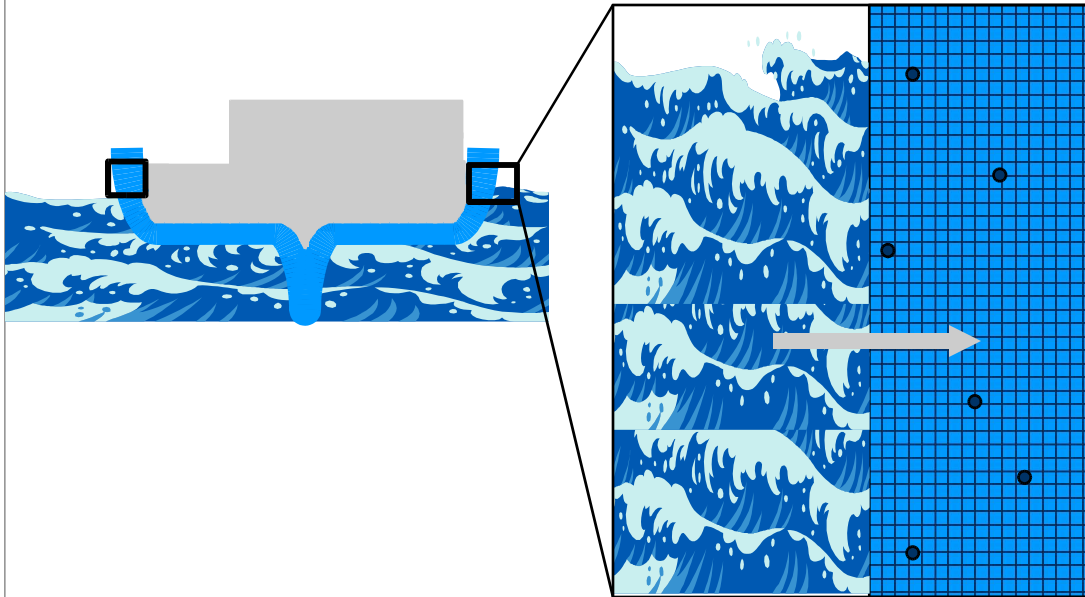


Blistering of FRP boat hull due to osmosis

Marine Application - Osmosis

Osmosis phenomenon starts with water diffusion into FRP

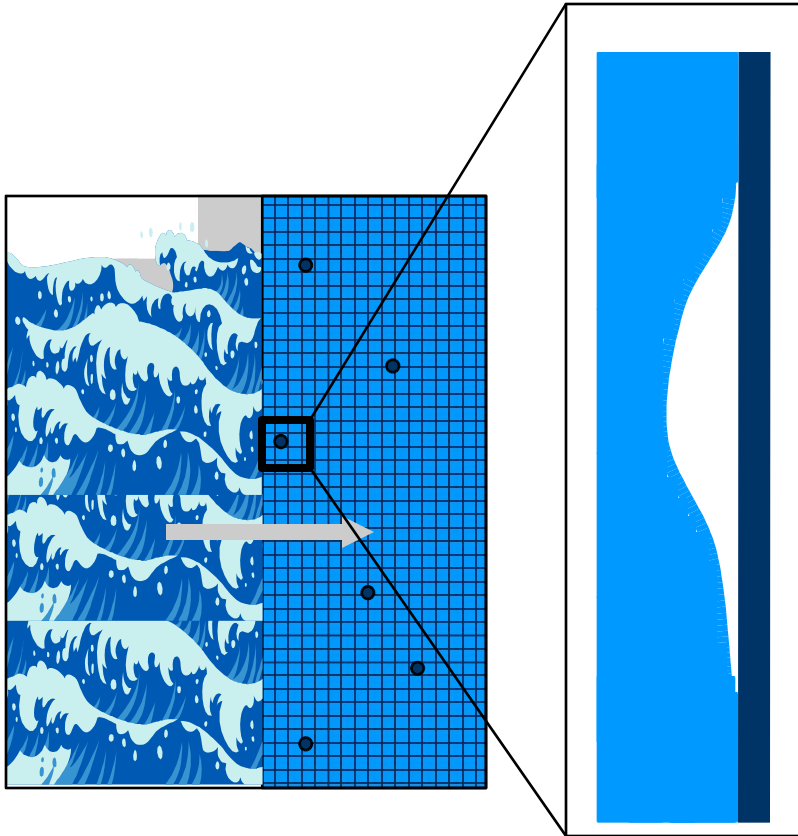


Polarity matrix

Amount and type of ester linkages

Tg of cured matrix (cross link density)

