PART III – Maintenance and repair

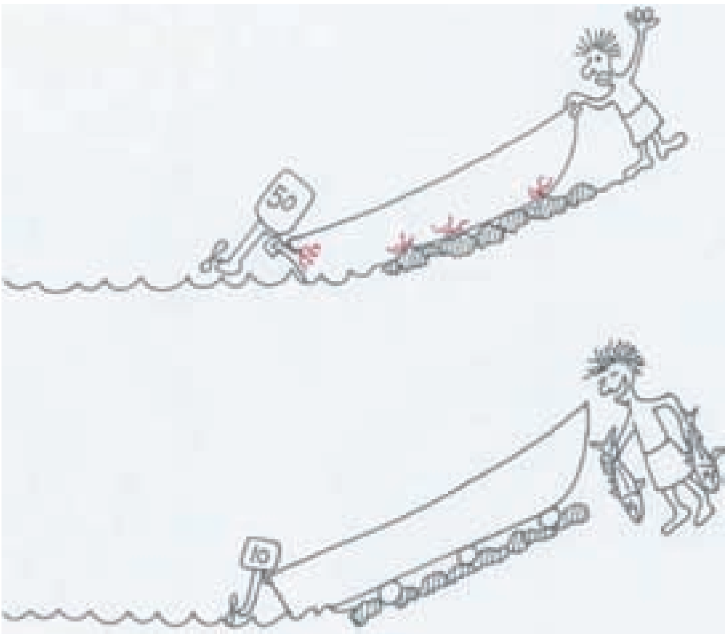
MAINTENANCE

What to look for and how to take care of your FRP boat

For everyday use, fibreglass reinforced polyester generally does not need much maintenance but this does not mean the boat will last forever. Wear and tear and the absorption of water do affect the lifespan of an FRP boat. The challenge is to determine if what can be observed on the surface is just cosmetic or more serious structural damage.

If unattended for a long time, a good quality FRP boat has the advantage of not requiring as much maintenance as a wooden boat.

A boat's smooth shiny surfaces can be protected by a good polishing with wax. This polish repels water and helps to keep the surface clean. Polishing is not a realistic option for rough surfaces like the inside surface of a boat. Wear and tear is often heaviest in these areas where the only protection is a layer topcoat.



FRP is brittle compared to wood, and is fairly easily damaged when dragged over or hitting rocks!

Check the boat for cracks after hitting hard objects and repair as soon as possible!

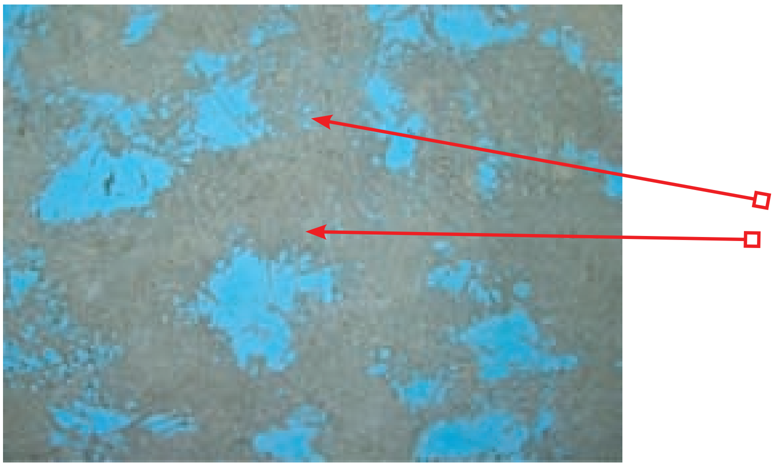
Do not use a bigger engine than the boat is intended for!

It is important to watch out for new cuts and crushing on the surface. Any such areas should be examined and sealed temporarily especially if the cracks are deep. As soon as possible, the damage should be repaired properly to prevent the areas from developing into more severe structural damage as a result of material fatigue during continued use of the boat.

When the surface becomes too worn, it should be degreased, cleaned and abraded properly to give good adhesion for a fresh layer of topcoat or paint. Above the waterline, a good quality marine paint is often a quicker, short-term solution than applying new topcoat. Paint has a glossier surface, and more easily repels dirt. However, gelcoat builds up thicker and generally resists mechanical wear better.

When a boat is left in the water constantly, water is absorbed by the polyester laminate. Gelcoat or topcoat does not stop water absorption. This absorption is not visible, but the laminate can absorb 1.5 to 2 percent water and become less stiff. After some years (5 to 15) the laminate can also react chemically with the water to produce hydrolysation which is comparable to rust in steel. The speed and extent of hydrolysation depends on the combination of water conditions, temperature, use of the boat, and how good the quality control was when the boat was built.

FIGURE 88



In this picture, old laminate showing typical results of hydrolysation can be seen. The polyester becomes depolymerized and is washed out of the laminate.

