Contains properties of air from 7th Edition of Fundementals of Mass and Heat Transfer

T_{air_2} $(°F)$	C_{p_air} $\left(\frac{Btu}{lbm \cdot R}\right)$	k_{air}
40	.240	1.401
100	.240	1.400
200	.241	1.397
300	.243	1.394
400	.245	1.389
500	.248	1.383
600	.250	1.377
700	.254	1.371
800	.257	1.365
900	.259	1.358
1000	.263	1.353
1500	.276	1.330
2000	.286	1.312

$$k_{air}(x) := \text{linterp}\left(T_{air\_2}, k_{air}, x\right)$$

$$\mu_{air}(x) := \text{linterp}\left(T_{air\_3}, \mu_{air}, x\right)$$

$$Re_m\left(Mdot, D_h, T_{air}\right) := \frac{4 \cdot Mdot}{\pi \cdot \mu_{air}\left(T_{air}\right) \cdot D_h}$$

T_{air_3} $(°F)$	μ_{air} $\left(lbf \cdot \frac{s}{ft^2}\right)$	ν_{air} $\left(\frac{ft^2}{s}\right)$
−40	$3.29 \cdot 10^{-7}$	$1.12 \cdot 10^{-4}$
−20	$3.34 \cdot 10^{-7}$	$1.19 \cdot 10^{-4}$
0	$3.38 \cdot 10^{-7}$	$1.26 \cdot 10^{-4}$
10	$3.44 \cdot 10^{-7}$	$1.31 \cdot 10^{-4}$
20	$3.50 \cdot 10^{-7}$	$1.36 \cdot 10^{-4}$
30	$3.58 \cdot 10^{-7}$	$1.42 \cdot 10^{-4}$
40	$3.60 \cdot 10^{-7}$	$1.46 \cdot 10^{-4}$
50	$3.68 \cdot 10^{-7}$	$1.52 \cdot 10^{-4}$
60	$3.75 \cdot 10^{-7}$	$1.58 \cdot 10^{-4}$
70	$3.82 \cdot 10^{-7}$	$1.64 \cdot 10^{-4}$
80	$3.86 \cdot 10^{-7}$	$1.69 \cdot 10^{-4}$
90	$3.90 \cdot 10^{-7}$	$1.74 \cdot 10^{-4}$
100	$3.94 \cdot 10^{-7}$	$1.79 \cdot 10^{-4}$
120	$4.02 \cdot 10^{-7}$	$1.89 \cdot 10^{-4}$
140	$4.13 \cdot 10^{-7}$	$2.01 \cdot 10^{-4}$
160	$4.22 \cdot 10^{-7}$	$2.12 \cdot 10^{-4}$
180	$4.34 \cdot 10^{-7}$	$2.25 \cdot 10^{-4}$
200	$4.49 \cdot 10^{-7}$	$2.4 \cdot 10^{-4}$
300	$4.97 \cdot 10^{-7}$	$3.06 \cdot 10^{-4}$
400	$5.24 \cdot 10^{-7}$	$3.65 \cdot 10^{-4}$
500	$5.8 \cdot 10^{-7}$	$4.51 \cdot 10^{-4}$
750	$6.81 \cdot 10^{-7}$	$6.68 \cdot 10^{-4}$
1000	$7.85 \cdot 10^{-7}$	$9.3 \cdot 10^{-4}$
1500	$9.5 \cdot 10^{-7}$	$15.1 \cdot 10^{-4}$

Equation for Discharge Coefficient from Crane 410 Paper - EQN (4-7a); Reader-Harris/Gallagher (1998)

$$C_{d\_C410}(d_o,\beta,Re_p,J,M'_2,L_1) := 0.5961 + 0.0261\cdot\beta^2 - 0.216\cdot\beta^8 + 0.000521\cdot\left(\frac{10^6\cdot\beta}{Re_p}\right)^{0.7} + (0.0188 + 0.0063\cdot J)\cdot\beta^{3.5}\cdot$$

$$C_d(d_o,d_p,m_{dot},T_0,L_1,L'_2) := C_{d\_C410}\left(d_o,\frac{d_o}{d_p},Re_m(m_{dot},d_p,T_0),\left(\frac{19000\cdot\frac{d_o}{d_p}}{Re_m(m_{dot},d_p,T_0)}\right)^{0.8},\frac{2\cdot L'_2}{1-\frac{d_o}{d_p}},L_1\right)$$

$$R_u \equiv 1545\cdot\frac{(ft\cdot lbf)}{°R\cdot mol} \qquad M_{bar\_air} \equiv 28.97\cdot\frac{lbm}{mol}$$

$$\rho_{air}(Temperature,Pressure) := \frac{Pressure\cdot M_{bar\_air}}{Temperature\cdot R_u}$$

