PART I

GENERAL INFORMATION

1 - FIBREGLASS REINFORCED PLASTIC

What is fibreglass reinforced plastic, or FRP? It is a composite of several materials (mainly fibreglass fibres and resin) laid down in alternating layers and hardened to form a solid laminate. By way of comparison, wood fibres in a tree are held together by their natural glue, lignin. Similarly in FRP, layers of fibreglass material are glued together with polyester resin. Both in a tree and in FRP laminate, the fibres give strength to the structure, and lignin and resin hold the fibres together, creating stiffness and distributing the load among the fibres.

If put together correctly, the laminate can be both strong and stiff with good resistance to fatigue and the influence of water. If constructed poorly, the laminate might still look good on the surface, but due to its poor quality, could degrade and collapse in half the expected lifetime or even less.

This basic manual concentrates on the process of preparing the mould and constructing an FRP boat by gluing together layers of bonded fibreglass fibres called chopped strand mat (CSM) with a resin called general purpose (GP) orthopthalic polyester ("ortho-polyester"). The fibreglass could also be glued together with other resins, like vinylester or epoxy.

The chemical, oil-based resin is toxic and flammable: therefore, safety considerations are important when working with this material. These precautions are set out in the following section.

Figure 1

This boatbuilder is saturating the fibres of CSM with polyester resin, using a resin roller.

He is also using a face mask respirator as protection against inhaling toxic fumes.

2 - MATERIAL DESCRIPTION AND HANDLING

2.1 FIBREGLASS - CSM (CHOPPED STRAND MAT)

Figure 2

CSM consists of randomly oriented fibres from 25–50 mm (1–2 inches) in length, held together with a styrene soluble polyvinyl acetate binder.

Figure 3

Chopped strand mat–E (CSM-E) fibreglass specified for marine applications.

2.2 POLYESTER RESIN

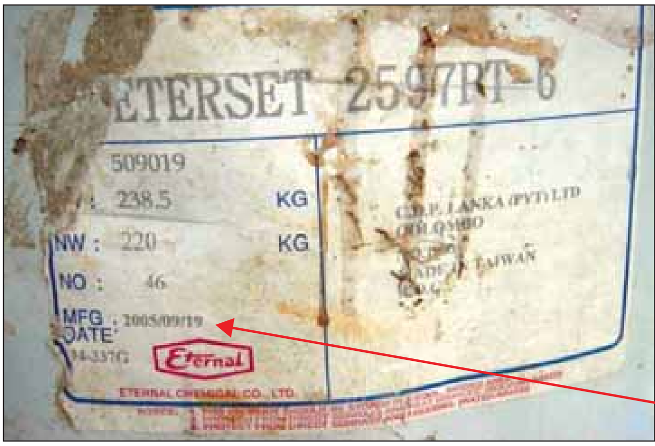

Figure 4

The most commonly used polyester resin is a general purpose (GP) orthopthalic-polyester ("polyester"). This resin, when mixed with 1% of methyl ethyl keytone peroxide (MEKP) catalyst, typically has a gel time of 8–15 minutes at 30 °C.

When stored in the dark and below 25 °C, the resin can remain stable for six months. When stored at standard tropical temperatures, stability will be reduced to three to four months from production date (as shown on the label attached to the drum).

2.3 GELCOAT / TOPCOAT

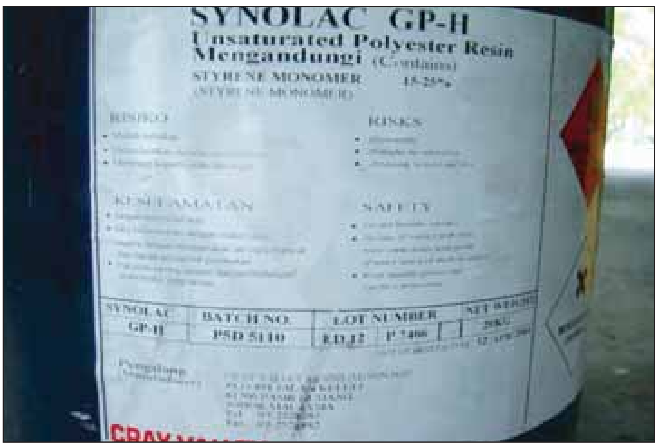

Figure 5

The date of production is written on the container label, and storing stability is the same as for polyester resin.