The results are visible as dark spots on the surface and white pockets deeper in the laminate.

If the gelcoat is intact, osmosis blisters might occur.

Old laminate is weaker and less stiff than new laminate, even if damage is not visible.

Water absorption will be slowed and working life of the boat improved if the hull laminate below the waterline is treated with several layers of epoxy barrier coat when the boat is new. Anti-fouling material applied to the hull to reduce marine growth improves fuel economy but has no effect on water absorption.

FIGURE 89

This photo shows typically worn interior of a fishing boat. The topcoat is worn off, and even FRP laminate covering the longitudinal stiffeners is gone.

The damaged laminate should already have been repaired to regain original strength and the surface recoated with topcoat or paint.

FIGURE 90

This photo shows what happens when laminate has not been maintained or repaired for too long.

The laminate has lost its strength and stiffness and, due to fatigue, the frame has broken.

At this spot the longitudinal stiffener is no longer supported by FRP laminate and, as a result, the bottom laminate can flex.

For fishing boats and workboats making and maintaining a glossy surface finish is not always realistic. However, such surfaces repel water more easily and take longer to deteriorate.

The goal of regular maintenance is to keep the vessel in a state of good repair and help it last as long as possible. The next two chapters focus on how to repair a damaged boat so that it is sound and as close to the original in strength and stiffness as possible. If such action is needed suggestions for improving the boat, compared to the original, are also given.

REPAIRING SMALL DEFECTS

The following notes refer to the repair of minor damage to FRP boats where the gelcoat has worn away or been chipped or cut but the laminate has not been seriously abraded. Figures 91 to 93 show an example of superficial damage and the steps needed in preparation for making the repair.

FIGURE 91

First of all, make sure it is really just a minor defect.

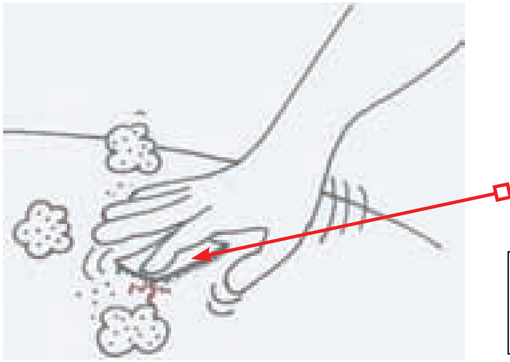
If the laminate is damaged, the site needs structural repair (as described in the section titled "Repairing structural damage").

FIGURE 92

Dirt, oil from the engine, grease, and blood from fish must be cleaned off before sanding begins!

Soap and water are used first followed by washing with available strong detergent.

FIGURE 93



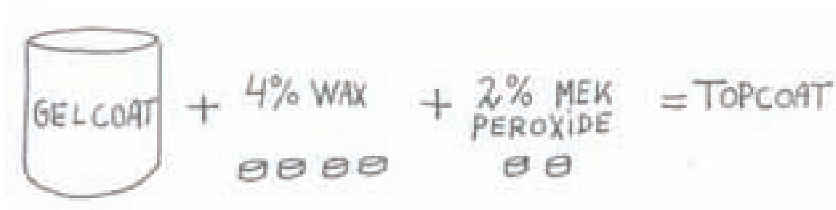
All broken gelcoat must be sanded away and any broken edges like the ones shown in Figure 91 must be smoothed.

A small piece of sandpaper (60 to 100 grit) should be used and size of repair area kept to a minimum.

Once sanded, no further washing or degreasing should occur before applying topcoat to the damaged area!

Topcoat should be prepared be combining the following ingredients in the proportions shown (half a litre of gelcoat, 20 ml of wax and 10 ml of MEK peroxide).

FIGURE 94



Figures 94 to 96 were copied from a repair folder. In Figure 94, the formula for topcoat is shown graphically. Figure 95 explains the two measures used in the above formula where a plastic bottle is cut down to hold half a litre (500 ml) and each bottle cap holds 5 ml (see Figure 95). Such measuring devices are readily available and provide a simple way to get the right ratio of materials for a good cure.

If there is a very thick layer of gelcoat and/or the damage extends slightly into the laminate but is not deep enough to be considered structural damage, the area can be repaired faster using putty. To make putty, mix in Colloidal Silica, the preferred option, or Talcome, if this is what is available, according to the formula in Figure 96. The amount of talcome/silica required depends on how much is needed to achieve the viscosity suitable for repairing the damaged area.

FIGURE 95

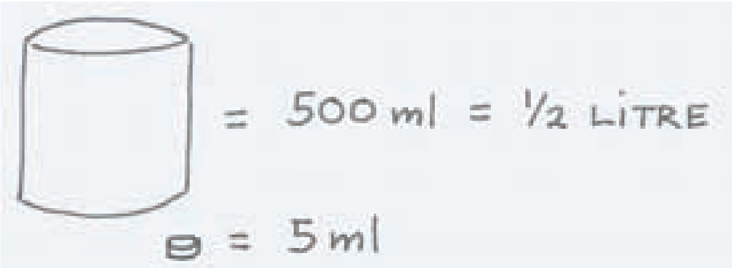


FIGURE 96

It needs to be emphasized that putty is much weaker than laminate and is not a good structural substitute for fibreglass reinforced polyester!

