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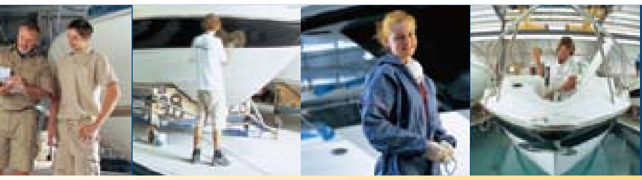
Fibre composite manufacturing



Good operating practice and alternative materials

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Eco-efficiency for the Marine Industry Fact Sheet

Do you want to

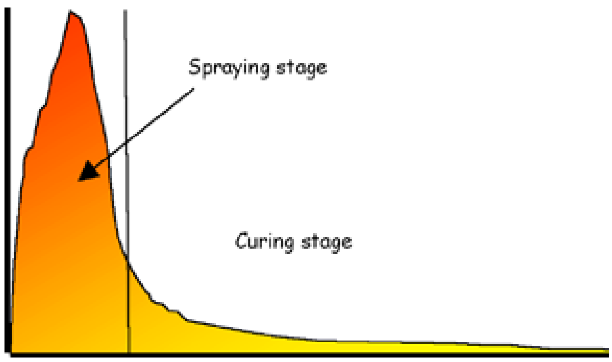
- ☑ achieve higher production rates?
- ☑ improve the performance of your operators?
- ☑ reduce your waste?
- ☑ reduce emissions that impact on human health and the environment?

Spray lay-up

Spray lay-up is a technique that is commonly used in the Queensland boat building industry. The process uses a handheld spray gun that projects a mixed stream of chopped fibre composite, resin and catalyst onto a mould covered in a layer of gelcoat.

Advantages
High production rates
Good control over spray pattern
Can be used on complex moulds with many recesses
Disadvantages
Greater air emissions and raw material loss due to overspray, overpressure, operator technique. 50% of volatile organic compounds (VOCs) are released during fabrication, 25% during rollout and 25% during curing. [1]

Figure 1: Over half of the VOCs are released during fabrication so good operating practice is essential[1]



Good operating practice[2]

In open moulding, good operating practice can reduce gelcoating emissions by up to 40% and resin emissions by up to 20%.

- Ensure that the spray tip is suitable for the flow rate and spray width required.
- Calibrate the spray gun to operate at the lowest possible fluid tip pressure setting.
- Turn pump pressure to zero and then slowly increase the pressure in 10 psi (70 kPa) increments until the spray pattern takes the shape of an ellipse. Hold the spray gun at 90°.
- Record this optimum pressure in a spray gun set-up log (see table 1). Operating above this pressure will result in poor transfer efficiency.
- Ensure that the spray tip is in good condition.
- Hold the gun at 90° to the surface for even film thickness, and less gelcoat peel, streaking, runs and overspray. Spray into internal and external corners at a 45° angle.
- Always keep spray strokes parallel to the surface and do not use an arching movement. Contain overspray using flanges or masking.
- Use a wet film gauge to check material thickness

Table 1: Ensure efficient spray by recording operating parameters[1]

Parameters	✔	Parameters	✔	Parameters	✔	Parameters	✔
Fluid pressure setting		Body position		Gun distance		Spray overlap	
Air pressure setting		Gun angle		Gun speed		Gun triggering	
Spray pattern		Gun stroke		Edge control		Thickness gauging	

Non-spray (non-atomising) technology

Non-spray application technology applies resin or gelcoat at a steady rate in droplets, rather than an atomised liquid. Non-spray technology can reduce emissions by up to 33% for gelcoat and up to 45% for resin coat applications.[3]

Table 2: Non-spray applications[4]

Flow coaters
Internal mix guns that produce low-pressure streams of catalysed resin. Chopped fibre composite can be simultaneously applied. The mixing chamber needs to be flushed periodically with solvent.
Fluid impingement
Two low-pressure streams of catalysed resin exiting the gun cross each other to create a spray pattern. Chopped fibre composite can be simultaneously applied. Training is essential and equipment needs to be grounded to prevent electrical charge repelling fibre composite from the resin stream.
Pre-pregs
Fibre reinforcements that are pre-saturated with resins. Pre-pregs ensure optimum resin-to-fibre ratios and thus have light weight but high strength. This technique reduces disposal costs, but involves higher raw materials and energy costs associated with transport, refrigerated storage and oven curing.
Impregnators
Impregnators feed fibre composite mats mechanically through a resin bath directly to the mould. This technology has some of the advantages of pre-pregs without the energy costs, and is able to use lower cost resins and fibre composite materials.
Pressure fed rollers
Catalysed resin is precisely measured and dispensed through a roller. This technique is not suitable for chopped reinforcement. Existing spray guns can be modified into resin rollers.
Rollers and brushes (hand lay-up)
Hand lay-up uses no chopping equipment or mechanical spraying. Reinforcement layers are wetted out with resin and then rolled to remove any air pockets. Layers are applied until the required thickness is achieved. This method is time consuming, but suitable for large parts and reduces waste from overspray.

Case study: Flow coaters reduce waste by 50% [4]

Cobalt Boats, a boat builder in Kansas, USA, replaced its high pressure chopper guns with flow coaters that spray at a higher volume and lower pressure. The flow coaters have helped to reduce overspray and emissions and the loss of valuable raw materials. The use of flow coaters has reduced the quantity of floor liner used each week from 2,722 kg to 617 kg (i.e. savings of about 110 tonnes of solid waste per year).

Case study: Fluid impingement technology reduces emissions [5]

Sunrise Fiberglass in Minnesota, USA, was able to reduce emissions by 43% from 1999 levels using fluid impingement technology coupled with low styrene resins—a saving of about AU$36,000 annually.

Improve transfer efficiency of spray delivery systems

The table below shows how different methods of resin atomisation (airless, air-assisted or high volume low pressure) can help to reduce air emissions and improve transfer efficiency.

Table 3 : Spray gun types and transfer efficiency[2,6]

Gun Type	Method of resin atomisation	Comments
Conventional	Resin stream delivered at a relatively low pressure (<60 psi). Air is directed across the stream as the fluid exits the nozzle resulting in the desired spray pattern.	Low transfer efficiency and high emissions
Airless	Resin stream delivered at a high pressure (1,000-3,000 psi). An abrupt pressure drop when exiting the nozzle causes the spray pattern.	Higher transfer efficiency than conventional guns, but with potential for overspray due to high pressures
Air-assisted Airless	Resin stream delivered at a lower pressure than airless guns (400–1,000 psi). Pressurised air on the outer edge of stream as it exits the nozzle causes the spray pattern.	Lower operating pressure, higher transfer efficiency and lower emissions than airless
High volume low pressure	Resin stream delivered with large volumes of air at a low pressure (10 psi).	Highest transfer efficiency and least overspray of the four technologies

Low styrene resins and other alternatives

Polyesters and vinyl esters, while cheaper, usually contain styrene monomers. Monomers in resins react with each other and with polymers to form a viscous liquid that cures into a strong and durable product. However, many of these monomers are released to air during application, rollout and curing. Lower styrene resins reduce these volatile organic compound (VOC) emissions by containing short chain polymer molecules that permit lower monomer content, or by containing other non-styrene monomers such as vinyl toluene or methyl methacrylate, which evaporate less when exposed to air[7]. Higher costs may be offset by improved physical characteristics (e.g. lighter product). Low styrene resins contain 35% or less styrene on a weight basis.

Other resins such as vinyl esters and epoxies are also used in the manufacture of boats. Epoxy resins have excellent performance characteristics and emit significantly less VOCs, but are costly and require different skills to apply. Some boats comprise 100% epoxy resins, while other fibreglass boats may have a vinyl ester or epoxy barrier coat on the outside of the craft only.

Advantages
A decrease in styrene content from 40% to 35% will reduce styrene emissions by 20% to 50%, depending on the application method. [3]
Prices are comparable with conventional resin.
Disadvantages
Low styrene resins will have different chemical and physical properties (e.g. higher viscosity or temperature sensitivity) and may require adjustments to application techniques

Case study: Sunrise reduces emissions by using low styrene resins[8]

Sunrise Fiberglass in Minnesota, USA, is a make-to-order moulder of fibreglass reinforced composite components and assemblies, including boats. Due to increased government regulations to reduce styrene emissions, the business began using low styrene emission resins in place of standard resins in their open moulding operations. Two of the three low styrene resins were substituted without equipment or process changes, with the third requiring about AU$1,600 worth of modifications. The initiative reduces emissions by approximately 35% and saves about AU$6,000 annually in reduced ventilation costs, while meeting the more stringent worker health standards.

USEPA evaluation of eco-efficiency techniques to reduce styrene emissions[10]

A study by the USEPA Air Pollution Prevention and Control Division evaluated several pollution prevention techniques that could be used to reduce styrene emissions from open moulding processes. The study found that good operating practice, low styrene/styrene-suppressed materials and non-atomising applications can reduce styrene emissions by between 11% and 52%.

Normal vs good practice

Spray technique	Total emissions (g)	Reduction (%)
Normal	513	Baseline
Good practice	391	24

Emissions using different resin formulations

Type of resin	Total emissions (g)	Reduction (%)
Regular – low profile	445	Baseline
Low styrene	395	11
Styrene suppressed	286	36
Styrene suppressed + wax	266	40

Regular vs low VOC gelcoats

Type of gelcoat	Total emissions (g)	Reduction (%)
Regular	387	Baseline
Low VOC	278	28

Emissions using different application techniques

Type of equipment	Total emissions (g)	Reduction (%)
Normal - spray gun	634	Baseline
Good practice – spray gun	445	30
Flow coater	306	52
Pressure fed roller	299	53

Vapour suppressing additives

Suppressants (usually waxes) can be added to resins to reduce monomer evaporation. These substances work by reducing the contact of the resin with air by creating a 'skin' on the surface of the resin. Vapour suppressing additives can reduce emissions by 30% to 50% in the curing stage.[9] Suppressants must, however, be left undisturbed during curing to enable a layer of wax to form. If suppressants are not carefully matched with the resin system, problems with bonding between laminates can occur. Light sanding of cured areas can improve bonding.

Inert fillers

Inert fillers reduce resin use by adding inert filler to the formula. In some cases this may also improve resin stiffness and fire-resistance.[11] Confirm with suppliers that new technologies are compatible with current systems.

UV-cured resins

UV-cured resins can seal fresh resin surfaces at low temperatures, reducing the opportunity for volatile monomers to evaporate.

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For further information

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