The gelcoat comes unpigmented, but colour can be added. Use no more than 10% and mix thoroughly at slow speed using a "blender" attachment on a power drill, prior to application. Add no more than 2% hardener to the gelcoat. The topcoat is made by mixing 4% of wax into the prepared gelcoat. The topcoat will air-dry on the surface and is often used as a finish coat.

2.4 HARDENER / CATALYST

Figure 6

The hardener, or catalyst, is used to make the polyester cure. It is extremely corrosive, and special care must be taken in handling and storage. Wear safety glasses and rubber gloves for personal protection.

When hardener and resin are mixed, the chemical reaction generates heat (exotherm). If hardener is spilled in quantity, it may react quickly with other materials and cause a fire. Hardener should be stored separately from polyester.

If accelerator is used to make a fast-cure “fixing putty”, the accelerator must be mixed thoroughly with the putty before hardener is added. Mixing accelerator and hardener together will cause an explosion. When temperatures are near 37 ºC, follow the manufacturer’s advice and use a minimum 0.8% of hardener, which will result in a shorter geltime. For ease of working, prepare this mixture in smaller batches.

2.5 WAX

Figure 7

When preparing a used mould for fibreglassing, a moderate amount of high quality paste release wax should be spread on the surface of the mould and then polished to a high gloss with a clean cloth.

When preparing (breaking-in) a new mould, apply five to ten layers of wax. Polyvinyl alcohol (PVA) may also be used as a mould release before starting the first five products. A good quality mould should not require use of PVA, and should need only a light waxing and polishing after each demoulding. This gives the best finished results.

2.6 BUFFING COMPOUND

Figure 8

The buffing compound, or paste polish, comes in different grades: coarse, fine or superfine. It is used when building up a new high-gloss finish in a mould or repairing an FRP hull. First, the surface is sanded with water and wet sandpaper in grits from 240 to 1 200 (Figure 15). Second, a coarse paste is used to polish the surface. Finally, after a thorough washing, the surface is buffed with fine grade paste and polished with wax.

When repairing a mould, the repaired spot has to be sanded, polished and then broken-in, as described above for a new mould.

2.7 ACETONE

Acetone is a liquid solvent, often used to dissolve and remove polyester from brushes, rollers and other tools before the polyester sets up or cures. Acetone can be absorbed through the skin and stored in the body. It also removes the natural oils that keep skin flexible and healthy. Extensive use of acetone over long periods without proper protection can have serious health implications. Direct contact should be avoided by using protective gloves when working with acetone. Hands should not be washed in acetone.

2.8 STYRENE

Styrene is a standard ingredient in polyester resin. It is also a solvent and can be used to lower the viscosity of polyester and gelcoat. While styrene is also necessary for the curing process, more than 5 percent should not be used. Higher amounts can unbalance the curing process and weaken the finished laminate. When repairing old laminates, a light styrene wipe prior to laminating can improve the bond between old and the new polyester laminates. Styrene is also effective for cleaning moulds.

GOOD VENTILATION IS EXTREMELY IMPORTANT WHEN WORKING WITH POLYESTER RESIN, STYRENE AND ACETONE! THE FUMES CAN BE HARMFUL TO HEALTH!

2.9 POLYURETHANE FOAM

Pourable polyurethane foam (PU) may be used inside thwarts and other hollow cavities for floatation. To make the foam, two liquids, delivered in separate cans A and B, must be mixed in equal amounts (1:1) for proper expansion and cure. The amount of liquid needed to achieve the desired volume should be confirmed before use. Typically, 1.6 kg of mixed liquid expands into approximately one cubic foot of foam. PU foam also comes in blocks and sheets in variable densities.

Polyester resin can be applied directly onto cured PU foam.

WHEN PU FOAM IS CURING, ICOCYANATE GASES DEVELOP THAT ARE HARMFUL IF INHALED!

2.10 EXPANDED POLYSTYRENE (STYROFOAM)

This material can also be used for flotation. Styrofoam is generally the cheapest foam available and comes in blocks and sheets. However, it is easily damaged by solvents and melts on contact with acetone, styrene and gasoline. This means that it is not practical to laminate directly on styrofoam without isolating it with solvent-proof plastic. Expanded polystyrene also absorbs water when exposed for long periods. It therefore has to be waterproofed, for example, with bitumen emulsion.

