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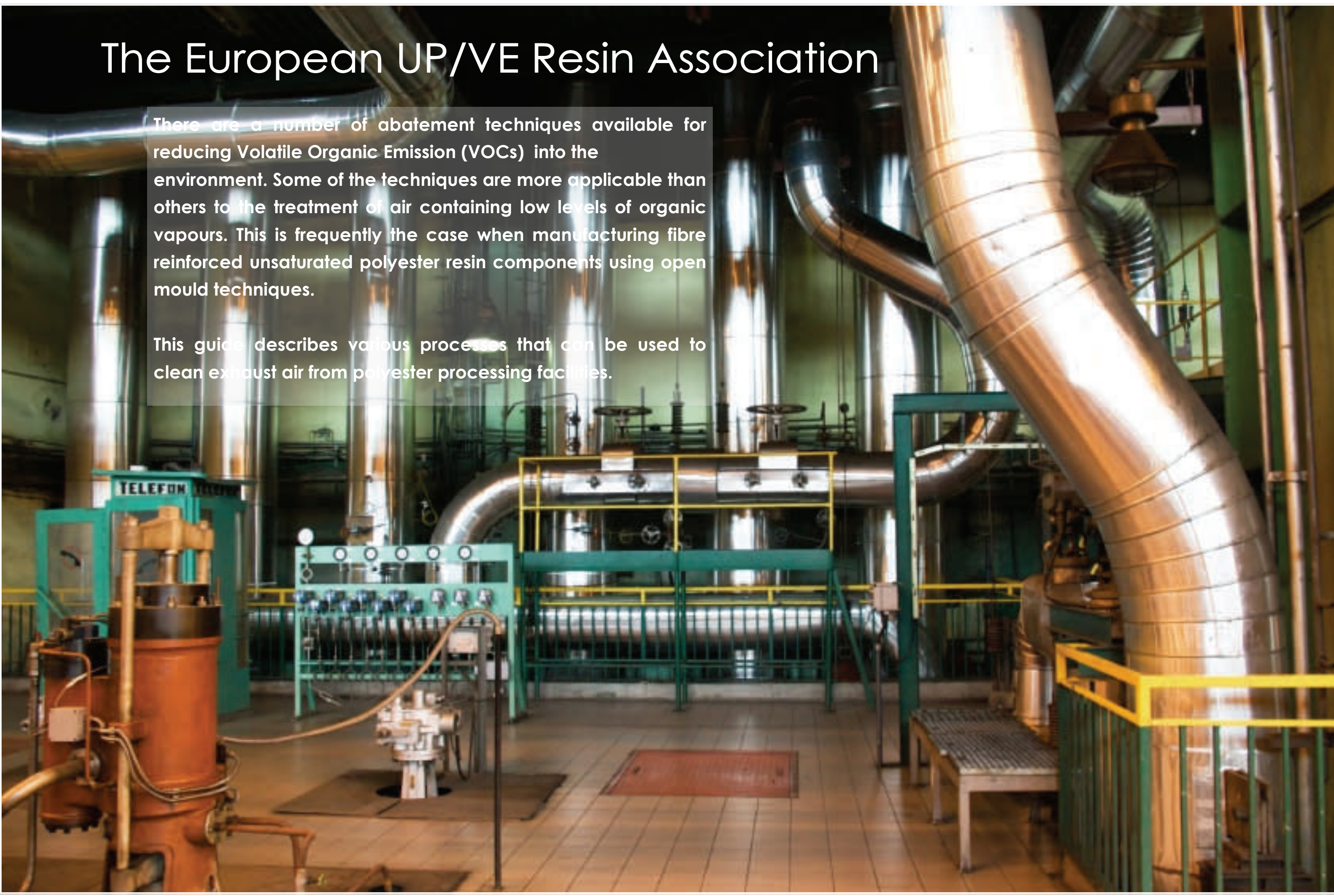
Styrene abatement techniques

Unsaturated Polyester Resin and Vinyl Ester Resin Safe Handling Guide

The European UP/VE Resin Association

There are a number of abatement techniques available for reducing Volatile Organic Emission (VOCs) into the environment. Some of the techniques are more applicable than others to the treatment of air containing low levels of organic vapours. This is frequently the case when manufacturing fibre reinforced unsaturated polyester resin components using open mould techniques.

