There are distinct disadvantages to using vinylester as well:

- Both polyester and vinylester are highly flammable. Being "Dangerous Goods" therefore storage and transport present significant problems and may invalidate the users insurance.
- Significant amounts of Volatile Organic Compounds (VOC) are emitted whilst it is being used and breathing protection may be necessary. This is due to the use of liquid styrene to thin it out (not good to breath).
- Sometimes it won't cure if the atmospheric conditions are not right due to its sensitivity to atmospheric moisture and temperature.
- It also has difficulty in bonding dissimilar and already-cured materials.
- It is not unusual for repair patches on vinylester resin fibreglass to delaminate or peel off and many vinylester hulls suffer delamination of the hull skins from core and bulkhead substrates.
- As vinylester resin ages, it becomes a different resin (due to it's continual curing as it ages) so new vinylester resin sometimes resists bonding to older vinylester, or will bond and then later peel off.
- Vinylester resins bond very well to fibreglass, but offer a poor bond to kevlar and carbon fibre due to the nature of those two more exotic fibres.
- Due to the touchy nature of vinylester resin, careful surface preparation is necessary if reasonable adhesion is desired for any repair work.
- Vinylester is fairly brittle compared to Epoxy and is prone to cracking where high point loads maybe applied or when used in areas where flexing occurs.

Epoxy is known in the marine industry for its incredible toughness and bonding strength. It is the best product to use when fibre glassing for the following reasons:

- It is extremely effective as a moisture barrier therefore reducing the risk of Osmosis.
- It is also a superb adhesive. It sticks to other materials with 2,000-p.s.i. vs. only 500-p.s.i. for vinylester resins and even less for polyesters.
- In areas that must be able to flex and strain with the fibres without micro-fracturing, epoxy resins offer much greater capability.
- Epoxy resin will bond dissimilar or already cured materials which makes repairs that are very reliable and strong.
- Epoxy offers excellent results in repair-ability when it is used to bond two different materials together.
- Epoxy is considerably stronger

The above factors make epoxy the resin of choice for repairs and for over coating a boats hull to help resist osmosis. Epoxy does degrade in strong ultraviolet light and it in turn must be protected with a UV resisting paint (most pigmented paints and of course Aquacote). Epoxy cannot be used with chopped strand mat due to the binder used to hold the mat together not being compatible with epoxy. Woven or knitted cloth must be used in repairs which provide a stronger structure than chopped strand.

Fairing powders (Bote Cote Sanding Filler) and epoxy are available to make a bog which can be sanded to fair the repair to a smooth surface. There are also filler powders available which can be mixed to make a structural adhesive and a structural filler for "filleting" applications.

Epoxy carries a small risk of allergic sensitization (2:1 ratios such as Bote Cote are much safer than 4 & 5:1 ratios), which provided adequate hygiene and good air circulation is employed does not present hazard to most people. It is not a dangerous good and has no particular transport or storage risks.

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FIBREGLASS REPAIR

Bote-Cote Epoxy bonds strongly (300% stronger than polyester or vinylester) to clean polyester fibreglass, therefore is ideal for repairing fibreglass boats. To repair impact damage to fibreglass, first grind away all shattered material, preferably to a uniform shape, say a circle, and feather out the edges radially some 6 to 8 times the depth of the hole. Apply a first coat of Bote-Cote thinned with TPRDA, this will wick into any remaining damage and re-bond the fibres. Then rebuild the area by laminating on patches of fibreglass with Bote-Cote, steadily increasing their size to match the increasing diameter of the hole until the patch is level with the surrounding surface. Finish off with a piece of Peel Ply, polythene film, or packaging tape to even out the surface and make it easier to sand flush after it has cured.

If the hole is right through the fibreglass follow the above procedure, but first fit a backing piece of plywood or thick poly plastic to provide a firm base for laminating. If this backer is to be temporary, cover it with polythene film first to prevent it sticking. After removal, if possible laminate some additional glass onto the inside of the patch to lock the repair around the edges of the hole.

Transoms and stringers whose core is rotten are favourite sources of rot in fibreglass boats. Most production boats are built with plywood transom inserts and timber stringers. These were not sealed properly during manufacture, being simply bonded into place using polyester resin, chopped strand mat, and 'bog'. Over not too many years this potent mixture weakens and delaminates from the plywood or timber, water enters and the timber rots away, leaving flappy transoms and bilge panels.

To repair these, first you must remove the fibreglass covering the stringer or inside of the transom, extract all the material inside it, and expose the original inside surface of the hull. Clean and sand this surface, prepare replacement timber or plywood to fit, and thoroughly coat it with BoteCote. Apply a thickened Bote-Cote mix to this replacement, and to its corresponding area of the hull, then fix the timber in place with enough clamping to ensure some of the mix is squeezed out all around. This can be smoothed into a fillet along all the edges, and further filletting mix should be applied to make generously rounded fillets. After this replacement has set, fibreglass the whole area with Bote-Cote, continuing the glass well out onto the adjacent area of the fibreglass hull. For transom repairs, we recommend Biaxial glass for maximum strength both across as well as up and down the transom. For stringers, use Double Bias tape, which will conform more easily to the corners and edges.

