MnTAP

# MINNESOTA TECHNICAL ASSISTANCE PROGRAM

Fact Sheet

UNIVERSITY OF MINNESOTA

# Reducing volatile emissions in the fiber reinforced plastics industry

This fact sheet provides information to fiber reinforced plastic processors on how they may reap benefits by reducing volatile emissions.

Most fiber reinforced plastics (FRP) processors are major sources of volatile emissions. The emissions from FRP processing facilities include styrene, the volatile component of polyester resin and gelcoat; and acetone, a solvent used to clean tools and other surfaces contaminated with resin.

Benefits of reducing volatile emissions include:

- Fewer emissions implies better raw materials use, improving the bottom line.
- Less concern about Occupational Safety and Health Administration (OSHA) regulations related to worker exposure to chemicals, especially styrene.
- Less concern about regulation of air pollutants as a result of the 1990 Clean Air Act Amendments (CAAA), and the Maximum Achievable Control Technology (MACT) standards.
- Reduced disposal cost of spent solvents as hazardous waste.
- Reduced risk of fires caused by high concentrations of chemicals in the workplace.

## Process Change Considerations

No single option is likely to replace the plant-wide use of solvent or completely eliminate the source of volatile emissions. Examine alternatives that combine several options. When considering a substitute, keep in mind the following:

- Do the new materials pose a worker health or safety risk?
- How much employee training will be required for successfully implementing a substitute?
- What experience have others in the industry had with the alternative technology?
- What regulations need to be considered?
- What will the effect be on product quality and production levels?
- Will a new waste stream be created? If so, how will it be handled?

## Reducing Styrene Emissions

Styrene emissions result primarily from materials application and laminate cure. While applying materials, styrene emissions often result from resin atomization and overspray. Laminate cure often results in high emissions due to the evaporating liquid. In general, the higher the styrene content and resin atomization during application, the higher the emissions. Opportunities for reducing styrene emissions include:

- Substitute styrene-free or low-styrene emission resins.
- Upgrade resin and gelcoat application equipment.
- Convert open-mold processes to closed-mold processes.
- Implement a controlled spraying program.
- Improve raw material monitoring through better processing control.

## Styrene-Free Resins

Styrene-free resin has demonstrated versatile structural and coating applications and does not contain or produce EPA reportable components or emissions. Styrene-free resins typically contain about 1% of volatile organic compounds (VOCs).

Styrene-free gelcoats and vinyl-ester resins are available commercially and serve to eliminate styrene from FRP processes. Because the resins contain a greater percentage of solids than low-styrene or conventional resins, the application cost is comparable. Operators or automated equipment will require retraining, as the greater percentage solids decreases the application quantity. Engineered components testing is also required when converting to styrene-free resins since they have less shrinkage. NOVOC®, a manufacturer of styrene-free resins, claims that the styrene-equivalent emissions from its resins are less than approximately 1.12% on a mass basis.[1] The product will effectively reduce styrene emissions 100%, and reduce VOC emissions by over 97%.



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## Low-Styrene Emission Resins

Low-styrene emission resins are grouped in two general categories: reduced styrene resins and vapor-suppressed resins.

### Reduced Styrene Resins

Reduced styrene resins contain 35% or less styrene on a weight basis. The chemistry of low-styrene resin has low viscosity and the desired appearance of a final laminate. However, their viscosity is higher than conventional resins and roll out over reinforcing material may be more difficult. The viscosity is much more sensitive to temperature fluctuations, which may require improved temperature control. The cost of low-styrene resins is comparable to conventional resins. The Unified Emission Factors developed by the American Composites Manufactures Association (ACMA)show that a decrease in the styrene content from 40 to 35 % will reduce styrene emissions by 20 to 50 %, depending on the application method.[2]

### Vapor-suppressed resins

These resins contain an additive that forms a barrier inhibiting the release of styrene during the laminate cure process. In the past, the additives were wax-like, but problems with secondary bonding limited their acceptance. The reactivity of the newer vapor suppressing additives safeguards secondary bonding, which allows crosslinking to occur within the vapor suppressing film. Appropriate concentration levels of the additive, ranging from 0.2 to 1.0 %, are crucial as high levels reduce effective secondary bonding. Tests done by BYK-Chemie, a resin manufacturer, suggest the use of vapor-suppressed resins reduces styrene emissions in excess of 50 %.[3]

## Upgrading Application Equipment

Many FRP processors apply resin or gelcoat using conventional spray equipment, which requires high fluid pressure or compressed air to create a finely divided spray. All conventional spray technologies produce misting, which results in overspray. Transfer efficiency decreases when material misses the mold surface. Misting, and particularly the resulting overspray, increases the surface area of the resin or gelcoat particles exposed to air during application, causing a higher evaporation rate which increases emissions.