2.11 MATERIAL HANDLING AND STORAGE

Precautions to be taken when handling and storing FPR materials include sections 2.11.1 to 2.11.5:

2.11.1 Ordering material

Choose a material supplier who is helpful and experienced. Build a good working relationship with him or her. Materials received should always be checked against those ordered from the supplier. It should never be assumed that what arrives is what was ordered. Lot number and date of production and/or expiry must be checked as soon as the containers arrive. If the product is old or of a different quality than ordered, it should be returned at cost to the supplier. Such cross-checking is important, because if the boat breaks down due to use of inappropriate raw materials, the boat owner will blame the builder, not the supplier.

Figure 9

Always check and write down the lot number and the production date when receiving storage time-sensitive products.

This information should always be given on the container.

This example shows a 20-kg bucket of gelcoat with required information on the label.

2.11.2 Documentation

The supplier should be asked for technical data sheets for each product, which should then be retained for future reference. Data sheets should give all the physical and technical properties required by the boat designer to produce a quality product. Resins can vary widely in characteristics such as viscosity and strength. Data sheets also provide key information such as proper mixing ratios and the critical temperature ranges suitable for laminating.

Always keep a record of all material used under the construction.

2.11.3 Fibreglass

Fibreglass (chopped strand mat) should be kept dry and clean. This is of great importance but difficult to achieve in a hot and humid climate. The fibreglass mat should be kept in a dry and ventilated room. If there is much dust or contamination in the air, or if there is a possibility of rain, cover the material in plastic.

2.11.4 Resin, catalyst and accelerator

Polyester and gelcoat should, if possible, be stored at less than 25 °C. The shelf life becomes greatly reduced at higher temperatures.

Resin, catalyst and accelerator should be stored separately, in a cool and dry place.

Thorough mixing of gelcoat and resins, in their original container, is required before use. According to current standards, resin is supposed to be mixed for 10 minutes every day to keep additives from separating and settling to the bottom of the drum. If not stirred before use, additives in gelcoat sometimes separate and rise to the top of the container.

Figure 10

If a drill with a proper mixing attachment is not available, the second best alternative is to roll the drum.

However, if the drum has been standing upright for some time, polyester resin near the bottom may already be of higher viscosity, and rolling the drum for a full 10 minutes might not be enough to fully mix the heavier and lighter resin. If not fully mixed, the first resin drawn from the drum tap may be of a different viscosity than that drawn later.

2.11.5 Temperature and humidity

For best results when doing the lamination, the raw materials, the mould and the working environment should all be at the same temperature.

Resin, catalyst and accelerator should be stored in a cool and dry place; the material will last longer if it is stored properly.

Figure 11

Even a simple workshop used for FRP construction should have a gauge showing temperature and relative humidity of air in the workshop.

The version shown here is sufficient and inexpensive.

If the temperature is much above 30 °C, for example 37 °C, geltime will be shortened. If the temperature is considerably lower than 30 °C, risk of insufficient curing is high. Lower temperatures and high humidity can also cause “aligatoring” (wrinkling) of the gelcoat.

If air humidity rises to above 80 percent, the binder in the CSM will absorb moisture and the reinforcement (CSM) will get “wet”, *i.e.* lose its strength.

A common solution to many of these problems is for lamination work to be done in the morning before the sun gets too hot or the humidity rises.

3 - WORKSHOP FACILITIES

The two main important things with FRP boat building is **the workshop** and **the quality**.

In the peak of summer in tropical countries, ambient temperatures may exceed 35° C. It is therefore very important that the premises are shaded from the sun and wind, dry and adequately ventilated to remove styrene fumes and dust from the moulds and laminating area. FRP materials must be stored in conditions as dark and cold as possible to ensure maximum shelf-life.

Figure 12

It is very important to protect the work area and FRP materials from the sun, wind and rain.

Similar care is important for storage of the raw materials.

If a workshop like the one shown at left is not possible, a temporary shelter should be constructed using, for instance, canvas.

Figure 13

Very important…

It is very important to have a reliable shelter to work in that protects the job from rain, sun, wind, dust (elements that can contaminate the laminate and retard the cure), moisture, heat and humidity (as much as possible).

A concrete floor is a good investment.

Keep the work area tidy!
Don’t get into sloppy habits!

