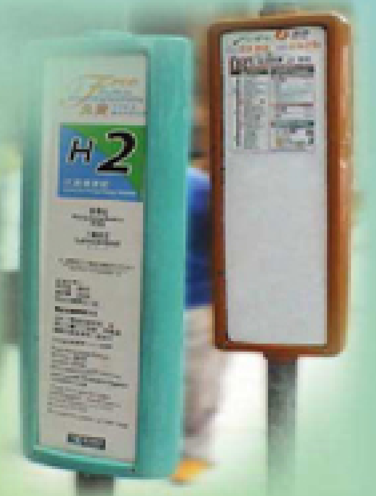
Chemical Safety in the Workplace



Guidance Notes on Chemical Safety in

Glass Reinforced Plastics Fabrication

Occupational Safety and Health Branch
Labour Department

Occupational Safety & Health Council

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1 Preface

Fibreglass is a man-made fibre formed by melting glass in a furnace where the molten material is forced through fine holes to form filaments or strands. The glass fibres are woven to form cloth which can be bonded together by a resin, usually a thermosetting polymer matrix, to form a composite material called glass reinforced plastic (GRP). Besides fibreglass, other materials such as graphite or aramid are also used as reinforcement. This book will focus on the safe use of chemicals in the production of GRP. GRP is widely used to manufacture sinks, baths, boats, pools, storage tanks, automobile components, pipes or reinforced building materials.

Many chemicals used in GRP fabrication are hazardous substances that may cause injury or ill health to workers, and even fire or explosion if they are not properly handled or no preventive measures are taken.

The principle of safety management should be applied to develop, implement and maintain a chemical safety programme, a vehicle for ensuring chemical safety in GRP fabrication. The programme comprises basically such elements as risk assessment of chemicals and related processes, safety measures, hazard communication, training and emergency response plan. Details of the chemical safety programme will be discussed in this guide.

This Guidance Notes is intended to provide employers, management personnel, professionals, safety personnel, supervisors and employees engaged in GRP fabrication with detailed information and advice on the development and implementation of an effective chemical safety programme for GRP production. As every workplace has its own uniqueness, readers should make use of the information to produce their own chemical safety programme that best suits their workplaces and ensures a healthy and safe environment for their employees.

2 Typical Manufacturing Methods of GRP

Glass reinforced plastic (GRP) products have a wide industrial application. They can be produced by a variety of processes which may be broadly classified as hand lay-up, spray lay-up, press moulding, and automated and continuous moulding.

2.1 Hand lay-up

2.1.1 It is one of the least expensive and the most common methods for production of GRP with relatively simple shapes and requiring only one face to have a smooth appearance. Layers of reinforcing media are manually applied to the mould of the product. The polymer resin is then either poured or brushed on after each layer is positioned.

2.1.2 The glass mat or roving can be applied to form a desired thickness. The lay-up with thermosetting resins, such as polyesters, usually cures at room temperature. The curing will be accelerated at elevated temperature. A smooth surface can be obtained by placing cellophane over the exposed side of the mould.

2.2 Spray lay-up

2.2.1 In this process, a polymer resin is sprayed together with chopped glass strands into the mould. Depending upon the thickness or density of the reinforcement, it may receive additional resin to improve wet out and allow better coverage over the mould surface.

2.2.2 The composite mixture is then rolled or brushed to compact it against the mould surface to remove entrapped air generated by the spraying system.

2.2.3 The advantage of above two processes is that there is no limit to the sizes of the product that can be made.

2.3 Press moulding

2.3.1 Press moulding is the most common method of moulding thermosetting plastic into sheet and bulk forms. This moulding technique involves pressing composite material containing a temperature-activated initiator in a heated metal die using a vertical press. This method allows the moulding to produce a good surface finish on both sides.

2.3.2 The moulding process starts with the injection of uncured composite components of high viscosity to the mould. As the mould closes, the resin and the isotropically distributed reinforcement flow to fill the mould cavity.

2.3.3 With the mould remains closed, the composite material undergoes a chemical change that permanently hardens it into the shape of the mould cavity.

2.3.4 When the mould opens, parts are ready for finishing operations such as deflashing, painting, bonding, and installation of inserts for fasteners.

2.4 Automated and continuous moulding

2.4.1 This process is used to fabricate composite parts of constant cross-section profiles. Typical examples include various rod and bar sections, ladder side rails, tool handles, electrical cable tray components and new bridge beams and decks.

2.4.2 Reinforcement fibres in the configuration of roving, mat or fabric are positioned in a specific location using performing shapers or guides to form the profile. The reinforcement is drawn through a resin bath or wet-out where the fibres are thoroughly coated or impregnated with liquid thermosetting resin.

2.4.3 Then the resin-saturated reinforcement enters a heated metal die whose dimension and shape define the finished part being fabricated. The heat energy activates the curing or polymerisation of the resin. The laminate solidifies when cooled and is continuously pulled through the machine and cut to the desired length.

3 The Chemical Hazards

3.1 Sources of hazards associated with GRP fabrication

3.1.1 The most important hazards associated with GRP fabrication come from:

(a) handling of glass fibre;

(b) handling of resins;

(c) handling of hardeners / initiators;

(d) cutting and sanding of GRP;

(e) cleaning solvents; and

(f) fillers and pigments.

3.1.2 Emissions of volatile organic compounds (VOC) from most GRP processors pose a significant health and safety risk to workers, workplace and the environment. Major VOC emission sources are exhausts primarily from the application and laminate cure of resin, and vaporization of cleaning solvent during cleanup process. Employers should comply with the regulatory control of VOC emissions.

3.2 Handling of glass fibre

3.2.1 Glass fibre, like all common forms of glass, is chemically inert. However, inhalation of the fibres may irritate the upper respiratory tract and contact with them may cause skin and eye irritation.

