Today, we will:

- Begin our discussion of **local ventilation** [Chapter 6]
- Discuss **hood suction velocities** and **isopleths**
- Discuss **capture velocity** and **capture of particles** [Section 6.1]
- Do an example problem – capture velocity

**Goal of a hood** — Don’t let the contaminant get into the room in the first place

A hood flow system is typically independent of the HVAC system.

We must design hoods for vapors and/or particles.

We will discuss both.
**Terminology**

- **fan**: $Q = \text{bulk flow rate}
- **U_{\text{face}} = \text{avg. speed across the face}
- \dot{Q} @ \text{face} = \dot{Q} @ \text{exit (exhaust)}

$U_{\text{face}} = \frac{Q}{A_{\text{face}}}$

**Fluid mechanics — Fundamental problem with hood**

- **The candle effect**

  - **Blow**: blowing $u$, directed $l$ (low momentum)
  - **Suck**: speed loss is small

You can't have a directed hood (sucking)

*Any suction device is limited by the candle effect*
ISOPLETHS — contours of constant speed (mag. of velocity)

Eg. Rectangular opening 10:1 aspect ratio

$S = \text{slat height}$

Plot $\frac{U}{U_{\text{face}}}$ as a %

Obliquity (in % of $U_{\text{face}}$)

Speed decreases rapidly with distance

See Fig 68 in text or next pg
Example: Rectangular inlet of aspect ratio 10:

- At $x/s = 1$ on centerline ($y/s = 0$)
- Top view
- Distance from opening ($x/s$)
- Distance from center line ($y/s$)
- Distance from center line ($z/w$)
- Velocity isopleths (curves of constant $U/U_{face}$, %) for an unflanged rectangular opening, aspect ratio 1:10 (adapted from Baturin, 1972).

**Figure 6.8** Velocity isopleths (curves of constant $U/U_{face}$, %) for an unflanged rectangular opening, aspect ratio 1:10 (adapted from Baturin, 1972).
ROUND GEOMETRIES

Face = pipe inlet
DIA = D

Flow into from all directions

Side view

See Fig 6.9
Example: Circular inlet without a flange (plain circular inlet):

\[ \frac{U(x, r)}{U_{\text{face}}} \]

**Figure 6.9** Velocity isopleths (curves of constant \( U/U_{\text{face}} \), %) and decay of \( U(x, 0)/U_{\text{face}} \) (along the centerline, %) for a plain circular opening (adapted from ASHRAE HVAC Applications Handbook, 1995).

\[ \frac{U(x, 0)}{U_{\text{face}}} = \frac{1}{1 + 10 \left( \frac{x}{D} \right)^2} \]

\[ \frac{U}{U_{\text{face}}} = 75\% \]

\[ \frac{x}{D} = 1 \]

\[ \text{at } x/D = 1 \text{, get } 0.0728 \approx 7.3\% \]

How to improve? — can add a flange.
Example: Circular inlet with a flange (flanged inlet):

![Diagram of flanged circular opening with velocity isopleths](image)

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

Compare non-flanged to flanged @ $x/D = 1$ on central line ($r = 0$):

- Unflanged: $\frac{U}{U_{face}} \approx 7.3\%$
- Flanged: $\frac{U}{U_{face}} \approx 8.8\%$ — little better

For $0 < x < 0.5$:

- $\frac{U}{U_{face}} = 1.1 \left(0.070\right) x^{10.5}$
- $0.5 < x < 1.5$

- $\frac{U}{U_{face}} = 0.1 \left(\frac{x}{D}\right)^{-1.6} x^{10.6}$
**PARTICLES**

* Capture Velocity \( V_c = \text{Velocity magnitude} \) required to "capture" a contaminant particle
  
  Is suck it into hood

Procedure — Select \( V_c \) from table for our process & location

- Set \( U = V_c \)
  
  \[ \text{air / particle} \]

\( V_c \) depend on process — particle size & density

See Table 6.1

E.g., Spray painting
Table 6.1 Capture velocities (abstracted from ACGIH, 2001).

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

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

\[ 5.7 \text{ mile/hr} = 2.5 \text{ m/s} \]
Room with a "snorkle hood"

Round unfanged hood

\[ A_{face} = \frac{\pi D^2}{4} \]

\[ D_{inlet} = 6" \]

\[ A_{face} = 0.78 \text{ ft}^2 \]

Particle \( D/2 = 6" \) on centerline

What is the required \( Q \)?

\[ U_{face} = \frac{1}{1 + \frac{40}{\pi} \left( \frac{X}{D} \right)^2} \]

\[ X/D = 0.5 \]

\[ U_{face} = 0.24 \text{ or } 24\% \]

Set \( U = V_c = 150 \text{ fpm} \)

\[ U_{face} = \frac{U}{0.24} = \frac{150}{0.24} = 630 \text{ fpm} \]

\[ Q = U_{face} \cdot A_{face} = 580 \text{ CFM} \]