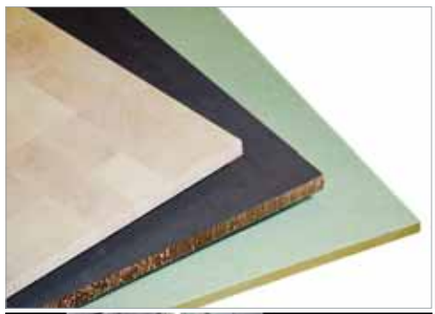
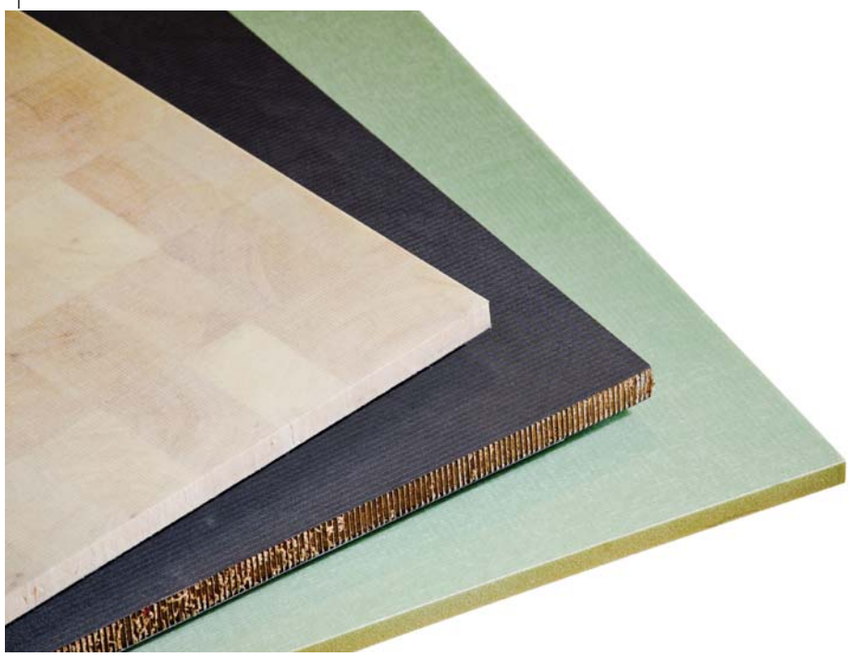
DuFLEX®

lightweight composite panels





- Strength
- Durability & Damage Tolerance
- Economy
- Expandability
- Kits
- Code approved manufacture available

DuFLEX® panels were specifically designed to reduce construction time and to optimise structural weight in high performance composite structures. Time-consuming laminating, coring and vacuum bagging steps normally required to fabricate high performance composites are avoided, and material waste, labour and tooling costs are greatly reduced.

Standard DuFLEX panels are cored with rigid end-grain balsa or structural foam cores, and laminated with a high performance epoxy resin reinforced with multiaxial E-fibreglass or carbon fibre skins. Fibre orientation and ply schedules are based on design or engineering specifications to best meet weight targets, stress and impact loads, and other design parameters.

DuFLEX Panels are manufactured in a controlled environment and under-go strict Quality Inspections, at all stages during the manufacturing process, to ensure dimensional stability and consistent thickness.

The core and laminates are co-cured in a hot press, a method that consolidates the laminate under pressure increasing the fibre volume and therefore the strength of the finished panel. The E-glass fibre content of DuFLEX laminates is approximately 62% by weight.

The panels are finished with peel ply to protect the laminates from contamination and to reduce the amount of preparation required prior to secondary bonding or laminating.

DuFLEX panels with carbon skins and foam or aramid honeycomb cores can be manufactured for high performance projects requiring superior stiffness or lightweight.

DuFLEX balsa panels BALTEK®

1 x 600g Biaxial E-glass either side of core*

Order Code	Core Thickness	Nominal Weight kg/m²
DP1010C6	10mm	3.8
DP1013C6	13mm	4.2
DP1016C6	16mm	4.7
DP1019C6	19mm	5.1
DP1025C6	25mm	6.0

2 x 600g Biaxial E-glass either side of core

DP2010C6	10mm	6.0
DP2013C6	13mm	6.5
DP2016C6	16mm	6.9
DP2019C6	19mm	7.2
DP2025C6	25mm	8.3

DuFLEX foam panels AIREX®

1 x 600g/18oz Biaxial E-glass either side of core*

Order Code	Core Thickness	Nominal Weight kg/m²
DX1010C6	10mm	2.8
DX1012C6	12mm	3.1
DX1015C6	15mm	3.3
DX1020C6	20mm	3.6
DX1025C6	25mm	4.0

2 x 600g/18oz Biaxial E-glass either side of core

DX2010C6	10mm	4.9
DX2012C6	12mm	5.1
DX2015C6	15mm	5.4
DX2020C6	20mm	5.6
DX2025C6	25mm	6.1

** Alternative laminates and cores are available on request*

vdLComposites Pty Ltd reserve the right to alter specifications without prior notice. Weight may differ slightly (up or down) due to variations in core density.

