APPLIED ION SYSTEMS

High Vacuum Engineering Calculations

Small-Scale Multipurpose High Vacuum System V5 Design

System Conductance and Effective Speed - Transitional Flow Water Vapor at 20C, 10^-2 Torr

1.) Diffusion Pump

→ Max Pumping Speed of Diffusion Pump @ 10^-2 torr (Derived Estimate for Water Vapor)

→ $\boldsymbol{S_{diff(k)} = 103\ l/sec}$

2.) Transitional Flow Conductance for Diffusion Pump to Water Cooled Baffle Adapter (@ 20C)

→ Conductance of Pipes in Transitional Flow

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

C_k = transitional flow conductance

C_m = conductance for molecular flow = $C_{baffle_adapter}$ = 1418.746 l/s

D = diameter (cm) = 12.70

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

$\boldsymbol{C_k = 3803.213\ l/sec}$

→ $\boldsymbol{C_{k(baffle_adapter)} = 3803.213\ l/sec}$

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

→ 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_{baffle} = 1421.145 l/s

D = diameter (cm) = 18.415

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

$\boldsymbol{C_k = 5003.101\ l/sec}$

→ $\boldsymbol{C_{k(baffle)} = 5003.101\ l/sec}$

4.) Transitional Flow Conductance for Diffusion Pump to 6" 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 = $C_{adapter}$ = 879.324 l/s

D = diameter (cm) = 10.16

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

$\boldsymbol{C_k = 2029.444\ l/sec}$

→ $\boldsymbol{C_{k(plate_adapter)} = 2029.444\ l/sec}$

5.) 6" to 2.75" Conflat Zero Clearance Reducer

→ 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 = $C_{reducer}$ = 118.234 l/s

D = diameter (cm) = 3.988

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

$$\boldsymbol{C_k = 166.470\ l/sec}$$

→ $\boldsymbol{C_{k(cross)} = 166.470\ l/sec}$

6.) 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} = 36.392 l/s

D = diameter (cm) = 3.556

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

$$\boldsymbol{C_k = 48.983\ l/sec}$$

→ $\boldsymbol{C_{k(cross)} = 48.983\ l/sec}$

7.) 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} = 73.420 l/s

D = diameter (cm) = 3.556

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

$$\boldsymbol{C_k = 98.823\ l/sec}$$

→ $\boldsymbol{C_{k(gate_valve)} = 98.823\ l/sec}$

8.) Total System Conductance

→ Conductance of Pipeline

$$\frac{1}{C_{k(pipeline)}} = \frac{1}{C_{k(baffle_adapter)}} + \frac{1}{C_{k(baffle)}} + \frac{1}{C_{k(plate_adapter)}} + \frac{1}{C_{k(reducer)}} + \frac{1}{C_{k(cross)}} + \frac{1}{C_{k(gate_valve)}}$$

$$\frac{1}{C_{k(pipeline)}} = \frac{1}{3803.213} + \frac{1}{5003.101} + \frac{1}{2029.444} + \frac{1}{166.470} + \frac{1}{48.983} + \frac{1}{98.823}$$

$$\boldsymbol{C_{k(pipeline)} = 26.797\ l/sec}$$

→ $\boldsymbol{C_{k(pipeline)} = 26.797\ l/sec}$

→ Effective Pumping Speed of the System

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

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

$$C_{k(pipeline)} = 31.756\ l/s$$

$$S_{diff(k)} = 103\ l/s$$

$$\boldsymbol{S_{e(k)} = 24.273\ l/s}$$

→ $\boldsymbol{S_{e(k)} = 21.265\ l/sec}$