Air quality guidance note

Composite structural products

This guideline deals with air pollution issues. It does not deal with water pollution or noise.

1 Industry description

The most common composite structural product is fibreglass-reinforced plastic (FRP). FRP is used in manufacturing a diverse range of products including boats, surfboards, bathroom fixtures (e.g. shower stalls, baths, vanity units, and spas), swimming pools, storage tanks and piping, simulated marble products and motor vehicle and truck fixtures and panels. FRP and other composite materials are extremely versatile, and because of this their applications as manufactured products continue to grow.

FRP normally contains unsaturated polyester resins and some form of fibre reinforcement—typically fibreglass—although other materials may be used. Some composite products contain polyamide (nylon), epoxy, polyurethane or polycarbonate resins, but this is rare in Australia at present. About 80% unsaturated polyester resin is used in reinforced applications and extended with various inorganic fillers, such as calcium carbonate, talc, mica or small glass spheres. Advanced reinforced products use carbon fibre, aramid fibre and aramid/carbon hybrids.

‘Aramids’ (from ‘ARomatic AMIDes’) are organic polymers from the nylon family and include Nomex® and Kevlar®.

Some resin-based products contain little or no reinforcement with the use of other materials, but they too can generate emissions that can impact on local air quality.

While the composition, shape and size of FRP products can vary significantly from one product or premises to another, the mould-based manufacturing process used is very similar throughout the industry.

Different moulding systems are available, including open, closed and centrifugal moulding systems.

1.1 Manufacturing processes

Most FRP manufacturing facilities include the following processes or equipment:

- mould preparation
- gel-coating and laminating
- equipment and tools clean-up
- ventilation and air filtration systems
- resin or gel coat transfer and storage systems.

The principle behind manufacturing these ‘plastic’ products involves using viscous liquid organic monomers (the resin) and a chemical catalyst (e.g. methyl ethyl ketone peroxide) to promote a chemical reaction that causes the monomers to combine (i.e. link or cross-link) and cure into a hard plastic (the polymer).

Monomers and solvents used

The monomers and solvents used are volatile materials which evaporate into the air and have distinctively strong odours associated with them. Some monomers have extremely low odour thresholds; that is, the compounds can be readily smelt at extremely low concentrations in air (i.e. parts per billion, ppb, to a few parts per million, ppm).

The styrene monomer content of the polyester resin is typically from 23–35% (w/w), and 45–55% (w/w) of the gel coat. Gel coat also contains methyl methacrylate monomer in varying percentages. The acrylate monomers have very low odour thresholds. The solvents used in these preparations include acetone, toluene, xylene and alcohols. Material Safety Data Sheets (MSDS) from product suppliers can provide information on the composition of resins, catalysts and gel-coats.

> The abbreviation ‘w/w’ means ‘weight for weight’ and simply means that the composition is in terms of the relative weights of the constituents, rather than their volumes (‘v/v’)