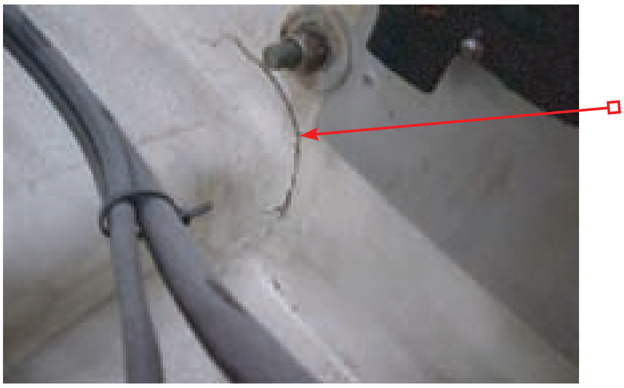
To create a lasting finish on the surface, the putty should be sanded down and a layer of topcoat added. At this stage, the appearance of the cured topcoat will be slightly rough and dull. To get a smooth and shiny finish, it is necessary to water sand the topcoat with an 800 grit (or finer). This should be followed by buffing and polishing to the same standard used for making plugs or repairing moulds.

REPAIRING STRUCTURAL DAMAGE

Practical guidelines for structural FRP repair

In general, repairing FRP boats can be easier than repairs involving other materials. However, proper preparation of the site, a dry working environment and the correct air temperature are critical.

FIGURE 97



This picture shows a typical fatigue fracture inside the transom on a boat powered by an outboard engine.

In this case, an attempt has been made to repair the crack but putty and gelcoat cannot mend structural damage.

Ideally, the boat should be repaired indoors to protect the work from rain and sun and to ensure a stable temperature. If working indoors is not possible, a tent should be made over the boat. All hardware and equipment which prevents access to the damaged area must be removed. A dust mask and eye and ear protection should be worn before any grinding starts. The grinding dust should be extracted at source. A commercial dust extractor or vacuum attached to the grinder can be used.

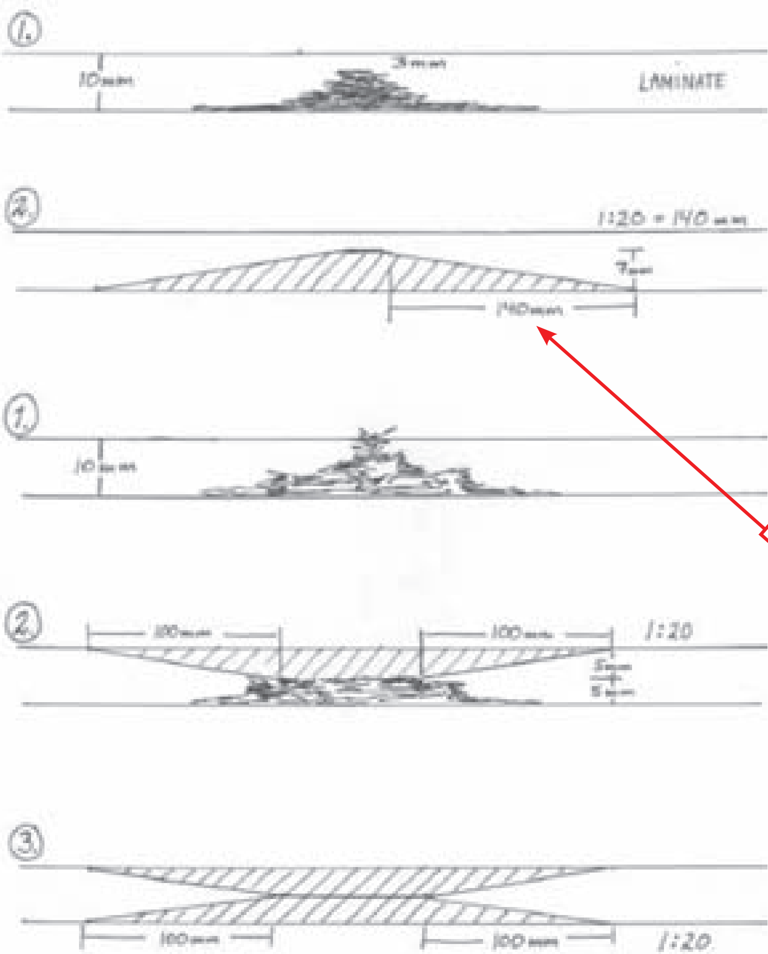
FIGURE 98

Prior to grinding, all surface contamination like oil and silicone should be washed off and removed with a suitable solvent. For grinding, 40 grit sandpaper is a good choice.

