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Workplace ventilation in the polyester industry

Introduction

When using UP resins or other styrenated products, monomeric styrene will evaporate during application, particularly when open-mould processes are being used. To maintain worker exposure below the TLV limits, proper fabrication lay-out and good housekeeping is important. Application equipment should be chosen which gives reduced styrene evaporation during use. Whenever possible, always use Low Styrene Emission (LSE) resin or Low Styrene Content (LSC) resins. Good workplace ventilation and suitable personal protection equipment are also essential to minimise exposure levels.

This information bulletin deals with the principles of workplace ventilation. It also gives information on how to estimate the required ventilation capacity in a polyester workshop.

Ventilation principles

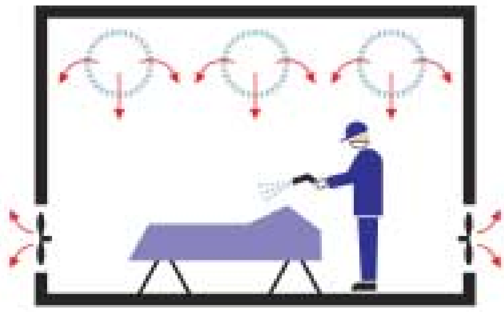
When working with polyester resins, the bulk of the styrene vapour is generated closest to the moulding operation. It should preferably be removed from the air as close as possible to its source. This ensures the most efficient ventilation of the workshop and means that the styrene vapour can be removed at relatively high concentrations with a low air displacement volume. If the styrene vapour is allowed to diffuse through the workshop, the required ventilation capacity to remove it becomes much higher.

The ventilation system should therefore be designed with this in mind. There is however no standard ventilation blueprint for a polyester workshop, since the volume of resin used and the processing technique are all contributory factors. A strong fluctuation in resin consumption will lead to a strong variation in emission. The ventilation capacity therefore has to be designed for the maximum emission. Essentially there are three different methods of ventilation, each with its specific advantages and disadvantages.

General Workshop Ventilation

When applying general workshop ventilation (also called dilution ventilation), the total air volume of the workshop is replaced several times per hour. This ventilation principle is popular as it is relatively simple and gives a great degree of flexibility in the movement of materials and products in the workshop. The disadvantage is the very high air displacement necessary to keep the styrene concentration at the desired level. In cold periods this may lead to excessive heating costs. General workshop ventilation is not always sufficient; especially for large mouldings like boats and silos.

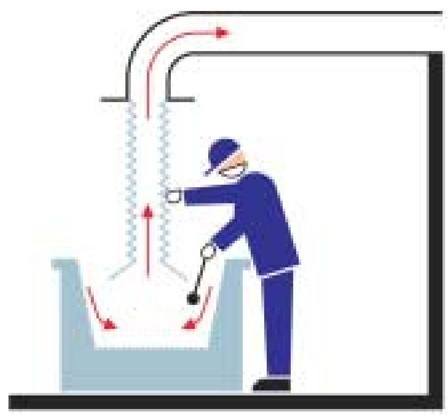
In these cases, general workplace ventilation is often supplemented with additional ventilators that blow the air-stream away from the operator. But this inevitably leads to a further dispersion of the styrene vapour throughout the entire workshop. This is why, when using general ventilation, it is important to keep the air speed as low as possible. This type of ventilation is often achieved by supplying fresh air through textile hoses placed under the ceiling of the workshop (See Fig 1). The styrene-concentrated air is extracted close to the floor level. Only in the case of small moulding operations is general ventilation alone sufficient.



Airflow through textile hoses (Fig 1)

Local ventilation

A more efficient method than general workshop ventilation because the styrene vapour is removed through ventilation hoods, installed as close as possible to the place where the styrene is generated. (see Fig 2).



Spot extraction with flexible hose (Fig 2)

(continued)

Siting the ventilation hoods can be made flexible, so they maintain their efficiency, even when different products are produced. To stay effective, ventilation hoods must be placed as close as possible to the work area. Ventilation hoods can hamper the freedom of movement around the mould, which is a significant disadvantage.

When ventilation hoods are combined with an array of airstreams that push the styrene-laden air directly to the ventilation hood, a so-called push-pull system results, which can reduce the styrene exposure very effectively. For small parts laminating tables can be equipped with down draft open pattern tops in combination with semi-enclosed exhaust hoods (see Fig 3). A good example of local ventilation is the use of suction channels in the floor of the workplace, combined with a supply of fresh air from above the mould. In this way the operator is always working with his breathing zone in fresh air (see Fig 4). Local ventilation is most effective when relatively small products are made in a fixed place.

Zonal ventilation

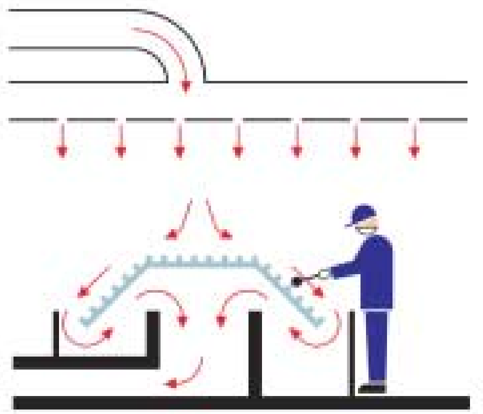
Zonal ventilation combines general ventilation with local ventilation. In this case part of the total workshop or compartment is ventilated in such a way that the styrene is removed before it is diluted into the air of the total workshop. Dividing a workshop into compartments is only effective when there is a good balance between the supply of fresh air to the compartment and the removal of the contaminated air.

