High Vacuum System Engineering Calculations
2.75" Conflat High Vacuum System
Design Iteration #2
Transitional Flow with Deuterium at 20C

CONDUCTANCE CALCULATIONS – TRANSITIONAL FLOW
(For Use with Deuterium Injected Fusor Systems @ 10^-2 Torr)

1.) Diffusion Pump

→ Max Pumping Speed of Diffusion Pump @ 10^-2 torr

→ $\boldsymbol{S_{diff(k)} = 100\ l/sec}$

2.) Transitional Flow Conductance for Diffusion Pump to 2.75" Conflat Adapter Plate

→ Conductance of Pipes in Transitional Flow

$$C_k = C_m(0.0736\frac{D}{\lambda} + \frac{1+1.25D/\lambda}{1+1.55D/\lambda})$$

C_k = transitional flow conductance
C_m = conductance for molecular flow = $C_{adapter}$ = 249.147 l/s
D = diameter (cm) = 3.556
λ = mean free path at average pressure (P=10^-2 torr) (cm) = 0.5

$$\boldsymbol{C_k = 335.350\ l/sec}$$

→ $\boldsymbol{C_{k(adapter)} = 335.350\ l/sec}$

3.) Transitional Flow Conductance for 2.75" Conflat Inline Poppet Valve

→ Conductance of Pipes in Transitional Flow

$$C_k = C_m(0.0736\frac{D}{\lambda} + \frac{1+1.25D/\lambda}{1+1.55D/\lambda})$$

C_k = transitional flow conductance
C_m = conductance for molecular flow = C_{poppet_valve} = 91.932 l/s
D = diameter (cm) = 3.556
λ = mean free path at average pressure (P=10^-2 torr) (cm) = 0.5

$$\boldsymbol{C_k = 123.740\ l/sec}$$

→ $\boldsymbol{C_{k(poppet\_valve)} = 123.740\ l/sec}$

4.) Transitional Flow Conductance for 2.75" Conflat Butterfly Valve

→ Conductance of Pipes in Transitional Flow

$$C_k = C_m(0.0736\frac{D}{\lambda} + \frac{1+1.25D/\lambda}{1+1.55D/\lambda})$$

C_k = transitional flow conductance
C_m = conductance for molecular flow = $C_{butterfly\_valve}$ = 163.939 l/s
D = diameter (cm) = 3.556
λ = mean free path at average pressure (P=10^-2 torr) (cm) = 0.5

$$\boldsymbol{C_k = 220.661\ l/sec}$$

→ $C_{k(butterfly\_valve)} = 220.661\ l/sec$

5.) Transitional Flow Conductance for 2.75" Conflat 4-Way Cross

→ Conductance of Pipes in Transitional Flow

$$C_k = C_m(0.0736\frac{D}{\lambda} + \frac{1+1.25D/\lambda}{1+1.55D/\lambda})$$

C_k = transitional flow conductance

C_m = conductance for molecular flow = C_{cross} = 108.857 l/s

D = diameter (cm) = 3.556

λ = mean free path at average pressure (P=10^-2 torr) (cm) = 0.5

$\boldsymbol{C_k = 146.521\ l/sec}$

→ $C_{k(cross)} = 146.521\ l/sec$

6.) Total System Conductance

→ **Conductance of Pipeline**

$$\frac{1}{C_{k(pipeline)}} = \frac{1}{C_{k(adapter)}} + \frac{1}{C_{k(poppet\_valve)}} + \frac{1}{C_{k(butterfly\_valve)}} + \frac{1}{C_{k(cross)}}$$

$$\frac{1}{C_{k(pipeline)}} = \frac{1}{335.350} + \frac{1}{123.740} + \frac{1}{220.661} + \frac{1}{146.521}$$

$\boldsymbol{C_{k(pipeline)} = 11.760\ l/sec}$

→ $C_{k(pipeline)} = 44.603\ l/sec$

→ **Effective Pumping Speed of the System**

$$\frac{1}{S_{e(k)}} = \frac{1}{C_{k(pipeline)}} + \frac{1}{S_{diff(k)}}$$

$$S_{e(k)} = \frac{C_{k(pipeline)} \times S_{diff(k)}}{C_{k(pipeline)} + S_{diff(k)}}$$

$C_{k(pipeline)} = 8.737\ l/s$

$S_{diff(k)} = 100\ l/s$

$\boldsymbol{S_{e(k)} = 9.103\ l/s}$

→ $S_{e(k)} = 30.845\ l/sec$