In the example shown here, grinding has uncovered deep delaminations. To ensure a lasting repair, the full extent of the delaminated fibreglass must first be removed, no matter how far or deep it extends.

A decision has to be taken on what kind of materials to use for laminating once the repair area has been identified and prepared. The following text is a guide to making this choice.

FIGURE 99



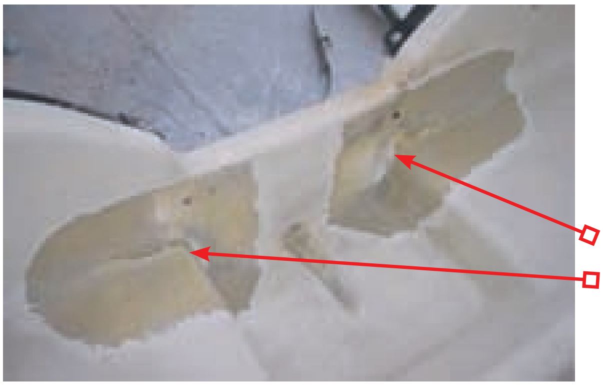
These schematic drawings illustrate the principle of laminate repair.

The first two images show damage which has not penetrated the whole laminate. The next three show a two sided repair.

Many books state that a scarf of 1:12 is sufficient for fibreglass repairs. This could be true for unloaded areas with thick laminates. However, for thinner laminates and loaded areas, the scarf should be at least 1:20.

In many cases, a scarf of 1:40 or more must be used to ensure adequate adhesion and absorption of stresses in loaded areas.

FIGURE 100



When the grinding is complete, the area to be laminated will likely be much bigger than suggested by the initial visual inspection.

For example, in this boat, tiny cracks in the gelcoat were visible on only one side of the engine well but grinding revealed that the delamination was just as deep on both sides.

Primary bonding

Primary bonding occurs when two surfaces are connected directly to each other, forming a chemically homogenous laminate containing no weak bond line.

A fresh, or "green", polyester laminate, has active molecules on the surface that will bind chemically to a new laminate. Laminating onto a green laminate gives a primary bond.

Apart from sanding off bumps and fibres which could cause defects and air pockets in the laminate, a fresh (green) polyester laminate requires no preparations before adding another layer.

How long the laminate surface remains active depends on a combination of the technical properties of the resin and the temperature during curing. Generally the open time for polyester resin is 24-48 hours.

When building a moderate sized boat, primary bonding can usually be achieved. When building large FRP boats, more time is needed to complete a layer of laminate and this makes operating within open time windows more difficult. Even so, achieving primary bonding between laminates in the main hull is crucial. In most cases, only secondary bonding will be achieved when laminating frames, stringers and bulkheads into larger boats.

An older polyester laminate is rarely completely cured. It will still have some reactive molecules that might, if properly sanded first, bond with the repair laminate. Wiping a sanded laminate lightly with styrene, immediately before applying a fresh polyester laminate, might also improve the bonding properties.

Secondary bonding

All repair work relies on secondary bonding. Consequently, stronger or additional replacement material will be needed to bring the damaged area back to its original strength.

When laminating over a cured laminate, the cross-linking reaction does not occur to a significant degree across the bond line. Since the polymer networks are discontinuous, the bond relies mainly on the adhesive strength of resin.

Choosing a resin for structural repair

In general, isophthalic polyester, vinylester, or epoxy resins are preferable to general purpose (GP) polyester resins for FRP repairs and alterations. After considering strength, cost and ease of processing for each, isophthalic polyester and vinylester resins are usually recommended for most repair work.

For more critical structural repairs, laminates made with epoxy resin are generally stronger (but not stiffer!). Epoxy resins are highly adhesive and have a longer shelf life than polyester and vinylesters. These characteristics make epoxy ideal for emergency repair kits. As they require no solvents, epoxy resin does not contaminate the surface of the original laminate and shows no shrinkage when curing (less tension).

Epoxies do not hydrolyse and this together with good adhesion, low shrinkage and high ratio of elongation to break, makes them more liable to perform well as a primary bonded laminate. However, epoxies are intolerant of bad mix ratios and the setting time cannot be shortened or lengthened by altering the amount of hardener. In addition, an epoxy surface is definitely not active with styrene; therefore, any further rework on an epoxy boat or an epoxy repair will have to be made with epoxy.

A thorough cleaning and preparation of the bonding surface is very important to achieve good epoxy adhesion.

As part of the repair process, a secondary bonding test can be made as follows.

BOX 2

A SECONDARY BONDING TEST FOR RESINS

1. Prepare a small piece of the laminate to be repaired.
2. Apply 3 layers of reinforcement and resin.
3. Cure for one day.
4. Separate new laminates. This may require use of a chisel.
5. If the new laminate pulls fibres out of the old laminate, the bonding is good!
6. Another simple testing method is by using small dry wooden blocks as shown in Figure 101.

