High Vacuum System Engineering Calculations
2.75" Conflat High Vacuum System
Design Iteration #3
Molecular Flow with Argon at 20C

CONDUCTANCE CALCULATIONS – MOLECULAR FLOW
(For Use with Argon-Ion Beam Systems @ <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 = 39.948 (average AMU of argon)
D = diameter (cm) = 3.556
L = length (cm) = 2.54
$\boldsymbol{C_m = 182.235\ l/sec}$

→ 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) = 182.235
D = diameter (cm) = 3.556
L = length (cm) = 2.54
$\boldsymbol{C_{short} = 63.570\ l/sec}$

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

$L/D = 0.714$
~+12% error max:
$C_{shortFinal} = C_{short} \times 0.88$
$\boldsymbol{C_{shortFinal} = 55.942\ l/sec}$

→ $\boldsymbol{C_{adapter} = 55.942\ l/sec}$

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 = 39.948 (average AMU of argon)
D = diameter (cm) = 3.556
L = length (cm) = 12.492
$\boldsymbol{C_m = 37.054\ l/sec}$

→ 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) = 37.054
D = diameter (cm) = 3.556
L = length (cm) = 12.492
$\boldsymbol{C_{short} = 26.859\ l/sec}$

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

$L/D = 3.5$
~+9% error max:
$C_{shortFinal} = C_{short} \times 0.91$
$\boldsymbol{C_{shortFinal} = 24.442\ l/sec}$

→ $\boldsymbol{C_{cross} = 24.442\ l/sec}$

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 = 39.948 (average AMU of argon)
D = diameter (cm) = 3.810
L = length (cm) = 5.050
$\boldsymbol{C_m = 112.071\ l/sec}$

→ 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) = 112.071
D = diameter (cm) = 3.556
L = length (cm) = 2.54
$\boldsymbol{C_{short} = 56.035\ l/sec}$

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

$L/D = 1.333$
~+12% error max:
$C_{shortFinal} = C_{short} \times 0.88$
$\boldsymbol{C_{shortFinal} = 49.311\ l/sec}$

→ $\boldsymbol{C_{gate\_valve} = 49.311\ l/sec}$

5.) TOTAL SYSTEM CONDUCTANCE

→ **Conductance of Pipeline**

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

$$\frac{1}{C_{pipeline}} = \frac{1}{55.942} + \frac{1}{24.442} + \frac{1}{49.311}$$

$$C_{pipeline} = 12.647\ l/sec$$

→ $C_{pipeline} = 12.647\ l/sec$

→ **Effective Pumping Speed of the System**

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

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

$$C_{pipeline} = 12.647\ l/s$$

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

$$S_e = 12.386\ l/s$$

→ $S_e = 12.386\ l/sec$