Core Mechanical Properties

RIGID END-GRAIN BALSA BALTEK® SB.100			
Nominal Density	ASTM C-271	150 kg/m³	9.4 lb/ft³
Tensile Strength perpendicular to the plane	ASTM C-297	13.0 MPa	1886 psi
Tensile Modulus perpendicular to the plane	ASTM C-297	3.52 GPa	510 ksi
Compressive Strength perpendicular to the plane	ASTM C-365	12.67 MPa	1837ksi
Compressive Modulus perpendicular to the plane	ASTM C-365	3.92 GPa	568 ksi
Shear Strength	ASTM C-273	2.94 MPa	427 psi
Shear Modulus	ASTM C-273	159 MPa	22.8 ksi
Thermal Conductivity @ 24°C(75°F)	ASTM C-177	0.066 W/m.K	0.453 BTU.in/hr.ft².°F

PVC CROSS LINKED FOAM AIREX® C70.75			
Nominal Density	ISO 845	80 kg/m³	5 lb/ft³
Tensile Strength perpendicular to the plane	ISO 527-2	2.0 MPa	290 psi
Tensile Modulus perpendicular to the plane	ISO 527-2	66 MPa	9600 psi
Compressive Strength perpendicular to the plane	ISO 844	1.3MPa	190 psi
Compressive Modulus perpendicular to the plane	DIN 53421	97MPa	14100 psi
Shear Strength	ISO 1922	1.2 MPa	175 psi
Shear Modulus	ASTM C-393	30.0 MPa	4350 psi
Shear elongation at break	ISO 1922	23%	
Thermal Conductivity @ 24°C(75°F)	ISO 8301	0.033 W/m.K	0.23 Btu.in/hr.ft².°F

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Technical Data

Epoxy Matrix

By using epoxy rather than polyester resin as the matrix in DuFLEX, a reduction of laminate thickness is achieved while improving damage tolerance. Epoxy exhibits better moisture and fatigue resistance, and has superior strain capabilities which provides DuFLEX laminates with greater impact resistance than polyester/E-glass laminates that are up to 3 times thicker.

Epoxy's excellent adhesion to balsa and foam cores, fibreglass, aramid and carbon fabrics allows the builder the advantage of selectively integrating these materials into the boat's structure to optimise strength, cost and weight.

Greater stiffness allows wider frame spacing, while further reducing weight and building costs. Total weight savings can reach 50%.

Compared to polyester resins, epoxies have greater strength, less shrinkage, better moisture and fatigue resistance, and there is no chance of osmotic blistering occurring in an epoxy matrix.

Tensile Modulus	3.650 MPa	(0.53E+6psi)
Tensile Strength	83.3 MPa	(12,800psi)
Tensile Elongation	9.8%	
Compressive Strength (yield)	98 MPa	(14,210psi)
Compressive Strength (ultimate)	130 MPa	(18,850psi)
Izod Impact	0.598 ft.lb/in notch	

Skin Mechanical Properties

DuFLEX Panel - Standard DuFLEX skin laminates are constructed using stitched biaxial E-glass manufactured to our exacting specifications. The material provides excellent properties in both warp and fill directions, surpassing American Bureau of Shipping (ABS) requirement for balanced laminates.

Compared to the ABS minimum tensile strength for basic laminate, DuFLEX skin laminates show far superior performance.

ABS Basic Laminate	Tensile Strength	Tensile Modulus
Warp (0°)	124.1 MPa (18,000 psi)	6,890 MPa (1.0E+6 psi)
Fill (90°)	99.28 (14,400 psi)	6,890 MPa (1.0E+6 psi)

DuFLEX Skin Laminate	Tensile Strength ASTM D3039	Tensile Modulus ASTM D3039
Biaxial-Warp(0°)	371.9 MPa (53,900 psi)	21.27 GPa (3.08E+6 psi)
Biaxial-Fill (0°)	327.6 MPa (47,500 psi)	18.22 GPa (2.64E+6 psi)
Laminate thickness	0.53mm per 600gsm (0.021" per 18oz)	
Fibre Fraction	62-64% weight fraction	
Poisson's ratio	0.10	

Compressive values have been extrapolated from sandwich flexural tests (ASTM C-273) conducted at the University of Southampton, UK in which skin bending was negligible.

DuFLEX Skin Laminate	Compressive Strength	Compressive Modulus
Biaxial-Warp (0°)	293.8 MPa (42,600 psi)	21.27 GPa (3.08E+6 psi)
Biaxial-Fill (90°)	255.5 MPa (37,000 psi)	18.22 MPa (2.64E+6 psi)

DuFLEX Skin Laminate	Increase Over ABS
Biaxial-Warp (0°) Tensile Strength	+300%
Biaxial-Fill (90°) Tensile Strength	+330%

DuFLEX Strip - A stitched uni-directional is used as the backbone to the DuFLEX strip system. The ability to place a large percentage of the reinforcement mass during planking has obvious benefits.