FIGURE 101

Choosing reinforcement for structural repair

If practical, the same reinforcement used when building the original boat should be used in the repair, especially if the part being repaired is heavily loaded and operating near its design limits. Use of lighter weight reinforcement will allow for better contact with the surface but the importance of this feature should be weighed against the importance of using the original reinforcement for maximum support.

Meanwhile, remember that there will be no continuous fibres attaching the old to the new laminate, and strength of the join will depend solely on adhesion of the new laminate to the old. Almost 100 percent of stiffness can be recovered if the laminate is built up to its original thickness; however, the strength and fatigue properties of the repaired laminate will be weaker than the original. Dimension of the fibre bundles is critical for the repair to perform well because large bundles and heavy mats/fabrics obscure air and resin-rich pockets that are more likely to form at the borderline between the old and new laminates.

It is important to take all these matters into consideration when designing the repair laminate (see Figure 102). If additional reinforcement is required to maintain the boat's overall strength, be careful to avoid excessive laminate build-up as this can increase the risk of developing stress concentrations.

FIGURE 102

In this example, the resin chosen for use was epoxy, but vinylester might also have performed well. Bear in mind that this was a single-sided repair and the original polyester laminate was already showing weakness from fatigue.

The reinforcement was a mix of 290 g woven twill and 450 g Double Bias fibreglass, chosen because of its drape ability and good performance with epoxy.

Surface preparation

It is important not to clean a freshly-sanded, porous, fibre laminate with acetone or solvent prior to lamination, unless it has been contaminated with oil or grease. If cleaning is necessary a light grinding with clean sandpaper after the washing is required followed by sufficient time to allow the solvent sufficient time to "air out" (evaporate). When solvent is absorbed by the porous surface, it "contaminates" the surface laminate and can dilute the new resin preventing optimum adhesion.

When using polyester, a light styrene wipe prior to laminating is the only acceptable procedure. A small amount of styrene will activate the surface slightly and improve adhesion. Too much styrene will weaken the bond line.

For repairs under the waterline, fresh styrene in the new polyester laminate is also liable to trigger hydrolysis (absorption of water) at an earlier stage than in the original laminate and cause premature failure in the borderline area between old and the new laminate.

An important issue when making repairs is to check the water content of the laminate with a moisture meter. If the laminate contains too much water, the bonding will fail sooner than it should and the new laminate will separate from the old one prematurely.

When it comes to the actual laminating, all the same procedures as for making a new boat must be followed including the maintainance of high quality control standard.

FIGURE 103

At this stage, the laminate build up has been completed and the surface has been ground flat to a nice "finish". Use of any form of putty on structural repairs is to be carefully avoided.

Putty has a short "elongation to break" ratio, and will break up and crack much faster than a laminate.

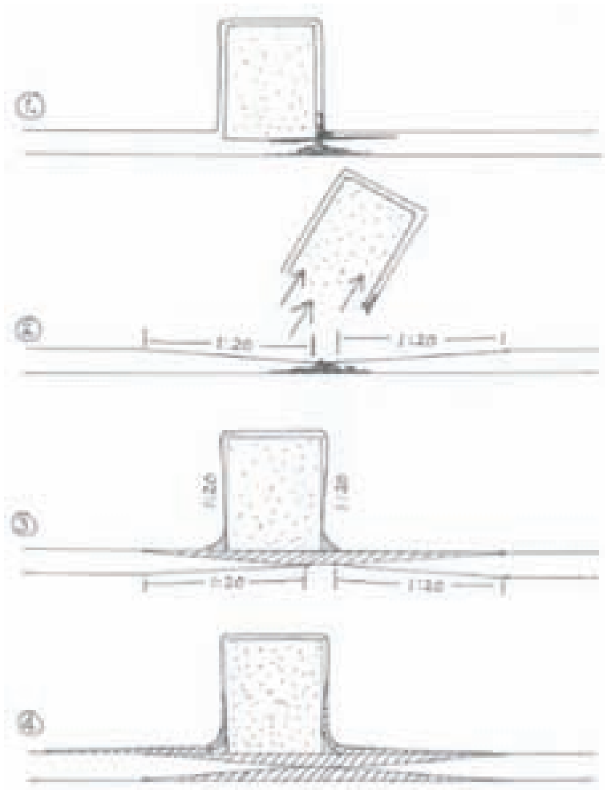
FIGURE 104

This picture shows the finished product. Topcoat has been applied, water sanded, buffed and polished to a decent gloss.

Polyester topcoat can be used on top of epoxy as long as the epoxy is cured properly before the topcoat is applied.

In this case, a 5 mm aluminum plate has also been attached to distribute pressure from the bolts over a larger area.