3.2.2 Irritation is caused by mechanical action (rubbing) on the skin, which will be aggravated by perspiration. Most people develop tolerance after a few months. Showering to remove the fibres will relieve the skin itchiness.

3.3 Handling of resins

3.3.1 Epoxy resins are caustic and can cause skin burns and dermatitis. Contact with the eyes can cause severe damage. Vapours of epoxies may irritate the eyes, nose and throat.

3.3.2 Polyester resin is usually dissolved in styrene, a cross-linking agent, with some containing up to 60% styrene. Workers doing hand lay-up or spray lay-up are often exposed to excessive amounts of styrene vapour emitted during the application and curing stages. The spray-up process may generate 2-3 times as much styrene vapour as the hand lay-up process. Styrene is flammable and hazardous to health.

3.3.3 Short-term health effects of styrene:

(a) it can cause mild irritation of the eyes, nose and throat at concentrations of around 100 ppm, definite irritation at 350-500 ppm and severe irritation at about 500 ppm;

(b) symptoms such as headache, dizziness and fatigue can be observed at concentrations of 100-200 ppm;

(c) other symptoms such as slower reaction times, reduced manual dexterity and impaired co-ordination and balance can be observed at concentrations of above 200 ppm;

(d) prolonged skin exposures can cause chapped skin, rash and dermatitis due to the fat-dissolving properties; and

(e) when splashed to the eyes, it can cause mild to severe irritation.

3.3.4 Long-term health effects of styrene:

(a) repeated exposure can affect the central nervous system;

(b) slower reaction times have been documented in workers exposed to concentrations of about 55 ppm and even lower over extended periods; and

(c) it is a possible human carcinogen and chromosomal changes in peripheral lymphocytes of styrene-exposed workers were found.

3.4 Handling of hardeners/initiators

3.4.1 Epoxy resin systems usually contain a hardener or curing agent which is mixed immediately prior to fabrication. The commonly used hardeners or curing agents include amines and acid anhydrides. In polyester resins, organic peroxide, such as methyl ethyl ketone peroxide (MEKP) and benzoyl peroxide, is added to initiate the polymerization of the resin.

3.4.2 Many hardeners such as amines and acid anhydrides are potent irritants or sensitizers. The hardeners used in room temperature curing are the strongest irritants and some can burn the skin and eye tissue. In addition, sensitization can result in asthma or rashes. The hardeners used for oven drying are usually less hazardous.

3.4.3 Organic peroxide initiators are available as solids (usually fine powders), liquids or pastes. They present serious fire and explosion hazards. They are also irritating and corrosive to eyes, nose, throat, airways and lungs. Irreversible damage to eyes can be caused by prolonged contact.

3.4.4 The double oxygen of the peroxy group renders the peroxides both useful and hazardous. Being chemically unstable, the peroxy group can easily decompose, giving off heat at a rate that increases with temperature. Many organic peroxides emit flammable vapours when they decompose, thus posing a fire risk. Some organic peroxides can decompose very rapidly or explosively if exposed to only slight heat, friction, mechanical shock or contaminated with incompatible materials.

3.4.5 Methyl ethyl ketone peroxide (MEKP) is often used as an initiator in polymerization of polyesters. It is a colourless liquid with a characteristic odour. Like other organic peroxides, it poses extreme risk of explosion from exposure to shock, friction, flame or other sources of ignition due to its high chemical reactivity. It liberates irritating gases when contacted with water or moist air. It is also very toxic and corrosive posing a risk of serious injury and ill-health to workers.

3.5 Cutting and sanding of GRP

3.5.1 Dust is created during cutting and sanding of GRP, and the floor with uncontrolled build-up of dust will become slippery. If not properly controlled, the dust will irritate skin, eyes and respiratory system. Even worse, a build-up of dust on ledges, plant, and ducts may produce conditions conducive to dust explosions.

3.6 Cleaning solvents

3.6.1 Acetone is commonly used for cleaning uncured polyester resin and gel coat from tools and contaminated surfaces. Its vapour is irritating to the eyes and respiratory tract and affects the central nervous system, liver and kidney. Prolonged contact with skin can cause dermatitis. It could also be harmful to the haemopoietic system in the long run.

3.7 Fillers and pigments

3.7.1 Fillers are mixed into resins for decoration, controlling their flow and improving their property, e.g. hardness. Usually, fillers are powders like silica, calcium carbonate and metals that cause dust nuisance, posing substantial risk to the respiratory system.

3.7.2 Pigments are used to colour GRP. They may cause dust nuisance if in powder form.

4 Chemical Safety Programme

4.1 Overview

4.1.1 To ensure safety and health of employees engaged in GRP fabrication, a carefully planned chemical safety programme is essential. In the programme, the hazards of the materials and processes used in GRP fabrication should be first identified. The risks arising from the hazards are assessed and appropriate preventive measures set up with their effectiveness being regularly monitored and reviewed. The associated hazards information and protection should be communicated to all affected employees. The chemical safety programme should also include other elements such as emergency planning and training of employees.

4.1.2 The chemical safety programme should be organized and integrated into the overall safety management system of the workplace. Employers should have adequate manpower and resources for the development, implementation and maintenance of the programme.

4.1.3 The advantages of establishing a workplace chemical safety programme are as follows:

(a) to avoid possible problems or failure due to oversight of hazards caused when any of the interrelated processing steps is changed;

(b) to provide management with a systematic look at the entire process, allowing easy detection of warning signs of potential incidents; and

(c) to render a safer operation consistent with increased efficiency and productivity.

