



INNOVATIONS FOR LIVING™

COMPOSITE SOLUTIONS BUSINESS

# Closed Mould Processes



# CLOSED MOULD PROCESSES

THE MOST CURRENT CLOSED MOULD PROCESSES ARE:

- Infusion
- RTM (Resin Transfert Moulding)
- RTM-Light

They are called «closed mould» processes, in opposition to Hand Lay-Up and Spray-Up «open mould» processes, because resin is

not in direct contact with the workshop air but is processed only when mould is tightly closed, so that no Volatile Organic Compound or Styrene is released in the air. Wet compression, which is not really a closed mould process, is also taken into account here because it has the same product requirements as RTM, RTM-Light and Infusion.

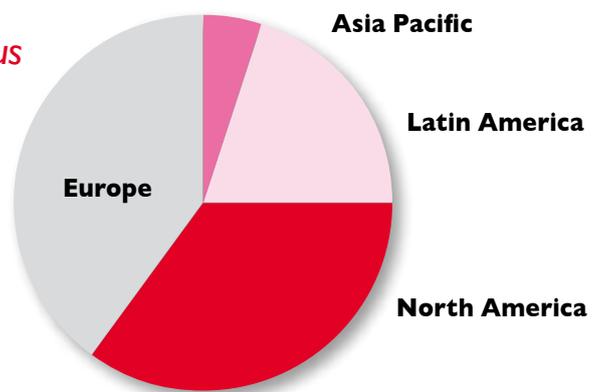
## PROCESS COMPARISON

	INFUSION	WET COMPRESSION	RTM-LIGHT	RTM
SERIES (FOR 1 SHIFT)	1 to 2 parts/day	2 to 8 parts/day	2 to 8 parts/day	4 to 20 parts/day
PART SIZE AND SHAPE	Up to 100m <sup>2</sup> Low to medium complexity	Up to 15m <sup>2</sup> Low to high complexity	Up to 75m <sup>2</sup> Low to high complexity	Up to 15m <sup>2</sup> Low to high complexity
PART SURFACE APPEARANCE	Finish on one side	Finish on both sides	Finish on both sides	Finish on both sides
MOULDS	Lower mould often in composite Upper mould = consumable bag	Composite	Composite	Composite or composite-concrete or metallic
INVESTMENT INDEX	100	150	200	400 to 1000

## END-MARKETS USING CLOSED MOULD PROCESSES

*Closed mould processes are used in various applications such as wind blades, marine, silos and tanks, buses and trucks, leisure, etc.*

Closed mould processes are frequently used in Europe and in North America, mainly limited at some significant players in Latin America and still not so frequently used in Asia Pacific.

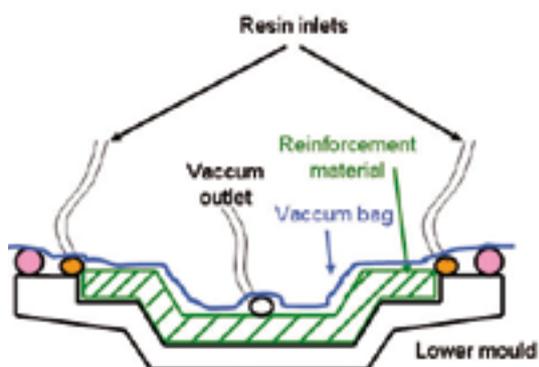


2009 references



# INFUSION

The Infusion process consists in impregnating one or several layers of reinforcement placed in a composite mould and covered by an air tight plastic film used as upper mould. The resin is drawn by vacuum into the reinforcement between mould and film and is not in contact with the air of the workshop (« closed mould » process). Once the resin is cured, the plastic film can be removed and should be thrown away after one use.



Reinforcements used in infusion are mainly Uni-Directional, Multiaxial, Woven Roving and Unifilo® mat but some 3 dimensional complexes can be used as well. A flow media can be laid on the top of reinforcements stack to help the resin to flow on the surface before impregnating layers in depth. For low thickness parts, surfacing flow media might not be necessary when reinforcement's in-plane permeability is high enough. Infusion allows to make very big parts such as boat hulls or windmill blades, with glass content up to 70%.