Gleichungslöser Nebenbedingungen Schätzwerte

$$r_c := 1$$

$$r_c^{\frac{1-k_{air}(T)}{k_{air}(T)}} + \left(\frac{k_{air}(T)-1}{2}\right)\cdot\left(\frac{d_o}{d_p}\right)^4\cdot r_c^{\frac{2}{k_{air}(T)}} = \frac{k_{air}(T)+1}{2}$$

$$r_{cr}(d_o,d_p,T) := \text{find}(r_c)$$

Gleichungslöser Schätzwerte Nebenbedingungen

$$m_{cr} := 0.001\ \frac{lbm}{s}$$

$$r_c := r_{cr}(d_o,d_p,T_0)$$

$$Y := 1 - \left(0.351 + 0.256\cdot\left(\frac{d_o}{d_p}\right)^4 + 0.93\cdot\left(\frac{d_o}{d_p}\right)^8\right)\cdot\left(1 - r_c^{\frac{1}{k_{air}(T_0)}}\right)$$

$$C_f(m_{cr}) := \frac{C_d(d_o,d_p,m_{cr},T_0,L_1,L'_2)}{\sqrt{1-\left(\frac{d_o}{d_p}\right)^4}}$$

$$m_{cr} = Y\cdot C_f(m_{cr})\cdot\left(\frac{\pi}{4}\cdot {d_o}^2\right)\cdot\sqrt{2\cdot\rho_{air}(T_0,P_0)\cdot(P_0\cdot(1-r_c))}$$

$$m_{cr410}(T_0,P_0,d_o,d_p,L_1,L'_2) := \text{find}(m_{cr})$$

$T_{min} := 150\ °C = 302\ °F$ $\quad T_{max} := 350\ °C$ $\quad P_{min} := 30\ psi$ $\quad P_{max} := 100\ psi$

$$T := \left\| \begin{array}{l} Vec_0 \leftarrow T_{min} \\ \text{for } i \in 1..100 \\ \quad \left\| \begin{array}{l} T_i \leftarrow \left(\frac{(T_{max} - T_{min}) \cdot i}{100} \right) + T_{min} \\ Vec \leftarrow \text{stack}\left(Vec, T_i\right) \end{array} \right. \end{array} \right.$$

$$P := \left\| \begin{array}{l} Vec_0 \leftarrow P_{min} \\ \text{for } i \in 1..100 \\ \quad \left\| \begin{array}{l} P_i \leftarrow \left(\frac{(P_{max} - P_{min}) \cdot i}{100} \right) + P_{min} \\ Vec \leftarrow \text{stack}\left(Vec, P_i\right) \end{array} \right. \end{array} \right.$$

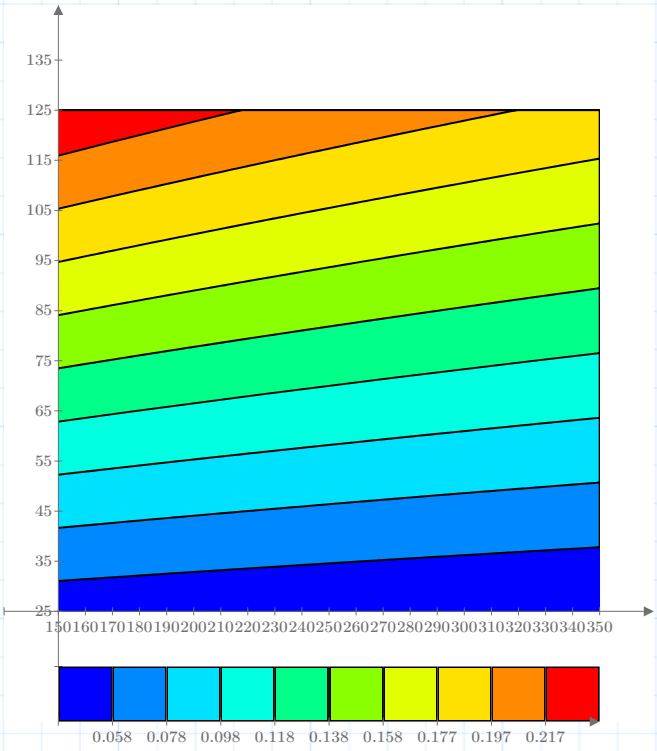
$$T_a := \begin{bmatrix} 330 \\ 300 \\ 280 \\ 250 \\ 230 \\ 185 \end{bmatrix} °C \qquad P_a := \begin{bmatrix} 100 \\ 90 \\ 75 \\ 65 \\ 55 \\ 45 \end{bmatrix} psi \qquad D := \begin{bmatrix} 0.4 \\ 0.3 \\ 0.35 \\ 0.2 \\ 0.3 \\ 0.4 \end{bmatrix} in$$