4 - TOOLS TO BE USED

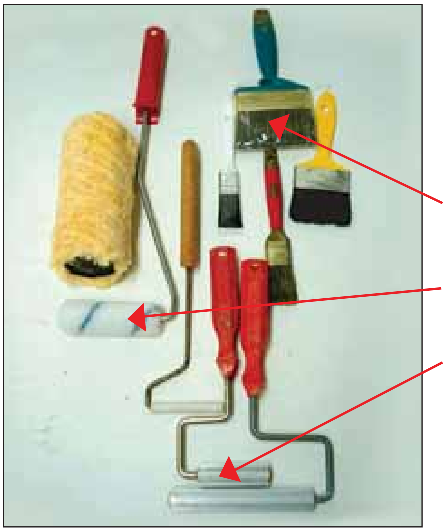

Figure 14

This photo shows examples of some tools used when building an FRP fishing boat.

The <u>brushes</u> are best for applying gelcoat, but can also be used for getting polyester resin into tight corners and onto small details.

Resin rollers of different sizes can be used. They should be made of materials that will not be damaged by solvents.

A variety of compacting rollers are employed for different applications.

The rollers must be used firmly but not too hard. Compacting must stop as soon as the resin starts to gel. Continued used of rollers at this time will only create air bubbles, not remove them.

Figure 15

The 60- (or courser) grit sandpaper is used to sand the laminate first. The 80- and 120-grit sandpapers are used for medium finish work.

Wet sandpaper should be in these grits: 240, 400, 600, 800, 1 000 and 1 200. These are intended for finish work on the mould and on the gelcoat of the hull.

Figure 16

<u>Funnels</u> are handy for pouring polyester safely into smaller containers when larger buckets are not being used.

Transparent <u>measuring containers</u> of several sizes are useful for measuring polyester and gelcoat.

A <u>weight scale</u> is an alternative for measuring small amounts of gelcoat and polyester, and also for weighing fibreglass.

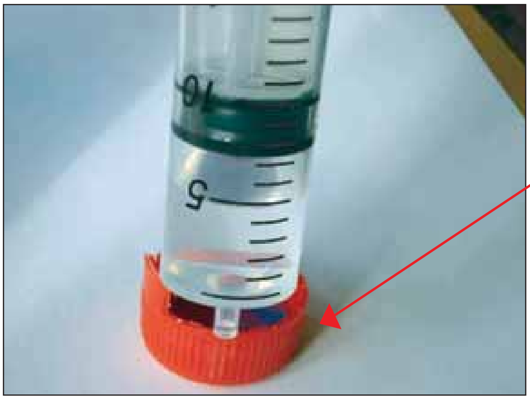

Figure 17

A variety of syringes can be used for correctly measuring very small amounts of hardener.

A typical cap from a soda bottle can usually hold around 5 ml of hardener.

Figure 18

Two sizes of masking tape are used for a variety of tasks. For example, it can be used to keep two different colours of gelcoat separate on the hull during construction or when isolating an area for repair operations. The tape is also handy for securing a plastic cover used for protection against dust or rain.

Scrapers with handles are used for spreading putty.

The wider, soft steel trowels typically used for bodywork on cars can also work well for this purpose.

Figure 19

A regular knife or utility-type knife with extra blades can be used for cutting dry reinforcement (CSM) or "soft" laminate from edges.

Screw drivers are needed for mounting stainless steel cleats and drain plugs.

CSM can also be cut with scissors or torn gently by hand.

A wood chisel is handy for removing bumps and cured strands of fibreglass.

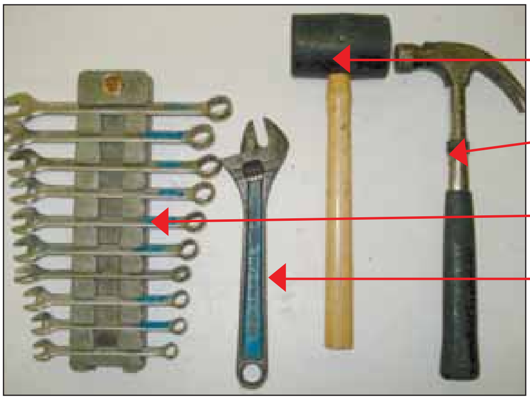

Figure 20

Rubber mallets are useful for careful tapping of moulds to help with demoulding.

A regular hammer is more useful for driving in wooden wedges inserted around the edge of the mould.

Combination wrenches are used for mounting bolts and nuts on the fender and with cleats, eye bolts and u-bolts.

A spanner (adjustable wrench) is also handy for holding bolts and nuts during tightening.

Figure 21

A wood saw can be used for cutting foam.

A hack-saw can be used for cutting both cured laminate and stainless steel bolts.