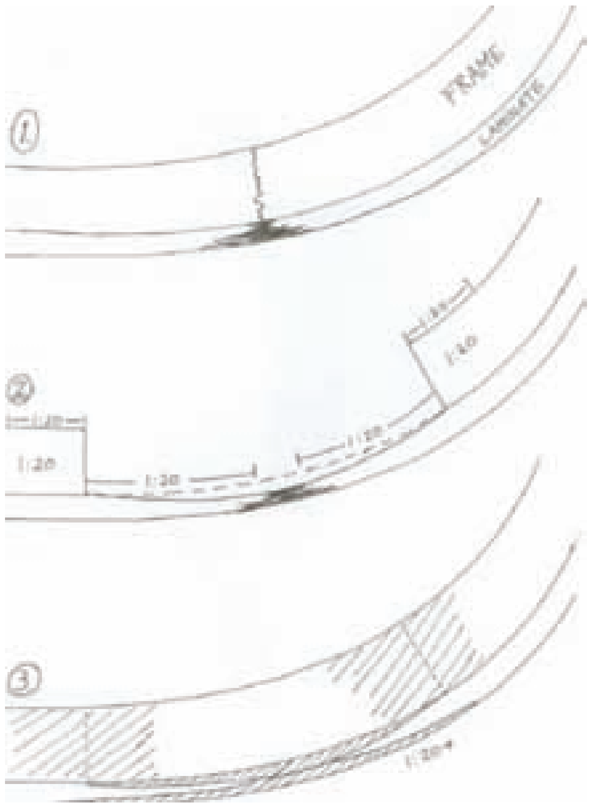
FIGURE 105



Cross-section showing structural damage to the frame of an FRP boat and the proper method of repair:

1. A fracture in the outer skin has penetrated the whole laminate, and caused delamination in the framework.
2. For the repair to be effective, the wooden frame must be cut and removed. Next, the hull laminate must be repaired as described earlier.
3. The frame has to be ground to a scarf wherever it will be joined with other laminate, and then bonded down with putty/glue and finished with a radius filet.
4. All lamination work on the frame is best done with easily drapable fabrics or 450 g/m² and lighter CSM.

FIGURE 106



Side view

1. This represents almost the same structural damage as shown in Figure 105, but viewed from the side.
2. The frame is shown cut and taken away making the damaged laminate accessable. In this case, no scarf in the core of the frame is required, as would be on a wooden boat, because this frame is filled with foam or air, which is not a structural member.
3. The place to cut and how to cut the frame will vary depending on the damage and will have to be estimated carefully in each case. Sometimes, when structural foam is involved, it is necessary to make a scarf in the same way as with a wooden frame. In some cases, "stepping" the scarf may also be an alternative. Using additional extra length reinforcement, such as unidirectional fibres along the top of the frame, must also be considered sometimes to add strength to the repair.

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Appendix 1

Copying old boat designs for construction with fibreglass reinforced plastics

It is possible to use an old wooden boat as a plug by first drying out the wood and then covering it with fibreglass reinforced polyester (FRP). The rest of the process of building up the surface is the same as described in the section Making the Plug.

It should be noted that not all old boats or canoes are of a suitable design to be copied directly in fibreglass. Wood and FRP have different mechanical properties. It is dangerous to think that, since FRP is stronger, it can easily be used to make the hull of any boat thinner and lighter.

If the design does not take into consideration the properties of FRP, the copied boat may loose stiffness quickly and be more exposed to fatigue.

The combination of an original wooden boat shape and the lighter weight of FRP could result in vessel instability and other less favourable seagoing characteristics.

FIGURE 107

This type of large traditional wooden canoe has demonstrated its seaworthiness and durability for generations, successfully going out to sea from shore through the surf, heavily loaded with nets.

FIGURE 108

This FRP boat was copied from a wooden canoe and was not old but already had broken frames and fatigue cracks in the bottom laminate.

The shape, size and use of these wooden boats make them unsuitable for exact reproduction as FRP copies. FRP is too brittle to survive such regular bending and the thinner walls make the structure vulnerable to fatigue.

The FRP version would have to be built much more heavily than this copy and with better designed and stronger stiffeners in order to withstand the stresses involved in carrying their typical load of fishing equipment and men out to sea through the heavy swell.

Appendix 2

Covering old boats with FRP

Choosing to cover an old worn-out wooden boat with fibreglass reinforced polyester to keep it floating on the water is a big risk. Even if the old wood can be dried out completely, the likelyhood of keeping rot away for any reasonable length of time is not very good.

There is a good chance that, within a few years, rot will eat up the boat from the inside!
Adding two to three layers of FRP on the wood will seem to produce a stiff and dry boat, but after a few years problems will start. To be safe at sea for a longer time, a new boat should be built.

FIGURE 109
This is an example of a bad boat!

