

High Vacuum System Engineering Calculations
2.75" Conflat High Vacuum System
Design Iteration #4
Molecular Flow with Air at 20C

CONDUCTANCE CALCULATIONS – MOLECULAR FLOW
(For Use in Standardized System Benchmark Comparisons @ < 10⁻³ Torr)

1.) Diffusion Pump

→ Max Pumping Speed of Diffusion Pump (Air)

→ **$S_{diff} = 600 \text{ l/sec}$**

2.) Diffusion Pump to Water Cooled Baffle Adapter (@ 20C)

→ Conductance of a Tube

$$C_m = 3.8 \left(\frac{T}{M} \right)^{\frac{1}{2}} \frac{D^3}{L}$$

C_m = conductance (l/sec)

T = temperature (K) = 293.15

M = molecular mass = 28.971 (average AMU of air)

D = diameter (cm) = 10.668

L = length (cm) = 1.27

$C_m = 11555.589 \text{ l/sec}$

→ Conductance of a Short Tube

$$C_{short} = C_m \left(1 + \frac{4D}{3L} \right)^{-1}$$

C_{short} = conductance of short tube (l/sec)

C_m = conductance of a long tube (l/sec) = 11555.589

D = diameter (cm) = 10.668

L = length (cm) = 1.27

$C_{short} = 947.179 \text{ l/sec}$

→ for $L/D < 5$, above equation is valid for short pipes, with error

$$L/D = 0.119$$

~+12% error max:

$$C_{shortFinal} = C_{short} \times 0.88$$

$C_{shortFinal} = 833.518 \text{ l/sec}$

→ Correction for Extended Baffle Fins

$$C_{shortFinal} = C_{short} \times 0.50$$

$C_{shortFinal} = 416.759 \text{ l/sec}$

→ **$C_{baffle_adapter} = 416.759 \text{ l/sec}$**

3.) Water Cooled Baffle (@ 20C)

→ Conductance of a Tube

$$C_m = 3.8 \left(\frac{T}{M} \right)^{\frac{1}{2}} \frac{D^3}{L}$$

C_m = conductance (l/sec)

T = temperature (K) = 293.15

M = molecular mass = 28.971 (average AMU of air)

D = diameter (cm) = 10.605

L = length (cm) = 2.032

$$C_m = 7095.044 \text{ l/sec}$$

→ Conductance of a Short Tube

$$C_{short} = C_m \left(1 + \frac{4D}{3L} \right)^{-1}$$

C_{short} = conductance of short tube (l/sec)

C_m = conductance of a long tube (l/sec) = 7095.044

D = diameter (cm) = 10.605

L = length (cm) = 2.032

$$C_{short} = 891.487 \text{ l/sec}$$

→ for $L/D < 5$, above equation is valid for short pipes, with error

$$L/D = 0.192$$

~+12% error max:

$$C_{shortFinal} = C_{short} \times 0.88$$

$$C_{shortFinal} = 784.509 \text{ l/sec}$$

→ Correction for Baffle Fins

$$C_{shortFinal} = C_{short} \times 0.50$$

$$C_{shortFinal} = 392.255 \text{ l/sec}$$

→ **$C_{baffle} = 392.255 \text{ l/sec}$**

4.) Diffusion Pump to 2.75" Conflat Adapter Plate

→ Conductance of a Tube

$$C_m = 3.8 \left(\frac{T}{M} \right)^{\frac{1}{2}} \frac{D^3}{L}$$

C_m = conductance (l/sec)

T = temperature (K) = 293.15

M = molecular mass = 28.971 (average AMU of air)

D = diameter (cm) = 3.556

L = length (cm) = 2.54

$$C_m = 213.992 \text{ l/sec}$$

→ Conductance of a Short Tube

$$C_{short} = C_m \left(1 + \frac{4D}{3L} \right)^{-1}$$

C_{short} = conductance of short tube (l/sec)