Note. Polyester (the resin normally used in fibreglass boats and for fibre glassing) is a poor adhesive. Polyester repairs are well known for “delaminating” (that is coming unstuck) after a period. Epoxy is an excellent adhesive and it adheres extremely well to existing sound polyester. Unfortunately, epoxy is attacked by ultra violet light (sunlight) so it in turn must be protected by a paint coating. The best of these are the two pack polyurethane coatings such as our Aquacote, which properly applied will give 3 years and usually many more years of protection.

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OSMOSIS

Osmosis is Fibreglass cancer. In permanently immersed polyester fibreglass boats, there are some laminates which contain certain defects which attract water into the structure of the fibreglass, and this water creates enough internal pressure to form blisters in the hull. These blisters are sometimes only in the outer layers of the fibreglass, sometimes they have penetrated very deeply into it. The causes, and best methods to deal with it, are still being investigated by both resin and boat manufacturers, and at this time there is no absolutely certain remedy. It is likely that most fibreglass boats manufactured using polyester resin will exhibit osmosis defects at some stage of their lives.

Some things are known. Polyester resin (which almost all fibreglass boats are made of) is not very good at preventing small amounts of water permeating through it. This is how the water gets to the defects. Anything which reduces the amount of water which permeate to the site of a defect will reduce the osmosis problem. This means that coating the outside of the hull with a good moisture barrier will certainly help with the osmosis problem. Keeping the inside of the boat (very) dry, removing salt encrustations and being fanatical about ventilation will help prevent moisture reaching defect sites from inside the boat. These measures will mean that it will take a lot longer before osmotic blisters appear, will reduce their size and reduce the number of them, and usually by a very substantial degree.

If the osmosis is caught soon enough, and it is restricted to the outer layer of the laminate, then repair is much easier and more certain. Epoxy is the best resin to carry out repairs as it has so much greater water resistance than polyester (something like 98% waterproof). The Bote-Cote marine coating epoxy is deal for this task. Cop-R-Bote is an epoxy-metallic copper antifouling and when applied over Bote Cote Epoxy it adds greatly increased resistance to the penetration by moisture.

The blistered area must be ground away, down to sound laminate, and the hull should then be left to dry out for many weeks. Some operators recommend localised heating of the hull, even to quite high temperatures, to destroy the chemical defects in the laminate. When the hull is dry, repair, recoat and restore with Bote-Cote as described in the following section.

Consideration should also be given to coating the underwater parts of the hull with epoxy to form a moisture barrier. To create an osmosis barrier over the whole hull, we recommend coating the hull with three coats of Bote-Cote. Coating the hull with Cop-R-Bote (which should be applied over either epoxy or the gel coat will also provide a good moisture barrier and it is an effective very long life antifouling.

Osmosis can also occur from inside the hull, as well. Areas which are constantly flooded with water, such as water tanks and deep bilges. Clansman are notorious for osmosis in the the freshwater tanks which is located in the forward cabin under the V-berth.

Fibreglass Reinforced Plastics (FRP) Explained

When we use the term fibreglass we mean plastic reinforced with fibres of glass commonly known as Glass Reinforced Plastic (GRP) or FRP. The fibres come in many different constructions (e.g. chopped strand, woven, knitted etc) and weights (amount of glass per square metre). The plastic can be many types but there are 3 types which are most commonly used when fibreglassing, being Epoxy, Vinylester & Polyester.

Most things which we describe as fiberglass use a polyester resin as the plastic system. Nearly all fiberglass boats are made from polyester based fiberglass, unless it is high performance when Epoxy is used and usually with carbon-fibre to reduce weight. Polyester is used as it is:

- Cheap and readily available,
- withstands ultraviolet light well and weathers slowly, but over a number of years, the surface does degrade and become chalky,
- Most people know how to use it, although two to one mix Epoxies, such as Bote Cote, are easier to mix and use.

Polyester Resin has a number of disadvantages:

- The most significant in the marine application is osmosis, which nearly every permanently immersed boat, manufactured using polyester, will eventually suffer from. These are blisters which form due to small defects within the fiberglass and the relative ease with which water can diffuse through polyester resin. Refer to the Osmosis brochure.
- It is a poor adhesive which makes it a poor choice for repairs as the repair stands a strong chance of delaminating or in layman's terms, coming off.
- It is also heavy as quite a thick lay-up must be used to achieve the desired strength and is best suited to building things that are not weight sensitive.
- Polyester resin is only compatible with fibreglass fibres. It will not adhere to Carbon or Kevlar fibres.
- Polyesters historically exhibit poor performance in the areas of adhesion and elongation, rendering the finished part prone to micro cracking and secondary bond failures.

Increasingly we are seeing Vinylester resin used. There are some boat parts and even the occasional whole boat made out of vinylester reinforced resin. Many yards use vinyl ester for repair work on polyester boats. Vinylester is actually based on an epoxy with polyester molecules incorporated into it to enable it to react just like conventional polyester. Unfortunately these polyester molecules bring with them polyesters problems as well. The advantages of Vinylester are:

- It is a distinct improvement over polyester but it is considerably more expensive.
- It shares with polyester the advantage of being reasonably resistant to UV light and it is fairly weather resistant.
- It is better at preventing moisture diffusing through it than polyester, but no where as good as unmodified epoxy.
- It is a better adhesive than polyester, but again it is no where near as good as un-modified epoxy.
- It is probably the best room temperature curing resin to use in high temperature applications.

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