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

CONDUCTANCE CALCULATIONS – MOLECULAR FLOW
(For Use with General Pump-Down @ <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 = 18.020 (average AMU of water vapor)
D = diameter (cm) = 3.556
L = length (cm) = 2.54

$$\boldsymbol{C_m = 271.333\ l/sec}$$

→ 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) = 271.333
D = diameter (cm) = 3.556
L = length (cm) = 2.54

$$\boldsymbol{C_{short} = 94.561\ l/sec}$$

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

$$L/D = 0.714$$

~+12% error max:

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

$$\boldsymbol{C_{shortFinal} = 83.293\ l/sec}$$

→ $\boldsymbol{C_{adapter} = 83.293\ l/sec}$

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 = 18.020 (average AMU of water vapor)
D = diameter (cm) = 3.556
L = length (cm) = 12.492
$\boldsymbol{C_m = 55.170\ l/sec}$

→ 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
$\boldsymbol{C_{short} = 39.991\ l/sec}$

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

$L/D = 3.5$
~+9% error max:
$C_{shortFinal} = C_{short} \times 0.91$
$\boldsymbol{C_{shortFinal} = 36.392\ l/sec}$

→ $\boldsymbol{C_{cross} = 36.392\ l/sec}$

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 = 18.020 (average AMU of water vapor)
D = diameter (cm) = 3.810
L = length (cm) = 5.050
$\boldsymbol{C_m = 166.864\ l/sec}$

→ 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) = 166.864
D = diameter (cm) = 3.556
L = length (cm) = 2.54
$\boldsymbol{C_{short} = 83.432\ l/sec}$

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

$L/D = 0.714$
~+12% error max:
$C_{shortFinal} = C_{short} \times 0.88$
$\boldsymbol{C_{shortFinal} = 73.420\ l/sec}$

→ $\boldsymbol{C_{gate\_valve} = 73.420\ l/sec}$

5.) TOTAL SYSTEM CONDUCTANCE

→ Conductance of Pipeline

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

$$\frac{1}{C_{pipeline}} = \frac{1}{83.293} + \frac{1}{36.392} + \frac{1}{73.420}$$

$$C_{pipeline} = \ 18.831\ l/sec$$

→ $\boldsymbol{C_{pipeline} = 18.831\ l/sec}$

→ Effective Pumping Speed of the System

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

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

$$C_{pipeline} = 11.078\ l/s$$

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

$$\boldsymbol{S_e = 18.258\ l/s}$$

→ $\boldsymbol{S_e = 18.258\ l/sec}$