4.2 Major elements

4.2.1 The major elements of a chemical safety programme should include:

(a) Risk assessment – to identify the potential hazards arising from the materials and processes used in GRP fabrication and to assess their risks;

(b) Safety measures – to adopt and maintain preventive and control measures to eliminate or minimize the risk to acceptable levels;

(c) Emergency preparedness – to establish plans and procedures for emergency response;

(d) Hazard communication – to establish appropriate and effective means to disseminate the safety and health information about the materials and processes to employees via adequate instruction and employee training; and

(e) Monitoring and review – to monitor the effectiveness of the adopted safety measures with regular review and revision that cope with any new requirements or significant changes in the materials or processes.

4.2.2 Depending on individual situation of the workplace, employers may find it beneficial to include other elements such as inspection, accident investigation and health surveillance in the chemical safety programme.

5 Risk Assessment

5.1 Overview

5.1.1 Risk assessment is the overall process of estimating the level of risk and deciding whether the risk is tolerable or acceptable. Before the risks can be assessed, the hazards related to the chemicals and the entire fabrication process have to be identified. The risk is then estimated in terms of the exposure to worker, the likelihood and potential consequences of the identified hazards. Suitable preventive measures will then be developed and implemented with periodic monitoring and reviews.

5.1.2 Reference should be made to relevant legislation, codes of practice, guidelines and best trade practices in order to decide on the need and adequacy of safety measures. Employers should take an inventory of all substances in the workplace and identify whether they are hazardous and currently handled and stored safely. It is also essential to obtain the Material Safety Data Sheet (MSDS) of the chemicals from the supplier, as it contains a host of information indispensable for risk assessment and emergency planning.

5.1.3 The risks associated with the chemicals or the entire fabrication process should be re-assessed when:

(a) there are changes to the operating procedure such as operating temperature;

(b) there are changes in the reactants or scale of the process; and

(c) safer procedures or improved preventive measures become available or reasonably practicable.

5.1.4 When the health risk is assessed, the Occupational Exposure Limits (OELs) of hazardous substances should be consulted. OELs refer to the airborne concentrations of individual chemicals below which no adverse health effects would impose on nearly all workers upon exposures by the route of inhalation. More information on OELs could be found in the *Code of Practice on Control of Air Impurities (Chemical Substances) in the Workplace* issued by the Labour Department.

5.1.5 As OELs do not represent 'no effect' levels at which every employee can be guaranteed protection, employers should:

(a) ensure the workplace exposure standards are not exceeded under normal operational conditions;

(b) keep the level of exposure as low as reasonably practicable; and

(c) eliminate or further reduce exposure in future whenever reasonably practicable.

5.1.6 Risk assessment should be performed by competent persons who are well knowledgeable about the hazards of the reactants/products/by-products as well as the physical and chemical changes at each stage of the entire process. They should consult specialists for expert advice if needed.

5.1.7 The book *Chemical Safety in the Workplace: Guidance Notes on Risk Assessment and Fundamentals of Establishing Safety Measures* issued by the Labour Department provides detailed information on the systematic approaches for conducting a risk assessment related to chemical hazards.

5.2 Factors to be considered in the risk assessment

5.2.1 In assessing the risks of GRP fabrication, the following factors should be duly considered.

5.2.2 Physical form of the chemicals

The physical form of a chemical has a pronounced effect on the extent of the hazards of the chemical. Gases, vapours, fumes, aerosols, dusts, airborne particles and powders increase their risk of entering the human body as well as the risks of fire and explosion. It should be noted that the powder forms of combustible materials could form explosive/flammable mixtures with an oxidizing agent or even air.

5.2.3 Chemical changes

If chemical changes are involved, the chemical reactions and products should be studied, and the associated hazards identified. Attention should also be paid to any possible side reactions and by-products.

5.2.4 Temperature and pressure changes

Exothermic chemical reactions will generate heat spontaneously and may, therefore create the following effects:

(a) formation of hazardous gases, vapours or fumes;

(b) pressure increase in the container causing explosion;

(c) rapid bubbling causing splashes of hot hazardous fluids; or

(d) increase in reaction rate generating more heat.

These effects will be intensified if there is no effective means to dissipate the heat evolved resulting in localised heating and superheating in part of the reaction mixture. Moreover, some exothermic reactions may auto-accelerate rendering the reaction rate too fast to be controlled.

5.2.5 Scale of the process

Scale of the process determines the amount of hazardous chemicals involved. Changes in the scale can hence affect the heating effect of the reaction as well as the heat dissipation and pressure change of the processing system.

5.2.6 Extent of exposure

The time of exposure of employees to hazardous chemicals during GRP processing is affected by:

(a) frequency and duration of exposure;

(b) rate of generation and concentration of the hazardous chemicals in the atmosphere; and

(c) effectiveness of safety measures in minimizing the exposure.

5.2.7 Working environment and facilities

The working environment may cause accumulation of hazardous chemicals in the atmosphere. The temperature and pressure of a mixing container may change due to the chemical reactions of the composite material therein. Employers should therefore consider the following factors when conducting the risk assessment:

(a) properly designed size and shape of the mixing container including the headspace and passage for release of pressure;

(b) avoidance of any nearby ignition sources when explosive/flammable mixtures are handled;

(c) whether processes undertaken or chemicals stored/used are sensitive to air, moisture or light; and

(d) adequate ventilation of the workplace.

6 Safety Measures

6.1 Overall strategy in establishing safety measures

6.1.1 The primary consideration is to adopt appropriate preventive measures to directly remove or control the hazards at source, such as by elimination or substitution. In case such measures are not possible, segregation of the chemicals or the processes should be provided. The use of personal protective equipment should only be considered a supplementary means or as the last resort to minimize workers' exposure to the hazards.

6.1.2 On many occasions, the substance, process or equipment can be replaced by a safer one that eliminates or minimizes the risks to acceptable levels. Such modifications or changes may include improving the control systems or material application methods such as mixing and dispensing procedures.

