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# Use With Adequate Ventilation?

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Consumer products such as paints, cleaning chemicals, and adhesives often contain toxic volatile chemicals. When these products are used indoors, these chemicals are released into the air resulting in inhalation exposures to applicators and other occupants. The resulting indoor concentrations can result in exposures that cause acute adverse health effects, including death, and/or explosion risks. Warning labels on these products and information in “safety data sheets” often simply caution to “use with adequate ventilation.”

But what does “use with adequate ventilation” actually mean? What is adequate?

ANSI C400.1/Z129.1,<sup>1</sup> defines “adequate ventilation” as a condition falling within either or both of the following categories: 1) Ventilation to reduce concentrations below that which may cause personal injury or illness, and 2) Ventilation sufficient to prevent accumulation to a concentration in excess of 25% of the level set for the lower flammable limit. In other words, having “adequate ventilation” is a good thing, the air is safe to breathe and explosions will be prevented.

However, the product information offered by manufacturers to consumers never contains guidance regarding the volume flow rate of ventilation (e.g., cfm [m<sup>3</sup>/h]) that constitutes “adequate ventilation.” Further confusing consumers, is that the same recommendation, “use with adequate ventilation,” is provided by manufacturers for both relatively non-toxic products and highly toxic products such as paint strippers.

Ventilation engineers routinely design ventilation systems to control the concentrations of chemicals in indoor spaces based upon the emission rates of the indoor sources. Many of the materials in office and residential buildings today (e.g., carpeting, furniture, adhesives, paints, etc.) are tested for chemical emissions, typically at 14 days following a 10-day conditioning

period and four days in a test chamber.<sup>2</sup> However, presently there is little testing of the chemical emission rates of wet products, such as paints, cleaning chemicals, and adhesives, when they are being applied. This is not because of any technical limitations, as the same small chamber chemical emission rate tests can be conducted using a glove box to measure the chemical emission rates of wet-applied products during their application as shown below.

Ventilation engineers can use this chemical emission rate data to calculate how much ventilation constitutes “adequate ventilation” for a specific application that will result in acceptable indoor exposures and not pose an explosion risk during the use of the product.

The following is an example of the calculation of how much ventilation is “adequate” for a popular consumer paint stripper. We selected a paint stripper for this example, since many paint strippers emit large quantities of methylene chloride, which is a very toxic chemical that is metabolized in the body to carbon monoxide, and has been the cause of injuries and deaths. The manufacturer’s Safety Data Sheet (SDS) discloses that the product contains 60% to 100% methylene chloride

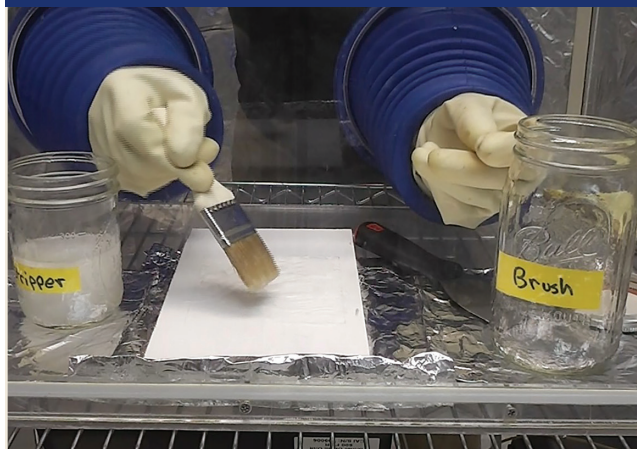
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(dichloromethane) and 10% to 20% methanol. The product label states: "Use with adequate ventilation" and "If using indoors open all windows and doors and maintain a cross ventilation of moving fresh air across the work area." The product label offers no guidance on how much ventilation constitutes "adequate ventilation" or how that may be achieved. There is no mention of use of a fan in a window to ensure that adequate ventilation is provided, and the recommendation of opening windows and doors suggests that just opening windows and doors will be sufficient. Simply opening windows and doors without use of an exhaust fan, does not ensure adequate ventilation, and should never be relied upon by itself. The air entering the window and door openings is dependent upon the natural driving forces caused by the indoor-outdoor temperature difference and wind speed, and if these driving forces are small there will be little ventilation.