A typical production layout

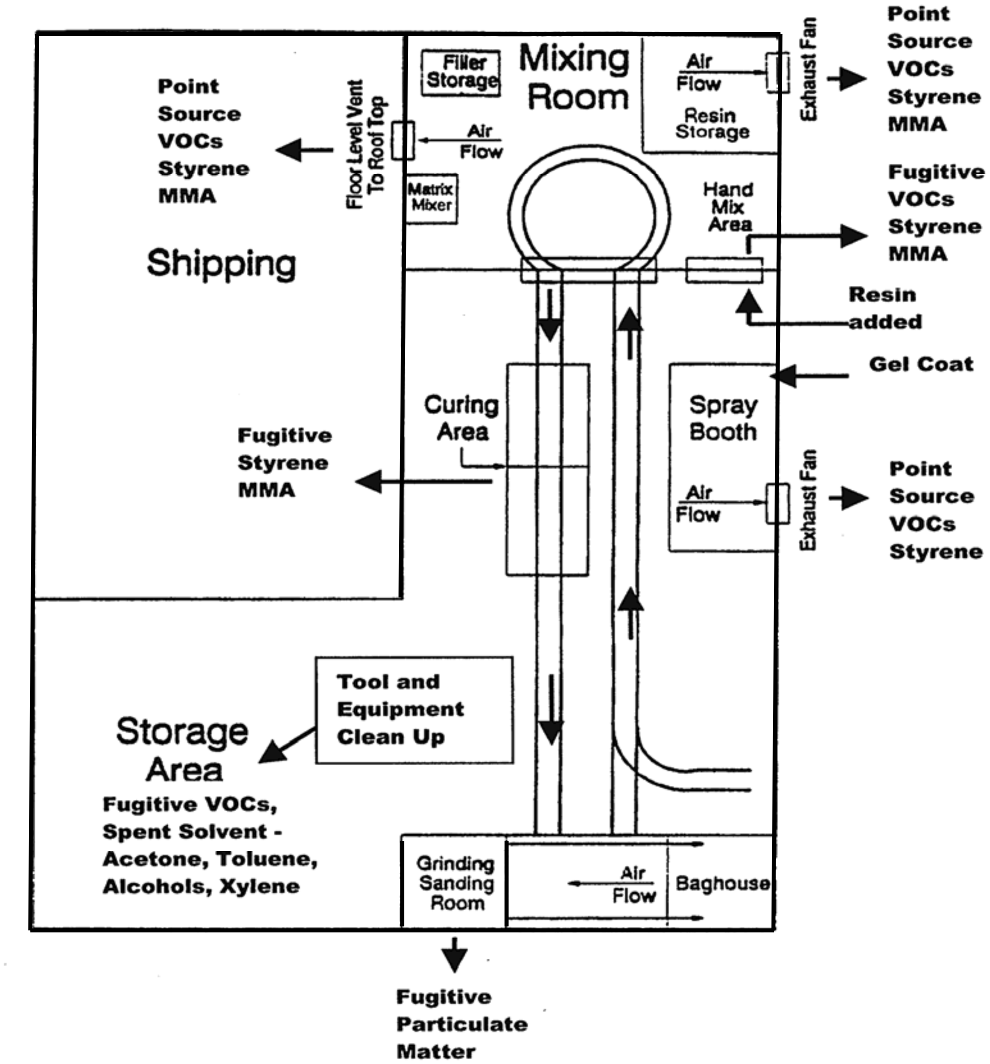
A typical FRP production layout depicting the major elements of the manufacturing process is shown in the diagram below (taken from Environment Australia’s *NPI Emission Estimation Manual for Fibreglass Product Manufacturing*).

Note the production elements that give rise to emissions.

Steps in manufacturing FRP products

Mould preparation

Mould preparation is the first step in manufacturing an FRP product. Moulds are usually handmade, often using standard patterns. After a mould is formed it is cleaned, waxed, and transported to a spray booth where a thin layer of gel coat is applied.



Casting

After gel-coating, moulds proceed to the **casting process**, which takes place in the **mixing room**.

Resin, filler (crushed marble for example), and catalyst are **mixed in a closed process** and applied to the moulds, which are then mechanically vibrated to remove bubbles and allow the resin to settle.

Laminating

Alternatively, **a layer of fibreglass matting is applied to cover the mould and then a layer of resin is applied,** followed by another layer of fibreglass matting, then more resin, and so on. This lamination process builds up the product to a desired thickness and strength.

Curing

The completed mouldings are then allowed to **cure and harden** in the curing area. In some applications a curing oven may be used to control or speed up the curing process.

Finishing

After the resin has hardened, the products are **polished and sanded** in the finishing (or grinding) room. Lastly, the finished products are taken to the warehouse for packaging and shipment.

The entire production operation can be conducted in a large single room, with the exception of the grinding and sanding area. This latter part of the process is usually contained in a separate, enclosed area within the manufacturing room.

> Workplace health and safety regulations require that the indoor air is vented outside at different points within the manufacturing process or throughout the premises, either through a series of exhaust fans, or through suitably designed collection and extraction hoods and ducting to an exhaust stack.