Spray booths are a good example of the use of zonal ventilation. A spray booth is a compartment, more or less separated from the rest of the workshop. The air stream can be better controlled and less air is necessary to remove the styrene vapour.

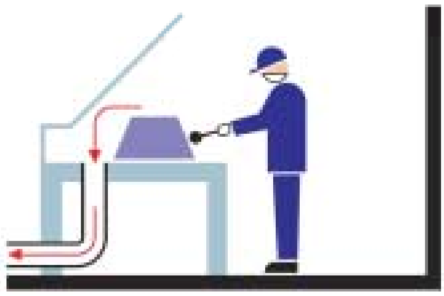
The airspeed in the entrance of a spray-booth should be designed between 0,3 and 1,0 m/s., which may still result in a major air displacement. There are various ways to optimize air displacement in a spray booth. Fig 6 series shows how the air flow in a spray booth can be optimised. The first sketch (6a) shows that an open spray exhaust may lead to a lot of turbulence. But if the spray booth is carefully designed to direct airflow to the back of the booth (see Fig 6 series b-d), then less turbulence is caused and hence less air is required for the extraction of styrene.

Estimating ventilation requirements

The rate of styrene evaporation in a polyester workshop depends on many variables, such as the type of resin, application process, application equipment used, tool design and configuration etc. As a guide, figure 7 indicates the typical percentage of styrene loss in different processing techniques, calculated as a loss in the weight of resin.

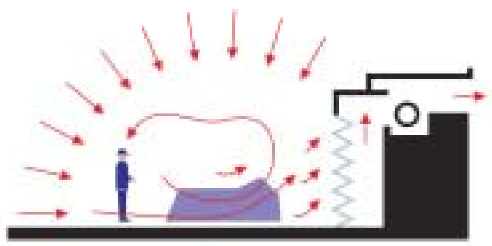


Out-mould induction 'push-pull' (Fig 3)



Portable table (Fig 4)

Booth optimisation set-ups



Open exhaust (5m ceiling) (Fig 6a)

Booth (5m x 2.5m opening) (Fig 6b)

(continued)

Process	Styrene loss (% of resin weight)
Gelcoat Spray	10-14 %
Spray-up, non-LSE resin	7-10 %
Gelcoat, Hand brush	6-8 %
Filament winding	5-7 %
Hand Lay-up, non-LSE resin	4-6 %
Spray-up, LSE/LSC resin	4-6 %
Topcoat, spray	4-5 %
Topcoat, Hand brush	3-4 %
Hand Lay-up, LSE/LSC resin	3-4 %
Pultrusion	1-3 %
Continuous lamination	1-2 %
SMC/BMC Manufacturing	1-2 %
SMC/BMC processing	1-2 %
Closed Processes (RTM/RTM Light/Infusion)	<1%

Fig 7, Styrene loss by process

From this table, the ventilation capacity can be estimated. A workshop has dimensions 40 x 20 x 5 m, so the volume of the workshop is 8000 m^3. If 150 kg of resin is spray laminated, using an LSE/LSC resin with a styrene evaporation rate of 4 %, then the styrene emission per hour is 6 kgs. Assuming this amount of styrene is spread evenly through the workshop atmosphere, this will lead to a styrene concentration of 750 mg/m^3.

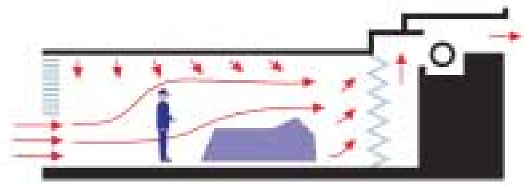
If dilution ventilation is used, we can estimate the minimum ventilation capacity, required to keep the styrene concentration below the MAC value. At a MAC value of 108 mg/m^3 (25 ppm) the workshop volume has to be refreshed 750 /108 = 7 times per hour. This would mean a minimum ventilation capacity of 56000 m^3/h.

The real ventilation requirement may be much higher. If the same workshop is also used regularly for gelcoating operations, the emission of styrene is considerably higher so the ventilation capacity must be increased accordingly. Careful design of the workshop ventilation system can lead to substantial cost savings. In practice, a properly designed fabrication layout and a ventilation system, optimized for flow and flow directions, will result in a lower ventilation capacity.

General recommendations

- It is a general misconception that because styrene vapour is heavier than air, it will instantly sink to the floor. Although the density of styrene vapour is 3.6 times the density of air, a styrene concentration of 500 ppm in the air will result in a density increase of just 0.13 %, compared to clean air. So slight convection currents and common air movements will already cause the styrene to dissipate throughout the entire workshop.

Booth (5m x 1m opening) (Fig 6c)



Booth (air jet support) (Fig 6d)

- Keep the workshop closed. A well-designed ventilation system will only be effective when the air streams are not disturbed by open windows or doors. Opening the doors in summer times to lower the temperature often results in a higher exposure to styrene.
- The inhalation of styrene vapour should be avoided, if necessary by using personal respiratory protection.
- Prevent resins coming into contact with skin and eyes by wearing appropriate safety clothing such as gloves, coveralls and goggles.
- Decant and mix UP resins in a separate well-ventilated room to reduce the likelihood of styrene vapours drifting into adjacent working areas.
- Follow the manufacturers' instructions when mixing and blending additives, accelerators, fillers and peroxides. Being reactive materials, certain additives or combinations of additives can cause unwanted reactions

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PlasticsEurope
Avenue E. van Nieuwenhuyse 4
B-1160 Brussels, Belgium
Telephone + 32 2 676 1732
Fax +32 2 675 3935
Email info@plasticseurope.org
www.plasticseurope.org