Exposure Assessment for Automotive Repair Tasks in an Attached Garage

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Background

The repair of automobiles generates volatile organic compound contamination of the air as a byproduct of the application of organic solvent based lubricants to loosen parts. The home mechanic is often exposed to the same hazards as mechanics within commercial shops but lacks the tools to adequately assess exposure.

Objectives

1. Indentify tasks with largest exposure contribution
2. Identify effects of cracking open garage door
3. Estimate duration to decay to background
4. Generate model to estimate at-home exposures

Methods

Winter measurements (Midwest)

Test two ventilation conditions, two garages
- Door open (30.5 cm, N=5)
- Door closed (N=4)

Examine 5 automotive repair tasks plus decay:

• Oil Change	20 min
• Brake Pad Replacement	20 min
• Shock Replacement	22 min
• Refueling	2 min
• Touch-up Painting	4 min
• Decay Period	120 min

Total Cycle Time = 188 min

Tasks performed in randomized order

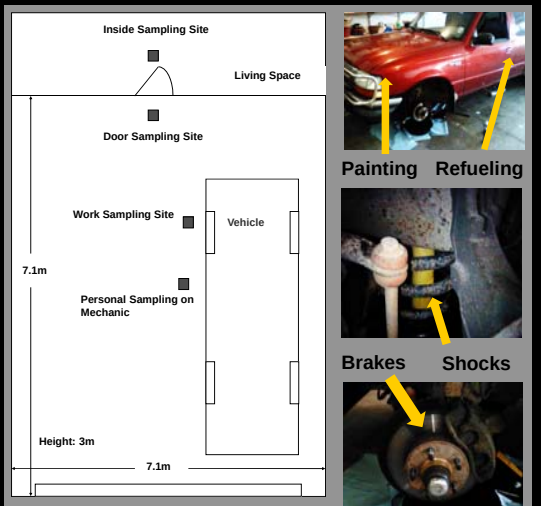

Figure 1: Sampling Locations

Results

Largest contribution of exposure is brake cleaning

Contribution	Closed Garage			Open Garage		
	Mean	SD	95th %	Mean	SD	95th %
Background	0.24	0.31	0.87	0.22	0.2	0.62
Oil Change	5.49	3.64	12.77	1.00	0.36	1.72
Shocks	2.01	0.49	2.99	0.07	0.15	0.37
Brake	23.94	13.64	51.22	6.51	5.22	16.95
Fuel	0.85	-	0.85	1.27	1.44	4.14
Paint	4.30	3.86	12.02	0.92	0.86	2.64

Table 1: Task-specific VOC Concentration

With garage door opened only 30.5 cm, significant reduction in VOCs were identified

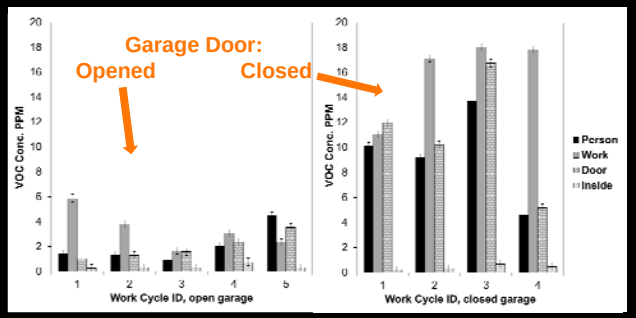

Figure 2: Time-weighted Averages of VOC Concentration, Work + Decay Periods

For garage with closed door: Q/V = 1/τ = 0.0065 min^{-1}, using linear regression

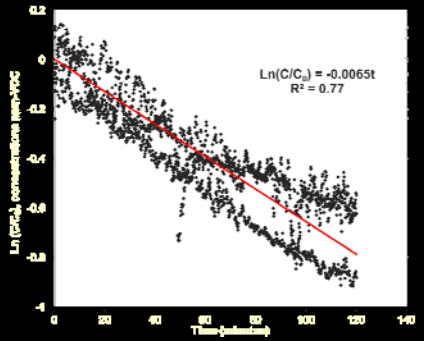

Figure 3: Decay Behavior of Solvents, Garage A (all tests) at "Worksite"

Garage	Residence time, minutes	R^2
A	169	0.68
A	178	0.88
A	120	0.96
A, Pooled	220	0.77
A, Averaged	156	-
B	156	0.77

Table 2: Computed Residence Time for Decay in Garages with Closed Door (SD Garage A = 31.2 min)

Exposure model developed, incorporating generation and decay

To estimate at-home exposures, information on tasks conducted and time spent in the garage after tasks (decay) are needed. Equations for Home Generation (H_G) and Home Decay (H_D) were developed from measures from this study:

$$H_G = \sum_{j=1}^{n}\left(\sum_{i=1}^{j} C_i\right)t_j \qquad H_D = \frac{\sum_{i=1}^{n} C_i}{-0.0065T_{end}}\left(e^{-0.0065\Delta T_{end}} - 1\right)$$

To compute Total Daily Exposure, occupational exposures are added to (H_G + H_D). Adjustments to TLVs based on (Work + At-Home) exposures are recommended.

For example, at-home exposures were estimated using these equations (105 min activity) and compared to TLVs.

Exposure Indicator	All Tasks Except Brake Pads	All Tasks	Worst Case, 95th Percentile
Percentage of Acetone TLV (500 ppm)	0.2%	0.5%	5.2%
Percentage of Toluene TLV (50 ppm)	0.8%	1.8%	18.2%

Table 3: Potential Contribution to Total Daily Exposure

Conclusions

Automotive repair by the home mechanic within an attached garage can constitute a significant exposure. The exposure created by home auto repair should be included in occupational exposure assessments for organic solvents.

Future Research

- A study testing the decay behavior of solvents within garages with a large sample size (n=30)
- The testing of additional repair tasks not performed within this study
- The testing of chemical mixtures not used within this study such as chlorinated brake parts cleaner

Acknowledgements

This research was funded, in part, by CDC/NIOSH Education and Research Center Training Grant, T42OH008491 and The University of Iowa's Executive Council of Graduate and Professional Students

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