A rough guide turbo pump selection

Making sense of the spaghetti of technical data and specifications

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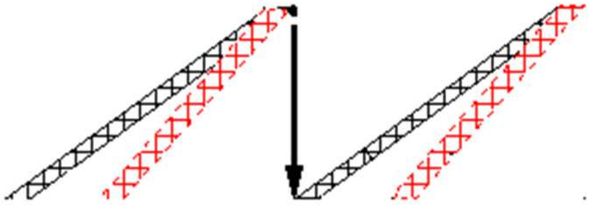
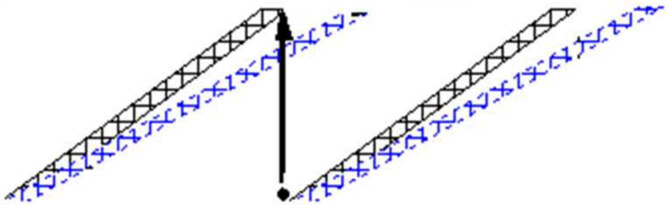
A rough guide turbo pump selection

- brief description of how a turbo works
- typical published data
- specifying a turbo for a system
- audience examples and discussion

How does a turbo pump work?



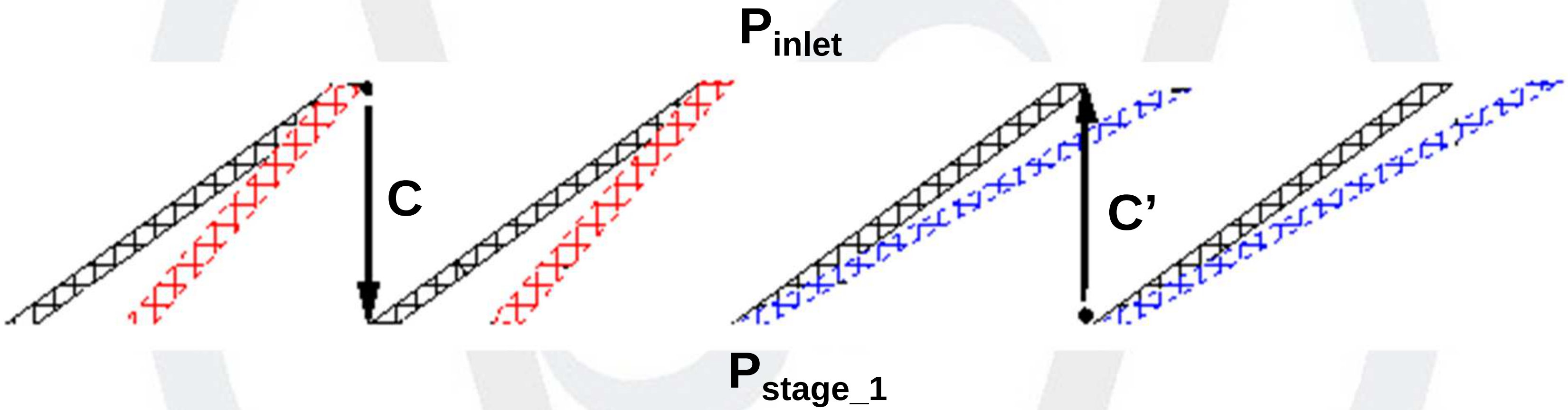
- Conductance for molecules entering pump is increased



- Conductance for molecules in contra-flow is decreased

How does a turbo work?