Laminate Type	Tensile Strength ASTM D3039	Tensile Modulus ASTM D3039
Unidirectional@(0°)	585.6 MPa (84,900 psi)	34.73 GPa (5.04E+6 psi)
Unidirectional@(90°)	23.00 MPa (3,330 psi)	8.295 GPa (1.20E+6 psi)
Laminate thickness	0.88mm per 800gsm (0.035" per 23.5oz)	
Fibre Fraction	62-64% weight fraction	
Poisson's ratio	0.26	

Z- Joint

To offset their individual size, DuFLEX panels can be supplied with both long edges pre-machined to facilitate joining. This Z-Joint is structurally effective and achieves a smooth and fair surface profile. The Z-Joint must be bonded with a high density epoxy adhesive mixture.

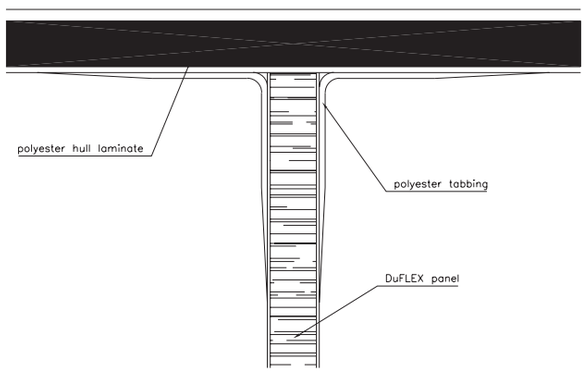
Particularly in strength critical applications the Z-Joint must be given adequate consideration. It can be considered analogous to a weld in aluminium, as a strength reduction exists.

DuFLEX Skin Laminate	Tensile Strength ASTM D3039	Strength Reduction
Biaxial-Warp (0°)	298.6 MPa (43,310 psi)	19.8%
Biaxial-Fill (90°)	262.9 MPa (38,130 psi)	19.8%
Unidirectional-Warp (0°)	488.6 MPa (70,870 psi)	16.6%
Unidirectional-Fill (90°)	23.0 MPa (3,330 psi)	0.00%

No reduction in modulus was recorded, resulting in continuity of panel stiffness and fairness during formation. The majority of marine applications are stiffness critical and therefore a strength reduction in the laminate due to the joints presence is normally of little consequence. A weft unidirectional tape can be used in situations where strength continuity is desired.

Secondary Bonding

The issue of secondary bonding between polyester and epoxy substrates has been an area of concern for some time. Comparative in-house tests have abounded, but without quantative results they can only demonstrate modes of failure and give a 'feel' for the force required at break. ISO 527 was modified to accommodate a tensile double lap joint. Four types of specimen were tested to show that polyester tabbing has the same strength when bonding polyester or epoxy substrates.
(See table below for specifications).



Secondary Bonding Lap Joint Test Results

	Failure Load	Apparent Shear Strength	Failure Mode*
A	42.45 kN (9,540 lbf)	5.66 MPa (820 psi)	Interlaminar Shear**
B	48.47 kN (10,900 lbf)	6.46 Mpa (937 psi)	Interlaminar Shear
C	46.50 kN (10,450 lbf)	6.20 MPa (899 psi)	Interlaminar Shear
D	47.08 kN (10,580 lbf)	6.28 MPa (911 psi)	Interlaminar Shear

* Interlaminar failure occurred with the CSM layer of tabbing laminates ** One specimen showed adhesive failure between the tabbing and substrate.
A - Polyester peel plied substrate, polyester tabbing B - Polyester sanded substrate (80 grit), polyester tabbing
C - Epoxy peel plied substrate, polyester tabbing D - Epoxy sanded substrate (80 grit), polyester tabbing

This data is provided as an aid to materials selection only. No express or implied warranty is made regarding the accuracy of the information contained herein.

Bonding Angle Performance Data

Queensland University of Technology (QUT) Test report CET 4149/3 - Tensile tests to fibreglass connections - fins.
Sample Data: Specimen 1 - polyester bonded : Specimen 2 - epoxy bonded
Test Equipment - Grade A Tinius Olsen Universal Testing Machine, loading rate = 5mm/min

Test	Specimen Thickness 1	2	Nominal Area Resisting Shear (mm^2)	Failure Load (kN)/ Failure Mode	Apparent Shear Strength (MPa)
1	21	21	48,400	77.6 part shear through polyester bond : part tearing	1.60
2	14	21	30,400	68.5kN shear through epoxy bond	2.25

In both circumstances, failure of the joins was through the adhesive rather than the Bonding Angle.

Technology vs Cost - Kits

Whether in computers, airplanes or boats, high tech is often associated with high cost.

Time is valuable and there is no doubt that DuFLEX, especially in kit form, speeds up construction of the basic hull and deck. Hours saved in construction time will go a long way to pay the extra cost of the materials.

With the DuFLEX system, boatbuilders can use widely spaced temporary female frames, or place hull panels over bulkheads which are aligned upside down over strongbacks. Large parts, for example a topside panel, may extend through two or more panels, so the panels are joined before the tabs are cut. Flat surfaces such as floors, walls and bulkheads are used as-cut, and curved surfaces are created by bending the flat panels into the required shape.

A strong, lightweight monocoque structure is achieved after adjacent parts and internal support structures are bonded together. On the hull interior, the joints are epoxy/fibreglass taped at points where differently angled panels meet; typically the keel, gunnels and chines.

