APPLICATION NOTE

CONDUCTANCE

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In Vacuum Science text books, training courses and the wisdom passed down the generations etc. we are instructed that ‘all vacuum connections should be short and wide as possible’. But, what happens when we do not do this? What is the consequence of non-compliance?

In vacuum terminology the conductance C between two points is defined as the gas throughput Q (through a component) divided by the pressure drop (ΔP) across it, where P_{up} is the upstream pressure of the system and P_{down} is the downstream pressure:

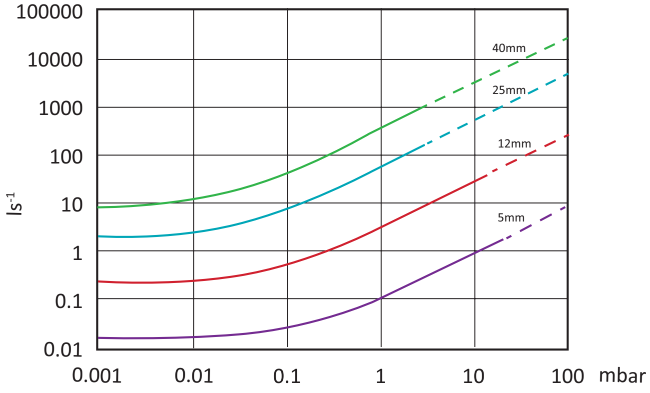
$$C = \frac{Q}{\Delta P} = \frac{PS}{P_{up} - P_{down}}$$

here **S** is the pumping speed at any point in the vacuum system.

Gas flow mechanisms can be divided into different regimes: continuum (where molecule-molecule collisions dominate behaviour), molecular (molecule-wall collisions dominate) and a transitional flow regime between these two regimes.

This is illustrated below (for air at 293K) where the conductance of a 1 metre length pipe is plotted for different diameters and pressures conductance varies as 1/length for long pipes.

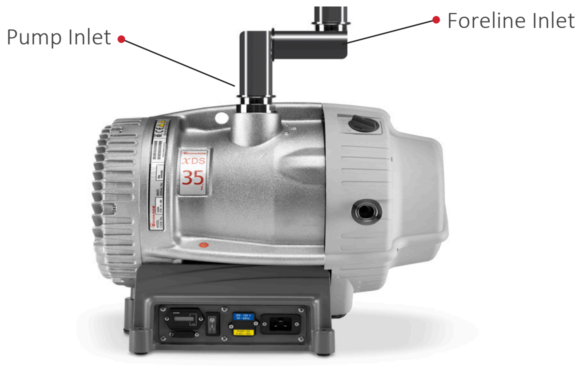
Conductance for 1 metre length of pipe



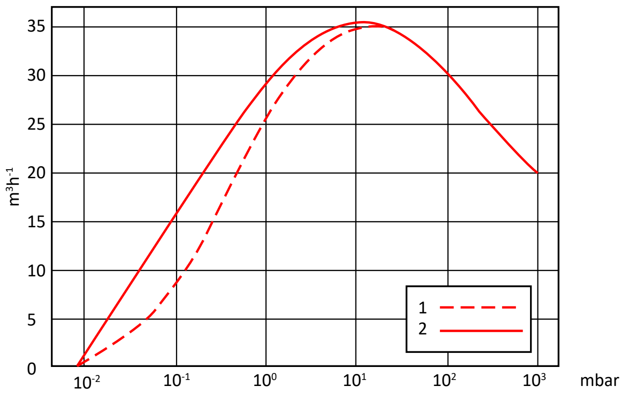
For molecular flow, conductance is independent of pressure (here $\lesssim$0.01 mbar), for continuum flow conductance is a linear function of pressure (here $\gtrsim$1 mbar) and the transitional flow and is an ‘admixture’ of the extreme pressure dependencies.

So what does this mean in the real vacuum world? We can illustrate by looking at a few examples.