## OWENS CORNING PRODUCT RANGE FOR INFUSION

ECR20A and ECR70A are two examples of **E-CR glass veils** (20 g/m<sup>2</sup> and 70g/m<sup>2</sup> respectively) that provide a smooth surface on an infused part.

### **Multimat® Lite and Multicore® products:**

are 3-Dimensional complexes made of glass reinforcement layers on both faces and a synthetic core or a glass + PE knitted core. They can be used in infusion when part complexity is high or in areas where a high glass content is not necessary. They are also appropriate for sandwich structures in a version with glass on one side only.

**Unifilo®** U813, U816, U850, U852 chemically bonded continuous filament mats show an outstanding permeability (in the range of 10-9 m<sup>2</sup>). They are used both as a flow media and as a reinforcement material.

**Uniconform®** mat is a soft and binder-free continuous filament mat. When used with a surfacing flow media, it shows a high transversal permeability and can be impregnated through high thicknesses.

### **Combination products can be made of:**

. a **Woven Roving stitched with chopped strands** to address in one single layer a mechanical function (Woven Roving) and a cosmetic function (chopped strands). FlowRo™ is the corresponding brand name available in the US.

. a **Multiaxial stitched with a Unifilo®** mat to address in one single layer a mechanical function and a resin flow function (Unifilo® mat). FlowTex® mat is the corresponding brand name available in the US.

**Uni-Directionals and Multiaxials** allow to reach very high glass contents and orientation controlled mechanical properties. ELT 850, ELTM 600/300, EXB 602, EQX 1168 are examples of 0/90° or Multiaxials possibly with stitched chopped strands.

**Woven Rovings** from 200g/m<sup>2</sup> up to 900g/m<sup>2</sup> allow to reach high glass content and mechanical properties.

# MAKING COMPOSITE MOULDS BY INFUSION

*Composite moulds are generally made by Hand Lay-Up and/or spray of a highly filled resin. Moulds can also be made by infusion to reach high glass content, stiffness, high impact resistance and very good ageing after numerous repeated exothermal peaks.*

**Owens Corning businesses propose the full range of products necessary to build a high quality and robust mould in infusion:**

First layer, starting from the model, can be obtained by Hand Lay-Up of glass veils ECR20 or ECR70 or chopped strand mat M113 100g/m<sup>2</sup> or 200g/m<sup>2</sup> to get an optimal surface appearance of the mould.

Then, all structural layers can be moulded in one shot by infusing, from a surfacing removable flow media, a stack of Uniconform<sup>®</sup> mat and fabrics or multiaxial layers. Uniconform<sup>®</sup> mat allows infusing easily 12 000g/m<sup>2</sup> for example, to get a 17 mm thick laminate of 55% glass ratio. Woven Roving or multiaxials should be used where even higher mechanical properties are necessary.

Multicore<sup>®</sup> or Multiconform<sup>®</sup> products one side may be used in the same infusion step for sandwich areas where foam or plywood stiffeners increase dimensional stability and handling easiness of the mould.



12 layers of Uniconform<sup>®</sup>  
1000g/m mat



Relative resin flow front,  
from a surfacing flow media

## RESIN TRANSFER MOULDING STANDARD AND LIGHT

The Resin Transfer Moulding process consists in injecting a resin into a closed mould where one or several layers of reinforcement have been dressed before mould closing. Resin injection pressure ranges from several bars to several tens of bars and the moulds have to be very stiff to withstand injection pressure with no deformation. They are often made of steel or aluminium but can also be made of concrete resin or composite with an electro-deposited metallic skin. Moulds are temperature controlled so as to accelerate resin curing and to shorten cycle time. A high capacity press may be necessary to open and close the heavy moulds. Injection is generally made from one single central point but several well located injection points may be a better option for big parts or complex shapes. Reinforcements need to be very stable and resist "washing effect" due to high injection pressure.



RTM process allows to use filled resin with low shrink additives for an excellent surface appearance of the finished part.

### OC<sup>®</sup> PRODUCT RANGE FOR RTM

**Glass veils** ECR20A and ECR70A are two examples of E-CR glass non woven that provide a smooth surface on an infused part. They are 20 g/m<sup>2</sup> and 70g/m<sup>2</sup> respectively (but other surface weights are available) and both have a low solubility binder to prevent fibre washing during infusion.