The panels are designed to provide a fair surface on the hull exterior, and while the builder may choose to add laminate for aesthetic or other reasons, it's not required structurally.

Computer aided design and manufacture (CAD/CAM) processes combined with computer numeric control (CNC) equipment allows the production of pre-fabricated DuFLEX Kits. The kit form process is practical even for one-off kit sets if the part files are available from a naval architect or designer. Parts to be formed into curved surfaces can be translated by design software into the correct flat panel shapes, and this electronic information is supplied to vdL's engineers, by your Naval Architect or designer. All parts required for the project are nested together within the panels to reduce wastage.

Once the panels are manufactured, the CAD information is used by a CNC router to machine the programmed shapes into the panels.

The DuFLEX Kit-Building system minimises structural weight, material waste, labour & tooling costs, maximises mechanical properties, tightens design allowables, improves product quality, simplifies quotations, & reduces VOC emissions.

The panels are sequentially numbered to indicate the correct joining sequence, and a nesting diagram, showing part numbers and descriptions is supplied for easy identification.

Each pre-cut part is left attached to the panel by small tabs to ensure the kit arrives with all components securely in place. The tabs are easily cut away, when the panels have been joined.

Custom kits can be engineered to meet the rules of all major regulatory authorities including Lloyd's Register of Shipping, American Bureau of Shipping, Det Norske Veritas, Germanishcer Lloyd and Australian Standard AS4132.

DuFLEX Strips

Compound surfaces are also common in boats, for example sail boat hulls and the flared topsides in sport fishing boats. These surfaces can be made by bending and edge gluing DuFLEX Strips around temporary frames, as with traditional strip planking.

DuFLEX Panels are pre-laminated with unidirectional pre-pregs, in a 1200mm x 2400mm sheet with Z-Joints on both short ends.

The unidirectional fibre allows the planks to conform readily to highly convex or concave contours and can provide up to 50% of the total laminate. The stiffness of the DuFLEX Strips allows them to bend fairly over half the number of the frames required by other strip systems, and increases the stability when turning a boat hull.

The laminating required to complete the structure can be reduced by up to half and any additional layers of reinforcement can be applied after the part shape has been stripped. Tapered-edge triaxial E-glass, laminated to the planking, can often complete the structural requirement without disturbing the near-perfect fairness of the planked surface.

To compliment the DuFLEX® System

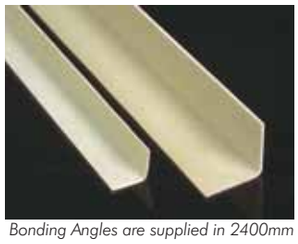
CNC-routed temporary frames

CNC-routed plywood or MDF (medium density fibre-board) temporary frames can also be supplied to provide the builder with accurate sections, cut exactly to drawing specifications.

CNC-routed plywood, or MDF jigs can be supplied by vdL Composites

FRP Bonding Angles

Composite 90° Bonding Angles have been designed to provide a quick and effective means for making right angle joints between DuFLEX panels. These pre-cured angles can be bonded in place with an epoxy paste adhesive, speeding up assembly and reducing wet lay-up. (Non -90° angles would be bonded with conventional wet lay-up tabbing techniques.)



Bonding Angles are supplied in 2400mm lengths

Bonding Angles consist of multiaxial E-glass in a high performance epoxy matrix, peel plied on all surfaces, with the fibre direction tailored for optimum load carrying capability. This combination of resin matrix, fibre content and orientation assures optimum mechanical properties while the use of an epoxy adhesive enhances the bond strength.

Advantages

- No wet lay-up
- Lighter and more consistent than wet lay-up
- Extremely high strength-to-weight ratio
- Faster to install than wet lay-up, especially overhead
- Improved stress transfer between laminates
- Fatigue resistant
- Can be curved for bases of partitions

FRP Bonding Angles

Order Code	Leg Length	Nominal Weight kg/m^2
ANT3042	42mm	0.30
ANT5084	84mm	1.00

Applications -

Marine

DuFLEX panels are suitable for hull shells, decks, super-structures, bulkheads, frames, stringers, partitioning and furniture for one-off construction, prototypes and running plugs. DuFLEX can also be used to extend hulls or modify superstructures of existing boats.

Panels are available in plain sheets, strips or kit forms for:

- recreational and pleasure craft
- cruising and racing yachts
- mega-yachts • high speed ferries
- water taxis • patrol craft

Road Transportation

- truck beds, bodies, side walls • bus floors

Industrial

- holding tanks and lids • staging, walkways, scaffolding
- form work • audio visual equipment containers

Rail Transportation

- flooring • roof/ceiling construction
- cabinetry and interiors • doors

Architectural

- long span roofing • lightweight wall panels

Basic Techniques

Joining the Panels

To streamline the joining process, ATL Composites have developed the proprietary Z-Press. The press applies heat and pressure to cure the epoxy adhesive on the Z-Joints. Joins are fully cured in 7 to 20 minutes, depending on the ambient temperature, type of hardener, core type and thickness of the panel. Checking the "squeeze-out" on the joint until it has become rubbery, will indicate when you can proceed with the next join.

