Occupational exposure to styrene

Introduction

When using unsaturated polyester (UP) resins, workers are exposed to evaporating styrene monomer. The level of allowable occupational exposure is governed, in most European countries, by maximum allowable exposure levels. The table opposite (fig 2) gives an overview of the TLV (Threshold Limit Values) as applied across Europe. Styrene concentrations shown in the table are calculated as the average concentration over an 8-hour working period. The STEL value (Short Term Exposure Limit) is the maximum permissible value over a short period, usually 15 minutes. Exposure to concentrations above the STEL value level is prohibited.

Measuring and monitoring emission requirements

A number of European standards outline the requirements for measuring workplace atmospheres and worker exposure to chemical agents like styrene:

EN 838 1996 Workplace atmospheres. Requirements and test methods for determining gases and vapours.
EN 689 1996 Workplace atmospheres. Guidance for assessing exposure by inhalation to chemical agents, for comparison with limit values and measurement strategy.
CEN/TC137 Published standards relating to workplace exposure to chemicals.

Exposure depends on processing techniques

Different application techniques have a marked effect on the amount of styrene evaporating from the resin surface. The rate of styrene evaporation depends on many factors, such as the type of resin, application process, application equipment used and tool design and configuration. As a guide, the table below (fig 1) indicates the typical percentage of styrene loss in the different processing techniques:

Process	Styrene loss %
Gelcoat spray	10-14
Spray-up, non-LSE resin	7-10
Gelcoat, 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, brush	3-4
Hand Lay-up, LSE / LSC resin	3-4
Pultrusion	1-3
Polymer concrete etc	1-3
Continuous lamination	1-2
SMC/BMC manufacturing	1-2
SMC/BMC processing	1-2
Closed processes (RTM/RTM Light/Infusion)	<1

Fig 1

Country	8hr avg TLV (ppm)	STEL (ppm)
Austria	50	100 (15 min)
Belgium	50	100 (15 min)
Czech Republic	47	234
Denmark	25	25 *
Finland	20	100 (15 min)
France	50	----
Germany	20	40 (30 min)
Hungary	12	----
Italy	50	100 (15 min)
Luxemburg	20	40 (30 min)
Netherlands	25	50 (15 min)
Norway	25	37.5 (15 min)
Poland	24	72
Spain	50	100 (15 min)
Sweden	20 **	50 (15 min)
Switzerland	50	100 (4 x 10 min)
United Kingdom	100***	250 (10 min)

* Ceiling limit
** 10 ppm for new installations
*** Obligation to reduce as much as possible

Fig 2

Assessing workplace exposure levels

It is essential that workplace styrene levels are regularly assessed. A separate information bulletin is available which describes the commercially available equipment for measuring and monitoring styrene concentrations.

Using such equipment enables FRP moulders to monitor levels and take appropriate measures, where necessary, to ensure compliance with local or national legislation.

Styrene workplace concentrations and ventilation capacity can be estimated as follows: assume an evaporation rate of 1 kg of styrene per hour. In order to stay below a workplace concentration of 20 ppm, approximately 12.000m³ of air is necessary to remove the styrene from the workplace air. Based on the emission factors for the different processes described in fig 1 and the consumption of resin per hour, the necessary ventilation capacity can be estimated.

(*Continued*)

Based on the emission factors described on page 1, the usage of resin in the process and the ventilation capacity of the workshop, can be combined to give an indication of the likelihood of the TLV being exceeded.

An illustration

If we assume that 50 kg of LSE resin is being processed by hand lamination in one hour, this means that the emission of styrene will be around 1.5 kg per hour. A minimum ventilation capacity of 18,000m^3 per hour will therefore be necessary to keep the styrene concentration below 20 ppm. But in practice, the installed ventilation capacity will need to be higher because the styrene vapour will never be homogeneously diluted in the workshop atmosphere. Typically for any hand laminating operation the air in the workroom has to be refreshed between 5 and 10 times per hour. For spray-up operations this refreshment rate may be considerably higher.

Keeping exposure levels down

There are many ways to keep exposure levels down. Some relate to the proper choice of the raw materials, some to the process or the equipment used, and some to the awareness and the dedication of the worker. Below we give - without being exhaustive - a number of suggestions to keep exposure levels down.

Cleaner processing

Good housekeeping can have a major impact in keeping styrene exposure down. It also has a very positive impact on safety and operational costs. Use LSE resins wherever possible and always use a resin with the lowest possible styrene content.

Avoid open resin/gelcoat buckets and pails

Resin and gelcoat storage should always be in a separate well-ventilated room. Avoid overspray and spills during spraying/lamination. Any spillages should be removed as soon as practically possible.

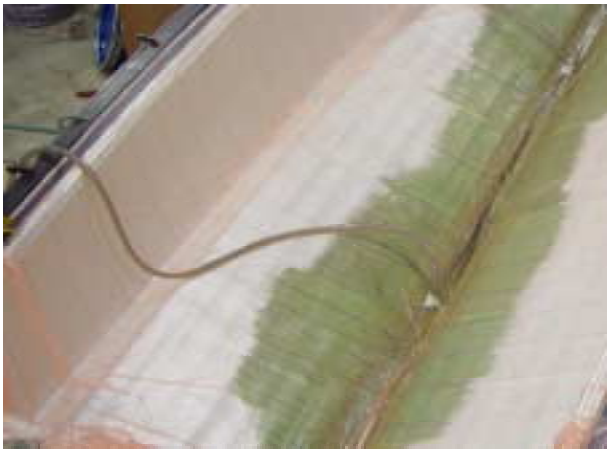
Keep workshop temperatures down

A high workshop temperature will increase styrene evaporation and thus exposures and emissions. Avoid open waste containers and ensure that all remnants of laminates and resin contaminated rags and paper are always put in a closed container. Such containers should be moved outdoors or into a well-ventilated area when the laminating operation is finished. Although the exposure to styrene takes place mainly through inhalation, excessive skin contact with resins should be avoided, which means always wearing protective clothing and gloves.

Switch to closed mould processing where possible

Use application techniques involving non-atomized dosing of resins, such as roller feeding or use modern spray equipment with fluid impingement nozzles. Robotized spraying is suitable when series numbers are sufficiently large.

Wherever closed moulding can be introduced it is well worth the investment. Not only will styrene emissions be substantially reduced (see fig 1) but also the finished products will have greater consistency. Closed moulding techniques include resin transfer moulding (RTM), resin injection (male and female moulds), or resin infusion (flexible film forms the male mould).



Styrene emission can be substantially reduced by switching to closed moulding techniques like resin infusion (above) or resin injection (below).

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