For example, the **spray booth discharges** through filters or a water wall to atmosphere via a stack. Similarly, particulates generated during the grinding and sanding operations are collected and filtered via air extraction systems before discharge to atmosphere.

In the mixing room and casting area indoor air is usually discharged directly to atmosphere via fans. Fresh air is introduced through floor level vents, or open windows and doors.

2 Potential emissions to air

Emissions to atmosphere from FRP and other composite products manufacturing include **particulate matter, volatile organic compounds** and **odours.** These emissions can have adverse off-site impacts if not properly managed or controlled.

Emissions may be discharged from:

- a **point source** (a stack or flue for example)
- **venting** a process or piece of equipment (spray booth for example)
- **wall fans** discharging indoor air horizontally to the outside, or
- a **fugitive source** from a building (such as passive venting out of doors or windows).

The activities that generate these emissions and the control or management options available for them are summarised in Table 1.

Table 1: Sources and management of air emissions in composite product manufacturing

Emission	Nature of source	Control/management options
Particulates	Grinding, sanding and polishing in the finishing area	Collection or extraction of particulates using fabric filter dust collectors
Volatile organic compounds (VOCs)	• Storage areas • Mixing room • Spray booth • Curing area or oven	• Discharge via general exhaust fans • Collection and discharge from stack of suitable configuration • Extraction and VOC removal using activated carbon before discharge **Caution**: If monomer is adsorbed rapidly onto activated carbon, the activated carbon may act as a catalyst, and the heat of adsorption and reaction may raise the temperature high enough to start a fire in the activated carbon bed. Another treatment system may be needed.
Odour	• Storage areas • Mixing room • Spray booth • Curing area or oven	• Effective extraction, dispersion and dilution via a stack • Use of an activated carbon filter. **Caution** as above.

Without adequate controls these emissions can be fugitive in nature and not released through a purpose-designed vent or stack. Discharges through doors and windows are typically at low heights, and therefore adequate dilution and dispersion does not occur, leading to potential impacts in the neighbourhood of the premises.

2.1 Particulate matter

Particulates are generated from grinding and sanding operations during the finishing process, but may also arise when handling and cutting fibreglass matting, because the product tends to shed glass fibres during these activities.

The handling, storage and transfer of inorganic fillers can also generate some particulates. Occupational health and safety requirements limit exposure to these materials and hence the FRP workplace needs to be well-ventilated.

Purpose-designed systems

Where the source of particulates is confined to a particular activity and location, purpose-designed extraction or collection systems can be used to stop particulates entering the workplace. If the potential particulate loading is high, such collection systems could also employ fabric filter dust collectors to minimise particulate discharges to atmosphere and their potential amenity impacts.

Where the particulate loading is high a **baghouse** with a self-cleaning mechanism should be used. **Cyclones** do not collect fine enough particulates to be of value in this type of application.

Grinding and sanding operations should have some form of particulate control. Other potential particulate sources should only require control where it can be demonstrated they are generating nuisance or occupational exposure standards are not being met.

Most of the particulates produced during FRP manufacturing operations are inert and not toxic in the concentrations expected to be encountered if they are managed appropriately.

Relevant MSDS should be examined to confirm whether any potential hazards exist (e.g. respirable silica levels in mica). Glass fibres from fibreglass matting are known to present a respiratory hazard and be an irritant to mucus membranes (i.e. eyes, nose, throat, lungs).

2.2 Volatile organic compounds

The main VOCs emitted from FRP manufacturing operations are listed below. The odour thresholds and design ground level concentrations are listed in Table 2 to enable comparison and to present an example of the variability of odour-based and toxicity-based criteria for environmental protection.

Table 2: Odour and toxicity thresholds for VOCs associated with FRP manufacturing

VOC	Odour threshold (mg/m3)	Toxicity threshold [1] (mg/m3)	Control and management options
Styrene	0.21	7.0	Capture and discharge emissions via a stack designed to disperse odours … or where this is not possible due to the level of odour … incorporation of activated carbon to adsorb odours from the gas stream before discharge. See the note about caution in Table 1.
Methyl methacrylate	0.21	13.4	
Methyl ethyl ketone	5.9	16.0	
Toluene	0.65	12.3	
Xylene	0.35	11.4	
Acetone	47.0	40.0	
Propanol	0.075	16.4	

1 Design ground level criteria based on toxicity; that is, 8-hour workplace exposure standard/30) and 3-minute averaging time.

