Capture Velocity with Slot Entry to Conical Hood

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Background

Hazardous chemicals are released into the air by industrial processes, exposing workers to dangerous levels of toxic materials.

Local exhaust ventilation (LEV) systems have been shown to significantly decrease the level of hazardous airborne contaminants.

A limitation of local exhaust hoods is the inconvenience of positioning the hood to maximize capture distance while keeping the hood from getting in the way of the work being performed.

Can we improve an LEV inlet?

Objectives

1. Determine if combining a flanged-slotted entry to a rounded duct significantly increases capture velocity at one duct diameter upstream of the hood opening
2. Develop an equation to estimate centerline velocity upstream of the hood entry
3. Determine the relative operating cost (SP)

Methods

Developed three designs (Figure 1)
- Constant solid angle (40º)
- Range of slot widths (4.95, 3, 2 cm)

Quantified system operation
- 243, 337, 467, 647, 897 cfm
- Measured with pitot tube

Obtained velocity measures (3 replicates)
- VelociCalc Plus 8386
- 9 Centerline locations upstream (0-34.9 cm)
- 39 off-centerline measurements

Data Analysis
- Paired t-test to compare capture velocity improvement
- Linear regression to generate centerline velocity model, similar to Silverman's slot equation

$$\frac{V}{V_s} = K_1 * \left(\frac{x}{w}\right)^{K_2}$$

Figure 1: Design plates and the conical hood

Results

No plate improved velocity through 1D. Widest opening (Plate 1) improved capture velocity the furthest upstream.

	All Positions	Effective		Ineffective	
Comparisons	p	X, in	p	X, in.	p
Plate 1-Conical	< 0.001	≤ 4.5	< 0.001	> 4.5	0.08
Plate 2-Conical	0.02	≤ 2	0.04	> 2	0.07
Plate 3-Conical	0.09	0	< 0.001	> 0	0.31

Table 1: Plate comparisons against the conical hood

Velocity predication equation over all plates: (R^2=0.82)

$$\frac{V}{V_s} = 0.241\left(\frac{x}{w}\right)^{-1.37}$$

Pressure drop increases with higher airflow rates and smaller slot widths

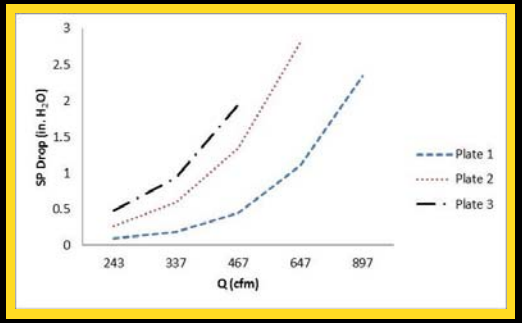

Figure 3: Static pressure drop across all plates at varying airflow rates relative to conical hood

Velocity contours between plates show a higher capture velocity near the hood with diminishing improvement further upstream.

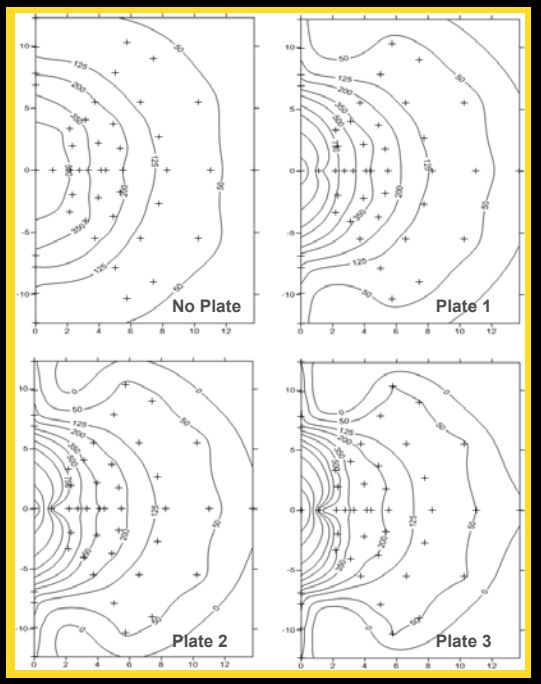

Figure 4: Velocity contours for 467 cfm

Conclusions

A circular slot hood improved capture within 4.5" of the slot entry.

Plate 1 performed the best, in terms of increased velocity and pressure drop.

Linear regression using Silverman's slot equation format explained ~82% of centerline velocity variability. The circular slot required an exponent of -1.37 compared to Silverman's rectangular slot (-1.0).

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