6.1.3 Safety measures can be realised by engineering and administrative methods. Engineering control methods such as installation of suitable types of ventilation can eliminate or lower the hazardous air-borne contaminants at source. Administrative controls such as by implementation of safe work practices and scheduling of breaks or rotating shifts can limit worker's time spent near the hazard to reduce their exposure.

6.1.4 It is desirable to consider safety and health aspects of the materials, processes and equipment at the design stage. This will save additional expenses and often reduce practical difficulty in subsequent adjustments to accommodate the safety features.

6.1.5 All preventive measures should be documented, for example, in the standard operating procedures (SOP) of the GRP fabrication, and should be made known to the workers concerned. The effectiveness of such measures should be constantly monitored to ensure adequacy of the adopted safety measures. If any changes are made to the SOP in respect of production or preventive measures, a fresh risk assessment should be conducted and the amended preventive measures should be documented in the SOP accordingly.

6.2 Elimination/Substitution

6.2.1 A typical example of elimination/substitution is illustrated in the reduction of styrene emission in GRP fabrication where conventional high-content styrene resin can be replaced with:

(a) Vapour-suppressed resins – contain wax-like additives that form a film on the laminate surface during curing and provide a barrier that significantly reduces evaporation of free styrene during the curing and lay-up phases.

(b) Low styrene resins – contain less than 35% styrene (as compared to 41-45% for the conventional resin) and hence reduce the vapour emission significantly.

6.3 Process and equipment modification

6.3.1 On many occasions, the process and equipment can be modified to minimize the VOC emissions and related risks arising from the hazardous substances. Modifications or changes can be made to process systems, equipment or material application methods.

6.3.2 In spray lay-up, conventional spray method produces mists which results in overspray. The following new technologies of application can limit the emissions:

(a) Flow coaters – they are internal mix guns that produce low-pressure stream of resin. These guns can be equipped with a glass chopper to simultaneously apply catalysed resin and reinforcing fibres.

(b) Fluid impingement – this processing equipment can be applied to either internal or external mix. In both cases, the resin or gel coat exists in the gun in two low-pressure streams which cross each other.

6.3.3 During rolling operations, rollers fitted with guards to reduce droplet formation will help reduce styrene emission. Long-handled rollers should be used where possible.

6.3.4 Automation is the ultimate solution in controlled spraying. For example, the use of robots can guarantee proper positioning of the spray gun and ensure optimized coverage.

6.4 Engineering control measures

6.4.1 The primary objective of adopting engineering control measures is to eliminate or lower the risk at source. In GRP processing, the main engineering control method against chemical hazards is exhaust ventilation. It provides an effective means of preventing accumulation of hazardous chemicals in the atmosphere. There are four major types of ventilation, namely, general dilution ventilation, booth ventilation, local exhaust ventilation, and push-pull ventilation.

Ventilation – General dilution ventilation

6.4.2 In general dilution ventilation, the contaminated air are diluted by fresh air which is supplied to the work area by mechanical supply fans or natural air currents through doors, windows or other openings therein. The contaminated air is discharged through relief openings or drawn out by exhaust fan.

6.4.3 This method only replenishes the supply of fresh air. It should therefore be used in conjunction with other means of ventilation in order to remove airborne contaminants from source.

Ventilation – Booth ventilation

6.4.4 Spray-up or hand lay-up is best carried out in a booth fitted with extraction ventilation. It is possible to construct mobile booths and booths with adjustable dimensions and capacity. Fan speed can be varied if necessary and booths may use a dry filter or a water curtain to collect the spray.

6.4.5 Booth ventilation is most effective in the control of air-borne contaminants. A carefully planned and designed ventilation system in a booth restricts the hazardous activity to a designated area and prevents the rest of the workplace from being contaminated.

Ventilation – Local exhaust ventilation

6.4.6 Vapours and particulate are captured and removed by forced air current through a duct near the point of emission before the contaminants could be dispersed into the work area. This method is generally applied to equipment that cannot be readily enclosed. Although local exhaust ventilation can be as effective as a booth ventilation system, it may not be suitable when working on large pieces. Local exhaust ventilation can be difficult to adjust and be moved around the workplace. However, it is important to ensure that the exhaust current does not pass through the breathing zone of the worker.

Ventilation – Push-pull ventilation

6.4.7 Push-pull ventilation systems are suitable for large work pieces. In these systems, fans are used to blow vapours away from the worker's breathing zone towards an extraction system. Again, the design of the system should ensure that the flow of contaminated air is not within the breathing zone of the workers.

6.5 Administrative controls

6.5.1 Administrative controls are measures to arrange work schedules and stipulation of safe work practices so that the exposure of individual employees to hazardous chemicals can be reduced. Employers should ensure that these are incorporated into the management system as far as practicable. A typical safe work procedure that reduces the worker's exposure to styrene emissions should include the following:

(a) restricting laminating (particularly spraying) to areas with suitable ventilation;

(b) ensuring the time spent near the hazard is kept to minimum. Workers should not stay between the work piece and the extraction system during spraying;

(c) keeping pots or drums of resin closed when not in use; and

(d) avoiding skin contact with the resin.

6.6 Personal protective equipment (PPE)

6.6.1 The primary objective of using PPE is to supplement control measures by minimizing workers' risk of exposure to hazardous chemicals through inhalation or skin contact. Again, it must be stressed that PPE are only passive protective measures and should not replace preventive measures.

6.6.2 PPE should be chosen with regard to the hazards and physical nature of the chemicals and their routes of entry into the human body. The information on an MSDS and the risk assessment will help determine the PPE requirements. Before and after use, they should be inspected for signs of damage. They should be regularly cleaned and stored in good condition. Contaminated PPE should be properly treated or disposed of as appropriate, and replacement sets kept readily available.