Appendix 3

Material list and hull lay-up for MDV-1

TABLE 1

HULL LAYUP FOR DECK AND BUOYANCY TANKS, SEE ALSO FIGURE 73

NO	ITEM	STRIP WIDTH mm	LAYUP CSM g/m²	TOTAL g/m²	AREA m²	TOTAL CSM kg
1	Whole area		1 x 300	300	12.3	3.7
2	Keel reinforcement	300	2 x 450	900	1.0	0.9
3	Side keels	100	1 x 450	450	0.6	0.3
4	Transom corner	100	2 x 450	900	0.3	0.3
5	Stem	150	2 x 450	900	0.2	0.2
6	Bottom reinforcement		1 x 450	450	5.7	2.6
7	Sheer reinforcement	100	1 x 450	450	1.0	0.5
8	Whole area		3 x 450 + 1 x 300	1650	12.3	20.3
9	Strip over keel	150	3 x 450	1350	0.5	0.7
10	Strip over rubbing keel	150	3 x 450	1350	0.6	0.8
					Total CSM	30.3 kg
					Additional 10%	3.0 kg
					Total CSM	33 kg

TABLE 2

COAMING, DECK AND FLOATATION BOXES

	ITEM	LAYUP CSM	g/m²	AREA m²	WEIGHT kg
1	Coaming	300 + 3 x 450	1650	3.07	5.06
2	Deck aft, engine well	"	"	1.09	1.80
3	Deck forward	"	"	0.95	1.57
4	Floatation boxes aft	"	"	1.00	1.65
5	Thwart boxes	"	"	1.20	1.98
6	Floatation forward	"	"	0.74	1.22
7	Floor forward	"	"	0.46	0.76
8	Strip in flange, assembly	450	450	0.40	0.18
CSM					14.22 kg
Waste 10 %					1.42
CSM Total					15.6 kg
Polyester, 30 % glass content: 2.40 x 15.6					37.4 kg
Total deck and floatation: FRP materials					53 kg
Wood fender and thward					14
TOTAL					67 kg

Polyester resin with glass content = 30% = 2.4 x 33 kg =	79 kg
Total weight of FRP in hull	= 112 kg
Coaming, deck, floating boxes	= 67 kg
Total weight of boat	= 179 kg

Total layup and thicknesses:

Bottom	2 x 300 + 4 x 450 = 2 400 g/m²	t = 5.6 mm
Sides	2 x 300 + 3 x 450 = 1 950 g/m²	t = 4.6 mm
Keel	2 x 300 + 6 x 450 = 3 300 g/m²	t = 7.7 mm
Side keels	2 x 300 + 5 x 450 = 2 850 g/m²	t = 6.7 mm
Sheer	2 x 300 + 4 x 450 = 2 400 g/m²	t = 5.6 mm
Stem	2 x 300 + 6 x 450 = 3 300 g/m²	t = 7.7 mm

These are approximate figures of the total amount of material needed:

Gelcoat:	20 kg
Polyester:	150 kg
MEK Peroxide:	4 kg
300 g/m² CSM mat:	14 kg
450 g/m² CSM mat:	50 kg
Acetone:	10 kg
Mould release wax:	0.3 kg
PVA release agent:	0.2 kg
Buffing compound:	0.2 kg
PU foam:	As required
Polystyrene foam:	As required

Hardware:

Oarlocks
Oars
PVC or wooden fender
Reinforcement plate of steel or aluminium
Two to four stainless steel U-bolts
Drainage plug
Bolts and nuts for fastening

Appendix 4

Offset table MDV-1

TABLE 3

LOFTING TABLE FOR 4.5 M MDV-1 **In mm to outside planking**

½ width from centre line	Keel underside	12	12	25	25	25	25	25	19	12
	Rabbet	12	23	35	35	33	32	31	25	12
	Sprayrail, inner						618	466	275	31
	Sprayrail, outer						640	506	314	35
	Sheer	669	762	817	843	838	801	722	587	367
	WL 1	450	549	641	675	643	536	379	183	
	WL 1 A	553	640	710	746	718	611	438	228	
	WL 2	586	676	741	773	754	667	519	274	12
	WL 3	625	718	777	802	790	717	576	360	64
	WL 4	648	738	796	821	810	755	629	420	121
	WL 5	661	754	811	836	826	782	677	486	188
	WL 6							719	553	271
Height from baseline	Keel underside	151	35	0	0	0	0	5	47	307
	Rabbet	151	137	120	102	85	67	63	78	307
	Sprayrail					251	267	290	316	353
	Sheer	694	680	668	669	679	697	724	762	815
	Buttock A	164	146	127	110	101	91	100	176	
	Buttock B	183	162	142	126	126	126	157		
	Buttock C	211	188	165	147	155	173	272		

Appendix 5

Technical information on GP polyester

EXAMPLE OF TECHNICAL DATA PAPER FOR GENERAL PURPOSE ORTHO

REICHHOLD

[PRODUCT BULLETIN]

August 2007

POLYLITE® 440-M850

Standard orthophthalic polyester resin

DESCRIPTION

POLYLITE® 440-M850 is a medium reactive orthophthalic polyester resin.
POLYLITE® 440-M850 is thixotropic and has a built-in accelerator system giving medium gel time, rapid curing combined with relatively low exothermic temperature and short demolding time.