C_m = conductance of a long tube (l/sec) = 213.992

D = diameter (cm) = 3.556

L = length (cm) = 2.54

$$C_{short} = 74.649 \text{ l/sec}$$

→ for $L/D < 5$, above equation is valid for short pipes, with error

$$L/D = 0.714$$

~+12% error max:

$$C_{shortFinal} = C_{short} \times 0.88$$

$$C_{shortFinal} = \mathbf{65.691 \text{ l/sec}}$$

→ **$C_{plate \text{ adapter}} = 65.691 \text{ l/sec}$**

5.) 2.75" Conflat 4-Way Cross

→ Conductance of a Tube

$$C_m = 3.8 \left(\frac{T}{M} \right)^{\frac{1}{2}} \frac{D^3}{L}$$

C_m = conductance (l/sec)

T = temperature (K) = 293.15

M = molecular mass = 28.971 (average AMU of air)

D = diameter (cm) = 3.556

L = length (cm) = 12.492

$$C_m = \mathbf{43.511 \text{ l/sec}}$$

→ Conductance of a Short Tube

$$C_{short} = C_m \left(1 + \frac{4D}{3L} \right)^{-1}$$

C_{short} = conductance of short tube (l/sec)

C_m = conductance of a long tube (l/sec) = 43.511

D = diameter (cm) = 3.556

L = length (cm) = 12.492

$$C_{short} = \mathbf{31.540 \text{ l/sec}}$$

→ for $L/D < 5$, above equation is valid for short pipes, with error

$$L/D = 3.5$$

~+9% error max:

$$C_{shortFinal} = C_{short} \times 0.91$$

$$C_{shortFinal} = \mathbf{28.701 \text{ l/sec}}$$

→ **$C_{cross} = 28.701 \text{ l/sec}$**

6.) 2.75" Conflat Gate Valve

→ Conductance of a Tube

$$C_m = 3.8 \left(\frac{T}{M} \right)^{\frac{1}{2}} \frac{D^3}{L}$$

C_m = conductance (l/sec)

T = temperature (K) = 293.15

M = molecular mass = 28.971 (average AMU of air)

D = diameter (cm) = 3.810

L = length (cm) = 5.080

$$C_m = \mathbf{131.601 \text{ l/sec}}$$

→ Conductance of a Short Tube

$$C_{short} = C_m \left(1 + \frac{4D}{3L}\right)^{-1}$$

C_{short} = conductance of short tube (l/sec)

C_m = conductance of a long tube (l/sec) = 213.992

D = diameter (cm) = 3.556

L = length (cm) = 2.54

$$C_{short} = 65.800 \text{ l/sec}$$

→ for $L/D < 5$, above equation is valid for short pipes, with error

$$L/D = 1.333$$

~+12% error max:

$$C_{shortFinal} = C_{short} \times 0.88$$

$$C_{shortFinal} = 57.904 \text{ l/sec}$$

→ $C_{gate_valve} = 57.904 \text{ l/sec}$

7.) TOTAL SYSTEM CONDUCTANCE

→ Conductance of Pipeline

$$\frac{1}{C_{pipeline}} = \frac{1}{C_{baffle_adapter}} + \frac{1}{C_{baffle}} + \frac{1}{C_{plate_adapter}} + \frac{1}{C_{cross}} + \frac{1}{C_{gate_valve}}$$
$$\frac{1}{C_{pipeline}} = \frac{1}{416.759} + \frac{1}{392.255} + \frac{1}{65.691} + \frac{1}{28.701} + \frac{1}{57.904}$$
$$C_{pipeline} = 13.834 \text{ l/sec}$$

→ $C_{pipeline} = 13.834 \text{ l/sec}$

→ Effective Pumping Speed of the System

$$\frac{1}{S_e} = \frac{1}{C_{pipeline}} + \frac{1}{S_{diff}}$$

$$S_e = \frac{C_{pipeline} \times S_{diff}}{C_{pipeline} + S_{diff}}$$

$$C_{pipeline} = 13.834 \text{ l/s}$$

$$S_{diff} = 600 \text{ l/s}$$

$$S_e = 13.522 \text{ l/s}$$

→ $S_e = 13.522 \text{ l/sec}$