6.6.3 Wrongly selected, improperly used or maintained PPE may do more harm than good as the user may have a false sense of security. Readers should refer to *Chemical Safety in the Workplace: Guidance Notes on Personal Protective Equipment for Use and Handling of Chemicals* for details.

Protective clothing

6.6.4 Protective clothing protects the skin or personal clothing from contact with hazardous chemicals and prevents spread of contamination. When handling resins or fibreglass, such as dispensing and storage, and conducting maintenance work, employees should always wear suitable protective clothing. Employers should also provide their employees with special clothing for use in emergencies.

6.6.5 Protective clothing includes aprons, gowns and overalls. It is important to choose protective clothing made of materials that resist penetration or damage by the chemicals used.

Hand protection

6.6.6 As GRP fabrication workers frequently have to manipulate many hazardous chemicals by hands, protective gloves have to be used. For protection from styrene, nitrile rubber gloves are considered most suitable. However, as no gloves will give long-term protection against any hazardous chemicals, they should be replaced regularly.

Face and eye protection

6.6.7 Where there is a reasonably foreseeable risk of eye injury through splashing, suitable eye protectors or face shields should be worn. Safety spectacles can be fitted with prescription lenses if required, while clear plastic safety goggles that completely enclose the eyes provide superior eye protection. If protection to the whole face including mouth, nose and eyes is required, face shield should be used.

Respiratory protective equipment (RPE)

6.6.8 Respiratory protective equipment (RPE) protects workers against exposure to dusts, gases, fumes and vapours, but exposure duration should be kept short.

6.6.9 RPE should be used to protect the workers where engineering control may not be reasonably practicable such as during maintenance, cleaning, or emergencies where hazardous fumes are generated from significant chemical spillage or inadvertent mixing of incompatible chemicals.

6.6.10 The choice of RPE depends on the concentration, duration of exposure and physical and chemical nature of the hazardous substances. For fire and other major emergencies where asphyxiation or inhalation of toxic gases at levels immediately dangerous to health or life is possible, RPE should comprise self-contained breathing apparatus.

6.6.11 With appropriate filters, the following RPE can protect against styrene vapour, resin mist and dust.

(a) Air purifying respirators – Most half-face respirators equipped with appropriate filters provide protection against contaminants of concentration up to 10 times, and most full-face respirators up to 50 times its exposure standard (OEL) when fitted correctly. Most powered air purifying respirators have similar efficiency as the latter. They use battery operated motor blower to draws air through filters.

(b) Airline respirators – Airline respirators supplying clean air to the mask, helmet or hood with an airline are most suitable for use in the fiberglass industry. The level of protection depends on whether a helmet, hood or mask is used. It can range from below 25 to more than 1000 times the safe exposure standard.

Details of OELs could be found in the *Code of Practice on Control of Air Impurities (Chemical Substances) in the Workplace.*

6.7 Monitoring

6.7.1 Monitoring provides a means to ensure the effectiveness of safety measures taken. Air monitoring generally involves measuring the concentration of airborne contaminants at strategic locations in the work area or at the worker's breathing zone. The monitoring can be continuous or periodic sampling and analysis using sensors with alarm device, direct-reading meters, static samplers and personal samplers.

6.7.2 Based on the work activities and the result of risk assessment, the management should establish and implement appropriate monitoring programme to ensure that the levels of airborne contaminants do not exceed the acceptable limits, such as the lower explosive limit (LEL) or the occupational exposure limit (OEL) of the chemicals. The monitoring programme should include:

(a) monitoring parameters such as concentrations;

(b) frequency of monitoring;

(c) location and method of monitoring;

(d) alarm levels based on the acceptable limits; and

(e) follow-up actions.

6.7.3 Investigation of accident or dangerous occurrence involving chemicals is a reactive means of monitoring after the event. All such events should be investigated and be taken as a 'learn-from-mistake' exercise. The investigation should be led by a line manager or professional having adequate knowledge in the operation.

6.7.4 Biological monitoring can be used to provide information on the amount of chemical that has entered the body. In GRP fabrication, biological monitoring of styrene involves measuring the level of its metabolite (what it breaks down into in the body) in worker's urine sample. Biological monitoring should be used only to supplement, rather than replace, air monitoring.

6.7.5 Health surveillance is an effective means of monitoring to detect adverse health effects at an early stage thereby preventing further harm, especially for employees who are liable to regular exposure to hazardous chemicals. The concerned surveillance is mainly done through pre-employment and periodic medical examinations. Where appropriate, medical examination should also be conducted upon and after termination of work involving hazardous chemicals, and upon resumption of work after prolonged sickness absence.

6.7.6 If monitoring reveals over-exposure to hazardous chemicals, the process should be suspended and the causes investigated. The management should also put in place suitable control measures and ensure that such measures are operating effectively before allowing resumption of the process. The lesson learnt is also useful in reviewing the chemical safety programme.

6.8 Some practical safety precautions

6.8.1 The management approach to ensure chemical safety in GRP fabrication has been discussed above. Some practical precautionary measures are now suggested below on those commonly encountered processing of hazardous materials such as delivery, storage, mixing, dispensing, moulding, curing and gumming. It should be noted that the suggested precautions are only exemplary as the hazards being dealt with may vary from workplace to workplace. The management approach should always be adopted to establish suitable safety measures.

Delivery and storage of hazardous substances

6.8.2 In the course of delivery of hazardous substances, the following factors should be considered:

(a) nature and compatibility of substances;

(b) types and size of package;

(c) emergency procedures in case of spillage of hazardous substances and its safe disposal; and

(d) discharge of tankers.

6.8.3 Potential hazards may arise from:

(a) spillage of resins like unsaturated polyester and epoxies, emission of styrene vapour and uncontrolled polymerisation due to heat or inadvertent mixing with initiators;

(b) spillage of initiator and accelerator and their accidental contact;

(c) build-up and discharge of static electricity; and

(d) handling of hazardous cleaning solvents like acetone.

