Musings on Capture Velocity

A Pump Jockey’s Perilous Journey

October 3, 2019
Connecticut River Valley Section, AIHA
Overview

- ESEAP
- Good Intentions…Poor Results
- Scenario
- Capture Velocity – Working Definition
- Collecting Field Measurements
- ACGIH Capture Velocity Guidelines
- Capture Velocity – Hands-on calculations
- Making System Improvements
- Q&A
Hierarchy of Controls

- Elimination
- Substitution
- Engineering Controls
- Administrative Controls
- PPE
Good Intentions… Not So Good Consequences

Wood dust can cause health problems ranging from nasal irritation to bronchitis to cancer, so you should take steps to protect yourself from these hazards. The first step is attaching all of your machines and as many power tools as possible to a dust-collection system. You also should wear a dust mask when sanding or producing fine dust in some other way.

A third step that many woodworkers take is to hang an air filter in their shops. However, some have challenged the effectiveness of these units. One manufacturer of dust-collecting systems—who doesn’t sell air filters—claims that air filters at best do not improve the quality of shop air, and might...
Bad

Good

Slot
Scenario

Employee is applying special coating per military specification using HVLP spray gun on workbench with rear draft multi-slotted hood. Fixture is vibrated to distribute compound to all surfaces of part.

Sample results = 1.5x’s over the TLV.

Capture velocity \((V_c)\) measured at point of generation (~19 in) = 80 fpm

Required \(V_c = 150 \text{ fpm}\)
Capture Velocity

Air velocity at any point in front of the hood necessary to overcome opposing air currents and to capture the contaminant at point of generation causing it to flow into the hood

Entrainment
Velocity Comes in Different Flavors
Capture Velocity Field Measurements

1. Preferred Method: At point of generation
   (Qualitative & Quantitative)

2. Model capture velocity – we’ll revisit later
## Capture Velocity Guidelines

<table>
<thead>
<tr>
<th>Condition of Dispersion of Contaminant</th>
<th>Examples</th>
<th>Capture Velocity, fpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Released with practically no velocity into quiet air.</td>
<td>Evaporation from tanks, degreasing, etc.</td>
<td>50 - 100</td>
</tr>
<tr>
<td>B. Released at low velocity into moderately still air.</td>
<td>Spray booths; intermittent container filling; low speed conveyor transfers; welding; plating; pickling</td>
<td>100 - 200</td>
</tr>
<tr>
<td>C. Active generation into zone of rapid air motion.</td>
<td>Spray painting in shallow booths; barrel filling; conveyor loading; crushers</td>
<td>200 - 500</td>
</tr>
<tr>
<td>D. Released at high initial velocity into zone of very rapid air motion.</td>
<td>Grinding; abrasive blasting, tumbling</td>
<td>500 - 2000</td>
</tr>
</tbody>
</table>

In each category above, a range of capture velocity is shown. The proper choice of values depends on several factors:

**Lower End of Range**
1. Room air currents minimal or favorable to capture
2. Contaminants of low toxicity or nuisance value only
3. Intermittent, low production.
4. Large hood—large air mass in motion

**Upper End of Range**
1. Disturbing room air currents
2. Contaminants of high toxicity
3. High production, heavy use
4. Small hood—local control only

With permission from ACGIH
Inhalables – Particle à la mode
Competitors for Capture Velocity
<table>
<thead>
<tr>
<th>HOOD TYPE</th>
<th>DESCRIPTION</th>
<th>ASPECT RATIO, H:W</th>
<th>AIRFLOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot</td>
<td>0.2 or less</td>
<td>Q = 3.7 LV_cX</td>
<td></td>
</tr>
<tr>
<td>Flanged slot</td>
<td>0.2 or less</td>
<td>Q = 2.6 LV_cX</td>
<td></td>
</tr>
<tr>
<td>Plain opening</td>
<td>0.2 or greater</td>
<td>Q = V_c(10X^2 + A_c) A_c = WH</td>
<td></td>
</tr>
<tr>
<td>Flanged opening</td>
<td>W_c &gt; \sqrt{A_c}</td>
<td>Q = 0.75V_c(10X^2 + A_c) A_c = WH</td>
<td></td>
</tr>
<tr>
<td>Booth</td>
<td>To suit work</td>
<td>Q = VA = WHH</td>
<td></td>
</tr>
<tr>
<td>Canopy</td>
<td>To suit work</td>
<td>Q = 1.4 PV_cX</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P = Perimeter of work or tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>X = Height above work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plain multiple</td>
<td>slot opening (2) or more slots</td>
<td>0.2 or greater</td>
<td>Q = V_c(10X^2 + A_c) A_c = HL</td>
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With permission from ACGIH
Effects of Flanging

