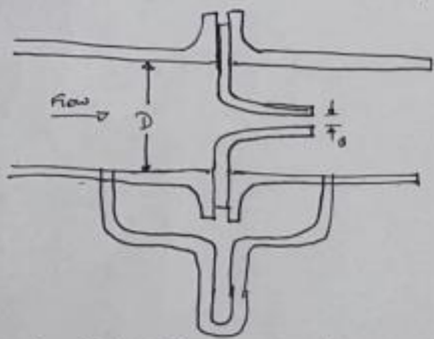
15.9) A flow nozzle is to be installed in a 5-in Type K copper tube carrying linseed oil at 77°F. A mercury manometer is used to measure pressure difference across the nozzle when the expected range of flow rates is from 700 $\frac{gal}{min}$ to 1000 $\frac{gal}{min}$. The manometer scale ranges from 0 to 8 in of mercury. Determine the appropriate diameter of the nozzle.



Given: $D_p = 5\text{ in}$ Type K copper $\rightarrow D = 0.4004\text{ ft}$

$Q = 700 \frac{gal}{min}$

$= 1000 \frac{gal}{min} \cdot \frac{1 \frac{ft^3}{s}}{449 \frac{gal}{min}} = 2.227 \frac{ft^3}{s}$

$h = 8\text{ in} \cdot \frac{1\text{ ft}}{12\text{ in}} = 0.6667\text{ ft}$

$\gamma_w = 62.4 \frac{lb}{ft^3}$, $\gamma_{L.O.} = 58 \frac{lb}{ft^3}$

$\gamma_m = 844.9 \frac{lb}{ft^3}$

$\eta = 6.91 \times 10^{-4} \frac{lb \cdot s}{ft^2}$

$\nu = 3.74 \times 10^{-4} \frac{ft^2}{s}$

Solution: $C = 0.9975 - 6.53\sqrt{\frac{\beta}{R_e}}$, use 0.95 first

$\beta = \frac{d}{D}$ $\quad R_e = \frac{vD}{\nu}$

$$Q = CA_1\sqrt{\frac{2gh\left((\gamma_m/\gamma_F)-1\right)}{(A_1/A_2)^2-1}}$$

$$\rightarrow \left(\frac{Q}{CA_1}\right)^2 = \frac{2gh\left[(\gamma_m/\gamma_F)-1\right]}{[A_1 \div A_2]^2-1}$$

$$\rightarrow \left(\frac{A_1}{A_2}\right)^2 - 1 = \frac{2gh\left[(\gamma_m/\gamma_F)-1\right]}{\left(\frac{Q}{CA_1}\right)^2}$$

$$\rightarrow \frac{A_1}{A_2} = \sqrt{\frac{2gh\left[(\gamma_m/\gamma_F)-1\right]}{\left(\frac{Q}{CA_1}\right)^2}+1}$$

$$\rightarrow A_2 = \frac{A_1}{\sqrt{\frac{2gh\left[(\gamma_m/\gamma_F)-1\right]}{\left(\frac{Q}{CA_1}\right)^2}+1}}$$

$$= \frac{0.12592\text{ ft}^2}{\sqrt{\frac{2(32.2\frac{ft}{s^2})(0.6667\text{ ft})\left[(844.9\frac{lb}{ft^3}/58\frac{lb}{ft^3})-1\right]}{\left(\frac{2.227\frac{ft^3}{s}}{(0.95)(0.12592)}\right)^2}+1}}$$

$A_2 = 0.076906\text{ ft}^2$

$A_1 = \frac{\pi}{4}(0.4004)^2 = 0.12592\text{ ft}^2$

$d = \sqrt{\frac{4A_2}{\pi}} = \sqrt{\frac{4(0.076906\text{ ft}^2)}{\pi}}$

$d = 0.312921$

Used Excel to find optimal "d". The chosen/guessed was only 0.57% off from optimal calculated in Excel, see attached spreadsheet.

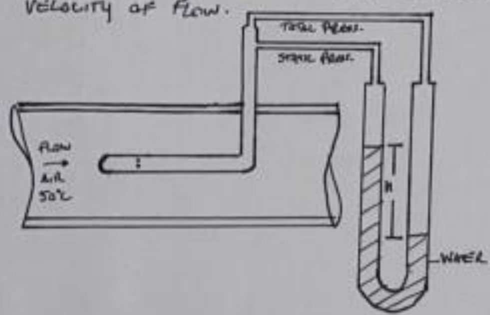
Flow Nozzle (Pr. 15.9) • Saved

G14 $\quad$ =SQRT(4*F14/PI())

	A	B	C	D	E	F	G	H	I	J	K	L
1	Problem 15.9											
2	D=	0.4004	ft									
3	Y_Linseed=	58	lb/ft3									
4	Q=	2.227	ft3/s									
5	h=	0.6667	ft									
6	Y_m=	844.9	lb/ft3									
7	g=	32.2	ft/s2									
8	nu=	0.00038	ft2/s									
9				C	A1(ft2)	A2(ft2)	d(ft)	beta	V(ft/s)	Re	C	%diff
10				0.95	0.12592	0.07691	0.31292	0.78152	17.6865	18441.9	0.95499	0.52%
11				0.95499	0.12592	0.07665	0.31241	0.78024	17.6865	18441.9	0.95503	0.00%
12				0.95503	0.12592	0.07665	0.3124	0.78023	17.6865	18441.9	0.95503	0.00%
13				0.95503	0.12592	0.07665	0.3124	0.78023	17.6865	18441.9	0.95503	0.00%
14				0.95503	0.12592	0.07665	0.3124	0.78023	17.6865	18441.9	0.95503	0.00%

Sheet1

(5.15) A PITOT-STATIC TUBE IS INSERTED INTO A DUCT CARRYING AIR AT STANDARD ATMOSPHERIC PRESSURE AND A TEMPERATURE OF 50°C. A DIFFERENTIAL MANOMETER READS 0.24 in OF WATER. CALCULATE VELOCITY OF FLOW.



GIVEN: $h = 0.24\,\text{in} \cdot \frac{1\,\text{ft}}{12\,\text{in}} = 0.02\,\text{ft}$

$\gamma_g = \gamma_w = 62.4\,\frac{\text{lb}}{\text{ft}^3}$

$\gamma_f = 10.71 \cdot \frac{6.36598 \times 10^{-9}\,\frac{\text{lb}}{\text{ft}^3}}{1} = 0.068179\,\frac{\text{lb}}{\text{ft}^3}$

SOLUTION: $V_f = \sqrt{2gh(\gamma_g - \gamma_f)/\gamma_f}$

$$= \sqrt{\frac{2(32.2\,\frac{\text{ft}}{\text{s}^2})(0.02\,\text{ft})(62.4\,\frac{\text{lb}}{\text{ft}^3} - 0.068179\,\frac{\text{lb}}{\text{ft}^3})}{(0.068179\,\frac{\text{lb}}{\text{ft}^3})}}$$

$V_f = 34.32\,\frac{\text{ft}}{\text{s}}$