POLYLITE® 440-M850 contains special additives which improve the working environment during and after application due to substantially reduced styrene evaporation. The resin contains wax which gives the cured laminate a tack-free surface.

APPLICATION

- POLYLITE® 440-M850 is a hand layup/sprayup resin.
- POLYLITE® 440-M850 is designed for marine, industrial and transport application.

Recommended laminate thickness applied wet-on-wet: 2-8 mm.

FEATURES	BENEFITS
• Excellent application properties	• Short application time • Good fiber wetting • Higher fiber content
• Medium reactivity	• Good curing • Short demoulding time
• Approvals	• Det norske Veritas, DNV, grade 2 Lloyd's Register of Shipping Bureau Veritas Germanischer Lloyd Russian Maritime register

REICHHOLD [PRODUCT BULLETIN]

TYPICAL PROPERTIES

PHYSICAL DATA IN LIQUID STATE AT 23°C

Properties	Unit	Value	Test method
Viscosity - Brookfield Model LVF, Spindle 2 at 12 rpm - Cone & Plate	 mPa·s(cP) mPa·s(cP)	 1100-1300 170-200	 ASTM D 2196-86 ISO 2884-1999
Specific gravity / Density	g/cm³	1,10	ISO 2811-2001
Acid number (max.)	mgKOH/g	24	ISO 2114-1996
Styrene content	% weight	44 ± 2	B070
Flash point	°C	32	ASTM D 3278-95
Gel time: 1% NORPOL PEROXIDE 1 (MEKP)	minutes	35-45	G020
Storage stability from date of manufacture	months	6	G180

TYPICAL NON-REINFORCED CASTING PROPERTIES

Fully post cured.

Properties	Unit	Value	Test method
Tensile strength	MPa	50	ISO 527-1993
Tensile modulus	MPa	4600	ISO 5271993
Tensile elongation	%	1.6	ISO 527-1993
Flexural strength	MPa	90	ISO 178-2001
Flexural modulus	MPa	4000	ISO 178-2001
Impact strength P4J	mJ/mm²	5.0-6.0	ISO 179-2001
Volume shrinkage	%	5.5-6.5	ISO 3521-1976
Heat distortion temp.	°C	62	ISO 75-1993

STORAGE

To ensure maximum stability and maintain optimum resin properties, resins should be stored in closed containers at temperatures below 24°C/75°F and away from heat ignition sources and sunlight. Resin should be warmed to at least 18°C/65°F prior to use in order to assure proper curing and handling. All storage areas and containers should conform to local fire and building codes. Copper or copper containing alloys should be avoided as containers. Store separate from oxidizing materials, peroxides and metal salts. Keep containers closed when not in use. Inventory levels should be kept to a reasonable minimum with first-in, first-out stock rotation.

Additional information on handling and storing unsaturated polyesters is available in Reichhold's application bulletin "Bulk Storage and Handling of Unsaturated Polyester Resins." For information on other Reichhold resins or initiators, contact your sales representative or authorized Reichhold distributor.

SAFETY

READ AND UNDERSTAND THE MATERIAL SAFETY DATA SHEET BEFORE WORKING WITH THIS PRODUCT

Obtain a copy of the material safety data sheet on this product prior to use. Material safety data sheets are available from your Reichhold sales representative. Such information should be requested from suppliers of all products and understood prior to working with their materials.

DIRECTLY MIXING ANY ORGANIC PEROXIDE WITH A METAL SOAP, AMINE, OR OTHER POLYMERIZATION ACCELERATOR OR PROMOTER WILL RESULT IN VIOLENT DECOMPOSITION

In many areas of the world, finding the type of timber needed to build a good quality wooden boat is becoming a problem. As a result, fibreglass reinforced plastic (FRP) is beginning to be used by many wooden boatbuilders. The information provided in this manual relates specifically to the production of a 4.5 m open fishing boat called the MDV-1. It is a simple, easily-driven, seaworthy boat intended for both rowing and power propulsion. Its general-purpose design is suitable for inshore waters around the world. A general basic knowledge in the use of FRP as a boatbuilding material is presented and step by step construction of a 4.5 m open fishing boat using FRP is set out in detail. In addition, the booklet describes how to maintain an FRP boat and how to recognize fatigue problems. Some simple guidelines on how to repair minor damage to FRP are also included. It is assumed that people planning to build a boat already have a good, general understanding of basic hand tool use. This manual should give boatbuilders and fishermen a better understanding of how FRP acts, how to recognize fatigue problems and more serious damage, and how to carry out needed maintenance and repair.

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