**Multimat<sup>®</sup>** product is a 3-Dimensional complex with a 100% glass knitted core and chopped strands stitched on both faces. Multimat<sup>®</sup> is a market reference in term of stretchability and mould dressing easiness.

**Unifilo<sup>®</sup>** U813, U816, U850, U852, U614 chemically bonded continuous filament mats show an outstanding permeability (in the range of 10-9 m<sup>2</sup>). They are very often used as a local reinforcement to help the resin to fill in the mould cavity.

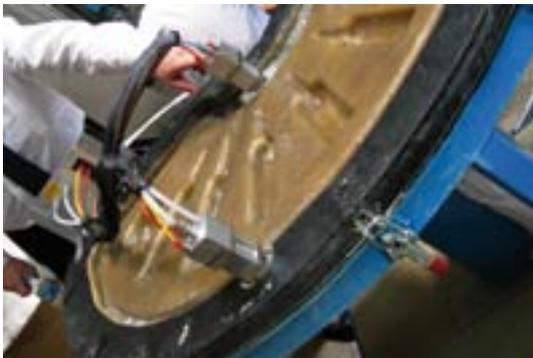
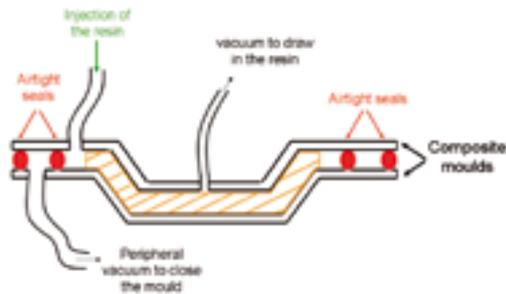
**Unifilo<sup>®</sup>** U720, U740 and U750 mats have a thermoplastic binder that allows hot preforming. Unifilo<sup>®</sup> preforms are very well adapted for high series RTM and can be available with a glass or synthetic surfacing veil for improved surface appearance.

**Uniconform<sup>®</sup>** mat is a soft and binder-free continuous filament mat. Appropriate for low to medium complexity shapes, it allows to reach high glass content (up to 55%). It is soft and shows good surface appearance.

**Woven Roving, Uni-Directionals and Multiaxials** can also be used as local reinforcements or for structural parts.

# RTM LIGHT

The Light Resin Transfer Moulding process consists in injecting a resin into a composite closed mould where one or several layers of reinforcement have been dressed. The closure of the mould can be made mechanically or thanks to vacuum applied between two seals in the mould peripheral flange. Injection pressure is generally lower than three bars and in most cases, resin starts to fill in a peripheral channel before impregnating the reinforcement layers toward one or several vents, sometimes connected to another vacuum port to help the resin flow. In that case, the process is called "vacuum assisted RTM-Light".



RTM-Light can be used to make small composite parts such as boxes, seats and benches, covers, console supports, etc, but allow also to mould wide deck if moulds are well designed.



## OWENS CORNING PRODUCT RANGE FOR RTM LIGHT

**Glass veils** ECR20A and ECR70A of 20 g/m<sup>2</sup> and 70g/m<sup>2</sup> respectively (other weights available) allow an improved surface appearance.

**Multimat®** product is a 100% glass 3-Dimensional complex that may be used for high complexity shapes and high glass content requirements.

**Multimat® Lite** product is a 3-Dimensional complex composed of light knitted core made of glass and Polyethylene filament stitched with chopped strands layers on both faces. Multimat® Lite mat has an impressive stretch ability and capacity to adapt to complex mould but also has an outstanding resistance to compression that allows the resin to flow easily even when composite mould are soft and tend to deflect with vacuum.

**Multicore®** mat is a 3-Dimensional complex with chopped strands outer layer stitched with a non-woven Polypropylene core. It is also available with chopped strand on one side only and is very appropriate in that case for sandwich structures.