In order to mitigate these negative effects, new application equipment technologies have been developed. These include non-spray and non-atomized technologies, such as flow coaters and fluid impingement equipment. Non-atomized technologies are viable in almost all open-molding operations.

Flow coaters are internal mix guns that produce low-pressure streams of resin. These guns can be equipped with a glass chopper to simultaneously apply catalyzed resin and reinforcing media. Because flow coaters rely on internal mixing of the resin and catalyst, the operator must periodically flush the mixing chamber with an appropriate solvent to minimize contamination build-up. Depending on the solvent used, this may affect hazardous waste generation.

Fluid impingement application equipment can be either internal or external mix. In both cases, the resin or gelcoat exits the gun in two low-pressure streams which cross each other. Their collision creates a fan pattern. As with the flow coaters, chopped glass can be simultaneously combined. The Coating Applications Research Laboratory at Purdue University found that the fluid impingement technology gelcoat system generated 32% fewer styrene emissions than conventional equipment.[4]

To successfully implement non-atomized application technologies, several issues must be addressed. First, non-atomized spray appears to wet-out slower than conventional spray. Although it takes slightly longer to saturate the glass, it will wet-out quickly once the roll out process begins if the equipment is adjusted for the appropriate glass-resin ratio. The operator must be trained on this aspect because the tendency is to apply excess resin and glass. Second, capturing the chopped glass in the resin stream is a concern. The chop chute needs to be adjusted more precisely than traditional equipment. Failure to do so results in a wider distribution than desired. A final concern is the electrical charge that may occur during spraying. On the extreme, glass is repelled away from the resin stream. Either proper grounding of the equipment or glass roving with a charge opposite of the system's may be required. It is best to consult the equipment supplier when addressing this issue.

## Converting to Closed-Mold Process

The closed-mold process reduces emissions and optimizes the glass-resin ratio, producing a higher quality laminate. Two techniques are presented here: vacuum bagging & resin infusion.

### Vacuum Bagging

Vacuum bagging technique applies resin and reinforcement in the traditional manner. Before the laminate starts to cure, a thin plastic film is placed over the uncured laminate and a vacuum is drawn over the system. This creates a pressure of one atmosphere over the laminate surface and forces excess resin from the system. Vacuum bagging techniques increase the glass to resin ratio, enhance physical properties of the laminate and reduce the amount of resin used. If the bag is not reusable, solid waste from applying this technique will increase.

### Resin Infusion

Resin infusion technique converts existing open-molds by fitting a flexible membrane around the mold perimeter. Reinforcements are tacked into place, the membrane is sealed around the mold edge and a vacuum is drawn on the system. The membrane stretches to make contact with the reinforcing media. A valve is opened and resin is sucked into and through the reinforcing media. Resin infusion reduces styrene emissions by eliminating the exposure of liquid resin to the environment during the manufacturing process. No overspray and less flashing waste are produced, while a minimum quantity of resin is used. Resin infusion increases part quality and part-to-part consistency. Reduced labor helps justify its large capital expense. Solid waste may increase, but the membrane can be used multiple times. Waste increase is typically less than vacuum bagging.

Resin infusion has been successful when parts require multiple reinforcing layers. For example, Larson Boats, of Genmar Holdings in Minneapolis, Minnesota, makes boat hulls using the Virtual Engineered Composition (VEC) process. The VEC process is a closed-mold approach to boat building that incorporates sophisticated automation to produce high quality high strength parts with part-to-part weight consistencies within one %. The entire molding process is enclosed, reducing styrene emissions by 77% and solid waste by 50 %.[5]

## Implementing Controlled Spraying Programs

Controlled spraying is an effective work practice that reduces styrene emissions in conventional open molding processes up to 25%. By minimizing spray gun atomization and reducing overspray loss, a manufacturer improves the transfer efficiency of resin or gelcoat. This approach is most effective for operations using atomization spray equipment, but certain aspects may benefit operations using non-atomized spray equipment as well. A controlled spray program is comprised of three elements: containment flanges around the mold perimeter, spray gun pressure calibration and spray operator training.

Containment flanges may be designed for new molds or added to existing mold. Masking may also be applied around the mold perimeter as a temporary flange. In each case, the flange acts as a barrier to potential overspray, which is captured and accumulated at the flange. Because resin and gelcoat particles have less surface area exposed to the air, styrene emissions are reduced.

Spray gun pressure calibration is a technique that reduces tip pressure to the lowest possible point while maintaining an acceptable spray pattern. This decreases styrene emissions by decreasing misting. One way to accomplish this is to apply the ACMA's calibration procedure:[6]

- Verify the correct temperature of the resin and that it has been mixed for the manufacturer's specified amount of time.
- Verify the spray tip is in good condition and it is sized appropriately for the flow rate and fan pattern width for the job.
- Hold the gun perpendicular, 12 to 18 inches from the floor, and aim it at a disposable floor covering.
- Turn pump pressure to zero and pull the trigger.
- Slowly begin to increase the pressure in 10 psi increments until the fan pattern is adequate. If the fan pattern produces a symmetrical ellipse, the pressure is optimum.
- Record this pressure in the spray gun set up log.
- Increasing the pressure above this point results in over atomization, increased overspray and poor transfer efficiency.

Operator training is crucial to producing high quality work and reducing styrene emissions. Precise spray gun aim is necessary in order to put as much material into the final part as possible. Operators need to develop a high level of concentration because application rate and gun movement determine an even thickness across the part. The use of a thickness gauge helps ensure proper material thickness, as well as part-to-part consistency and optimal material use. When spraying the perimeter, keep within the area of the containment flange. Overspray that hits the floor increases styrene emissions.

## Improved Process Control

### Robots

A tight labor market allows FRP open-molding processes to consider the use of robots. A robot with the appropriate automation is the ultimate in controlled spraying. Robots guarantee proper positioning of the spray gun and ensure optimized coverage. Although somewhat capital intensive, these systems produce parts faster, improve part-to-part consistency, optimize materials use, reduce plant ventilation requirements and reduce ergonomic injuries. Some robots are also capable of collecting production data.

Weight tolerance of parts is greatly improved resulting in significant material savings. Overall material use for manual application is higher because excess overspray and weight difference from part to part will have a larger statistical spread. For example, if part-to-part weights for manual application have a spread of +/- 10 % and robotic application has a spread of +/- 5 percent, then a robotic application consuming 1,000 lb of material per day will save more than 50 lb of material.[7] Material savings, increased rates of production and improved part quality ensure a quick payback on the system.

Maintenance issues may require additional training for personnel. On-site computer programming and fitting new products into the process may require extra expertise.

## Raw Material Monitoring Systems

Raw material monitoring systems are electronic devices capable of delivering real time information concerning resin, glass and catalyst application. These systems allow processors to keep track of material used and to achieve part weight goals. As a result, part-to-part consistency is maintained and overall material use decreases resulting in fewer emissions. Data from these systems can be transferred to a computer for improved costing or record monitoring. A payback of one year or less is achievable.

## Reducing Acetone Emissions

Acetone is a commonly used solvent for cleaning uncured polyester resin and gelcoat from tools and contaminated surfaces. In a typical FRP operation, more than 50% of the solvent used can be lost to air through evaporation. The remaining spent solvent can be processed on-site to reclaim the acetone or disposed of off-site as hazardous waste. Still bottoms remaining from the reclamation step must be disposed of as hazardous waste.

Even though acetone is classified as a non-volatile organic compound (VOC), its hazardous qualities are still strong incentives for FRP shops to implement alternatives. These qualities include fire hazards associated with elevated concentrations of vapors and waste management of the spent hazardous solvent. Acetone substitutes can be used to reduce volatile emissions. These substitutes are grouped into two general categories: higher-boiling solvents and aqueous cleaners.

### Higher-boiling Solvents

These solvents work the same way as acetone, by dissolving the resin. When using higher-boiling substitutes the liquid film remaining on the part may be removed with a towel or by some other means, as these solvents do not evaporate as readily.

Higher-boiling solvents can be substituted for acetone in many applications. However, their effectiveness needs to be verified for each cleaning situation. Carefully review the Material Safety Data Sheet (MSDS) to note any potential safety or worker exposure hazards. Protective equipment such as splash goggles and gloves may be necessary.

### Aqueous Cleaners

Aqueous cleaners rely on mechanical action, such as brushing, to clean resin from contaminated surfaces. The mechanical action separates resin from the part surface and the resin droplets are wetted by the aqueous cleaner. The coated resin settles to the bottom of the cleaning tank. A towel or a stream of air can then be used to dry the tool prior to reuse.

Although aqueous cleaners eliminate volatile emissions, they create two other waste streams including the spent aqueous solution and the under-cured resin material collected in the cleaning tank.

Information from the MSDS for some aqueous cleaners suggests that the spent liquid solution can be disposed of by sewering. However, prior to disposal, be sure to obtain approval from your local sewage treatment facility and comply with all local, state and federal regulations.

Both higher-boiling solvents and aqueous cleaners are effective substitutes, but special attention is needed when educating employees about new cleaning procedures. Lack of training usually results in poor cleaning, and employees' lack of acceptance causes implementation to fail.

## Managing Small Amounts of Waste Resin or Gelcoat

Small batches of uncured resin or gelcoat can be disposed of as nonhazardous solid waste if they are hardened by adding an appropriate amount of catalyst. Refer to the Minnesota Pollution Control Agency's Best Management Practices for Treating Waste Polyester-Resin and Gelcoat fact sheet for the requirements and proper procedures.[8]

## Additional Sources of Information

The following publications and Web sites provide further information on waste reduction in the fiberglass fabrication industry:

- Hillis, David. Establishing Waste Reduction Benchmarks and Good Manufacturing Practices for Open-Mold Laminating, North Carolina Division of Pollution Prevention and Environmental Assistance, 1997.
- Hillis, David and David, Darryl. Waste Reduction Strategies for Fiberglass Fabricators, East Carolina University, 1995.
- American Composites Manufactures Association <www.cfa-hq.org/>.
- Pacific Northwest Pollution Prevention Resource Center <www.pprc.org/hubs/toc.cfm?hub=10&subsec=7&nav=7>.
- Composite Materials Technology Center <www.winona.msus.edu/engineering/comtec/overview.htm>.
- Coating Applications Research Laboratoy <www.ecn.purdue.edu/cmti/carl>.

## References


*1. Hall, S.J., Noonan, J.R. and Devine, R.M. Alternative Gel-Coat Technology Emissions Testing, Indianta Clean Manufacturing Technology and Safe Materials Institute, November 21, 2000.*

*2. Unified Emission Factors for Open Molding of Composites, American Composites Manufactures Association, <www.acmanet.org/ga/uef_table_23jul01.pdf> April 7, 1999.*

*3. Briedenbach, D. and Dotson, E. "The Practical Use of Styrene Suppressants and Testing with the ACMA's 'Vapor Suppressant Effectiveness Test,'" Composites Fabrication. November/December 2000, p. 28.*

*4. Noonan, J.R. and Hall, S.J. New Gel-Coat Application Technology Emission Study, Coating Applications Research Laboratory, Clean Manufacturing Technology and Safe Materials Institute, Purdue University, November 22, 2000.*

*5. Genmar Holdings Governor's Award Summary, Minnesota Office of Environmental Assistance, <www.moea.state.mn.us/berc/govaward99.cfm#genmar>, September 2000.*

*6. Lacovara, B. "Controlled Spraying: New Techniques for Efficiency—With No Downsides," Composites Fabrication. March 1998, p. 8.*

*7. Schwamberger, R. "How Robots are Used in the Composites Industry," Composites Fabrication. July 2000, p. 28.*

*8. Best Management Practices for Treating Waste Polyester-Resin and Gelcoat, Hazardous Waste Division Fact Sheet #4.50, Minnesota Pollution Control Agency, April 1997.*




## For More Information

MnTAP has a variety of technical assistance services available to help Minnesota businesses implement industry-tailored solutions that maximize resource efficiency, prevent pollution, increase energy efficiency, and reduce costs. Our information resources are available online at <mntap.umn.edu>. Please call MnTAP at 612.624.1300 or 800.247.0015 for personal assistance or more information about MnTAP's services.