1. **What is the effect of on the net pumping speed of a XDS35i scroll pump with a 5m NW40 fore-line with 2 bends?**



For air at 293K

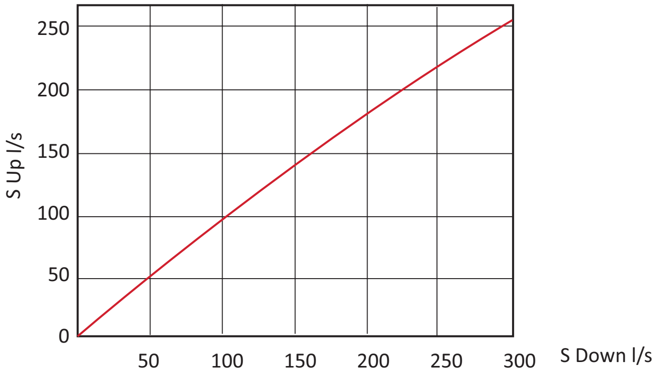


1. Forline Inlet 2. Pump Inlet

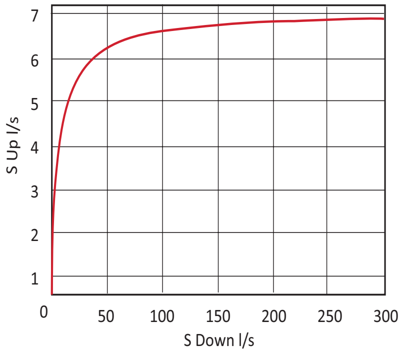
We can see that at higher pressures (where the pipe conductance is highest) there is no impact on the net speed. The percentage difference though becomes more pronounced at < 10 mbar (50% loss) and then only becomes negligible at the ultimate pressure of the system (with zero net speed).

2. System with a gate valve

Consider a system with a turbo-molecular pump (TMP) connected directly to a chamber via an ISO100 gate-valve (which has a stated relatively large molecular conductance of ~ 1,700 l/s). The graph below shows the net System speed (S_{Up}) with a range of TMP speeds (S_{Down}); a small loss of conductance in molecular flow conditions.

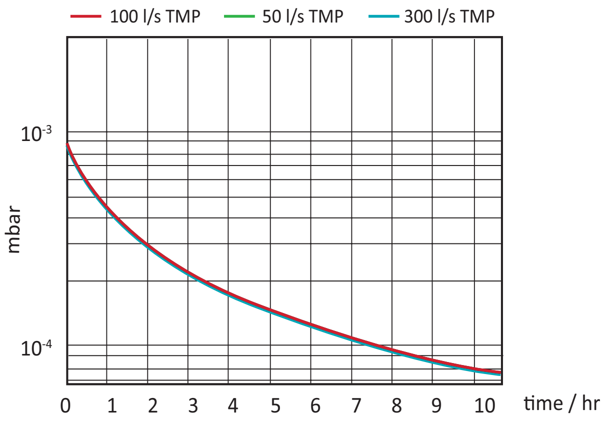


3. **The previous example shows a not too different outcome reflecting the relatively large conductance of the gate valve involved.** As a comparison it is interesting to use this same example but in this case we add a 1m x NW40 pipe connection. There is a significant impact on net speed as shown.



4. **Thermal solar vacuum (glass) tubes concentrate solar radiation to heat a transfer fluid.** They have typical dimensions 2 m x 8 cm diameter and are connected to a vacuum system by a short glass ‘stub’ connection of ~8 mm in diameter x 5 cm length.

Clearly we would expect to see a significant limitation on the pump-down performance of this ‘stub’ restriction. This is shown below for the evacuation (from a vacuum of 0.01 mbar) of a thermal vacuum tube with different TMP speeds: the benefit of using a larger TMP is extremely limited.



So, yes short and wide is the Vacuum Golden Rule!

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