Drums, or a purpose-built receiving stand, should be set up to support the full sized panel being joined. Once joined, the tabs can be cut to remove the full size parts of the DuFLEX kit. Large parts, for example a topside panel, may extend through two or more panels, so the panels should be joined before the tabs are cut.

Applying Adhesive to the Z-Joint

Prior to applying adhesive to the Z-Joint, carefully remove approximately 25mm of peelply from the outside edge of the male scarf, taking care not to damage the laminate. Scarfs should be brushed with a clean brush to remove dust and any contamination that would inhibit adhesion.

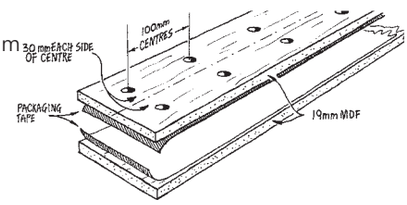
It is important to apply enough high-density adhesive to cover both Z-joints and exposed core, and to allow adequate squeeze out when the joints are pushed together.

The panels should be pushed together by sliding them back and forth to make a tight join of no more than 1mm, prior to applying pressure with the Z-Press or manual joining strips.

Manual Edge Joining Instructions

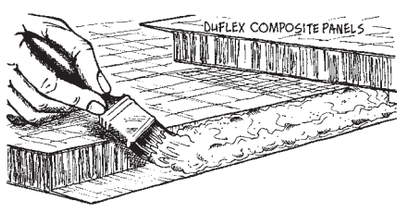
Step1

Take two strips of 100mm wide, 19mm MDF (fibreboard) the length of the long side of the composite panel (2400mm). Cover one side of each strip with plastic tape as shown. Drill pairs of 3mm (approx.) screw holes, 30mm each side of centre, through one strip at 100mm centres.



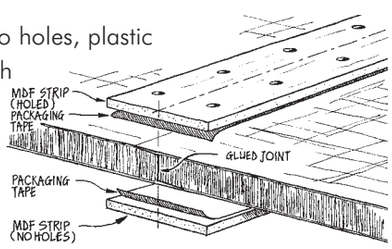
Step2

Apply a high-density epoxy adhesive to both Z-Joints, making sure there is adequate adhesive to cover all core and scarf joint areas, and push joints together with a maximum gap of 1mm.



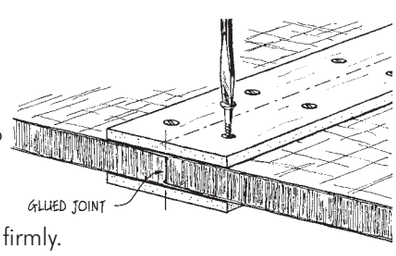
Step 3

Lay the strip with no holes, plastic side up, underneath the glue joint; lay the holed strip, plastic side down, on top of the glue joint.



Step 4

Screw through the holed top strip into the bottom strip, ensuring faces are squeezed together firmly. Leave to cure overnight.



Diamond-coated fibreglass tooling is recommended for best tool life, for example, a jigsaw with a Makita No. 10S Type 150 blade to cut out parts.

Working with Epoxy Resins, Hardeners & Fillers

Most problems related to the proper curing of epoxy can be traced to the wrong ratio of resin and hardener. Accurate measurement and strict adherence to manufacturer's instructions are critical. Essentially, error-free epoxy mixing involves three separate steps:

1. Dispense and measure the proportion of resin and hardener into a mixing pot. Begin with a small batch if you are unfamiliar with the pot life or coverage of the epoxy.

2. Stir the two ingredients together thoroughly with a wooden mixing stick (2 minutes is recommended). Scrape the sides and the bottom of the pot as you mix. Use the flat end of the mixing stick to reach the inside corner of the pot.

3. When fillers are required, stir them into the epoxy AFTER the resin and hardener have been thoroughly mixed.

If you are going to be using the mixture out of a roller pan, mix it thoroughly in a mixing pot before transferring it to the roller pan. **DO NOT USE** a power mixer unless you thoroughly scrape the sides and corners of the mixing pot while mixing.

Removing Amine Blush

Amine blush is a by-product of the epoxy curing process that forms as a wax-like film on epoxy surfaces during final cure phase. The blush is water soluble and can easily be removed, but can clog sandpaper and inhibit subsequent bonding if not removed. Wash the surface with clean water and an abrasive pad, such as a Scotchbrite pad. Dry the surface with plain white paper towels to remove dissolved blush before it dries on the surface. After washing with the abrasive pad, the surface should appear dull. Sand any remaining glossy areas with 80 grit sandpaper.

Clean Up

Contain large spills with sand, clay or other inert absorbent material. Use a small scraper to contain small spills and collect as much material as possible. Follow up with absorbent towels.

Clean resin, or mixed epoxy residue with acetone. Follow all safety warnings on solvent containers. Clean hardener residue with warm soapy water.

Do not dispose of resin or hardener in a liquid state. Waste resin and hardener can be mixed and cured, in small quantities, to a non-hazardous inert solid.