As can be seen above, some VOCs can be smelled at concentration levels well below those of health concern and before there may be potential concern about their toxicity (styrene for example), and others can exceed the relevant exposure criteria (based on toxicity) before being of sufficient concentration to be detected (acetone for example).

Where amenity impacts from the detection of odours in residential areas (or other sensitive land uses) is of concern, the design ground level concentration for that compound is its odour threshold, and where a compound can exhibit concerns about toxicity before it can be smelt then the toxicity-based criterion is used.

Therefore, in the above list, acetone would be the only material that would be assessed on the basis of its potential toxicity.

It should be noted that the toxicity-based criteria are very conservative (i.e. protective) and have had a number of safety factors included in their derivation.

2.3 Odour

The odour associated with the emission of VOCs is the real driver for emission controls in FRPs.

VOCs arising from FRP manufacturing operations should not be able to be smelled beyond the boundary of the premises, although some latitude may be applied in industrial areas. Certainly no such odours should be detectable in residential or other sensitive land uses (e.g. schools, hospitals, etc.).

> Smelling odours from FRP manufacturing operations in the atmosphere is in itself recognition of an exposure to these substances.

Odour and toxicity

A sense of smell cannot be used to judge whether the exposure is of concern with respect to toxicity. People complaining about chemical odours may well be seeking assurances that the level of exposure is not hazardous to their health. This can be difficult for mixtures of VOCs because some may require a many-fold increase in concentration above the odour threshold for potential toxicity to be of concern—a factor of about 220 times for propanol for example)—but other compounds may require significantly lesser increases for these issues to be of concern (3 times for methyl ethyl ketone).

> In situations where there is any doubt about possible health implications, an assessment of potential impacts should be carried out using the techniques described in the DEC publication *Approved methods for the modelling and assessment of air pollutants in NSW* (2005).

Location of FRP premises in the planning and approval process

The level of control of emissions will also depend on the location of the premises in terms of the separation distance from sensitive land uses or potential complainants.

The technical assessment described in *Approved methods for the modelling and assessment of air pollutants in NSW* will generally require specialist input.

Each of the following criteria is important at development planning and approval stages:

- the location of FRP manufacturing premises
- the expected level of emissions, and
- the planned level of emission control or management.

3 Assessing problems

Before going on site for an inspection or assessment the following should be checked:

– the consent conditions for the premises or the activity, and

– any previous reports on file including diagrams, photographs, maps etc.

3.1 Visual inspection

A visual inspection of a FRP manufacturing facility is required to find out the nature of activities taking place and the standard of emissions management and control.

3.2 Housekeeping

Housekeeping is important both inside and outside the premises.

- **Wastes** such as empty drums and other containers must be **tracked throughout NSW** in accordance with the POEO (Waste) Regulation 2006, and are subject to DECC requirements. Waste must be stored in an environmentally safe manner.
- **Fibreglass matt offcuts** that cannot be used in the production process can release fibres and should be sealed in plastic bags before disposal.
- **Baghouse waste collectors** need to be emptied regularly and not allowed to overflow and create unnecessary particulate emissions.
- **Dust control** can be important within the premises from both occupational and quality control perspectives.
- Most smaller FRP operations use resins and other raw material in 200 L drums or smaller containers. A major source of odour can arise where these materials are **inappropriately decanted, handled or stored**, and lids, bungs or caps should always be in place sealing the container whenever the material is not being used.

Questions to ask about housekeeping:

– What is the housekeeping program for the premises?

– Do all staff know and understand this program?

– Is the program being followed effectively?

3.3 Managing the FRP production process

The major sources of VOCs and odour in FRP production processes are:

- applying gel coats to moulds
- laminating resin and fibreglass matting onto moulds, and
- the subsequent curing process.