Marine Application - Osmosis



Diffusion

Water will fill voids in FRP and low molecular weight materials will dissolved in water phase

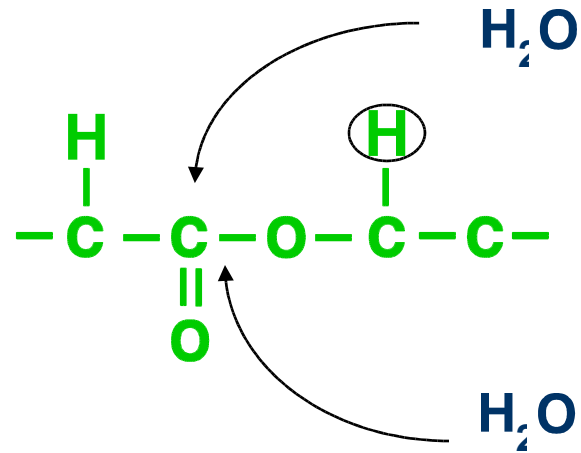
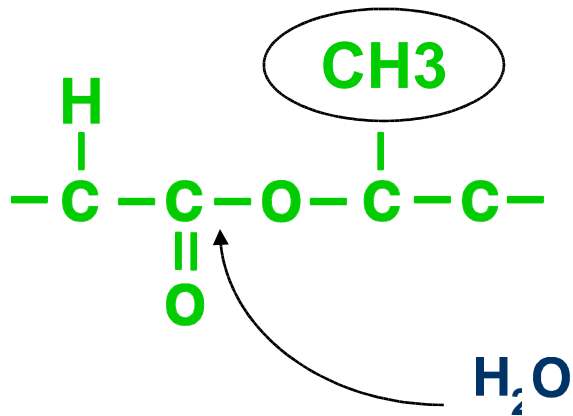
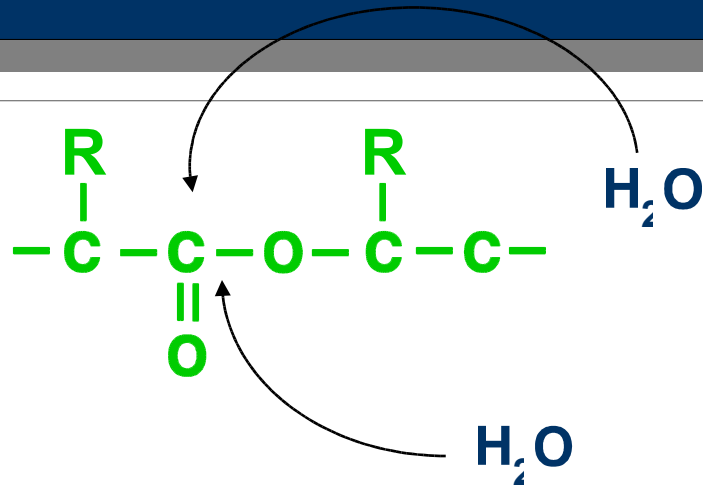
Osmosis

Due to difference in concentration in water of soluble materials, extra water will move from outside to the void resulting in build up of osmotic pressure.

Flexibility

When osmotic pressure exceeds flexibility properties of resin matrix a crack is initiated and blister will start to grow.