Epoxy Safety Tips

Epoxies are relatively benign chemicals. The risk of exposure to resin, hardener and mixed epoxy is greatest when they are liquid and as epoxy cures, the chemical ingredients react to form a non-hazardous solid. As it solidifies, epoxy and its components are less likely to enter the body.

Skin contact is the most common means of exposure to resins and hardeners. Exposure by inhaling vapors is unlikely because epoxy evaporates slowly, however, the risk increases when ventilation is inadequate or when the products are heated. Sanding partially cured epoxy produces airborne dust, which increases your risk to exposure by skin contact, inhaling or ingesting. Do not overlook or underestimate this hazard.

vdL Composites recommends:
WEST SYSTEM® and PRO-SET® epoxy systems

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Fibreglass & Fibreglass Taping

PRO-SET® high performance laminating epoxies are specified for laminating the fiberglass tapes in DuFLEX kit construction, and for additional reinforcements that may be required, such as curved areas of a kit that need to be strip-planked and fibreglassed on each side, or for extra reinforcing in specific areas.

Temperature and humidity levels should also be considered before you begin the laminating job.

• When the temperature is low, epoxy becomes thicker and flows less. This makes the epoxy harder to apply. It also increases the possibility of air bubbles becoming trapped in the mixture, which reduces bond strength and moisture barrier effectiveness.

• Epoxy will usually cure without clouding or other moisture-related symptoms with the relative humidity as high as 80%, assuming that there is no other source of moisture contamination. One problem with extremely high humidity is that there is too much moisture in the substrate to obtain a good bond.

Unless the design has been specified to have the core rebated at panel joints, epoxy/fibreglass tapes are applied on the inside and outside of where the DuFLEX panels meet.

Prior to taping, it is important to prep the surface well. Make sure the surfaces are free from contamination and have been sanded well to key the surface for good adhesion.

Use WEST SYSTEM resin/hardener with 403 Microfibres to create a neat cove in the join prior to applying your taping. Ideally the coving and taping should be done wet-on-wet to save work and time, and to give a nice, neat finish. A 20mm radius is generally sufficient.

Take into consideration the number of layers of tape that need to be applied and stagger the joins to reduce bulky overlaps, and keep the tapes neat and straight. To optimise the strength of these tapes, the fibreglass needs to be oriented in the correct direction over the join. If in doubt, ask your designer or materials supplier.

Spirited 380
Designed by Spirited Designs

Applying the Fibreglass Tapes

1. Unroll the reinforcement and pre-fit it over the joint, cut it so that several excess inches extend beyond the taping surface. After pre-fitting, roll up each segment of reinforcement neatly and set it aside while you cove the joint. Roll a neat coat of resin/hardener onto the surface to be taped.

2. Unroll your tape and position it carefully over the wet epoxy and cove, and in most cases the surface tension will hold it in place. If the area is too vertical, you may want to wait until the epoxy becomes tacky. Work out any wrinkles by lifting the edge of the tape and smoothing from the centre with your gloved hand or a squeegee.

3. Apply a second coat of epoxy with a foam roller to thoroughly wet-out the fabric.

4. Squeegee away any excess epoxy before the first batch begins to gel. Drag the squeegee over the fabric, using even-pressured, overlapping strokes. The object is to remove excess epoxy that could cause the fabric to float off the surface, while avoiding the creation of dry spots caused by squeegeeing too hard.

5. Finally, run a brush down the centre of the cove to make sure you have good adhesion.

Repeat steps 2 thru 5 until you have applied the correct number of tapes to the joint.

If tapes cannot be applied wet-on-wet, it is wise to apply a layer of peel-ply tape to the last layer to avoid having to prep and sand the surface prior to applying the next layer of tape the following day.

Fairing

A mixture of WEST SYSTEM resin / hardener and 410 Microlight fairing compound is best for minimum weight and ease of sanding. Because the panels are inherently smooth, fairing should be minimal.

If the boat is to be painted a dark colour, 407 Microballoons is the recommended fairing filler.

There are several methods of fairing, but one that vdL recommends, is to take temporary battens of thin plywood or laminex, about 25mm wide, and tack them at even, comfortable spacings around the hull. The battens should be covered in plastic packaging tape to avoid inadvertent bonding.

Screed fairing compound in between the battens with a trowel, then take a 5mm * aluminium batten 50mm wide, the length of the space + the vertical batten width, with a fine edge on one side, press firmly on the battens and drag the horizontal batten down the side of the hull. This takes off the high spots and levels the panel to the height of the temporary battens.

** Curved areas will require a more flexible batten, similar to the ones taped on the hull.*

Remove the temporary battens and allow the compound to cure. Sand the batten space to a bevel edge and fill that space with compound to the same level as the main hull. Let it cure - nice and smooth, and then do your final fairing.

Alternately, you can use the fibreglass tapes on the panel joints as a guideline to apply the fairing compound, and screed horizontally the full length of the boat in two applications. Allow to cure and do initial fairing. Follow with another full length run to cover the join. Allow to cure and then sand. Apply a final vertical screed to make sure all low spots are filled, prior to final fairing.

In all cases, the key is to screed carefully in the beginning to avoid extra work.