Figure 22

An electric drill should be available with a full set of:

- twist bits;
- flat wood bits of different sizes for countersinking the 6 mm bolts for wooden fenders;
- hard metal hole saw attachments are used with the electric drill for making larger holes in the FRP laminate.

Figure 23

Electric disc grinders are mainly used for sanding away damaged FRP, but also for abrading the laminate prior to assembly and to improve secondary bonding. They can be fitted with rubber backing discs for use with 40-grit sandpaper.

Carborundum cutting and grinding discs can be attached and used for cutting or grinding cured laminate and cutting off stainless steel bolts.

The machine at the right of the exhibit is excellent for flattening large areas.

Figure 24

Belt sanders are excellent for sanding in preparation for repairs and for getting into tight corners.

Figure 25

A power saw with a laminated hard metal blade, like the one shown here, is useful for cutting both wood and FRP laminate.

5 - BASIC LAMINATE BUILDING

5.1 PREPARING THE MOULD

Prepare the mould by either applying release wax and polishing, or applying mould release agent, as described in Figure 26. The next step in building an FRP boat is the preparation and application of gelcoat. After the gelcoat has been mixed with the right amount of hardener, as stated on the data sheet, it is important that the right thickness be applied either by rolling, brushing or spraying. An ideal total thickness of this layer of gelcoat is between 0.4 and 0.8 mm. Gelcoat thickness can be measured using a simple "wet film gauge" obtained from the gelcoat supplier. A gelcoat thickness gauge can also be made from a piece of metal. For practical reference, since a generous layer of gelcoat applied by brush is around 0.25 to 0.3 mm, two layers should be sufficient.

Figure 26

Brushing gelcoat on to the black surface of the mould is shown in the photo.

Figure 27

The photo shows the use of a gelcoat thickness or wet film gauge.

This initial layer of gelcoat must be properly cured before lamination can start. It is best to wait 3–4 hours for curing to be complete. If laminating starts sooner than one and a half hours after gelcoating, there is a danger that the polyester will soften up the gelcoat, causing it to wrinkle. This effect is called “aligatoring”.

To achieve a good primary bond between the gelcoat and polyester resin, the lamination process should be started as soon as possible after four hours and definitely within 24 hours of gelcoat application. This rule also applies for the “open time” (working time) of the polyester to ensure a good primary bond between laminate layers. (Primary bond is discussed in more detail in Part IV – Manufacturing defects and repairs). Precautions should be taken against contamination of the gelcoat surface. If a mould with fresh gelcoat is left overnight in an open shed, the mould should be covered with light plastic. This is especially important in wet or windy weather or other conditions that might result in gelcoat contamination.

All required materials should be prepared before starting to laminate over gelcoat. The fibreglass resin should be thoroughly stirred and at room temperature before hardener is added and mixed. Once resin is mixed with hardener, all steps needed to build a layer of laminate must be completed quickly as the mixture can be worked for only 10–15 minutes. Suppliers should provide a technical paper detailing how long polyester can be worked at a certain temperature with a specific amount of hardener.

Only mix as much polyester and hardener as can be applied to the fibreglass mat in the time available. A small amount of polyester mixed in large container, as shown in Figure 28, is less likely to start gelling early than if the same amount of polyester is mixed in a small container. The difference in gel time is caused by increased exotherm buildup. This problem can also occur if laminates are too thick.

5.2 MIXING POLYESTER RESIN

Follow the initial steps set out in the section on “Material Description and Handling”, make sure that you use the correct amount of hardener for a good cure.

Figure 28

A handy tool for measuring hardener can be made by attaching a piece of steel wire to a bottle cap. A syringe can be used to measure the exact amount contained in the bottle cap.

A typical cap from a soda bottle will hold 5 ml of hardener. To measure 1% of hardener by volume, one capful is sufficient for 500 ml (1/2 litre) of polyester.

A coat of polyester resin should always be applied before laying on the fibreglass mat. The metal roller is effective for working out any air bubbles and for compacting the resin and fibreglass layers together.

In case there is no scale for measuring polyester resin, one may assume that one kilogram equals almost one litre. For either measure, there will be no significant loss of quality when working with these materials on a sturdy structure such as the IND-30 boat.

5.3 THE FIRST LAYER, OR BACKUP LAYER

The first layer (backup layer) consists of resin and a 300 g mat. There should be no bumps or contamination on the cured gelcoat prior to starting the lamination. It is vital that all air bubbles are carefully worked out and the first layer is allowed to cure for 4 to 6 hours, maybe even overnight, before the next layer is added.