Marine market - Hydrolysis resistance - the Ester Linkage



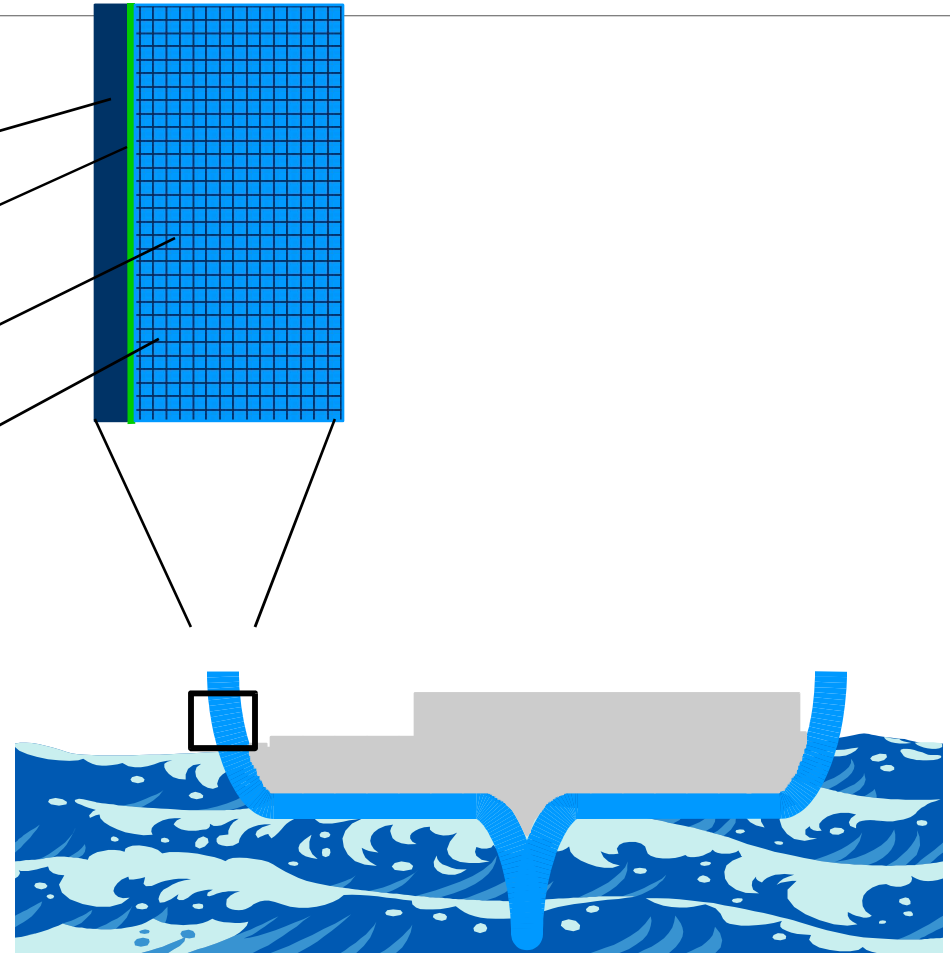
DSM Composite Resins

Unlimited. **DSM**

Marine Application – How to prevent blistering

- Parameters osmosis

- Gelcoat
- tiecoat
- Resin matrix
- Glass fibres
- Cure system
- Cure temperature
- Processing



Gel coat

- Good hydrolysis resistance:
 - VE > ISO/NPG > ISO/PG > ISO/Standard glycols > OPA/Standard glycols
- No / low fillers / type of fillers
- Special types of pigments:
 - No influence of hydrolysis resin matrix
 - No influence on cure
 - Only based on unsaturated polyester paste resins
- **Processing**
 - layer thickness between 0.4 - 0.75 mm
 - Gelttime on mould \pm 20 minutes
 - Void free
 - Prevent styrene inhibition (ventilate!)