To calculate how much ventilation this paint stripper requires during application, we measured the chemical emissions of the product in a 114 L (4.2 ft<sup>3</sup>) glove

FIGURE 1 Paint stripper chemical emissions test during application in a ventilated glove box.



box as depicted in Figure 1. A 30 cm × 15 cm (11.75 in. × 6 in.) piece of plywood, with one coat each of primer and a semi-gloss paint, was put into the test chamber and the paint stripper was applied to a 14 × 12 cm (4.7 × 5.5 in.) center area. We measured the concentrations of methylene chloride in real-time entering and exhausted

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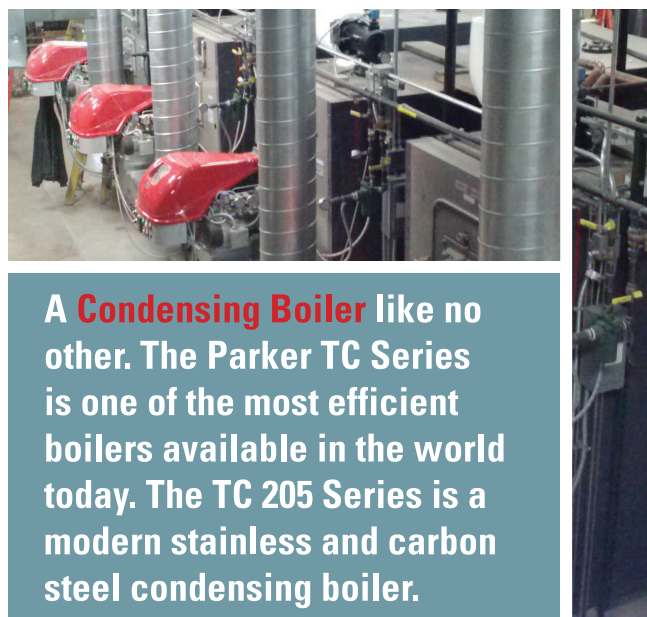
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from the glove box. The glove box exhaust rate was 17.3 L/min. (0.61 cfm, 9.1 air change per hour). The paint stripper was applied to the painted surface with a brush and allowed to set for 15 minutes, as recommended in the manufacturer's application instructions, and then the stripper and paint was scraped off. The chemical emissions were calculated as the product of the concentration difference (exhaust–entering air) and the exhaust rate divided by the area of the applied product and consisted of two very large peaks; 782 g/m<sup>2</sup>·h (73 g/ft<sup>2</sup>·h) when the product was applied, followed by a second larger peak of 1080 g/m<sup>2</sup>·h (100 g/ft<sup>2</sup>·h) when the product was scraped 15 minutes later, and a declining emission rate measured to be 205 mg/m<sup>2</sup>·h (19 g/ft<sup>2</sup>·h) at 60 minutes following application.

These chemical emission rates were then input into an indoor air mass balance model to calculate the indoor concentrations for different amounts of product usage and exhaust ventilation. For this calculation, we assumed that the concentration for the applicator exposure is the same as the concentration in the exhaust air (e.g., the applicator is between the exhaust fan and the paint stripping activity).

To calculate the ventilation required to satisfy the two objectives of health and explosion, we used the following criteria for methylene chloride:

- Acute non-cancer: 1/4 of the OSHA<sup>3</sup> Short-Term Exposure–15 minutes: 31 ppm (109 mg/m<sup>3</sup>)
- Cancer: No Significant Risk Level<sup>4</sup> Long Term Exposure–70 years: 200 µg/day
- Explosion: 1/10 of the Lower Explosive Limit: 13,000 ppm (45 200 mg/m<sup>3</sup>)

We note these acute non-cancer exposure guidelines are not intended for sensitive occupants such as infants, pregnant women and the elderly, for which much lower (e.g., 31 times lower) concentrations would be required.

For this product, consisting of methylene chloride and methanol, the determining criterion for acceptable ventilation is health, not explosion, as the health exposure guideline concentration is more than 400 times lower than the explosion guideline. With respect to the health guideline, the amount of required ventilation is determined by the methylene chloride emissions, as methanol is present in the product at much lower concentrations and has a much higher allowable exposure limit.

The calculated ventilation requirement that constitutes “adequate ventilation” for this product is presented

as both ventilation per area of product application and ventilation per volume of product. For applicators stripping well defined areas, ventilation per area of application area is appropriate. For applicators who are stripping objects that are not well defined by application area, ventilation per volume of product used is more appropriate.