This guide describes various processes that can be used to clean exhaust air from polyester processing facilities.



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Pollution prevention

The most effective abatement technique is to prevent the escape of VOC's into the workplace and subsequently into the atmosphere. The use of low styrene emission and low styrene content resins will assist in this respect in open moulding applications. It reduces the level of VOC emitted, compared with conventional resins.

Even more effective are the use of closed mould techniques, such as vacuum bagging, Resin Transfer Moulding (RTM), RTM light (using a light weight, inexpensive male tool) and hot and cold press moulding.

Types of abatement techniques

When styrene emission has to be controlled a number of abatement techniques exist.

Recovery methods

Recovery is only really viable if there is a large amount of solvent that can be recovered and sold, or there is a use for the recovered solvent on the site where it has been recovered. In the GRP industry the exhaust gas contains only low concentrations of VOCs and this increases the capital and running costs of a solvent recovery process; hence there is little economical justification for recovery systems in this industry.

Solvent recovery

- Adsorption recovery, pressure swing or thermal (using zeolites, polymeric adsorbents or activated charcoal)
- Condensation (cryogenic)
- Absorption of oils

Solvent destruction

- On-site oxidation using thermal or catalytic oxidiser (either regenerative or recuperative)
- Bio-filtration or bio-scrubbing
- Adsorption onto a sacrificial bed (activated carbon)
- Absorption into a sacrificial liquid
- Concentration systems followed by oxidation

Abatement techniques where the styrene vapour is removed by incineration or biological processes are more appropriate for the polyester processing industry.

The following processes are used and have proven to be suitable:

Incineration

High temperature incineration or catalytic incineration (at a lower temperature) gives high efficiency of around 99% with energy recycling. To be economically viable the process must use only the combustible pollutant as fuel and require no additional fuel input (except for start up or during short stoppages).

Direct thermal oxidisers

Regenerative thermal oxidisers offer good destruction efficiencies (96-98%) with 90% heat recovery using gravel or ceramic beds.
They can operate auto-thermally, without using extra solvent, at approximately 1g/m3 recovery of solvent. At inlet concentrations below this level additional sources of energy, gas/electricity, are required to keep the oxidiser up to temperature. These oxidizers operate well between 1-5g/m3 and at large air flow-rates and are relatively easy to operate with low capital costs.

Comparative thermal oxidisers use heat exchangers rather than a gravel or ceramic bed to recover the heat, limiting the heat recovery to around 70%.
Hence, more solvent is required in the inlet stream (2-3g/m3) to obtain auto-thermal destruction than with the regenerative oxidiser.

Direct catalytic oxidisers

Catalytic oxidisers have the advantage of lower operating temperatures and greater destruction efficiencies than thermal oxidizers and, hence, lower running costs. However, the cost of the catalyst usually results in higher capital costs. Mini-catalytic systems can be used where the air flow-rates are low or can be used where emissions are intermittent.

Bio-filtration systems

Bio-filtration is the bacterial oxidation of organic matter and results in the conversion of organic matter, like incineration, into carbon based gases and water vapour. Biofilters are good at removing low concentrations of solvent but they suffer the disadvantages of the time taken to destroy VOC's, efficiency of destruction and process control.

Some solvents are easily destroyed by the micro-organisms in the filters but larger molecules, like styrene, need longer residence times for destruction to occur requiring larger systems with greater area. The efficiencies vary from 60-70% for long dwell time bio-filters to 80-90% for buffer effect bio-scrubbers.

Extraction concentrations are limited to 1g/m3 for bio-scrubbers and 0.35g/m3 for bio-filters. Inlet conditions, especially temperature (20 and 40°C), require careful control to ensure the optimum destruction efficiency and to reduce costs. Humidity control is also essential for the survival and metabolism of the micro organisms.

