Characterizing Ventilation in Collision Repair Spray Painting Booths

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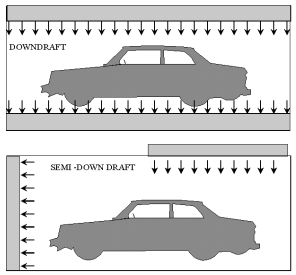
Introduction

Adequate ventilation in auto body spray booths is critical to protect spray painters against over spray of auto paints. It has been well-documented that many automotive paints contain isocyanates which cause skin irritation, respiratory sensitization, reduced lung function and occupational asthma[1]. Among all Washington industries, the auto repair industry had the second highest rate of compensable asthma claims from 1995 to 2002, ten times the overall rate[2]. Previously, it is has been found that many shops have inadequate ventilation or inappropriate respiratory protection, in terms of respirator type or use.[3] While more work is being done on glove and coverall permeation, the evaluation of booth ventilation systems is an appropriate task in order to estimated the risk of respiratory exposure to isocyanates.

Objective Assess paint booth ventilation in local collision repair shops in order to provide recommendations for booth selection and maintenance.

Methods

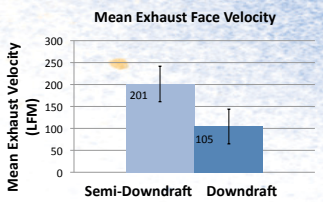
- 19 spray booths were evaluated at 11 local collision repair shops: 11 downdraft and 5 three- and 3 four-walled semi-downdraft booths.
- Using a rotating vane anemometer (LFM, ±20) the exhaust face velocity (EFV) and breathing zone velocity (BZV) were measured
- Exhaust filter change date and booth installation year were determined
- Booth dimensions (length, width, height) were measured
- Using this information, air exchanges per minute (ACM) was calculated using the following equation:
  (mean LFM (exhaust area))/booth volume = ACM
- Three- and four-walled semi-downdraft booths were grouped together for analysis as they were not statistically different in ACM (p=0.5), total airflow (p=0.7), average LFM (p=0.7) and breathing zone velocities (p=0.19)

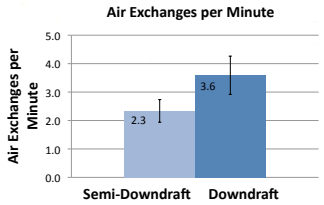


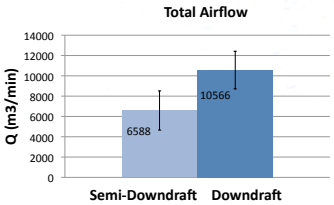
Results

Semi-downdraft versus Downdraft Booth Performance

	Downdraft	Semi-downdraft
Q range (CFM)	6060-17180	4300-11800
ACM range	2.6- 6	1.6-3.3
EFV range (LFM)	24-213	22-308
% EFV Dead Zones	26	2.5
BZV range (LFM)	0-38 (n=10)	11-194 (n=5)
% BZV Dead Zones	58	38
Mean Exhaust Area (ft²)	150	34







Meeting Regulations and Recommendations

Fire Code: Mean EFV≥100 LFM
- Downdraft booths: 45% (n=5)
- Semi-downdraft booths: 100% (n=8)
- Total: 68% (n=13)

ACGIH semi-down recommendation[3]: 100 ft³/1 ft² cross-section (50 ft³/ft² if cross-section is greater than 150 ft²)
- Semi-downdraft booths: 13% (n=1)

INRS[3*] downdraft and BZ predictor[4+] recommendation: 10,000 CFM
- Downdraft booths: 64% (n=7)
- Semi-downdraft booths: 12.5% (n=1)

Actual BZ above 80 LFM
- Semi-downdraft booths: 20% (n=1)

Booth Age, Filter Age and Ventilation

There were no correlations between:
- **Exhaust filter age and ACM** for downdraft (R^2=0.001) or semi-downdraft (R^2=0.03),
- **Installation year and ACM** for downdraft (R^2=0.01) or semi-downdraft (R^2=0.13),
- **Exhaust filter age and EVF** for downdraft (R^2=0.01) or semi-downdraft (R^2=0.025) ,
- **Installation year and EVF** for downdraft (R^2=0.23) or semi-downdraft (R^2=0.01).

There was a correlation between **semi-downdraft filter age and EFV** (R^2=0.57); older filters were associated with higher EFV's.

Conclusions

- Downdraft booths have higher ACM's and Total Airflow than semi-downdraft booths
- Semi-downdraft booths have higher average EFV's than downdraft booths
- In agreement with previous reports, downdraft booths generally offer better overspray protection than semi-downdraft.[2]
- According to previous findings the average airflow around a car, in the breathing zone, should be 80 LFM and to maintain this the total volume of airflow should exceed 10,000 CFM.[3] However, it was found that there was not a significant correlation between Q and BZV for neither semi-downs (R^2=0.03) nor downdrafts (R^2=0.35). It cannot be assumed that high total volume airflow translates to adequate breathing zone velocities
- No booth met all regulations and recommendations. Only 27% (n=3) of the downdrafts and 13% (n=1) of the semi-downs met the non-BZ criteria of their class.
- Error may have been introduced due to small BZ sample sizes, booth contents and measurement technique variability.

Discussion

Average velocity, the unit used in most fire code standards, should be used in concert with other methods of evaluation, such as breathing zone measurements, total airflow, and ACM. Further investigation is necessary to determine the relationship between regular maintenance, such as filter changes and ventilation. In addition to selecting appropriate ventilation equipment, educating painters about their particular booths, dead zones, good maintenance practices, and techniques to reduce overspray could dramatically reduce exposure to hazardous chemicals in auto paints.

References: [1]Tornling, G., Alexandersson, R, Hedenstierna, G, and Plato N. (1990). Decreased Lung Function and Exposure to Diisocyanates (HDI and HDI-BT) in Car Repair Painters: Observation On Re-Examination 6 Years After Initial Study. American Journal of Industrial Medicine 17:299-310. . [2]SHARP (2003). Work-Related Asthma in Washington State: A Review of Worker's Compensation Claims from 1995-2002. Safety & Health Assessment & Research for Prevention (SHARP) report 64-6-2003. Olympia, Washington. December 2003. [3]Heitbrink WA, Cooper TC, Edmonds MA, Bryant CJ [1993]. In-Depth Survey Report: Control Technology for Autobody Repair and Painting Shops at Blue Ash Autobody Shop, Blue Ash, Ohio. U.S. DHHS, PHS, CDC, NIOSH, NTIS Pub. No. PB-93-215838. [4]Heitbrink, W.A.: "A Control Matrix for Spray Painting at Autobody Repair Shops." [Online] Available at http://www.osha.gov/SLTC/autobody/docs/nioshctm/nioshctm.html (Accessed August 4, 2010) 6American Conference of Governmental Industrial Hygienists (2004). Industrial Ventilation - A Manual of Recommended Practice. 25nd edition. Cincinnati Ohio.

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