APPLIED ION SYSTEMS

High Vacuum Engineering Calculations

Integrated High Vacuum Test Stand - High Vacuum Pumping Assembly
System Conductance and Effective Speed - Molecular Flow with Water Vapor at 20C

1.) Diffusion Pump
→ Max Pumping Speed of Diffusion Pump (Derived Estimate for Water Vapor)

→ $\boldsymbol{S_{diff} = 624\ l/sec}$

2.) Diffusion Pump to Water Cooled Baffle Adapter (@ 20C)
→ Conductance of a Tube

$$C_m = 3.8(\frac{T}{M})^{\frac{1}{2}}\frac{D^3}{L}$$

C_m = conductance (l/sec)
T = temperature (K) = 293.15
M = molecular mass = 18.020 (average AMU of water vapor)
D = diameter (cm) = 12.70
L = length (cm) = 2.54

$$\boldsymbol{C_m = 12360.288\ l/sec}$$

→ Conductance of a Short Tube

$$C_{short} = C_m(1 + \frac{4}{3}\frac{D}{L})^{-1}$$

C_{short} = conductance of short tube (l/sec)
C_m = conductance of a long tube (l/sec) = 12360.288
D = diameter (cm) = 12.70
L = length (cm) = 2.54

$$\boldsymbol{C_{short} = 1612.212\ l/sec}$$

→ for L/D < 5, above equation is valid for short pipes, with error

$$L/D = 0.200$$

~+12% error max:

$$C_{shortFinal} = C_{short} \times 0.88$$

$$\boldsymbol{C_{shortFinal} = 1418.746\ l/sec}$$

→ $\boldsymbol{C_{baffle_adapter} = 1418.746\ l/sec}$

3.) Water Cooled Baffle (@ 20C)
→ Conductance of a Tube

$$C_m = 3.8(\frac{T}{M})^{\frac{1}{2}}\frac{D^3}{L}$$

C_m = conductance (l/sec)
T = temperature (K) = 293.15

M = molecular mass = 18.020 (average AMU of water vapor)
D = diameter (cm) = 18.415
L = length (cm) = 5.08
$\boldsymbol{C_m = 18840.942\ l/sec}$

→ Conductance of a Short Tube

$C_{short} = C_m(1 + \frac{4}{3}\frac{D}{L})^{-1}$
C_{short} = conductance of short tube (l/sec)
C_m = conductance of a long tube (l/sec) = 18840.942
D = diameter (cm) = 18.415
L = length (cm) = 5.08
$\boldsymbol{C_{short} = 3229.876\ l/sec}$

→ for L/D < 5, above equation is valid for short pipes, with error

$L/D = 0.276$
~+12% error max:
$C_{shortFinal} = C_{short} \times 0.88$
$\boldsymbol{C_{shortFinal} = 2842.291\ l/sec}$

→ Correction for Baffle Fins

$C_{shortFinal} = C_{short} \times 0.50$
$\boldsymbol{C_{shortFinal} = 1421.145\ l/sec}$

→ $\boldsymbol{C_{baffle} = 1421.145\ l/sec}$

4.) Diffusion Pump to 6" Conflat Adapter Plate

→ Conductance of a Tube

$C_m = 3.8(\frac{T}{M})^{\frac{1}{2}}\frac{D^3}{L}$
C_m = conductance (l/sec)
T = temperature (K) = 293.15
M = molecular mass = 18.020 (average AMU of water vapor)
D = diameter (cm) = 10.16
L = length (cm) = 2.54
$\boldsymbol{C_m = 6328.468\ l/sec}$

→ Conductance of a Short Tube

$C_{short} = C_m(1 + \frac{4}{3}\frac{D}{L})^{-1}$
C_{short} = conductance of short tube (l/sec)
C_m = conductance of a long tube (l/sec) = 6328.468
D = diameter (cm) = 10.16
L = length (cm) = 2.54
$\boldsymbol{C_{short} = 999.232\ l/sec}$

→ for L/D < 5, above equation is valid for short pipes, with error

$L/D = 0.250$
~+12% error max:

$$C_{shortFinal} = C_{short} \times 0.88$$
$$\boldsymbol{C_{shortFinal} = 879.324\ l/sec}$$

→ $\boldsymbol{C_{plate_adapter} = 879.324\ l/sec}$

5.) TOTAL SYSTEM CONDUCTANCE

→ Conductance of Pipeline

$$\frac{1}{C_{pipeline}} = \frac{1}{C_{baffle_adapter}} + \frac{1}{C_{baffle}} + \frac{1}{C_{plate_adapter}}$$
$$\frac{1}{C_{pipeline}} = \frac{1}{1418.746} + \frac{1}{1421.145} + \frac{1}{879.324}$$
$$\boldsymbol{C_{pipeline} = 392.813\ l/sec}$$

→ $\boldsymbol{C_{pipeline} = 392.813\ l/sec}$

→ Effective Pumping Speed of the System

$$\frac{1}{S_e} = \frac{1}{C_{pipeline}} + \frac{1}{S_{diff}}$$
$$S_e = \frac{C_{pipeline} \times S_{diff}}{C_{pipeline} + S_{diff}}$$
$$C_{pipeline} = 392.813\ l/s$$
$$S_{diff} = 624\ l/s$$
$$\boldsymbol{S_e = 241.062\ l/s}$$

→ $\boldsymbol{S_e = 241.062\ l/sec}$