Changes in the solvent inlet concentration affects the metabolism of the micro organisms and will result in low efficiencies at higher inlet solvent concentrations.

Bioway Zerochem system for bacterial oxidation

Adsorption and adsorption onto sacrificial intermediates

These two technologies are similar with the exception of the media and they both suffer from similar disadvantages. Adsorption usually occurs onto a carbon filter whilst absorption is into a liquid. When saturated with solvent the media are removed and sent off-site for regeneration or disposal.
These systems are not used on continuous or semi-continuous exhaust systems but in areas that are purged intermittently. The running costs are high.

Concentration systems

Concentration systems are probably the best technique for low VOC abatement from exhaust levels typically found in the GRP industry.
There are two types of concentration systems, rotary wheels and fluidised bed. Both remove solvents from the inlet air by adsorption onto zeolites or polymeric adsorbents and desorbs them into a hot air stream that is a fraction of the level of the original airflow.

The concentrated air stream contains solvent between 2 and 8 g/m3, which can be destroyed in a catalytic oxidiser with no extra fuel, reducing both capital and operating costs. The selection of a specific concentration system depends upon the concentration ratio required bearing in mind that the objective is to achieve as high a concentration ratio as possible in order to reduce both the capital cost (by decreasing the size of the unit) and the operating cost (by ensuring the system is always auto thermal).

Extra heat generated can be used for reheating the replacement air. The following table gives an overview of the process conditions and approximate investment costs for some of the abovementioned systems.

Literature

Assessment of styrene emission controls for FRP/C and boat building industries
http://www.epa.gov/ttn/atw/rpc/finalrpt.pdf

Emission Control Technologies, a guide for Composites Manufacturers. Ray Publishing.

VOC abatement info

- Chematur Limited (Polyad)
- CSO Technic Limited (Therminodour)
- Air Protekt
- Forbes Environmental Technologies
- Bioway

Companies listed in the abatement section

Chematur Limited (Polyad)
http://www.chematur.se/
CSO Technic Limited (Therminodour)
http://www.csotech.com/
Air Protekt
http://www.airprotekt.co.uk/
Forbes Environmental Technologies
http://www.forbes-group.co.uk/index.htm
Bioway
http://www.bioway.nl/

Air Protekt catalytic oxidation system

Technique	Capacity	Ingoing concentration	Outgoing concentration	Investment €/1000Nm^3/h)	Advantages	Disadvantages
Adsorption on active carbon	100-100.000 m^3/h	10-10.000 mgr/m^3	5-100 mgr/m^3	5.000 – 10.000	- Simple robust technique	Saturated sorbent is chemical waste
Bio filtration	50 – 200 m^3/m^2.h	50 – 500 mgr/m^3	> 10 mgr/m^3	5.000 – 20.000	- Simple construction - Biological process	- Large volume installation - Sensitive to poisoning - Inflexible at changing concentrations
Catalytic oxidizer	1000 – 30.000 m^3/h	> 1.000 – 2.000 mgr/m^3	< 20 – 50 mgr/m^3	10.000 – 40.000	- High yield - Relatively compact installation	- Use of additional fuel when not running auto thermal
Thermal oxidizer	1000 – 30.000 m^3/h	> 1.000 – 2.000 mgr/m^3	< 20 – 50 mgr/m^3	5.000 – 40.000	- High yield - Relatively compact installation - Heat recovery possible	- Use of additional fuel when not running auto thermal - Emission of CO_2 and NO_x
Regenerative adsorption	N.A.	500 – 5000 mgr/m^3	100 – 250 mgr/m^3	N.A.	- No chemical waste	- Complex installation
Cryocondensation	0 – 1000 m^3/h	200 – 1.000 gr/m^3	1 – 5 gr/m^3	500.000	- Compact technique - Recovery of VOC's	- Use of liquid nitrogen - Not suitable for wet gas streams

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