Once you have the hull faired, you will need to apply 2 coats of neat WEST SYSTEM resin/hardener above the waterline and 4 coats below the waterline, to seal the fairing compound prior to applying primer/undercoat.

Spirited 380
Designed by Spirited Designs

Interior Bulkheads & Furniture

Structural bulkheads will need to be coved with a high density mixture of WEST SYSTEM brand resin/hardener and 403 Microfibres, and fibreglass taped into position. Non-structural bulkheads and interior furniture with no loading may be coved with a low density mixture of WEST SYSTEM brand resin/hardener and 409 Microsphere Blend and taped into position.

It will be much easier to make modules on your workbench rather than inside the boat. Once the parts have been released from DuFLEX panels, they should be joined, coved, and glassed in the usual manner. Edge detailing of the panels will be a new task.

Edge detailing is the removal of the core on exposed edges of the parts and replacing it with a low density epoxy compound of WEST SYSTEM resin/ hardener and 409 Microsphere Blend.

Once the modular part is assembled, it should be dry-fitted to check the positioning and shape. Remove to the workbench to cove and tape the joins, and coat the surfaces. Once the joints have cured the part can then be permanently fitted in the boat.

For large curved pieces of furniture, such as cockpit or saloon seating, the DuFLEX panels can be kerffed to achieve the required shape. To make each of the radiused corners, run a portable circular saw against a plywood straightedge, through the core to the inside of the outside laminate. The kerfs vary depending on the desired bend, so it is a good idea to draw the shape on the floor of the area it will be positioned and make a temporary jig of the curve required. To determine the distance between the cuts - look for the flat spots in the curve on the floor and measure.

A mixture of WEST SYSTEM resin/hardener and 403 Microfibres should be spread into the open cuts: the panel is then bent over a temporary jig of its final shape and temporarily clamped until the epoxy cures. Fill the internal angle, with a 20mm radius of modified epoxy and allow to cure. Apply an additional layer of fibreglass cloth to the inside of the angle, overlapping the fillet by 25mm on each side.

46 VEG
Designed by Judel Vrolijk Yacht Design
Built by Yachtwerft Heiligenhafen Germany

Planning for high-stress deck hardware

With DuFLEX panels it is advisable to remove the balsa or foam core and replace with solid timber, or high density foam inserts, in preparation for deck hardware bonding, fitting rudder tubes and windows. This distributes high, single-point loads over a larger area. The core should be routed out without damaging the inside laminate and the ply should be bonded in place and laminated with the same thickness and weight as the original panel, and faired in.

When holes are drilled in the timber core for bolts or screws they should be overdrilled and filled with epoxy and redrilled for the fastener after the resin has cured. This allows the epoxy to seal and protect the core exposed by the fastener hole. Fasteners should always be coated in resin before fitting.

Additional information on hardware bonding is available from vdL Composites.

Deck hatches

Make a pattern from the cut out information supplied by the hatch manufacturer, and cut the shape in the DuFLEX panel. Rout out the core and back fill the edges in the usual manner. Mark the location of the fasteners and then position the hatch. Silicone the edges to seal against water ingress.

For flat parts that need to be fitted to curved surfaces, such as hatches to the side of hulls, you will need to make a pattern, draw it onto the hull and cut the inside shape out. Make up a temporary jig and clamp over the hole on the outside. Backfill with a mixture of WEST SYSTEM resin/hardener and 409 Microsphere Blend to make it fit flush. Fair and mold in prior to attaching the part.

Final exterior finish

Final finishing is important for cosmetic reasons and to protect the epoxy from ultraviolet light.

1. Allow the final sealing coat of epoxy on the fairing compound to cure thoroughly.

2. Wash the surface with a Scotchbrite pad and water to remove amine blush.

3. Sand to a smooth finish. The amount of sanding required will depend on how smoothly you applied the final epoxy coatings and which finishing system you choose.

If there are runs or sags in the epoxy coating, begin sanding with 80 grit paper to remove the highest areas. Sand until the surface feels and looks fair; then switch to 120 grit wet or dry paper. After all the scratches from 80 grit paper are removed, switch to 220 grit paper, then on to the finest grit that meets your needs. If a primer is used, 80 grit is usually sufficient. After you are satisfied with the texture and fairness of the surface, rinse the surface with fresh water and dry it with clean paper towels. Proceed with your final coating operation, following the specific instructions of your paint or coating system supplier.

Photograph supplied by Yachting Developments NZ

Quintessential 30.49m
Designed by Allan Warwick Yacht Design
Built by Yachting Developments NZ

For the Amateur Builder

Planning the Shop

Spend as much time planning your workshop as you do every other aspect of the boat. After all, you will be spending a large part of your time working there. Working in a cramped shop or one with bad lighting turns, what should be pleasurable hours, into pure torture. Even small things like the placement of electrical outlets can become major frustrations. Like everything in boatbuilding, careful preparation pays dividends.

Even in the sunny tropics, a DuFLEX boat must be built under shelter and kept dry and clean. Peel ply should be left on the panels as long as possible to reduce the risk of surface contamination. From a practical standpoint, the best way to build your boat is inside a conventional building with a roof, side walls and a solid floor.

