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

CONDUCTANCE CALCULATIONS – TRANSITIONAL FLOW
(For Use in Standardized System Benchmark Comparisons @ 10^-2 Torr)

1.) Diffusion Pump

→ Max Pumping Speed of Diffusion Pump (Air) @ 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 = $C_{adapter}$ = 65.691 l/s

D = diameter (cm) = 3.556

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

$\boldsymbol{C_k = 88.420\ l/sec}$

→ $\boldsymbol{C_{k(adapter)} = 88.420\ l/sec}$

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} = 24.239 l/s

D = diameter (cm) = 3.556

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

$\boldsymbol{C_k = 32.626\ l/sec}$

→ $\boldsymbol{C_{k(poppet\_valve)} = 32.626\ l/sec}$

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 = $C_{butterfly\_valve}$ = 43.225 l/s

D = diameter (cm) = 3.556

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

$\boldsymbol{C_k = 58.181\ l/sec}$

→ $C_{k(butterfly\_valve)} = 58.181\ l/sec$

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} = 28.701 l/s

D = diameter (cm) = 3.556

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

$$\boldsymbol{C_k = 38.631\ l/sec}$$

→ $C_{k(cross)} = 38.631\ l/sec$

6.) Total System Conductance

→ Conductance of Pipeline

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

$$\frac{1}{C_{k(pipeline)}} = \frac{1}{88.420} + \frac{1}{32.626} + \frac{1}{58.181} + \frac{1}{38.631}$$

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

→ $C_{k(pipeline)} = 11.760\ l/sec$

→ Effective Pumping Speed of the System

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

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

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

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

$$\boldsymbol{S_{e(k)} = 10.523\ l/s}$$

→ $S_{e(k)} = 10.523\ l/sec$