

Capture Velocity

Today, we will:

- Define **Capture Velocity**, and show how to use it to choose hood flow rate
- Do an example problem

Capture velocity and how to use it:

Definition: Capture velocity = v_c = magnitude of velocity required to “capture” a contaminant particle and suck it into a hood.

Procedure:

1. Use **Table 6.1** (or other online tables) to specify v_c for the activity being analyzed.
2. Set $U = v_c$ at the location of interest.
3. Use isopleth contour plots (or centerline equations when appropriate) from previous lectures to calculate U/U_{face} .
4. Calculate the required magnitude of average hood face velocity U_{face} .
5. Calculate the required volume flow rate Q_{hood} through the hood.

Table 6.1 Capture velocities (from H&C textbook, abstracted from ACGIH, 2001). *ft/min*

characteristics of contaminant emission	examples <i>Activity</i>	capture velocity (FPM) <i>ft/min</i>
1. contaminant enters quiescent air with negligible velocity	degreasing tank, evaporation	50-100
2. contaminant enters slightly moving air with a low velocity	welding, vessel filling	100-200
3. contaminant actively generated and enters rapidly moving air	spray painting, stone crushers	200-500
4. contaminant air enters rapidly at high velocity	grinding, abrasive blasting	500-2000

Lower values of capture velocity:

- room air movement minimal or conducive to capture
- contaminants of low toxicity
- intermittent use or low production rates
- large hood and large mass of air moved

Upper values of capture velocity:

- adverse room air movement
- contaminants of high toxicity
- heavy use and high production rates
- small hood and small mass of air moved

Best illustrated by an example:

Example: Capture velocity and hood design

Given: A flanged round inlet is used as a hood to capture overspray particles from spray painting. The hood inlet (face) diameter is 0.50 m. The spray paint region of concern extends to $x = 0.50$ m (axially) and $r = 0.25$ m (radially) as sketched.

To do: Calculate the *range* of required volume flow rate through the hood in units of CFM.

Solution: Follow the above procedure:

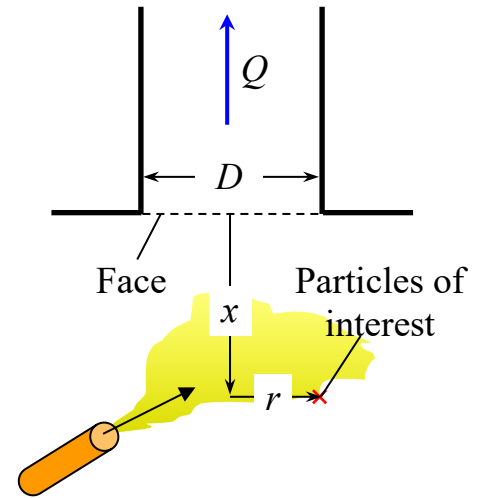
Step 1. See Table 6.1 above to get range of v_c .

$$V_c = \underline{200} \text{ to } \underline{500} \text{ FPM}$$

Step 2. Set range of required U to this range of v_c .

$$U = v_c \rightarrow 200 \text{ to } 500 \text{ FPM}$$

Step 3. Calculate U/U_{face} . Here, Figure 6.10 is the appropriate isopleth plot.