Marine Application – gelcoat range

DSM Gelcoat range for Marine

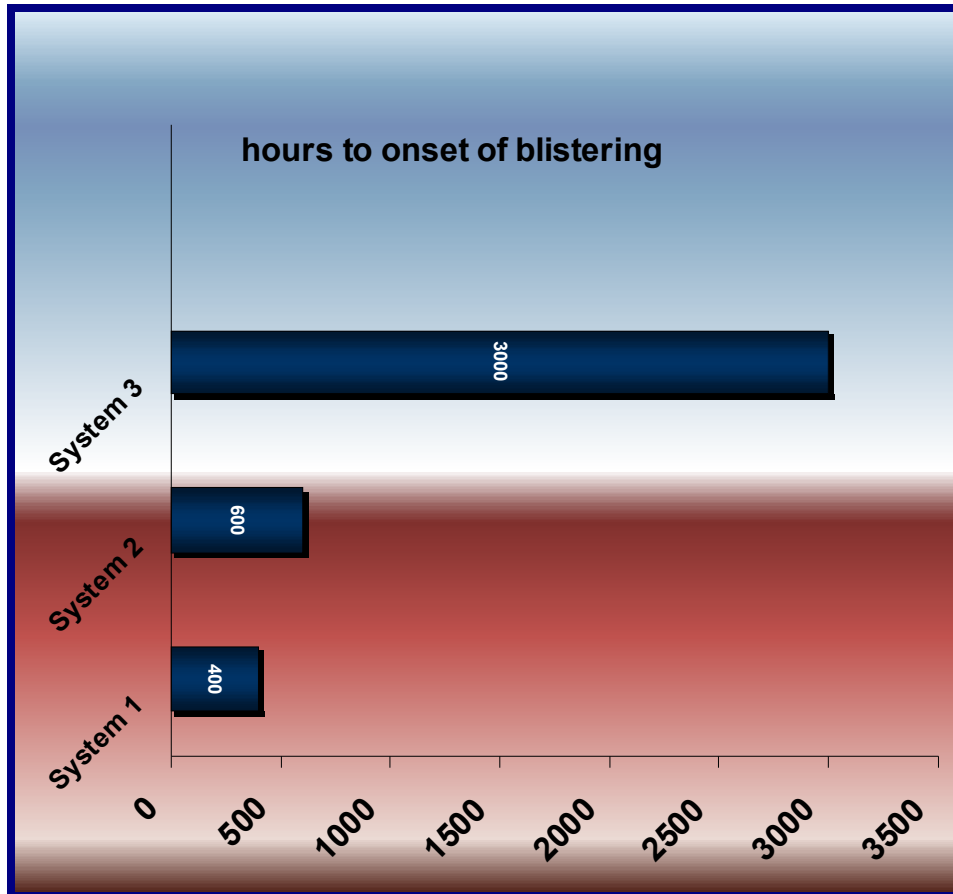
	Resin type	processing	colour	application
Neogel NPG 8373	ISO-NPG	Spray	unlimited	Boat, swimming pools
Neogel NPG 8375	ISO-NPG	Brush / roller	unlimited	Boat, swimming pools
Neogel ECO NPG 9373	ISO-NPG low VOC	Spray	Light colours	Low emission for marine
Neogel ECO NPG 9375	ISO-NPG Low VOC	Brush / roller	Light colours	Low emission for marine

Tiecoat

- **Additional resin rich layer, acting as water barrier and adhesion layer between gelcoat and structural layer**
- **Properties**
 - **Glass content: Low**
 - **Fast wetting characteristic**
 - **Low water absorption value**
 - **High mechanical performance**
- **State of the art: Atlac 580 ACT**
 - Vinyl ester urethane resin
 - Maximum water absorption: 0.6%
 - High mechanics
 - Tensile strength: 85 MPa
 - Elongation at break at full post cure: 4.2%

Excellent osmosis and
water resistance

Comparison of resin systems to resist osmotic blistering (time to onset of blistering using accelerated test QCT at 60°C)



System 1:

Iso/npg gelcoat, cured thickness 0.4 mm

Ortho-resin in buffer-laminate 1x450 g/m²

Ortho-resin in structural laminate 2x450 g/ m²

System 2:

Iso/npg gelcoat, cured thickness 0.4 mm

Iso-resin in buffer-laminate 1x450 g/ m²

Ortho-resin in structural laminate 2x450g/ m²

System 3:

Iso/npg gelcoat, cured thickness 0.4 mm

Atlac 580 ACT buffer-laminate 1x450 g/ m²

Ortho-resin structural laminate 2x450g/ m²

DSM tiecoat resins

	STATE OF THE ART Atlac 580 ACT	LOW VOC Version Atlac E-Nova MA6325
	Vinyl ester urethane resin	High solid vinyl ester modified resin
solid content (%)	50 - 52	65 - 67
Water absorption (%) *60 days at 60°C	0.6	1.4
tensile strength (Mpa)	83	70
Elongation at break (%)	4.2	2 - 3

Marine Application - Processing

- **Workshop**

- Temperature > 20°C
- Relative humidity as low as possible (the lower the better)
- Resins, glass, equipment, tools and moulds have to be conditioned to workshop temperature.