For the backup layer, it is especially important that the fibreglass mat be torn (Figure 29) rather than cut. For this layer, the pieces of mat should be placed edge to edge with no overlap. This technique provides a smooth transition between the skin coat and subsequent layers, and does not interfere with the structure of the boat. Since the skin coat is not a structural layer, joining fibreglass pieces together in this way does not interfere with the overall strength of the final product.

Iso-polyester should always be used in the backup layer to help waterproofing the hull and avoid osmosis.

Figure 29

This photo shows how the first layer (backup layer) of fibreglass is applied.

The gelcoat is completely covered with a generous layer of polyester to make sure no air is trapped close to it.

Fibreglass mat with torn edges is then applied carefully over the polyester layer and rolled thoroughly.

Figure 30

Proper use of compacting rollers is very important. They are used to ease fibreglass mat into the underlying polyester and remove all air trapped between the two. This process must be completed before the polyester begins to set up and cure.

This boatbuilder is using a small compacting roller to push fibreglass into a tight groove and ensure that any trapped air is removed.

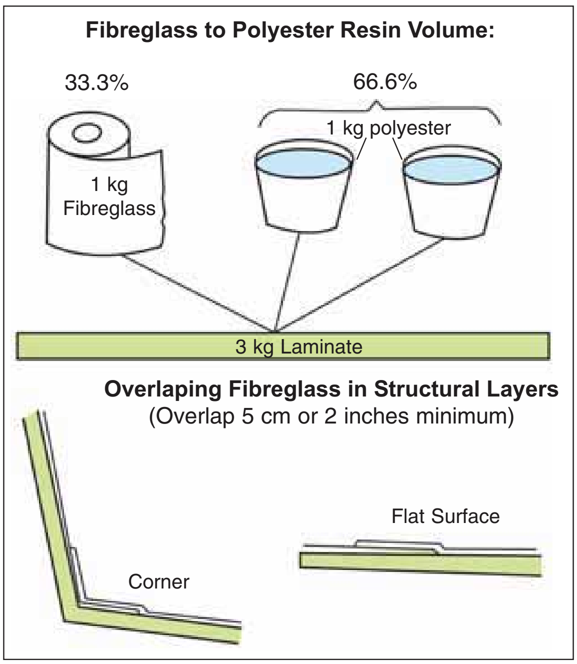

Figure 31

Shows the right amount of fibreglass (CSM) and polyester to use in a CSM laminate, and how to stagger/overlap the pieces of fibreglass mat in a structural layer.

5.4 INSPECTIONS

Continuous visual inspection is very important for quality control. A close watch must be kept to detect surface contamination and trapped air. If the fibreglass is too wet, the laminate will turn white. If the exotherm builds up too quickly, the colour of the laminate will change and appear aerated/foamy. If too much polyester has been used, wet puddles will occur. The boatbuilder is usually the only person who can detect and correct such faults, and when the next layer of laminate is in place, the faults will be invisible. If such faults are not corrected immediately, the finished new boat will already have weaknesses, minor or major.

Figure 32

This photo shows the results of poor quality control.

Large pockets of air have been left in the first fibreglass layer on top of the gelcoat.

5.5 LAMINATION OR MOULDING

For construction of the 8-m IND-30 BLC, both CSM and woven roving (WR) are being used. A main concern when laminating is to assemble each layer at the proper time interval. The laminate should be allowed to cool down after the curing process (exotherm) before starting on the next two layers. The topic of primary and secondary bonding and preparation of the surface to be laminated are set out in more detail in Part IV, Manufacturing defects and repairs.

6 - QUALITY

Quality is very important. Because the FRP boats are hand-made, the quality will always vary. Since you are the boatbuilding expert, you will probably be blamed if the quality suffers whenever a customer insists on cutting expenses.

FRP boats should comply with national safety legislation. For guidance, see also Annex 4 of this manual and the *Safety guide for small fishing boats* (BOBP/REP/112, 2009).

High quality starts with good design and drawings, and is greatly helped by being well organized.

The IND 30 is designed by an experienced professional naval architect who, as part of his training, has studied all aspects of boat design. It is for these reasons that the drawings should be understood and the boat built according to the drawings.

See the drawings for the IND-30 in Annex 3.

Air, moisture, dust and dirt in the laminate all contribute to quality problems with the boats.