The first consideration in choosing a building shed should be, 'How am I going to get the boat out of here?' If the doorway is not wide enough to just pull the boat out, you may be able to tilt it on its side to take advantage of the diagonal of the door, which is longer than its height or width. The other option is to remove the door/wall completely to provide the necessary exit.

Build your boat so that either the bow or stern is pointed straight at the opening to the outside world. This makes things a lot easier on moving, or turning, day. Outside, there must be enough driveway space for the boat hauler's truck to pick-up the completed vessel. Extra out-door space will be necessary if cranes are needed to turn the boat over or to hoist it onto the truck.

Working space inside the shop is the next major consideration. The building should be high, as you will not only need clearance for the boat, but also to allow you to stand and work on the cabin top and roof. It will also keep the factory cooler and allows for storage space underneath the boat if the shed is narrow. A wide shed will give you space so that the boat can be walked around and accessed from all sides, and helps to keep parts and equipment away from the main structure.
Searching for a factory to rent is the most realistic solution for the majority of amateur builders, but temporary shelters are another option. Environmental variables need to be considered when building in partially enclosed shelters, as extremely low or high temperatures, and high humidity will affect the working characteristics of epoxy resin and hardeners and the long term performance of the products.

Work Stations

Separate, free-standing work stations, for each worker, should be set up around the perimeter of the boat. You should be able to walk completely around the workstation, so they should be positioned away from walls or corners.

A sheet of 1200mm x 2400mm 17mm ply wood sitting on 2 x empty 200 ltr drums, with a frame to stop it from sliding, makes an excellent work bench. It provides a good working height, is easily moved around the workshop, and is a versatile space for large or small modular construction.

Build a separate workbench for the epoxy resin, hardener and powder modifiers. Mixing epoxy can be a bit messy, so it pays to separate this operation from the rest of the shop. The resin pumps should be at a comfortable height and have a drip pan. Be sure there is an adequate supply of mixing containers, mixing sticks, and gloves stored on, or near, the bench for easy access.

Power, Light & Ventilation

For efficiency, it is best to position the workstations close to power outlets, and for each station to have a portable power-board and a set of 2 power leads. A short lead for power tool operation at the bench and a long lead that will allow access to any location on the boat. Extra power-boards should be on hand so they can be taken to different locations on the boat.

A well-lit factory will also make working on your boat more efficient and pleasant. Most rental factories will have adequate overhead lighting, and portable fluorescent lights provide shadow-less light for working inside the boat without generating too much heat.

Ventilation is also important even when working with chemicals as benign as epoxy resins. While the bulk of the air in the shop is fresh, the same can't be said for the deep recesses of the hulls. Portable fans should be included in your tool kit.

The Tool Kit - General Hand Tools

- Screwdrivers - both straight and Phillips in a variety of sizes
- Hammers - a standard carpenters claw hammer is always handy. Other handy hammers includes one with soft rubber head and a dead blow mallet
- Pliers - include a pair of standard 200mm slip-joint pliers. Diagonal cutters and needlenose pliers will come in handy if you decide to install your electrical wiring
- Wrenches - full sets of socket and combination wrenches are indispensable when installing an engines and associated gear
- Knives - a couple of different types of knives. The standard shop utility knife with replaceable blades does most of the work, but a pocketknife and a single edge razor blade scraper are also needed
- Hand saws, planes, chisels and rasps & wood files, and tape measures

Power Tools

- Pistol drills • Sanders
- Router with tungsten bits
- Circular saw - with a diamond tipped blade for cutting through the DuFLEX laminate
- Power plane • Sander/polisher
- 4" grinder • Jigsaw • Power drill

Composite Tools

Diamond-coated fibreglass tooling is recommended for best tool life, for example, a jigsaw with a Makita No. 10S Type 150 blade to cut out parts.

Cutting glass cloth requires sharp tools, and a large, good quality pair of scissors will make life easier. Battery operated fibreglass shears are available.

Epoxy Application:

- WEST SYSTEM 800 Foam roller covers
- roller frames • plastic roller trays
- metal laminate rollers • rubber squeegees
- disposable brushes • plastic mixing containers
- mixing sticks • disposable gloves
- scotch-brite scouring pads

Other Useful Items

- Coving knives can be made up by machining 25mm paint scrapers to 20mm wide radiused ends.
- Step ladders and simple scaffolding to put beside the boat to access higher areas of hulls for strip planking in curved areas, positioning of panel parts and fairing
- An industrial wet & dry vacuum cleaner is a handy addition to keep your work space clean & tidy, especially if it can be attached to your tools to act as a dust extraction device
- Heavy duty gardening gloves will prevent injury when handling fibreglassed parts, as the fibreglass edges can be quite sharp.

Barefoot 40
Designed by Grainger Designs

Storage

DuFLEX panels should be stored flat, out of direct sunlight, and kept dry and clean.

Safety

Avoid inhalation and eye contact with machining dust. Wear protective equipment such as hearing protection and safety glasses during cutting operations, and gloves to avoid cuts. Use guards as per machinery manufacturers instructions.

vdL Composites
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