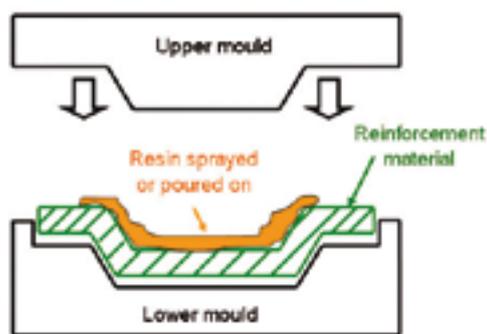
**Uniconform®** mat is a binder free continuous filament mat that suit RTM-Light application for high glass content need in a high permeability version.

**Unifilo®** U720, U740 and U750 mats have a thermoplastic binder that allows hot preforming. Unifilo® preforms are very well adapted for high series RTM and can be available with a glass or synthetic surfacing veil for improved surface appearance.



# WET COMPRESSION OR PRESS MOULDING

*This process consists in placing one or several reinforcement layers into the mould cavity, spraying or pouring resin on and closing the mould by press or by hand with a peripheral vacuum. The pressure applied onto the resin by the mould when closing makes the resin flow and impregnate the reinforcements.*



## OWENS CORNING PRODUCT RANGE FOR WET COMPRESSION

**Glass veils** ECR20A and ECR70A of 20 g/m<sup>2</sup> and 70g/m<sup>2</sup> respectively (other weights available) allow an improved surface appearance.

**Multimat®** product is a 100% glass 3-Dimensional complex that may be used for high complexity shapes and high glass content requirements

**Multimat® Lite** product is a 3-Dimensional complex composed of light knitted core made of glass and Polyethylene filament stitched with chopped strands layers on both faces. Multimat® Lite mat has an impressive stretch ability and capacity to adapt to complex moulds.

**Multicore®** mat is a 3-Dimensional complex with chopped strands outer layer stitched with a non-woven Polypropylene core. It is also available with chopped strands on one side only and is very appropriate in that case for sandwich structures.

**Uniconform®** mat is a binder-free continuous filament mat that shows a very high transversal permeability in wet compression process. It can be compressed to reach high glass content but keeps a nice surface finish thanks to high solubility sizing.

# FIRE RESISTANT APPLICATIONS

OC businesses have a unique range of closed mould reinforcements made of glass fibres only, with no synthetic cores, that allow to reach high fire resistance level when used with an appropriate resin. Woven Rovings and Multiaxials are used for high glass content and simple shapes whereas Uniconform® and Multimat® mats are easy to adapt on complex shapes. They have synthetic material ratio lower than 1% by weight (glass fibre sizing and possibly stitching yarns) and provide an optimal behaviour in fire resistance test.



# THE ADVANTAGES OF THE ADVANTEX<sup>®</sup> GLASS

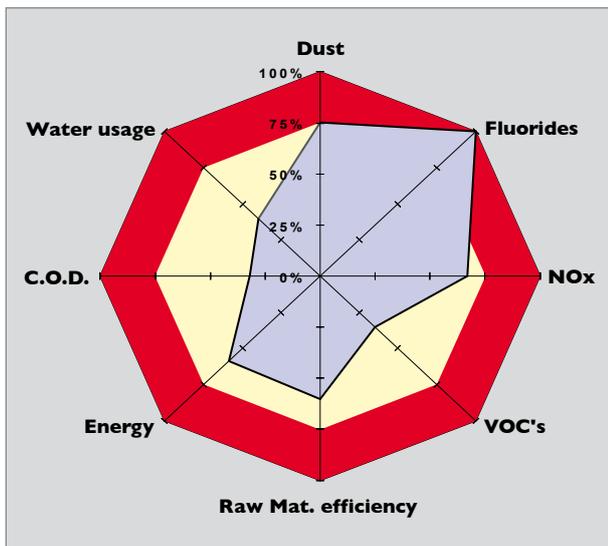
- Advantex<sup>®</sup> glass offers the unique attributes of being both a boron free E-glass and E-CR glass in accordance with ASTM D578 and ISO 2078.
- Performing better than traditional E-glass particularly in acids and water and to a certain extent in alkaline solutions.
- Allowing material savings versus E-glass.
- With a excellent resistance to high temperature (higher softening-point temperature compared to standard E-glass).