With permission from ACGIH
Field Measurement Method #2

Model $V_0$

1. Measure duct velocity = 3000 fpm (6” diameter duct)
2. Measure hood face area $A = (L \times W)$ or $\frac{\pi d^2}{4}$
3. $Q = AV$, solve for $Q$

Example
$V = 3000$ fpm duct velocity, $A = \frac{\pi (6”/12”)^2}{4} = 0.196$ ft$^2$

$Q = 588$ cfm
For Plain Opening Hood

\[ Q = V \left(10X^2 + A\right) \]

\[ V = \frac{Q}{10X^2 + A} \]

\[ V = \frac{588 \text{ ft}^3/\text{min}}{10(1 \text{ ft})^2 + 0.196 \text{ ft}^2} \]

\[ V = 58 \text{ fpm} \]

From Vent. Manual
Plain Opening
X is Sensitive to Change

\[ Q = V(10X^2 + A) \]
X is Sensitive to Change

Good Location
1000 cfm needed

Bad Location
4000 cfm needed

Adapted from ACJH Manual
### TABLE 6-3. Summary of Hood Airflow Equations

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<tr>
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<th>ASPECT RATIO, H/L</th>
<th>AIRFLOW</th>
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<td><img src="image" alt="Slot" /></td>
<td>Slot</td>
<td>0.2 or less</td>
<td>( Q = 3.7 , V \sqrt{X} )</td>
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<tr>
<td><img src="image" alt="Flanged slot" /></td>
<td>Flanged slot</td>
<td>0.2 or less</td>
<td>( Q = 2.6 , V \sqrt{X} )</td>
</tr>
<tr>
<td><img src="image" alt="Plain opening" /></td>
<td>Plain opening</td>
<td>0.2 or greater and round</td>
<td>( Q = V_{in} (10X^2 + A_i) / A_i = WH )</td>
</tr>
<tr>
<td><img src="image" alt="Flanged opening" /></td>
<td>Flanged opening ( W_i &gt; \sqrt{A_i} )</td>
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<td>To suit work</td>
<td>( Q = VA = WWH )</td>
</tr>
<tr>
<td><img src="image" alt="Canopy" /></td>
<td>Canopy</td>
<td>To suit work</td>
<td>( Q = 1.4 , PVX ) ( P = ) Perimeter of work or tank ( X = ) Height above work</td>
</tr>
<tr>
<td><img src="image" alt="Plain multiple slot opening" /></td>
<td>Plain multiple slot opening (2) or more slots</td>
<td>0.2 or greater</td>
<td>( Q = V_{in} (10X^2 + A_i) / A_i = HL )</td>
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Calculations are nice but…. in the field, just where exactly is X?
Making System Improvements

1. Flanges → 3-sided enclosure
Making System Improvements

1. Flanges → 3-sided enclosure → 4-sided enclosure
Making System Improvements

2. Put all LEV on a PM

3. Check blast gates are open

4. Flex duct hose? Check excessive bending, increases turbulence, SP loss
Making System Improvements

5. Dust Collection System? - Filters could be clogged, fan starves air - i.e. Machining parts – Torit clogs quickly

6. Post PM dip in performance? - check with HVAC if fan in reverse or fan belt slipping
Making System Improvements

7. Install air venturi in ductwork – can be effective for some applications - not all.

8. Increase Q – is adjustable pulley on fan? If no then bigger fan = $

Place accountability on your HVAC contractor for \( V_c \) performance!
LEV SPECIFICATION

System will supply a minimum capture velocity of [ ] fpm at [ ] inches centerline distance from front of hood face.
Musings on Capture Velocity

Thank You