6.8.4 The nature and compatibility of the substances should be carefully studied. Reactive substances should be adequately separated. For example, initiators like MEKP and accelerators which are usually cobalt salt should always be stored apart and neither should be stored with resins.

6.8.5 During off-loading and in storage areas, all sources of ignition should be excluded and no smoking should be allowed. All hazardous and highly flammable substances should be clearly labelled.

6.8.6 Containers such as drums, which are unused, should be carefully stored or disposed of, as they may contain residues that give out flammable vapour.

Mixing of hazardous substances

6.8.7 Preparation of the materials for GRP fabrication such as resin mixes should be carried out in place specially set aside for the purpose.

6.8.8 The mixing hazards mainly come from the vapours of styrene and resins. Care must therefore be exercised to guard against the accidental mixing of accelerator and initiator, which would otherwise result in serious physical hazards such as fire and explosion.

6.8.9 The floor and workbench surfaces should be kept free from spillage and any build-up of catalysed resin. To reduce fire risk, non-absorbent material such as polythene sheeting should be used to cover the floor and workbench to enable easy removal of spilt resins and initiators.

6.8.10 When mixing hazardous substances, operators should wear eye protection, gloves and chemical resistant clothing. In the mixing areas, emergency showers and eyewashes should be provided and located nearby.

Moulding

6.8.11 The major chemical hazards arise from the vapours of styrene or other chemicals released during moulding and curing.

6.8.12 If spray lay-up is undertaken, additional hazard may arise from the release of initiator in the form of droplets from the spray gun.

6.8.13 Smoking should be strictly prohibited and adequate ventilation provided to keep hazardous vapours below their exposure limits.

6.8.14 When spraying process is conducted in the moulding area, regular inspection and maintenance of airline, gauges, pressure valves and related equipment are necessary.

6.8.15 Resin mixes not in immediate use should be kept covered to reduce evaporation and avoid contamination.

Curing and trimming

6.8.16 During curing, flammable organic vapours are frequently given off in relatively substantial amount. Electrical equipment and lighting in these areas should therefore be properly designed, constructed, installed and maintained to prevent ignition of the flammable atmosphere. In addition, these areas should be adequately ventilated.

6.8.17 Dust is created during trimming when sanders are used. The use of tool incorporating dust extraction system or the installation of local extraction at sanding booth will greatly reduce dust generation.

6.8.18 Operators should wear suitable PPE. Overalls that adequately cover the body will reduce or eliminate skin irritation. Dust masks and goggles will reduce respiratory exposure and eye contact.

Handling of organic peroxides

6.8.19 To minimize or control the hazards from organic peroxides which are commonly used as initiator in GRP fabrication, the following precautions should be taken:

(a) A well-designed and maintained ventilation system should be adopted to remove airborne organic peroxides from the workplace.

(b) The amount of organic peroxides stored should be kept as small as practicable. Relevant statutory requirements could be found in the *Dangerous Goods Ordinance (Cap.295)* administered by the Fire Services Department and the *Factories and Industrial Undertakings (Dangerous Substances) Regulations, (Cap.59)*.

(c) Before storing, it is important to check that all incoming containers are in good shape and properly labeled. Defective containers should not be accepted.

(d) For organic peroxides requiring temperature control, the recommended storage temperature range should be marked on the container to avoid decomposition at elevated temperature.

(e) Organic peroxides should be stored in suitable and labeled containers in a cool dry area. Containers should be protected against impact or other physical damage during storage, transfer or use.

(f) Containers should be kept tightly closed to avoid contamination.

(g) Organic peroxides should be stored away from processing and handling areas. They should be kept away from incompatible materials such as strong acids and bases, other oxidizing substances, flammable or combustible materials.

(h) In the course of mixing or dispensing organic peroxides, containers should be opened and dispensed in a designated room or area outside the storage area. No ignition source is allowed in the vicinity. The organic peroxides should not contact combustible or other incompatible substances when dispensed.

(i) Organic peroxides should not be mixed directly with any accelerators, as it may lead to violent explosion. If the accelerator is added to the resin mixture first, it should be thoroughly mixed before adding the organic peroxide.

(j) Organic peroxide wastes are hazardous. Unused or contaminated organic peroxides should be disposed of according to the supplier's recommendation and the regulatory requirements by the Environmental Protection Department.

(k) Operators who handle organic peroxides should use proper PPE.

7 Emergency Preparedness

7.1 Overview

7.1.1 Emergency preparedness is vital, as quick and correct response is necessary in case of emergencies to reduce injuries, harm and other damages. In GRP production, common emergency situations involving chemicals include fire, explosion, spill or release of hazardous chemicals, splashing of hot fluid, personal injuries and illnesses.

7.1.2 In regard to chemical safety in the concerned processing, the management team should:

(a) identify and list out all possible emergency situations in the workplace;

(b) assess the effects and impacts of the emergency situations;

(c) establish emergency response plans;

(d) provide and maintain emergency equipment and other necessary resources; and

(e) ensure that staff are familiarised with the arrangements in case of emergencies by providing procedural instructions and employee training and organising drills.

7.1.3 Appropriate first aid facilities should be provided and adequate numbers of employees should be trained in first aid as required by the *Occupational Safety and Health Regulation.*

7.1.4 The MSDS in respect of handling accidental release of chemicals and disposal of waste should be consulted.

7.2 Emergency response plan

7.2.1 Emergency response plans should be established for handling all foreseeable emergency situations in the workplace and should provide the following:

(a) assignment of responsibilities;

(b) alarm systems;

(c) emergency procedures; and

(d) schedule for emergency drills.

