

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

CONDUCTANCE CALCULATIONS – TRANSITIONAL FLOW
(For Use with Deuterium Injected Fusor Systems and System Purging @ 10⁻² Torr)

1.) Diffusion Pump

→ Max Pumping Speed of Diffusion Pump (Air) @ 10⁻² torr

→ $S_{diff(k)} = 100 \text{ l/sec}$

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 = $C_{baffle_adapter} = 1580.655 \text{ l/s}$

D = diameter (cm) = 3.556

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

$C_k = 2127.549 \text{ l/sec}$

→ $C_{k(baffle_adapter)} = 2127.549 \text{ l/sec}$

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 = $C_{baffle} = 1487.715 \text{ l/s}$

D = diameter (cm) = 3.556

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

$C_k = 2002.453 \text{ l/sec}$

→ $C_{k(baffle)} = 2002.453 \text{ l/sec}$

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 = $C_{adapter} = 249.147 \text{ l/s}$

D = diameter (cm) = 3.556

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

$C_k = 335.350 \text{ l/sec}$

$$\rightarrow C_{k(\text{plate_adapter})} = 335.350 \text{ l/sec}$$

5.) Transitional Flow Conductance for 2.75" Conflat 4-Way Cross

→ 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 = $C_{\text{cross}} = 108.857 \text{ l/s}$

D = diameter (cm) = 3.556

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

$$C_k = 146.521 \text{ l/sec}$$

$$\rightarrow C_{k(\text{cross})} = 146.521 \text{ l/sec}$$

6.) Transitional Flow Conductance for 2.75" Conflat Gate Valve

→ 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 = $C_{\text{gate_valve}} = 219.615 \text{ l/s}$

D = diameter (cm) = 3.556

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

$$C_k = 295.600 \text{ l/sec}$$

$$\rightarrow C_{k(\text{gate_valve})} = 295.600 \text{ l/sec}$$

7.) Total System Conductance

→ Conductance of Pipeline

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

$$\frac{1}{C_{k(\text{pipeline})}} = \frac{1}{2127.549} + \frac{1}{2002.453} + \frac{1}{335.350} + \frac{1}{146.521} + \frac{1}{295.600}$$

$$C_{k(\text{pipeline})} = 73.204 \text{ l/sec}$$

$$\rightarrow C_{k(\text{pipeline})} = 73.204 \text{ l/sec}$$

→ Effective Pumping Speed of the System

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

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

$$C_{k(\text{pipeline})} = 73.204 \text{ l/s}$$

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

$$S_{e(k)} = 42.265 \text{ l/s}$$

$$\rightarrow S_{e(k)} = 42.265 \text{ l/sec}$$