2}}{K_{0H_2}} + \frac{p_{FVG2}}{K_{0G2}} + \cdots$$

Q_P = Process gas flow
Q_{Des} = Desorption gas flow
Q_L = Gas flow caused by leaks

Chamber Pressure Calculation



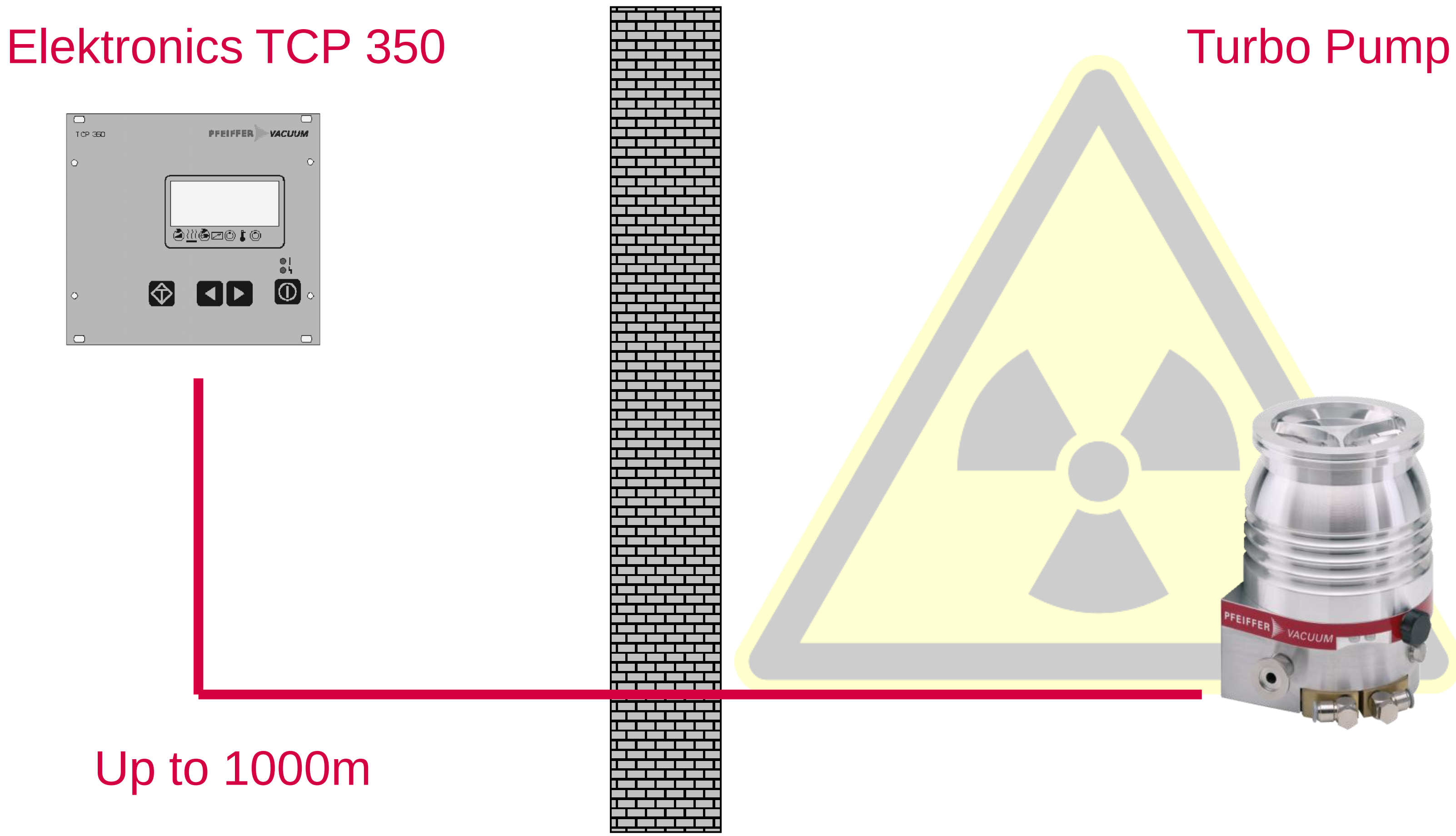
UHV Applications

$$p_{HV} = \frac{Q_{Des} + Q_L}{S_{TMP,eff}} + \frac{p_{FV H_2}}{K_{0H_2}} + \frac{p_{FV G2}}{K_{0G2}} + \cdots$$