$$M := \overrightarrow{m_{cr410}\left(T_a, P_a, D, 0.75\ in, 0, 0\right)} = \begin{bmatrix} 0.157 \\ 0.08 \\ 0.093 \\ 0.027 \\ 0.052 \\ 0.081 \end{bmatrix} \frac{lb}{s}$$

$T_{min} := 150\ °C$ $\quad \Delta T := 10\ \Delta °C$ $\quad steps_T := 20$ $\quad T_{max} := T_{min} + steps_T \cdot \Delta T = 350\ °C$

$P_{min} := 25\ psi$ $\quad \Delta P := 5\ psi$ $\quad steps_P := 20$ $\quad P_{max} := P_{min} + steps_P \cdot \Delta P = 125\ psi$

$m_{cr410\_}(T, P) := m_{cr410}(T\ °C, P\ psi, 0.4\ in, 0.75\ in, 0, 0)$



$m_{cr410\_}\left(\frac{lb}{s}\right)$

$$MM := \text{CreateMesh}\left(m_{cr410\_}, \frac{T_{min} - 0\ °C}{\Delta °C}, \frac{T_{max} - 0\ °C}{\Delta °C}, \frac{P_{min}}{psi}, \frac{P_{max}}{psi}, steps_T, steps_P\right)$$

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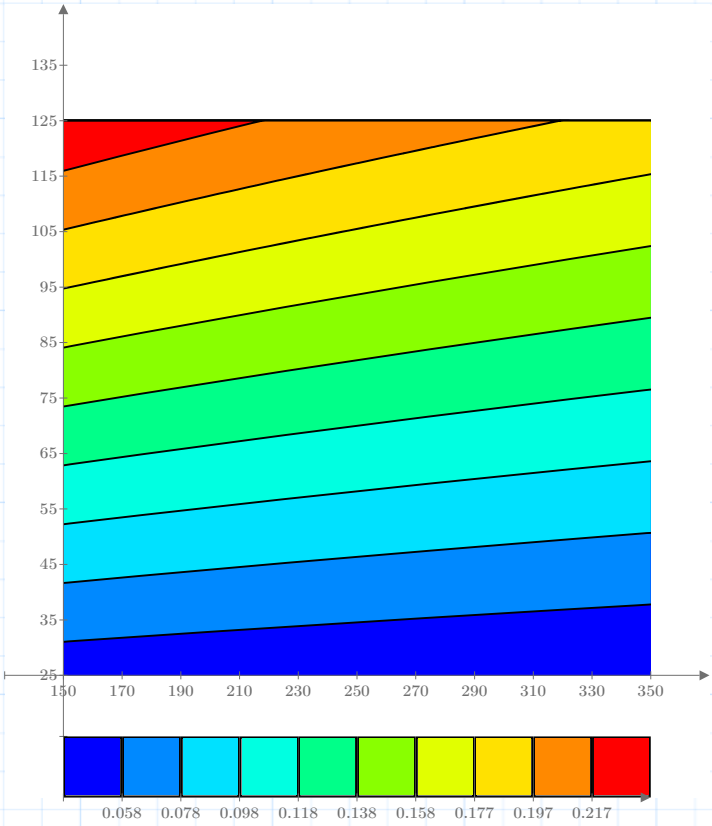

$MM\ \left(\frac{lb}{s}\right)$