High Vacuum System Engineering Calculations
2.75" Conflat High Vacuum System
Design Iteration #3
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)

→ $\boldsymbol{S_{diff} = 600\ l/sec}$

2.) Diffusion Pump to 2.75" Conflat Adapter Plate
→ Conductance of a Tube

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

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

→ Conductance of a Short Tube

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

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

→ for L/D < 5, above equation is valid for short pipes, with error
$L/D = 0.714$
~+12% error max:
$C_{shortFinal} = C_{short} \times 0.88$
$\boldsymbol{C_{shortFinal} = 65.691\ l/sec}$

→ $\boldsymbol{C_{adapter} = 65.691\ l/sec}$

3.) 2.75" Conflat 4-Way Cross
→ Conductance of a Tube

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

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
$\boldsymbol{C_m = 43.511\ l/sec}$

→ Conductance of a Short Tube

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

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
$\boldsymbol{C_{short} = 31.540\ l/sec}$

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

$L/D = 3.5$
~+9% error max:
$C_{shortFinal} = C_{short} \times 0.91$
$\boldsymbol{C_{shortFinal} = 28.701\ l/sec}$

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

4.) 2.75" Conflat Gate Valve

→ Conductance of a Tube

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

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
$\boldsymbol{C_m = 131.601\ l/sec}$

→ Conductance of a Short Tube

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

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

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

$L/D = 1.333$
~+12% error max:
$C_{shortFinal} = C_{short} \times 0.88$
$\boldsymbol{C_{shortFinal} = 57.904\ l/sec}$

→ $\boldsymbol{C_{gate\_valve} = 57.904\ l/sec}$

5.) TOTAL SYSTEM CONDUCTANCE

→ **Conductance of Pipeline**

$$\frac{1}{C_{pipeline}} = \frac{1}{C_{adapter}} + \frac{1}{C_{cross}} + \frac{1}{C_{gate\_valve}}$$

$$\frac{1}{C_{pipeline}} = \frac{1}{65.691} + \frac{1}{28.701} + \frac{1}{57.904}$$

$$C_{pipeline} = 14.851\ l/sec$$

→ $C_{pipeline} = 14.851\ l/sec$

→ **Effective Pumping Speed of the System**

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

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

$$C_{pipeline} = 14.851\ l/s$$

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

$$S_e = 14.492\ l/s$$

→ $S_e = 14.492\ l/sec$