Osmosis is one problem to be avoided as much as possible; cleanliness, thoroughness, correct material storage and choice will all help.

FRP is almost waterproof but not totally, and water will work its way through the gelcoat and cause osmosis, collecting in any voids or pieces of dust and dirt behind the gelcoat, and will begin to blister and rot the laminate.

FRP laminates with osmosis can lose up to 30 percent of their strength from osmosis.

A good boatbuilder is a careful boatbuilder, and the quality of the work can be judged years after the job has been done.

Four practices to avoid

1. **The practice of laying dry glassfibre into a mould and wetting through is unacceptable. You must wet the job first to get the fibres wet out correctly.**
2. **The practice of laying all layers in one go is unacceptable due to problems of exotherm (laminate gets hot and turns white or purple, loses strength and pulls and shrinks the part in that area).**
3. **The practice of using unpromoted resin (pure resin without accelerator) as a solvent for storing brushes is dangerous. You will be using a brush with resin in it that will not cure properly.**
4. **Do not use less than 0.8% catalyst (8 ml to 1 kg polyester) or less than 1% accelerator, or the part may not cure properly. Check with your resin supplier.**

Figure 33

Examples and consequences of bad practice:

- Avoid standing barefoot directly on the laminate. This is very dangerous to your body as well as to the construction. Sweat, talc and dirt will weaken the strength of the bond between the layers.
- Avoid wetting through the CSM mat, as mentioned above.
- While laminating and curing, never expose any part of the FRP boat to the sun.

AVOID BAD PRACTICES!

7 - HEALTH AND SAFETY ISSUES

Personal and environmental safety when working with FRP

7.1 PERSONAL SAFETY

7.1.1 Eye safety

In all industrial environments, protection is needed to prevent objects or chemicals from getting into workers' eyes. When working with FRP, care is needed to avoid both chemical hazards, including anything from eye irritation to severe corrosion and physical hazards such as irritation from airborne particles.

For example, the catalyst/hardener (**methyl ethyl ketone peroxide, or MEKP**) is a severely corrosive liquid. Grinders produce many dangerous airborne particles. In both cases, eye protection, mainly in the form of goggles, should be worn when working with FRP materials.

Figure 34

At left are examples of goggles for effective eye protection, ear protectors for hearing safety, and a dust mask for lung protection during grinding.

7.1.2 Hearing safety

Being exposed to loud sounds, constantly or even periodically, can eventually lead to permanent hearing loss. Ear protection should always be used whenever a power tool, such as a grinder or other noisy machinery, is in operation. For safety reasons, extra attention is necessary when communicating with and locating co-workers when ear protection is used; otherwise, it will not always be possible to hear a warning.

7.1.3 Breathing safety

Lungs are one of the most obvious and important organs to protect in a boatbuilding plant. Most boatyards have mechanical ventilation to keep the levels of volatiles, or hazardous fumes, and dust below an acceptable level. Even if fans/extractors are operating, a suitable respirator should be worn when there is direct exposure to hazards such as styrene fumes and fibreglass dust. There may be no immediate indication that exposure to such hazards is having an effect, but in the long-term, fibreglass dust will collect in the lungs, causing breathing problems and eventually result in lung collapse. The styrene fumes from polyester can cause nerve problems and possible brain damage, while the isocyanides released by the curing of polyurethane are poisonous and the amines released during the curing of epoxy have been linked to cancer.

When working with volatile fumes in a closed area with poor or no ventilation, such as inside a boat, respirators with an external source of fresh air must be worn for protection. Failure to use such protection can result in chemical lung inflammation.

Figure 35

The most commonly used respirator for protection against fumes is shown here. The filter in the front is disposable and should be replaced regularly.

Different filters are available for specific fumes and also for dust.

The filter must be clean and of the proper type.

Figure 36

This picture shows a battery-powered face mask. The battery pack is worn on the belt. Air is forced through the filters and pushed up into the mask, which provides protection for both eyes and lungs.

This apparatus is comfortable to wear and facilitates communication since only the eyes and nose are covered.

7.1.4 Walking and climbing safety

Uncured fibreglass and resin are very slippery. Spills on the floor, steps and scaffolding used for climbing can result in severe falls and other accidents. In particular, when working on larger boats, it is important not to cause damage when accessing wet laminate. Care is needed when constructing and when using steps and ladders. Electrical cables can also cause tripping.

Figure 37

Watch your step!

Great care is needed when walking on narrow planks and stepping on wet slippery fibreglass.