7.2.2 Assignment of responsibilities – It is extremely important that all employees understand their own roles during any emergency situations. A senior staff such as a line manager or safety officer should be assigned to lead the emergency response team and charged with the following duties:

(a) assessing the emergency situation and taking necessary actions;

(b) overseeing the implementation of the emergency response plan;

(c) organising regular drills; and

(d) ensuring all emergency equipment is well maintained.

7.2.3 Emergency procedures – Emergency procedures are operating instructions for employees to follow in case of emergency situations. Appropriate procedures should be established for each type of emergency situations and cover the following:

(a) reporting, declaring and clearing off emergencies;

(b) handling of emergency situations;

(c) evacuation; and

(d) deployment of employees to perform critical operations before they evacuate.

7.2.4 The emergency response plan and related information should be documented and communicated to all employees: evacuation routes, names and locations of the first aid team members, locations of safety equipment, telephone numbers of key personnel and emergency services. The documents should be in the form of manual or notices that are kept or posted in prominent places in the workplace for easy access by all staff.

7.3 Emergency equipment

7.3.1 Appropriate emergency equipment should include but not limited to:

(a) fire alarm;

(b) fire-fighting equipment, such as fire hoses, fire extinguishers and fire blankets;

(c) emergency lights and backup for fume extraction in case of power failure;

(d) emergency showers and eyewashes;

(e) first aid facilities, such as first aid kit; and

(f) absorbent material for cleanup of minor chemical spills.

7.3.2 All emergency equipment should be properly maintained and regularly inspected for proper performance. Expired items should be replaced. Locations of emergency equipment in the workplace should be made known to all staff.

8 Hazard Communication

8.1 Hazard communication

8.1.1 Under *the Occupational Safety and Health Ordinance*, employers are obliged to provide such information as is necessary to ensure the safety and health of their employees at work.

8.1.2 The information is indispensable in the identification of potential hazards related to the use and handling of workplace chemicals during risk assessment and preparation of emergency response plans.

8.2 Sources of hazard information

8.2.1 Limited but yet essential hazard information can be found on the label of the container of the substances, whereas detailed information can be obtained from the suppliers (chemical manufacturers, importers or distributors) of the chemicals. Other information sources include chemicals catalogues, chemistry journals, chemical handbooks and online databases.

8.3 Means of hazard communication

8.3.1 Typical means of hazard communication include labels, MSDS, standard operating procedures and employee training. Employers may find placards, notices and signboards useful for their workplaces also.

Labels

8.3.2 Labelling each container containing hazardous substance is the most direct means of hazard communication. The label should include the following information:

(a) identity of the substance – chemical name(s) or common name(s);

(b) hazard classification and symbol(s);

(c) indication of the particular risks inherent in the substance; and

(d) indication of the required safety precautions.

8.3.3 If it is not reasonably practicable to put full information on a container, the container should at least be labelled with the identity of the chemical and the hazard group(s) and symbol(s). Other required information can be given in an information sheet placed in the close vicinity. Statutory requirements for labelling of dangerous substances are prescribed in *the Factories and Industrial Undertakings (Dangerous Substances) Regulations.*

Material safety data sheets (MSDS)

8.3.4 An MSDS with the standard format recommended by ISO 11014-1 should contain the following sixteen sections of information:

(i) product and company identification;

(ii) composition/information on ingredients;

(iii) hazards identification;

(iv) first-aid measures;

(v) fire-fighting measures;

(vi) accidental release measures;

(vii) handling and storage;

(viii) exposure controls/personal protection;

(ix) physical and chemical properties;

(x) stability and reactivity;

(xi) toxicological information;

(xii) ecological information;

(xiii) disposal considerations;

(xiv) transport information;

(xv) regulatory information; and

(xvi) other information.

Standard operating procedures

8.3.5 Hazard information can also be communicated via standard operating procedures (SOP) of GRP fabrication. These refer to a set of systematic step-by-step written procedures to be followed for completing a process or operation. They should describe the tasks to be performed, data to be recorded, operating conditions to be applied, and the associated safety and health precautions.

8.3.6 The inclusion of appropriate hazard information in SOP relies very much on how thorough and thoughtful the risk assessment is undertaken, so as to effectively eliminate or control the risks in the entire process.

9 Information, Instruction and Training

9.1 Overview

9.1.1 After assessing the risks in the workplace and adopting appropriate preventive measures, employers should make sure that their employees fully understand the risks at work, and that the work practices can help them perform their jobs safely. To achieve this, employees should be provided with adequate safety information, instruction and training.

9.2 Information and instruction

9.2.1 Employees should be informed of the following:

(a) the safety information (e.g. MSDS) about the hazardous substances that they could be exposed to, including the nature of hazards, exposure standards, possible routes of entry into the body and risks to health;

(b) information on the safe handling of plant and equipment;

(c) safe work procedures on the use, handling, storage, transportation, cleaning up and disposal of hazardous substances;

(d) correct labelling of substances and the significance of label details;

(e) the location, content and significance of safety sign, warning placard and MSDS;

(f) measures to control risks of exposure to hazardous substances and the reasons for such control measures;

(g) emergency response procedures, including locating and using emergency equipment and facilities such as first aid, decontaminating and fire-fighting;

(h) procedures for reporting faults and incidents, including spills; and

(i) proper selection, use and maintenance of PPE.

9.2.2 Information and instruction should be provided to employees by:

(a) SOP or safety manual and emergency procedures are the primary means and these documents should be located in prominent locations in the workplace easily accessible by employees; and

(b) others such as notice, poster and video show should be used as appropriate in arousing the safety awareness of everyone on handling hazardous substances and processes in GRP fabrication.

9.3 Employee training

9.3.1 Training helps employees to acquire the necessary skills and knowledge to enable them to follow safe working procedures, take appropriate control measures, use appropriate personal protective equipment and follow emergency procedures. Training should also enable employees to participate in decision-making relevant to workplace safety and health.

