High Vacuum System Engineering Calculations
2.75" Conflat High Vacuum System
Design Iteration #4
Transitional Flow with Argon at 20C

CONDUCTANCE CALCULATIONS – TRANSITIONAL FLOW
(For Use with Argon Plasmas and System Purging @ 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 Water Cooled Baffle Adapter (@ 20C)

→ Conductance of Pipes in Transitional Flow

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

C_k = transitional flow conductance
C_m = conductance for molecular flow = $C_{baffle\_adapter}$ = 354.911 l/s
D = diameter (cm) = 3.556
λ = mean free path at average pressure (P=10^-2 torr) (cm) = 0.5

$\boldsymbol{C_k = 477.707\ l/sec}$

→ $\boldsymbol{C_{k(baffle\_adapter)} = 560.954\ l/sec}$

3.) Transitional Flow Conductance for Water Cooled Baffle (@ 20C)

→ Conductance of Pipes in Transitional Flow

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

C_k = transitional flow conductance
C_m = conductance for molecular flow = C_{baffle} = 304.043 l/s
D = diameter (cm) = 3.556
λ = mean free path at average pressure (P=10^-2 torr) (cm) = 0.5

$\boldsymbol{C_k = 409.240\ l/sec}$

→ $\boldsymbol{C_{k(baffle)} = 409.240\ l/sec}$

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

→ Conductance of Pipes in Transitional Flow

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

C_k = transitional flow conductance
C_m = conductance for molecular flow = $C_{adapter}$ = 55.942 l/s
D = diameter (cm) = 3.556
λ = mean free path at average pressure (P=10^-2 torr) (cm) = 0.5

$\boldsymbol{C_k = 75.297\ l/sec}$

→ $\boldsymbol{C_{k(plate\_adapter)} = 75.297\ l/sec}$

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} = 24.442 l/s

D = diameter (cm) = 3.556

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

$\boldsymbol{C_k = 32.899\ l/sec}$

→ $\boldsymbol{C_{k(cross)} = 32.899\ l/sec}$

6.) Transitional Flow Conductance for 2.75" Conflat Gate 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_{gate_valve} = 49.311 l/s

D = diameter (cm) = 3.556

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

$\boldsymbol{C_k = 66.372\ l/sec}$

→ $\boldsymbol{C_{k(gate\_valve)} = 66.372\ l/sec}$

7.) Total System Conductance

→ **Conductance of Pipeline**

$$\frac{1}{C_{k(pipeline)}} = \frac{1}{C_{k(baffle\_adapter)}} + \frac{1}{C_{k(baffle)}} + \frac{1}{C_{k(plate\_adapter)}} + \frac{1}{C_{k(cross)}} + \frac{1}{C_{k(gate\_valve)}}$$

$$\frac{1}{C_{k(pipeline)}} = \frac{1}{560.954} + \frac{1}{409.240} + \frac{1}{75.297} + \frac{1}{32.899} + \frac{1}{66.372}$$

$\boldsymbol{C_{k(pipeline)} = 15.881\ l/sec}$

→ $\boldsymbol{C_{k(pipeline)} = 15.881\ l/sec}$

→ **Effective Pumping Speed of the System**

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

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

$C_{k(pipeline)} = 15.881\ l/s$

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

$\boldsymbol{S_{e(k)} = 13.705\ l/s}$

→ $\boldsymbol{S_{e(k)} = 13.705\ l/sec}$