$$\frac{x}{D} = \frac{0.50 \text{ m}}{0.50 \text{ m}} = 1.0$$

$$\frac{r}{D} = \frac{0.25 \text{ m}}{0.50 \text{ m}} = 0.5$$

$$\frac{U}{U_{\text{face}}} = 7.5\%$$
$$= \underline{\underline{0.075}}$$

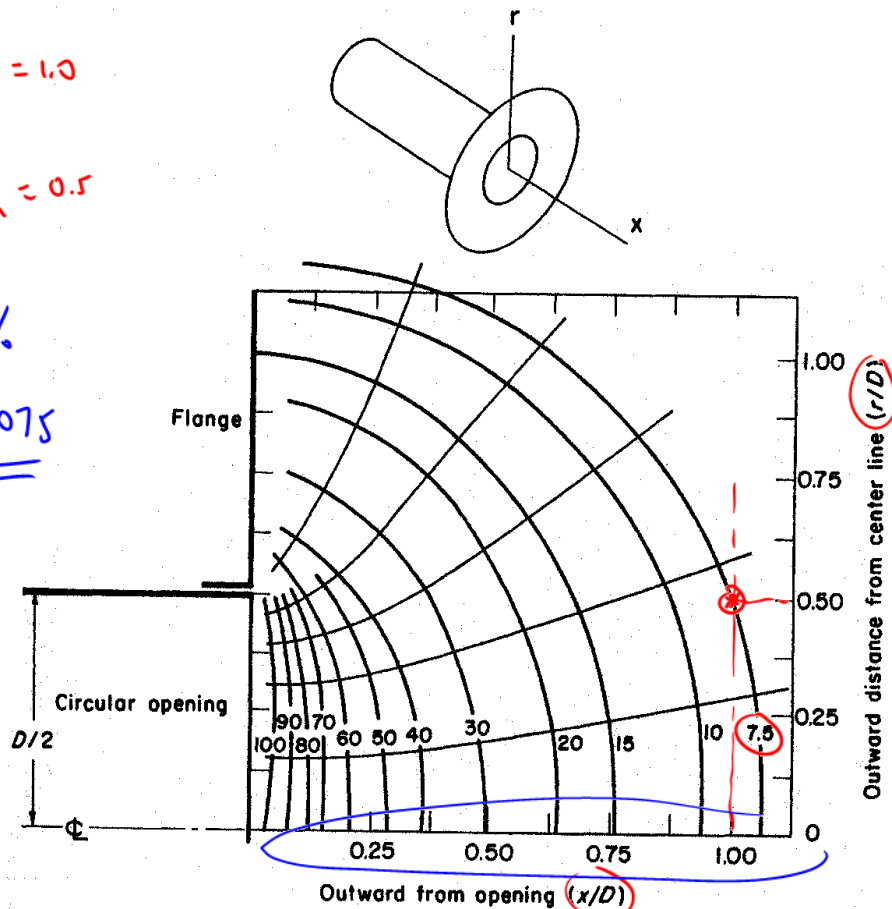


Figure 6.10 Velocity isopleths (curves of constant U/U_{face} , %) for a flanged circular opening (adapted from ASHRAE HVAC Applications Handbook, 1995).

Step 4. Calculate range of U_{face} .

$$\frac{U}{U_{face}} = 0.075 \rightarrow U_{face} = \frac{U}{0.075} = \frac{200 \text{ to } 500 \text{ ft/min}}{0.075} \Rightarrow \begin{array}{l} U_{face} = \\ \underline{\underline{2666.7 \text{ fpm}}} \\ \text{to } 6666.7 \text{ fpm} \end{array}$$

Step 5. Calculate range of Q_{hood} .

$$Q_{hood} = U_{face} \cdot A_{face} \cdot \frac{\pi D^2}{4}$$

• Lower limit $Q_{hood} = \left(2666.7 \frac{\text{ft}}{\text{min}} \right) \cdot \frac{(0.50 \text{ m})^2}{4} \left(\frac{1 \text{ ft}}{0.3048 \text{ m}} \right)^2 = \underline{\underline{5636 \text{ CFM}}}$

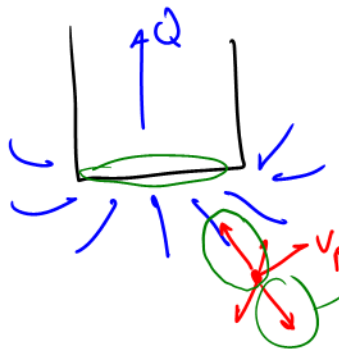
• Upper limit $Q_{hood} = \left(6666.7 \frac{\text{ft}}{\text{min}} \right) \cdot \frac{(0.50 \text{ m})^2}{4} \left(\frac{1 \text{ ft}}{0.3048 \text{ m}} \right)^2 = \underline{\underline{14090 \text{ CFM}}}$

Answer Range of $Q_{hood} = \underline{\underline{5600 \text{ to } 14000 \text{ CFM}}}$

COMMENT:

1) Large Range! Not rocket science

2) Fundam. problem $\rightarrow V_c$ is a speed, not a velocity
mag only, not direction



Capture velocity take the worst case scenario
(partly moving in opposite direction of the air)

Conservative # V_c is conservative