- **Moulds/tools**

- Clean and free from dust and condense

- **Lossing agent**

- Wax -> not too thick layers, well polished
 - Polyvinyl alcohol -> well dried
- (in both cases 'when not', agent will dissolve in curing resin matrix, resulting in reduction of properties)

Marine Application – Structural resins for hulls and decks

Resins for Open-mold applications :

hand lay up and spray up represent more than 95% of the volume of resin processed in boat building industry

Resins for Closed-mold applications :

Vacuum injection, Light RTM, RTM represent less than 5% of the volume of resin processed in boat building industry.

➤ Both technologies have their own advantages and limits and consequently require different products and know-how.

Ortho resins

Synolite 0188 series

- Thixo and preaccelerated
- Colour change indicator
- Low exotherme
- Good workability
- Structural parts of boats

Synolite 1408 series

- Thixo and preaccelerated
- Promoted
- Colour change indicator
- Low exotherme
- Good workability
- LSE

ISO resins

Synolite 0280 and 0288 series

- Thixo and preaccelerated.
- Low exotherm.
- Good workability.
- Structural parts of boats.

DCPD resins

- Low styrene content (36% for 44% in ortho resins)
- Low viscosity → low fibre print through
- Low styrene emission in dynamic phase

8388 series






- Thixo and preaccelerated
- Colour change indicator
- Low to medium exotherm
- Good workability
- L.S.E available
- Structural parts of boats

HLU / SU applications

Resin	type	Thix	Peak exo	Approval	Colour Change indicator
0188	Ortho	Yes	Low (110)	Lloyds, Rina, DNV	Yes
1408	Ortho	Yes	Low (80)	DNV	Yes
8388	DCPD	yes	Medium (130)	Lloyds, Rina	Yes
0280	Iso	yes	Medium (150)	Rina, DNV	No
0288	Iso	yes	Low (100)	Lloyds, Rina, DNV	Yes






HLU / SU - System Silver

- *Laminate built up for workboats, RIBs, small standard crafts:*
 - Iso gel coat (500 micron)
 - structural layer: Ortho or ISO or Synolite 1573-I-1 or Synolite 1573-P-1

ECONOMY	
PRODUCTIVITY	
WEATHERING	
BLISTER RESISTANCE	
PRINT THROUGH	






HLU / SU - System Gold

- *Laminate built up for medium sized, medium value boats with white gel coat:*
 - 500 micron NPG gel coat: Neogel NPG 8373/8375
 - Iso Synolite 0280/288 tiecoat – 2x 300 g/m² p.b. CSM
 - Ortho or Iso for structural layer: Synolite 1408-P-1

ECONOMY	
PRODUCTIVITY	
WEATHERING	
BLISTER RESISTANCE	
PRINT THROUGH	

HLU / SU - System Platinum High surface quality

- *Laminate built up for large, high value boats, coloured or white gelcoat, permanently afloat and/or in hot humid climates:*
 - 500 micron NPG gel coat: Neogel NPG 8373/8375 or Neogel ECO 9373/9375
 - Atlac 580 ACT tiecoat – 2x 300 g/m² p.b. CSM
 - DCPD for structural layer: Synolite 8388-P-1

ECONOMY	
PRODUCTIVITY	
WEATHERING	
BLISTER RESISTANCE	
PRINT THROUGH	

Typical time intervals between layers

- Gel coat – constructive layers: 2-24 hrs
- Gel coat – tie coat: 2-24 hrs
- Gel coat – Barrier (spray) coat: 1-24 hrs

- Tie coat – constructive layers: 16 hrs – 1 week
- Barrier (spray) coat – constructive layers: 16 hrs – 1 week

- In general: Longer time intervals = better surface quality
(However, risk for bad secondary bonding at some surfaces)