Based on the chemical emission rate tests, the ventilation rates that constitute “adequate ventilation” for this product are as follows.

380 cfm/ft<sup>2</sup> of product application (6950 m<sup>3</sup>/h·m<sup>2</sup>)

203 cfm/ounce of product applied (12 m<sup>3</sup>/h·mL)

Cancer: Limit lifetime exposure to less than four times per year when using the above recommended ventilation rates.

What does this mean for users of these products? Paint strippers containing methylene chloride (as do many paint strippers), produce very high emissions of methylene chloride and require high ventilation rates for safe indoor applications. Whenever possible, paint stripping should be conducted outdoors as often is suggested on product labels. If that is not possible, then a fan should be operated to exhaust air from the work space directly to outdoors at the recommended rates, with a source of makeup air, such as a window to outdoors or a door to adjacent spaces, kept open.

For many consumers the exhaust fan options are window fans and box fans installed in windows. Window fans typically have two or more fans (4 to 8 in. [10 to 20 cm] diameter) and are rated at 100 to 400 cfm (170 to 680 m<sup>3</sup>/h). Box fans typically are 20 in. (51 cm) in diameter and are rated at 1,000 to 2,000 cfm (1700 to 3400 m<sup>3</sup>/h). The specific exhaust flow rate ratings for exhaust fans can be found in the manufacturers specifications.

Thus, if a consumer has a 1,000 cfm (1700 m<sup>3</sup>/h) box fan, then the maximum amount of application area is 2.63 ft<sup>2</sup> (0.24 m<sup>2</sup>), not a very big area, or on a volume basis, not more than 4.9 ounces (146 mL), a small amount of product.

As is clear from these calculated ventilation requirements, paint strippers containing methylene chloride require impractically large ventilation rates for paint stripping activities involving more than a very small area, and thus cannot be conducted indoors with

“adequate ventilation.” Such indoor work would require pressure demand respiratory protection.

It is not surprising that there are so many injuries and deaths cause by the use of paint strippers in residential bathroom remodeling projects. In these projects there is often a large area to be stripped in a small room air volume. If the consumer considers the operation of the bathroom exhaust (e.g., 50 cfm [85 m<sup>3</sup>/h]) as being “adequate ventilation,” that would be a fatally wrong assumption. The modeled peak indoor concentrations for a 9 ft<sup>2</sup> (0.84 m<sup>2</sup>) application with a 50 cfm (85 m<sup>3</sup>/h) exhaust fan, is 3,070 ppm, which is more than 1.3 times the NIOSH IDLH (Immediately Dangerous to Life and Health) concentration of 2,300 ppm.<sup>5</sup> If the application areas are larger then the peak indoor concentrations will be proportionally higher.

In addition, the required duration of the fan operation after completing the paint stripping may be calculated as follows. The stripped paint waste continues to be a significant emitter of methylene chloride for many hours following the stripping, so it is important that when the job is completed that the stripped paint waste

be removed and disposed of properly as soon as possible along with all residual stripper/paint on the stripped surface. Following the removal of these materials the exhaust fan should operate for a minimum of three air changes to reduce the indoor concentrations following the application by 95%, calculated as follows:

$$\begin{aligned}\text{Exhaust Fan Operation Time Following Application/} \\ \text{Removal (Hours)} &= V/(20 \times Q) \text{ (IP)} \\ &= 3 \times V/Q \text{ (SI)}\end{aligned}$$

where

$V$  = the room volume (ft<sup>3</sup> [m<sup>3</sup>]), which is length × width × ceiling height

$Q$  = exhaust ventilation rate in cfm (m<sup>3</sup>/h).

Thus, for a 3,000 ft<sup>3</sup> (85 m<sup>3</sup>) room (15 ft × 25 ft × 8 ft ceiling [4.6 m × 7.6 m × 2.4 m]) with an exhaust fan operating at 1,000 cfm (1699 m<sup>3</sup>/h) the exhaust fan needs to be operated for at least 0.15 hours (9 minutes) following removal of all of the paint stripper material.

In conclusion, chemical emission rate testing for wet-applied products under actual or simulated use conditions can be determined by relatively simple testing and should be used by manufacturers to provide specific guidance to consumers as to how much ventilation constitutes “adequate ventilation.”

Providing consumers with the required ventilation rates and product quantity limitations for indoor applications of paints, cleaning chemicals, and adhesives should significantly reduce adverse health impacts associated with the use of these products.

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