9.3.2 Employers should ensure that all persons involving in GRP processing, including workers, supervisors, store persons, emergency personnel and safety and health representatives are adequately trained.

9.3.3 The employee training programme should include:

(a) the reasons for, and the nature of, the safety measures which are in use or are planned;

(b) the work practices and procedures to be followed in the use, handling, storage, transportation, cleaning up and disposal of workplace hazardous substances;

(c) safe and healthy work practices in operating the equipment and processes;

(d) reporting of faults and incidents, including spills;

(e) the selection, use and maintenance of PPE;

(f) the use of emergency equipment and the location of emergency facilities for washing, fire fighting;

(g) the practice of personal hygiene;

(h) the method of labelling containers and the significance of label details; and

(i) the location, content and significance of safety signs, warning placards and MSDS.

9.3.4 Training should be an ongoing process so that employees can learn about the new developments of workplace safety and continue to improve their relevant knowledge and skills. Refresher training is useful and should be provided, especially to employees returning from an extended leave of absence or changes of workplace that render previous training obsolete.

9.3.5 The training programme should be reviewed periodically to make sure that employees are gaining the skills and knowledge they need. Employers should also ensure that their employees, after undergoing the appropriate training, understand what they have been taught.

9.3.6 Employers should keep the training record which should include at least the following:

(a) the names of employees receiving training, and the dates of attendance;

(b) an outline of the course content; and

(c) the names and credentials of persons providing the training.

Appendix I

References

1. *Occupational Safety and Health Ordinance and its subsidiary legislation (Cap 509)*

2. *Factories and Industrial Undertakings Ordinance and its subsidiary legislation (Cap 59)*

3. *Occupational Safety and Health Regulation (Cap 509, sub. leg.)*

4. *Factories and Industrial Undertakings (Dangerous Substances) Regulations (Cap 59, sub. leg.)*

5. *Waste Disposal Ordinance and its subsidiary legislation (Cap 354)*

6. *Dangerous Goods Ordinance and its subsidiary legislation (Cap 295)*

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8. Canadian Centre for Occupational Health and Safety, *Organic Peroxides - Hazards,* 1999, Canada.

9. Department of Consumer and Employment Protection, *Code of Practice: Styrene,* 2000, Government of Western Australia.

10. Labour Department, *Chemical Safety in the Workplace – Guidance Notes on Risk Assessment and Fundamentals of Establishing Safety Measures,* 1st edition, 2001, HKSAR Government.

11. Labour Department, *Chemical Safety in the Workplace – Guidance Notes on Personal Protective Equipment (PPE) for Use and Handling of Chemicals,* 1st edition, 2002, HKSAR Government

12. Labour Department, *Code of Practice on Control of Air Impurities (Chemical Substances) in the Workplace*, 1st edition, 2002, HKSAR Government.

13. National Occupational Health & Safety Commission, *Steps to prevent styrene exposure in the fiberglass industry,* 1994, Commonwealth of Australia.

14. National Occupational Health & Safety Commission, *Working with Fibreglass Reinforced Plastics,* 1992, Commonwealth of Australia.

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16. National Occupational Health & Safety Commission, *Working with Fibreglass,* 1990, Commonwealth of Australia.

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Appendix II

Summary of the potential chemical hazards of some commonly used material sin GRP fabrication

	Fibreglass	Polyester Resin	Styrene	Methyl Ethyl Ketone Peroxide	Cobalt Naphthenate	Acetone	Epoxy Resins	Hardeners
Physical state	Solid	Liquid	Liquid	Liquid	Solid	Liquid	Liquid	Liquid
Fire	NA	Flammable	Flammable and gives off irritating or toxic fumes (gases) in a fire	Emits toxic fumes under fire conditions	Gives off irritating or toxic fumes (or gases) in a fire	Highly flammable	Emit toxic and/or irritating fumes under fire conditions	NA
Explosion	NA	NA	Vapour/air mixtures are explosive	May explode when heated	Finely dispersed particles form explosive mixtures in air	Vapour/air mixtures are explosive	NA	NA
Inhalation	Causes upper respiratory tract irritation	Causes nasal and respiratory irritation	Causes dizziness, drowsiness, headache, nausea and weakness	Causes burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting	Causes cough, shortness of breath, sore throat and wheezing	Causes sore throat, cough, confusion, headache, dizziness, drowsiness and unconsciousness	NA	Cause lung sensitisaton
Skin	Causes skin irritation	Causes skin irritation and sensitisation	Causes redness	Causes skin irritation	Causes redness and pain	Causes dry skin	Repeated exposure may cause skin irritation	Cause skin irritation
Eyes	Causes eye irritation	Causes eye irritation	Causes redness and pain	Can cause blindness	Causes redness and pain	Causes redness, pain, blurred and possible corneal damage	May cause slight transient eye irritation	Cause eye irritation
Ingestion	Causes temporary gastrointestinal irritation	Causes gastrointestinal irritation	Causes abdominal pain	Causes changes in structure or function of esophagus, nausea, vomiting and other gastrointestinal effects	Causes diarrhoea and weakness	Affects nervous system causes nausea and vomiting	Single dose oral toxicity is considered to be extremely low	NA

Notes: Readers should refer to MSDS for detailed safety and health information.
NA = Not Applicable

Enquiries

If you wish to obtain further information about this guide or require advice on occupational safety and health, please contact the Occupational Safety and Health Branch of the Labour Department through:

Telephone	:	2559 2297 (auto-recording after office hours)
Fax	:	2915 1410
E-mail	:	enquiry@labour.gov.hk

Information on the services offered by the Labour Department and on major labour legislation can also be found by visiting our Home Page at http://www.labour.gov.hk.

You can also obtain information on the various services provided by the Occupational Safety and Health Council through its telephone hotline at 2739 9000.

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