

APPLIED ION SYSTEMS

High Vacuum Engineering Calculations

Integrated High Vacuum Test Stand - High Vacuum Pumping Assembly
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)

→ $S_{diff(k)} = 103 \text{ l/sec}$

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 = $C_{baffle_adapter} = 1418.746 \text{ l/s}$

D = diameter (cm) = 12.70

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

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

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

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 = $C_{baffle} = 1421.145 \text{ l/s}$

D = diameter (cm) = 18.415

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

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

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

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

D = diameter (cm) = 10.16

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

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

$$\rightarrow C_{k(\text{plate_adapter})} = 2029.444 \text{ l/sec}$$

5.) Total System Conductance

→ Conductance of Pipeline

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

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

$$C_{k(\text{pipeline})} = 1046.510 \text{ l/sec}$$

$$\rightarrow C_{k(\text{pipeline})} = 1046.510 \text{ l/sec}$$

→ Effective Pumping Speed of the System

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

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

$$C_{k(\text{pipeline})} = 1046.510 \text{ l/s}$$

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

$$S_{e(k)} = 93.771 \text{ l/s}$$

$$\rightarrow S_{e(k)} = 93.771 \text{ l/sec}$$