7.1.5 Hand and finger safety

Fibreglass boat construction requires fully functioning hands and fingers. Boatbuilding careers can be lost once hands and/or fingers are damaged or lost.

Disc grinders and power saws should always be equipped with a suitable guard.

Although wearing gloves is a very important protection from chemicals and abrasion, they can sometimes hamper the ability to work safely with power tools. It is necessary to balance work needs with maximum protection against chemicals and power tools.

7.1.6 Skin safety

Invisible threats can be just as dangerous as visible ones.

Direct contact with solvents like styrene and acetone must be avoided. They can be absorbed into the skin and, ultimately, the bloodstream. This absorption can result from directly touching the liquids or the air when heavily polluted with solvents during the use of spray equipment. The effects of repeated, direct contact with solvents are cumulative and long-term.

Figure 38

This photo shows the proper use of long- sleeved gloves when applying resin.

These workers are also wearing half-mask respirators for protection against volatile fumes like styrene.

Boatbuilders should always have available a generous supply of industrial gloves capable of withstanding the solvents being used.

7.1.7 Fire hazard safety

Smoking and open fire should not be permitted in a boatbuilding plant or boatyard.

Most materials used for FRP construction are highly volatile and flammable. Everyone in the workplace must take responsibility for eliminating fire hazards. The combined effect of smoking cigarettes and inhaling volatile fumes greatly increases health risks. At least one fire extinguisher should always be available in a boatyard.

Electrical appliances and power tools must be used with care. Electrical cables represent major risks, including poor wire condition and loose contacts that can cause explosions or start fires. Air-powered tools are safer.

Any leakage or spillage of catalyst can pose a significant fire hazard whether spraying or hand laminating.

When too much catalyst is used or when too much time is spent on some laminating details, resin may begin to set up in the bucket (early “kick off”). In such circumstances, the exotherm can quickly build up causing a fire unless the bucket is removed to a safe place and water is poured on top of the resin.

Abnormal exotherm buildup can also occur when saturated wet fibreglass is discarded into a waste container. Rags, wet with solvent, should not be discarded into the same container.

Mixing accelerator and catalyst (promoter and initiator) together causes explosions.

7.2 WORKSHOP SAFETY

7.2.1 Controlling dust and fumes

When sanding, the most effective way of controlling dust is at the source. An extraction fan/dust collector with a large hose diameter, or a vacuum cleaner (preferably a “HEPA VAC”) connected to a hose attachment on the grinder itself, is required.

Because it is very difficult to eliminate all dust at the source, a combination of approaches can be useful in maintaining good working environment in a workshop where several operations are being carried out at the same time.

In a boatbuilding plant, the most effective approach is to carry out as much of the sanding and grinding as is practically possible in a separate room.

To control fumes, there should always be some sort of air extraction and ventilation in the painting, gelcoat or laminating work areas. This arrangement minimizes the part of the boatbuilding plant where respirators are required.

Figure 39

The man on the left is spraying gelcoat and has a respirator with an external air supply. This is good practice. The man on the right is preparing CSM and wearing no respirator, even though the air is heavily loaded with styrene. This is bad practice.

In addition, since the activities are carried out so closely together, the gelcoat overspray will contaminate the fibreglass on the cutting board. This could reduce the quality and strength of the resulting laminate.

7.2.2 Controlling fire hazards

Figure 40

One example of very dangerous conditions in a workshop.

The electric grinder is shown sitting on top of a full barrel of polyester, which is highly flammable!

The shop manager has overall responsibility for maintaining a safe working environment and reducing the risk of fire!

7.2.3 Reducing waste and disposal of material

Plans and good routines for waste disposal are necessary to minimize fire hazards and pollution. Local authorities have regulations on how to handle the hazardous waste. Money can often be saved by separating hazardous and non-hazardous waste.

Careful management of raw materials to avoid wastage also saves money

Note that discarded chemicals, hardened resins and foams all have short- and/or long-term negative effects on the environment.

7.2.4 Raw material storage

Ideally, all raw materials should be stored in separate rooms to retain quality prior to use and for safety reasons. In particular, it is important to keep the catalyst in a separate room from the polyester and gelcoat in order to reduce the potential hazard of fire.

7.2.5 Documentation

All technical data sheets provided by the supplier for each material purchased should include everything needed to handle the chemical safely. It is recommended that all technical data sheets be collected in a binder, kept in a safe place and be available to all personnel who may potentially be exposed to these chemicals.