## Advantex<sup>®</sup> glass has

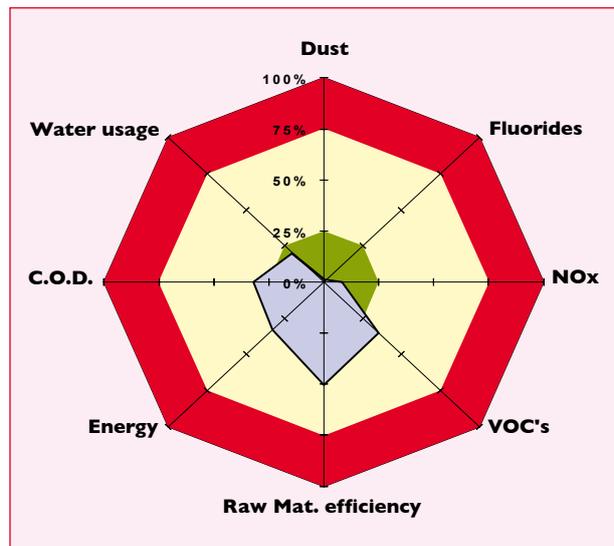
- Up to **54% higher** allowable strain in strain-corrosion testing in H2SO4 vs. E-glass
- Up to **50 Years** life expectancy vs. 3 months using E-glass using FRP pultruded rods under stress-corrosion conditions in salt water
- Up to **50 Years** patented corrosion resistant E-CR glass meeting ASTM D578 and ISO 2078 standards for best glass type used in corrosive environments.

(Comparing to standard E glass: based on Claude Renaud, Owens Corning, 2008, Environmental Benefits of using Advantex<sup>®</sup> Glass Fibers as Reinforcements in Composite Materials, Mark Greenwood, Owens Corning, 2002, Stress Corrosion Lab Testing, NSL Analytical Services Inc, 2012, test report (NSL Lab No: 1216768), Cleveland, Ohio)

Traditional E-glass



Boron and fluorine-free OC<sup>®</sup> Advantex<sup>®</sup> E-CR glass



The Boron and fluorine-free OC<sup>®</sup> Advantex<sup>®</sup> E-CR glass helped Owens Corning improve our own operational performance with energy reductions and reductions of ingredients such as boron and fluorine.

The above comparison data is limited to Owens Corning own production facilities and shows an internal, Owens Corning E-glass to Owens Corning new Advantex<sup>®</sup> process comparison and is not comparing to other's E-glass production. It was typical for Owens Corning plant conversions. Actual results vary from plant to plant.

# OC® PRODUCT RANGE FOR CLOSED MOULD PROCESSES - SUMMARY

PRODUCTS	SURFACE WEIGHT (G/M²)	ROLL WIDTH (CM)	INFUSION	RTM	RTM-LIGHT	WET COMPRESSION	TOOL BUILDING BY INFUSION	FIRE RESISTANT APPLICATIONS
Unifilo® U813, U816, U850, U852, U614	100 to 900	50 to 300	Yes	Local patch	Local patch	For simple shape	Yes	Depending on binder content
Unifilo® U720, U740, U750	300 to 900	50 to 300	/	Preforms	/	/	/	Depending on binder content
Uniconform®	450 to 2400	125 or 250	With surface flow media	Yes	Yes	Yes	With surface flow media	Yes
Multimat®	1100 to 2700	125 or 250	/	Yes	Yes	Yes	/	Yes
Multimat® Lite	735 to 2010	125 or 250	Yes if high glass content not necessary	Yes	Yes	Yes	/	No
Multicore®	480 to 2050	125 or 250	Yes if high glass content not necessary	Yes	Yes	/	One side version for sandwich areas	No
Woven Roving	200 to 900	125 or 250	Yes	Locally	Locally	Locally	Yes	Yes
Combination FlowRo™ - FlowTex™	400 to 1500	125 or 250	Yes	Locally	Locally	Locally	Yes	Yes
Uni-Directionals and Multiaxials	400 to 1600	125 or 250	Yes	Locally	Locally	Locally	Yes	Yes
C- or Advantex® Non-Wovens	20 and 70	5 - 210	Yes	Yes	Yes	Yes	Yes	/

## YOUR GLOBAL PARTNER FOR COMPOSITE SOLUTIONS

- Headquarters in Toledo, Ohio, US
- Operating 30 plants in 15 countries globally
- 6 science and technology centers globally
- Supporting glass fiber innovation and new composite technologies

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