Storing and handling resins and associated organic solvents are also potential sources of VOCs and odour, but these can be minimised with careful housekeeping.

Object size and air exchange

The surface area of the object being manufactured will have a significant influence of the amount of odour generated during the lay-up and curing processes.

Sufficient air exchange within the workplace will be necessary to meet occupational exposure standards. The preference should be to discharge odorous indoor workplace air to atmosphere via a stack of suitable configuration to disperse and dilute odours to a level that does not cause nuisance or offence off site.

Flammability of gases

Where VOCs are being collected and discharged, the potential flammability of the gases should be considered with respect to the potential for a fan or switches to act as an ignition source. This is a specialised area of knowledge. If the status of electrical equipment, switches, fans and lighting are unknown or considered to be in poor condition WorkCover NSW can be contacted to follow-up on these compliance aspects.

Two of the relevant Australian standards are:

– AS 2430–Identification of hazard zones (equipment suitable for flammable vapours)

– AS2381–Selection of electrical equipment and wiring methods.

Estimating emissions

The usage and consumption rate of resins and other volatile organic materials (such as solvents) needs to be understood in order to estimate emissions from these types of activities.

Simple odour test

The simplest way of determining whether a potential odour problem exists is to stand downwind at the property boundary (e.g. the footpath outside or shop entrance), or at the nearest premises from which complaints may or have been generated, on a day with low wind speeds and when production is at maximum capacity (in terms of anticipated emissions).

If the odours associated with FRP production processes can be clearly discerned at the locations described above, it is likely that operations at the premises could potentially cause nuisance and health impacts. In this case either pollution control at source or improved dispersion of pollutants is required, or both.

If the odour is coming from a stack or roof ventilator, it should not be detectable until the odour plume reaches the ground. The technique for detecting and tracing odour sources outlined in Module 3 Part 2, ‘Practical regulation of air pollution sources’ should be used in the investigation.

The principles of stack configuration are covered in Module 3 Part 1, ‘Air pollution control techniques’.

3.4 Managing finishing processes

If particulate emissions generated by FRP finishing processes are visible at their point of discharge to atmosphere, or have been a source of nuisance or complaints off site, the particulates should be collected and filtered using a fabric filter dust collector before discharge to atmosphere.

Allowing emissions of particulates from doors or windows, or conducting finishing operations outside can also be a source of nuisance to adjacent land users.

Where possible such activities should occur inside and with dust collection and extraction equipment in place. This should be a requirement for new workshops.

4 Improving emission performance

Most impacts from smaller FRP manufacturing operations will be limited to the immediate and local area. However, depending on the topography and meteorology (for example, in a small valley when atmospheric conditions are still or there is an atmospheric inversion layer) the fugitive emission of odours can result in limited dispersion and therefore have a more wide-spread impact.

A broad range of options is available to smaller FRP manufacturing operations to improve their emission performance.

They may be categorised as being either management options or control technology options. In most cases a combination of these techniques will be the most effective solution.

4.1 Management options

Management options include waste minimisation and cleaner production initiatives (e.g. using less odorous resins, or resins with odour suppressants), and the manner in which equipment is operated and maintained (e.g. training staff to avoid overspray in a spray booth operation).

Housekeeping is also important, e.g. keeping the workplace tidy and free of excessive quantities of dust and other debris, keeping lids on containers of volatile materials and promptly cleaning up spills etc.

Ensuring that carbon filters are replaced when they are no longer effective (see Module 3 Part 1, ‘Air Pollution Control Techniques’) and that particulates collected by the baghouse are regularly emptied and contained appropriately for disposal will help avoid emissions from these areas.

Land use planning

An important option, which may only be available on one or two occasions, is managing the premises location in relation to surrounding land uses, and making sure that the separation distance to the nearest receptor is appropriate for effective dispersion of residual emissions after good-practice control technology has been applied.

An unsuitable location or unsympathetic development close to a sensitive receptor (such as housing or a school) can create problems that may be difficult to manage and control in the future. Residential encroachment can also be a problem.

The separation distance required will depend on the size of the premises, the local topography and meteorology and the control technology employed.