$$S \equiv Q/P$$



$$Q = P_{inlet}C - P_{stage\_1}C'$$

Pumping Speed

$$Q = P_0 C_1 - P_1 C_1^{'}$$

$$P_0 = {(Q + P_1 C_1')} \big/ {C_1}$$

$$S = C_1 - C_1' \frac{P_1}{P_0}$$

many stages – (cf 9): P_1 from P_2 ; P_2 from P_3 etc; P_{last} from P_{back}

each stage has an incremental effect

Compression ratio, *R*

$$R \equiv P_{back} / P_{inlet}, Q = 0$$

$$P_0 = \frac{C_1'}{C_1} P_1$$

$$P_n = \frac{C_{n+1}'}{C_{n+1}} P_{n+1}$$

Total compression ratio is the product of all the stages

Comments on *S* and *R*

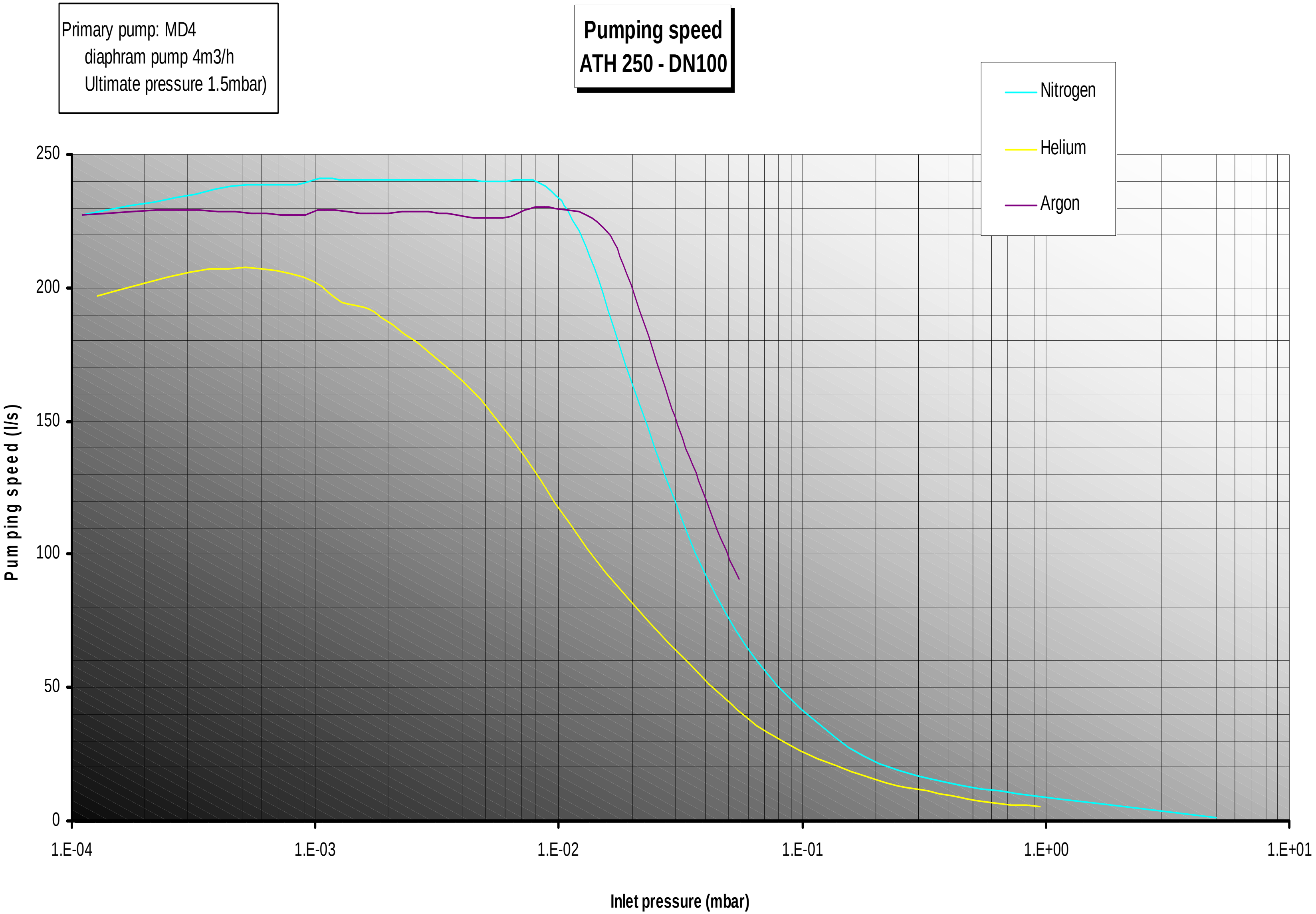
lighter gases move faster so “Mach” angle of blades is reduced:

- reduced pumping speed
- reduced compression ratio

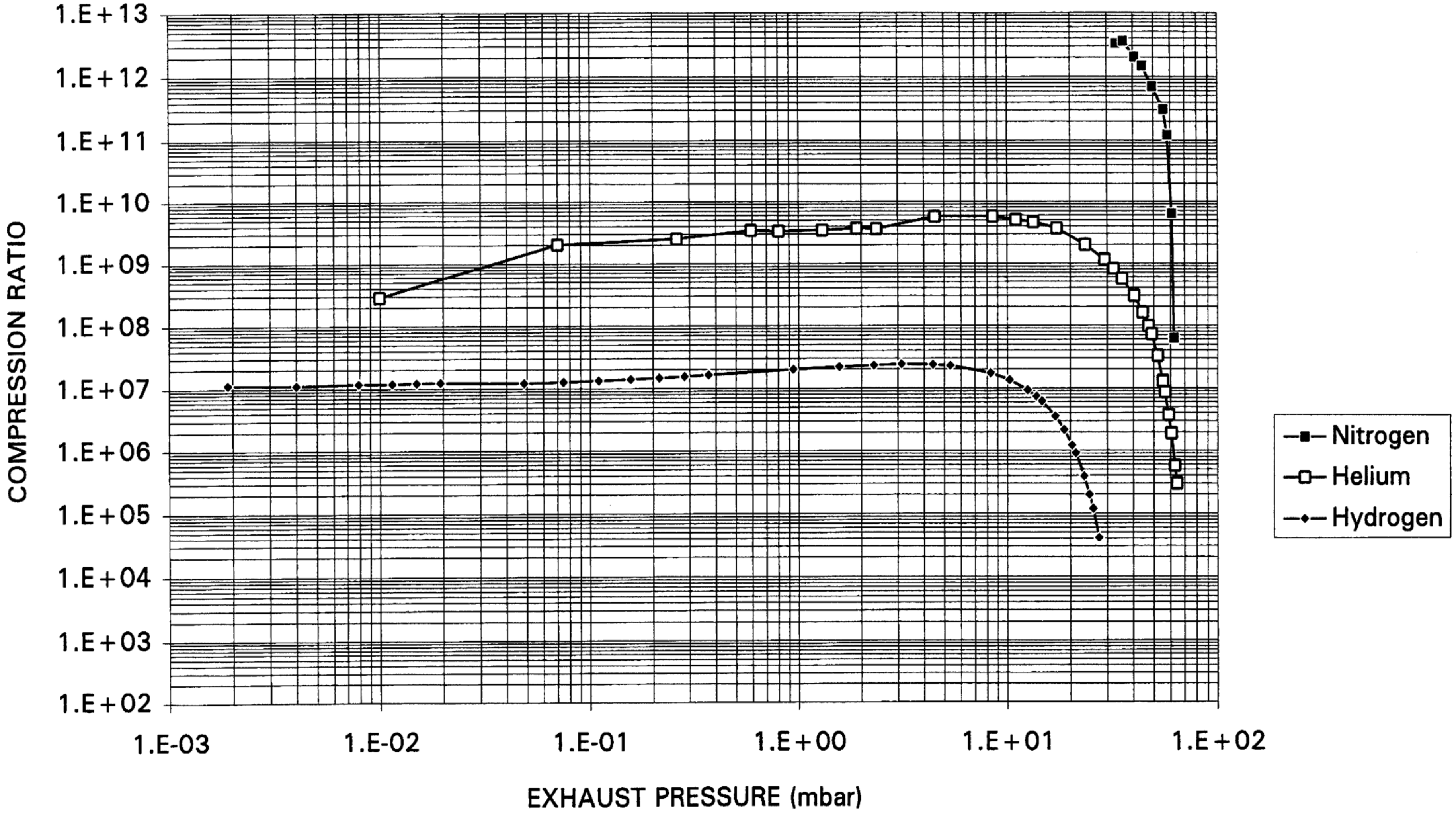
heavier gases are less mobile so slower to pump:

- reduces pumping speed

Pumping speed



Compression ratio



Technical Specifications

Characteristics		Unit	ATH 300	ATH 300 Ci
Inlet flange	DN		100 ISO-K / 100 CF-F 160 ISO-K / 160 CF-F	
Rotation speed		rpm	42,000	
Pumping speed at inlet	N2 He	l/s	250 (DN 100) 215 (DN 100)	300 (DN 160) 240 (DN 160)
Pumping speed*** at intermediate port	N2 He	l/s	- -	2-5 3-5
Compression rate at inlet	N2 He		1×10^{9} 1×10^{5}	
Compression rate at intermediate port	N2 He		- -	7×10^{4} 2×10^{2}
Ultimate pressure* at inlet		mbar	$< 1 \times 10^{9}$	
Ultimate pressure* at intermediate port		mbar	-	1×10^{6}
Maximum pressure at inlet** in continuous operation		mbar	1×10^{1}	
Maximum pressure at exhaust** in continuous operation		mbar	10	
Noise level		dBA	< 53	
Weight		kg	6.5 (ISO-K)	10.5 (CF-F)
Recommended primary pump			RVP, ACP 28, AMD	
Vibration level		mm/s	< 0.3	
Starting power		VA	250	
Nominal power		W	300	
Start-up time (0 to 42000 rpm)		min	< 3.5	
Cooling			Standard: natural convection Forced air: option Water: option	
Mounting orientation			any	
Intermediate port flange	DN		-	16 ISO-KF
Exhaust flange	DN		25 ISO-KF	

* Measured according to Pneurop Standard with CFF flange and RVP, after 48h in vacuum oven.
**The two maximum pressures cannot occur at the same time.
*** According to the intermediate port pressure.

Technical Specifications

Technical Data

Turbomolecular Pump	TURBOVAC	SL 80		SL 300		SL 700	
Inlet flange	DN	63 ISO-K	63 CF	100 ISO-K	100 CF	160 ISO-K	160 CF
Pumping speed							
N_2	l/s	65		270		690	
Ar	l/s	60		260		630	
H_2	l/s	49		190		580	
He	l/s	55		255		360	
Max. gas throughput with water cooling device							
N_2	mbar l/s	2.0		2.9		5.6	
Ultimate pressure*							
with dual-stage oil-sealed rotary vane pump	mbar	$< 2 \times 10^{-10}$		$< 1 \times 10^{-10}$		$< 10^{-9}$	
Max. foreline pressure for N_2, water-cooled version	mbar	< 20		< 8		< 15	
Recommended fore vacuum pump							
dual-stage oil-sealed rotary vane pump		TRIVAC 2.5 E TRIVAC NT 5		TRIVAC NT 5 TRIVAC NT 10		TRIVAC NT 10 TRIVAC NT 16	
scroll vacuum pump		SCROLLVAC SC 5 D		SCROLLVAC SC 5 D SCROLLVAC SC 15 D		SCROLLVAC SC 15 D SCROLLVAC SC 30 D	
diaphragm pump		DIVAC 2.5 VT		DIVAC 2.5 VT		–	
Run-up time	min	1.5		4		5	
Power consumption at ultimate pressure	W	17		18		60	
Noise level	dB(A)	< 46		< 49		< 47	
Weight with TURBO.DRIVE	kg	2.5	3.7	5.8	8.0	14.8	18.1

* CF flange configuration

Specifying a turbo pump

- Pumping Speed:
  - volumetric pumping: $t = -\frac{V}{S} \ln \frac{P_t}{P_0}$; about 2.3V/S sec/decade
  - but surface degassing: $\frac{dP}{dt} = \frac{1}{V}\left\{-SP + Q(t)_{desorb} + Q_{leak}\right\}$
  - ultimate pressure only linear with pumping speed
  - vacuum is logarithmic!
  - big turbos don't guarantee UHV!

Specifying a turbo pump

- Compression Ratio:
  - compression ratio limit contribution to high vacuum pressure:
  - $P_{comp} = P_{back}/R$
  - so $P_{hv} = Q/S + P_{back}/R$
  - backing pressure can have an impact on high vacuum pressure, especially when pumping light gases:
  - high throughput turbos for high gas load applications;
  - high compression turbos for UHV applications
  - hybrid turbos have built in HV backing pump!

Specifying a turbo pump

- Cooling and motor power:
  - in high load applications look out for max continuous inlet pressure
  - can depend on type of cooling
  - for high throughput lookout for ramp up time and motor power

Summary

- Gas load applications:
- eg. sputtering -
  - look for high throughput turbo
- match application to flow vs inlet pressure curves
- High throughput applications:
- fast cycle times -
- look for high motor power and rapid ramp up
- UHV applications:
- look for high compression esp. in H_2
- high speed in H_2