Q_{Des} = Desorption gas flow
Q_L = Gas flow caused by leaks

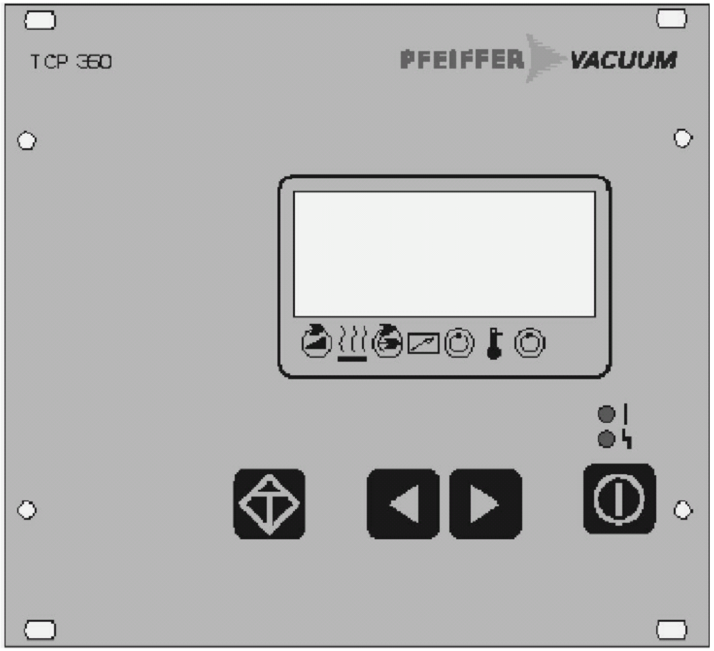
K_0 = Compression ratio
p_{FV} = Fore vacuum pressure

Turbo Pumps with external Controller



TCP 350 - Controller for radiation environment

- Turbo controller for rack mounting
- For applications in radiation environment
- No semiconductor elements on the pump



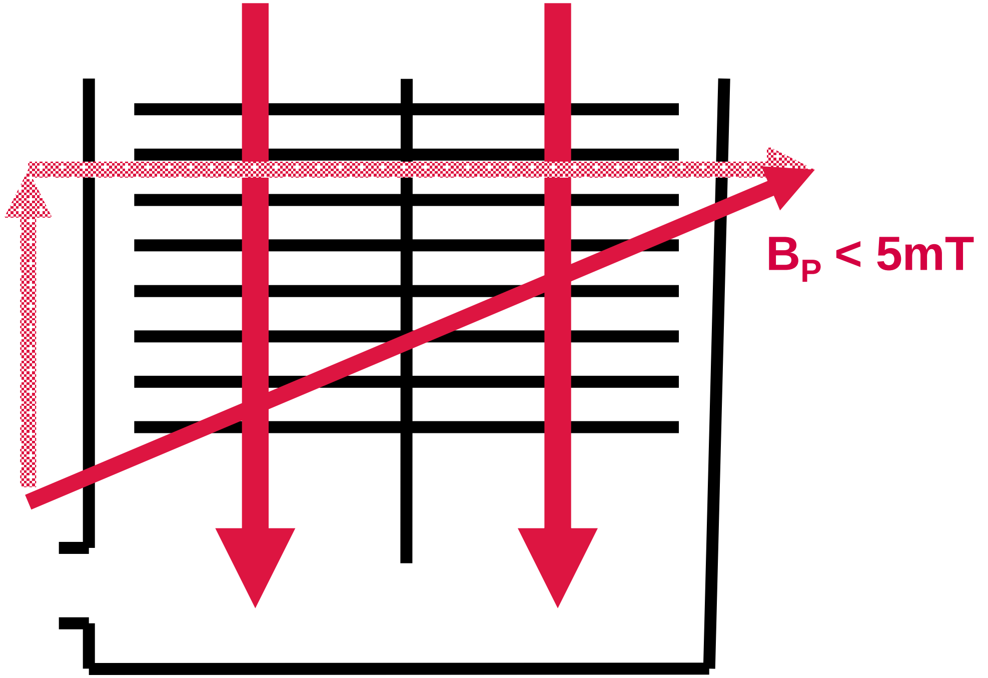
Easy on Side Service

- Bearing installed in a cartridge
- Easy to exchange
- Exchange possible on side
- No adjustment of the bearing
- No rotor rebalancing required
- Service interval 4 years in clean applications

Application Limits

Rotor Temperature < 120°C

- Gas friction
- Magnetic fields
- Heat radiation



Summary

- The turbo pump is suitable for very many applications
- It has been proven as a reliable tool in all kind of industries
- With modern technologies it is easy to operate and to maintain
- Even for UHV applications it is the right choice

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