4.2 Control technology

A full description of the control options applicable for FRP manufacturing is contained in Module 3 Part 1 'Air Pollution Control Techniques'. In summary, the emissions that need controlling are:

- particulate matter
- odour and VOCs.

5 Considerations for consent conditions

Other conditions may be necessary to control environmental impacts other than air pollution.

5.1 Standards to be met

- In cases where odour modelling and testing is to be undertaken, odours from the premises to comply with the requirements of DEC draft policy *Assessment and management of odour from stationary sources in NSW* (2001).
- Solid particle emissions to comply with POEO (Clean Air) Regulation 2002 for any stack discharges on the site:
  - 400 mg/m^3 for plant installed before 1 Aug 1997 (not for a new development consent)
  - 250 mg/m^3 for plant installed between 1 Aug 1997 and 1 Sept 2005 (not for a new development consent)
  - 100 mg/m^3 for plant installed after 1 Sept 2005.
- Smoke to comply with Ringelmann 1 or 20% opacity.
- Need for compliance testing to be considered in each situation, balancing expense incurred by the operator against likely sensitivity and the extent of likely impact.
- A typical compliance testing condition would require:
  - tests to be carried out in accordance with the DEC publication *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*, by an accredited testing body (NATA or equivalent), and within a reasonable time of commissioning (typically three months)

  - results to be reported to council within a specified time (typically one month from the testing), and
  - interpretation and commentary on the test results to be provided to council.
- Dust emissions constituting environmental nuisance not to impact on neighbours.
- Plant to be operated and maintained in a proper and efficient manner which does not cause air pollution, in accordance with s. 124 and 125 of the POEO Act.
- Materials to be handled in a proper and efficient manner which does not cause air pollution, in accordance with s. 126 of the POEO Act.
- Construction, installation and maintenance of spray booths, spray painting areas and paint mixing rooms to comply with AS/NZS 4114.1 & 2 2003.

5.2 Operational and control requirements

- Odours from the premises not to be detectable at the nearest sensitive land use.
- Odorous exhaust gases from process areas handling odorous materials, such as resins and solvents, to be either:
  - vented at a height which complies with the requirements set out in DEC publication *Approved methods for the modelling and assessment of air pollutants in NSW*, or
  - treated by activated carbon adsorbers before the exhaust gases are discharged to atmosphere.
- Where activated carbon adsorbers are used:
  - the ventilation system to be equipped with efficient filtration equipment to remove particles and aerosols from the exhaust before it enters the activated carbon adsorbers
  - adsorbers to be checked regularly for ‘odour breakthrough’ and the filter changed once breakthrough has been reached, and
  - spent activated carbon to be disposed of to landfills which are licensed and approved to accept this type of waste material.
- Exhaust stacks to be vented at a height clear of downwash effects from the building in which the activity is located and adjacent buildings, and a minimum of 3 m above the highest point of the building roof ridge line, or above that of any higher, adjacent building within 50 m.
- Exhaust stack gases to be vented with a design exit velocity of at least 10 m/s without any impediment to vertical discharge.
- Spray booths, filters and other control devices to be operated and maintained in accordance with the manufacturer’s requirements.
- Spray booth filters to be replaced or cleaned when the negative pressure requirement of 50 Pa is compromised by more than 10 Pa (i.e. < 40 Pa or > 60 Pa).
- Particles generated during the finishing processes to be captured at source and discharged to atmosphere through fabric filters or other devices in such as way as to prevent fugitive dust emissions and control collected emissions.
- Dust collectors to be individually fitted to tools or pieces of machinery, or a centralised dust collection unit to be installed with an appropriately designed ducting and collection interface.
- Particulate collection points to be emptied on a regular basis and to be configured so as not to give rise to fugitive dust emissions.

- No visible particulate emissions to be discharged from a point source serving a baghouse.
- Cyclones, fabric filters and other dust collectors to be maintained in a proper and efficient manner at all times.
- Monitoring of control equipment to be based on:
  - extent of emissions
  - toxicity or odorous potential of emissions, and
  - sensitivity of the activity.
- Appropriate monitoring devices to be used, as specified in Table 6 of the Module 3 Summary tables.
- All activities, including housekeeping, to be carried out according to industry best practice.
- Hours of operation to be restricted where appropriate to make sure there are no impacts on sensitive receptors

Composite structural products: air quality management checklist

This checklist has been designed for:

- assessment officers—to help identify potential air pollution issues early in the assessment process and devise consent conditions which will prevent or minimise air pollution problems.
- compliance officers—to help with routine inspections, as part of an audit program or as part of a complaint investigation.
- owners and operators—as part of a set of educational materials and to help identify and manage potential air quality issues.

Company
Address
Site location

Contact	Permit assessment
	Complaint response
Phone	Compliance inspection
Fax	Time & date of inspection
Email	Inspector's name

A Site location and context

What are nearby sensitive land uses (e.g. schools, hospitals, car detailers, etc.)

	Land use	Distance	Comments
North			
South			
East			
West			

What are the characteristics of the site that will effect the dispersion of air pollution?

Topography	
Winds	
Other	

B Sketch plan of the site

Draw a sketch plan of the site showing the surrounding land uses, nearby buildings and local topography.

N ↑

Note particularly:

- nearby sensitive land uses (schools, homes, other affected premises, etc.)
- locations of any complainants
- locations and heights of nearby buildings or trees
- locations and heights of stacks on premises
- wind directions during times of complaint (night and day)
- any other relevant features.

Comments:

C Results of odour survey

Date	Time	Location [1]	Wind speed [2] (estimate)	Wind direction	Temperature [3]	Weather: cloudy sunny	Odour type	Odour strength: weak medium strong	Comment

1 Make observations upwind and downwind of source premises.

2 Estimate in metres per second, or knots, or by the Beaufort scale, or failing that, descriptively, e.g. still, light breeze, moderate wind, strong wind and so on.

3 If the temperature is not known or can not be measured at the time of the survey, then find and record it later.

D Products being manufactured

Identify the products being manufactured and add comments.

Products made on site	Comments

E Waste disposal

Identify the wastes being generated and add comments.

Wastes generated on site	Comments

F Standard of housekeeping on the premises

Indicate: satisfactory (✓), unsatisfactory (x) or NA and any action required.

Activity		**Actions required**
Materials reception		
Resin and solvent storage		
Waste storage		
Mould preparation area		
Spray booth		
Lay-up area		
Finishing area		
Other		

General comments on housekeeping:

G Management of particulates

Indicate: satisfactory (✓), unsatisfactory (x) or NA and any action required.

Question		Actions required
Are trafficable areas hard-surfaced?		
Are yard and waste storage areas watered down if necessary to control dust?		
Are baghouses used to collect particulates?		
If so, is there a log for the maintenance and replacement of bags?		
Is there a functioning manometer in place and is the pressure drop OK?		
Is all of the ducting airtight?		
Are any particulates visible in the baghouse exhaust?		
Are dust collection hoppers serviced regularly?		
Is particulate fallout (dust deposition) detectable outside the premises?		
How are collected dusts managed?		
Are wastes properly contained and transported off site in covered vehicles?		

H Management of odours

Indicate: satisfactory (✓), unsatisfactory (x) or NA and any action required.

Question		Actions required
Can odours be detected outside the premises?		
If so, indicate where on the site location plan in Part B above.		
Do odours cause offence to neighbours?		
How are odours collected and controlled in the premises?		
Are there any fugitive odour emissions?		
Can odours be captured and controlled to reduce any impact?		

I General safety issues

Operational aspect		Comments
Are fans and other electrical equipment handling dusts intrinsically safe [1]?		
Is any dust-collecting ductwork made of plastic pipe? (Note: plastic pipe is likely to collect static electricity. Metal pipe with good earth connection is better.)		
Are fire protection measures appropriate[2]?		
Are chemicals appropriately stored and handled?		

1 The electrician who installed the equipment, or who currently services the premises, may have to be consulted.

2 Check with the local fire authority.

List any attachments here: