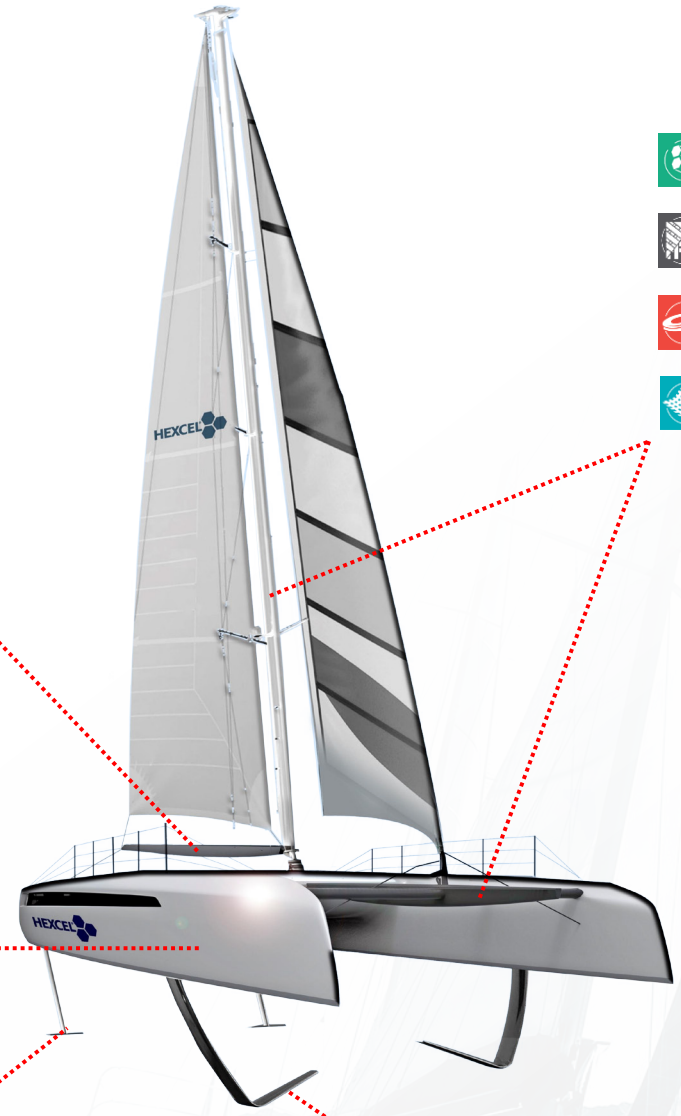
Composite Materials for

High Performance Yachts and Racing Boats

- HexTow® carbon fiber
- HiMax™ multiaxial non-crimp reinforcements
- HexForce® woven reinforcements
- HexBond™ adhesives
- HexPly® prepregs
- HexWeb® honeycombs
- HiTape® reinforcements

HEXCEL®

Composite materials were first used in the marine industry back in the 1970s, when Hexcel supplied glass reinforcements for performance boats, canoes and dinghies. Hexcel now has a comprehensive range of products aimed at racing yacht and luxury boat builders that include America's Cup, IMOCA class and DNV GL-approved prepregs, woven reinforcements and multiaxial fabrics for hull and deck structures, masts and appendages.



MAST & SPAR

HexWeb® Honeycombs

HiMax™ Non-Crimp Fabric
Glass, Carbon, DPA

HexTow® Carbon Fiber
AS4C, AS7,IM2C, IM2A, HM

HexPly®
M79, M49, M9.X Prepregs

BOOM

HexTow® Carbon Fiber
AS4C, AS7,IM2C, IM2A, HM63

HULL & DECK

HexWeb® Honeycombs

HiMax™ Non-Crimp Fabrics
Glass, Carbon, DPA

HexBond™ Adhesives
609, ST1035

PrimeTex® Fabrics

RUDDER

HexTow® Carbon Fiber
AS4C, AS7,IM2C, IM2A, HM63

PrimeTex® Fabrics

FOIL

PrimeTex® Fabrics

HexPly®
M79, M49, M9.X Prepregs

HexTow® Carbon Fiber
AS4C, AS7,IM2C, IM2A, HM63

Specialized Advanced Composite Materials

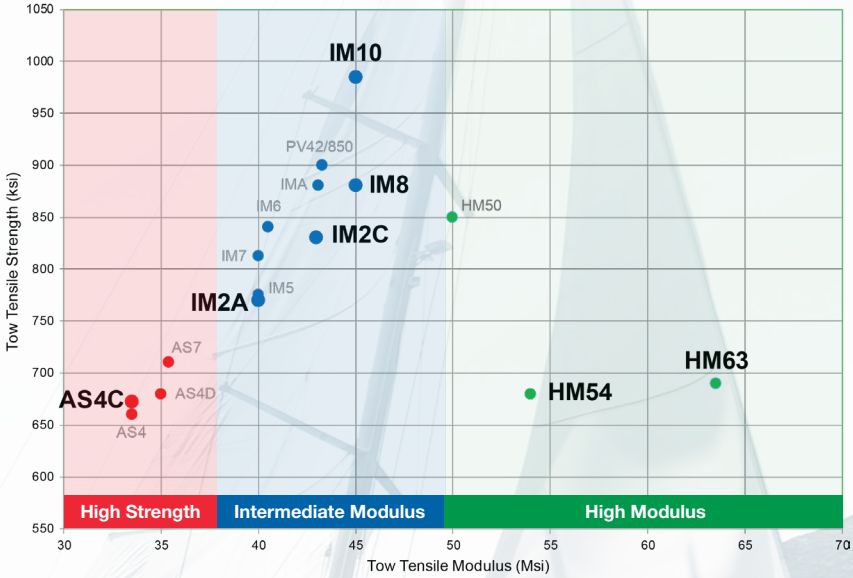
Carbon Fiber Specialists

Hexcel manufactures a full range of high strength, intermediate modulus and high modulus carbon fibers from its own polyacrylonitrile precursor (PAN). Hexcel's HexTow® carbon fibers are used for prepreg and infusion for boat hulls, masts, rudders, rigging and reinforcing sails.

HexTow® intermediate modulus carbon fibers provide high tensile strength and modulus, as well as good shear strength, allowing structural designers to achieve higher safety margins for both stiffness and strength critical applications. HexTow® IM2C is the highest modulus fiber to meet, yet not exceed, the rigorous criteria of Americas Cup regulations. HexTow® IM8 carbon fiber has been selected as the highest performing industrial carbon fiber on the market and will be used by rigging manufacturer Future Fibres to manufacture their AERОrazr solid carbon rigging for all the teams in the 36th America's Cup.

Hexcel also provides a range of high modulus fibers which add an exceptional level of stiffness to marine structures. HexTow® HM63 has the highest tensile strength of any high modulus fiber and provides outstanding translation of fiber properties in a composite, including superior interlaminar shear and compression shear strength.

HexTow® Carbon Fiber Portfolio: Strength vs. Modulus



Typical HexTow® Carbon Fibers for Marine Applications

Fiber Type	Number of Filaments	Tensile Strength		Tensile Modulus*		Strain**	Weight/ Length	Density
		(ksi)	(MPa)	(Msi)	(GPa)	(%)	(g/m)	(g/cm³)
AS4C	3000	685	4723	33.5	231	1.8	0.200	1.78
	6000	670	4619	33.5	231	1.7	0.400	1.78
	12000	660	4550	33.5	231	1.8	0.800	1.78
IM2A	12000	770	5309	40.0	276	1.7	0.446	1.78
IM2C	12000	830	5723	43.0	296	1.8	0.446	1.78
IM8	12000	880	6067	44.3	305	1.8	0.446	1.79
IM10	12000	985	6791	45.0	310	2.0	0.324	1.79
HM54	12000	680	4688	54.0	372	1.2	0.423	1.76
HM63	12000	690	4754	63.5	438	1.0	0.420	1.84

*Refer to specific product data sheets for more details on each product. * Tensile Modulus Calculated as Chord (6000 - 1000) ** Strain at Failure*

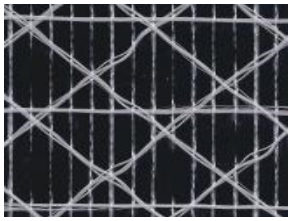
Options in Reinforcements

Multiaxial Reinforcements

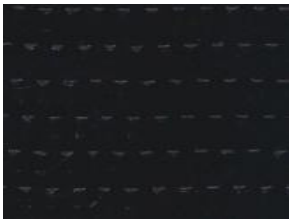
Hexcel is a leading manufacturer of woven, multiaxial and non-crimp fabrics, supplying a wide range of Lloyds Register approved products for boat-building. The HiMax™ range includes ultra-lightweight carbon biaxials, reinforcements with micromesh, woven with enhanced infusion and non-print through as well as carbon unidirectional tapes, solutions for infusion control and non-stitch finish.

Hexcel's HiMax™ DPA (Dot Pattern Adhesive) reinforcements are non-crimp fabrics supplied pre-tacked, allowing multiple fabrics to be laid-up more easily in preparation for resin infusion. Providing an optimal, consistent level of adhesion, they allow a faster and more consistent resin flow, as well as eliminating the use of spray adhesive for a healthier working environment and lower risk of contamination. Simply unrolled and applied to the mold or core layer before the introduction of resin, HiMax™ DPA fabrics are widely used in boat building, where lay-up times can be reduced by up to 50%.

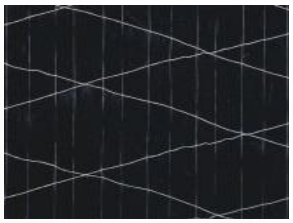
HiMax™ Carbon Fiber UD Variants



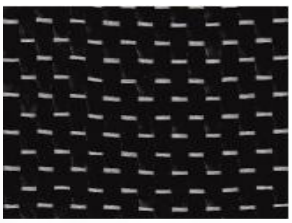
Stitched



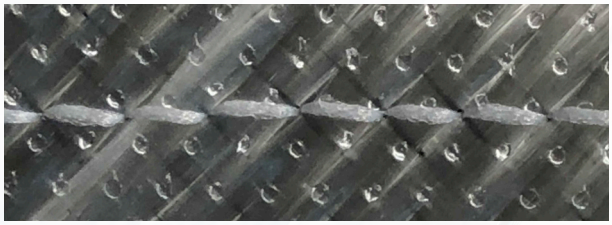
Heat-Set



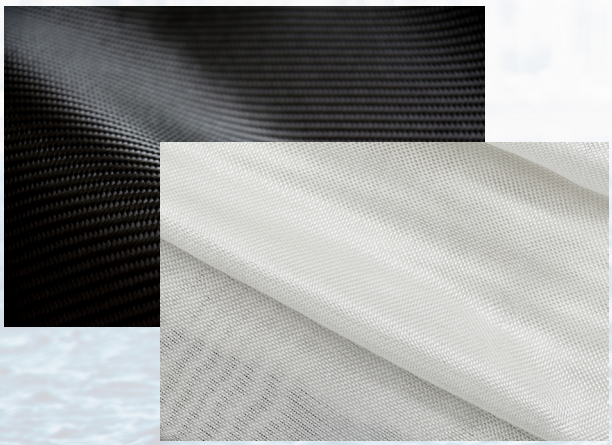
Bonded



Infusion



HiMax™ DPA (Dot Pattern Adhesive)

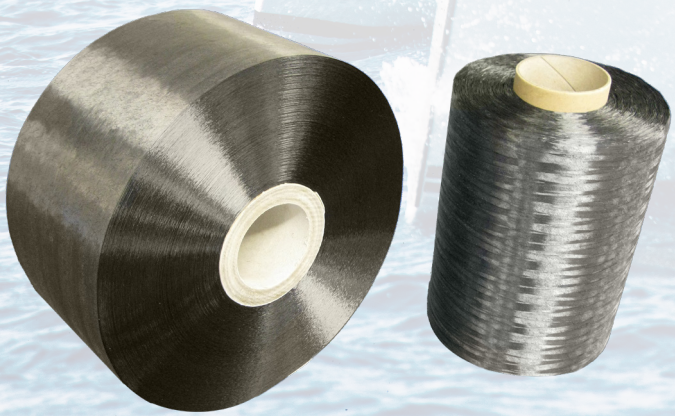


Woven Reinforcements

Hexcel offers the largest range of woven reinforcements in the marine industry enabling marine customers to design high-performance boat structures with a full portfolio of HexForce® carbon and glass woven reinforcements. A wide range of fiber selection, weaving styles and areal weights are available to meet industry requirements for hulls, decks and foils. Hexcel also supplies PrimeTex® carbon reinforcements, processed to provide enhanced aesthetic appearance for high-quality boat parts thanks to smooth and closed weave fabric.

HiTape® Reinforcements

HiTape® innovative high performance dry unidirectional reinforcements allow dry preforms to be manufactured in a fully automated lay-up, similar to the AFP and ATL processes widely used for UD prepregs. The tight width tolerance of HiTape® gives total control of the automated dry preform process – and it is a waste-free operation, even for complex structures, as the materials are placed exactly where required.



HiMax™ multiaxials on the Southern Wind SW105

Southern Wind is the leader in the production of 90-120 footer superyachts and Hexcel has participated in the construction of the SW105 miniseries with three units launched in three years. Southern Wind's SW105 high-performance cruiser has exceptional sea-keeping characteristics. It provides all the comforts of a modern superyacht whilst excelling on coastal or transatlantic racecourses.

Hexcel's HiMax™ multiaxial fabrics were used to create advanced composite sandwich structures that form the hull and deck, with carbon reinforcements used for the inner skin and E-glass and aramid reinforcements used for the outer skin of the hull. The deck is also an advanced composite sandwich structure featuring carbon reinforcements for the inner and outer skins.

Some of the HiMax™ fabrics used in the construction benefited from Hexcel's latest Dot Print Adhesive (DPA) technology. HiMax™ DPA fabrics are supplied pre-tacked, with a controlled amount of adhesive applied by machine in dots across the whole fabric.

Hexcel is proud to support the performance and reliability of these bluewater yachts, renowned for their ability to sail around the world in safety and comfort.

Images courtesy of Southern Wind Shipyard

Leaders In Prepreg Technology

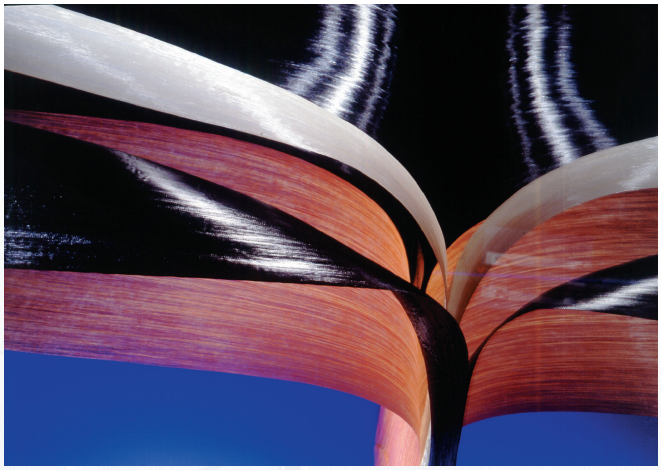
HexPly® Prepregs

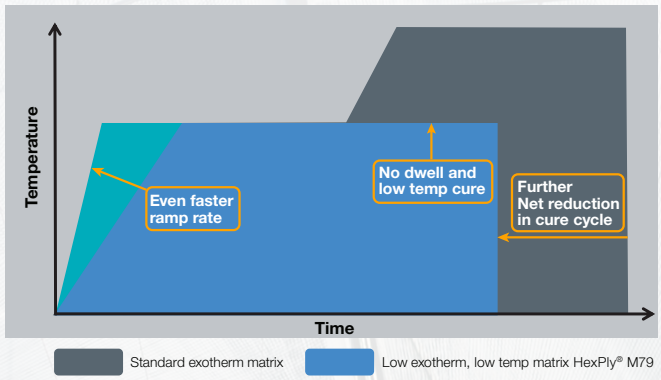
Prepregs are fiber-reinforced resins that cure under heat and pressure to form exceptionally strong yet lightweight components. Hexcel is a world leader in prepreg technology and has developed products to meet the demanding requirements for competition yachts and high performance boats.

HexPly® M79 epoxy prepreg was designed for applications requiring a cure temperature between 70 and 100°C, and can be used in combination with a number of unidirectional fibers and multiaxial fabrics. ***HexPly® M79 prepreg also has low tack.*** It is specifically suited to the manufacture of thick laminate sections and, due to reduced exotherm, the time-consuming dwell period is eliminated. HexPly® M79 prepreg offers significant flexibility in terms of cure cycles, allowing manufacturers to optimize their processes and costs. It was developed to be price competitive compared with other manufacturing techniques, thereby providing customers with a real option for the highest quality technology in a cost-effective package.

HexPly® M9.1 (high tack) and M9.6 (moderate tack) prepregs cure in short cycles at 100°C and provide an excellent balance between ease of processing and high mechanical performance.

HexPly® M37 prepreg provides very high mechanical performance, including high dry and wet T_g, and is designed for racing boat structures.





Prepreg Nomenclature

Non-crimp-fabrics (NCF) or Unidirectional (UD) prepregs

SF-M77 / 38% / UD300 / CHS

Special prepreg abbreviation*
Resin type
Resin content
% in weight
Reinforcement type & FAW
NCF: Longitudinal **(L)**, Biaxial **(BB)**, Transversal **(T)**, Unidirectional **(UD)**
Fiber type
Carbon High Strength **(CHS)**, Glass **(G)**, Aramide **(A)**

SF-M77 / 42% / 200T2 / CHS

Special prepreg abbreviation
Resin type
Resin content
% in weight
FAW & Fabric weave
Plain **(P)**, Twill (e.g. **T2/T4**), Satin (e.g. **H4/H8**)
Fiber type
Carbon High Strength **(CHS)**, Glass **(G)**, Aramide **(A)**

**SF: SuperFit, XF2: Surface technology, Starting with resin type means standard prepreg*

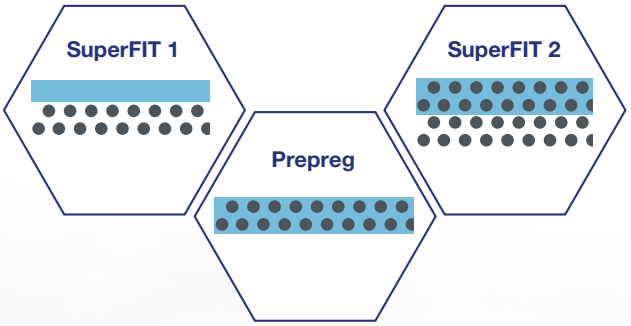
Prepreg Innovations

HexPly® SuperFIT™

HexPly® SuperFIT™ prepregs (or semipregs) are glass and carbon fiber reinforcements that have been partially impregnated with epoxy resin, leaving one tacky face and one dry face. The high resin content of the tacky face provides easy positioning of the materials in the mold and holds the plies together. Meanwhile the dry face facilitates repositioning of plies, especially beneficial in large structures, and facilitates the draining of air or volatiles inside the laminate, thereby minimizing voids. Direct contact with the resin is reduced or eliminated, having a positive impact on health and safety during manufacturing.

SuperFIT™ prepregs are processed by applying heat and vacuum which activates the resin, enabling it to flow and fully infuse the reinforcement. SuperFIT™ prepregs provide a quick and cost-effective way of producing large, thick laminates.

SuperFIT™ is available with glass or carbon reinforcements in various weights, fiber directions and different resin systems. It can be used in conjunction with standard prepregs.

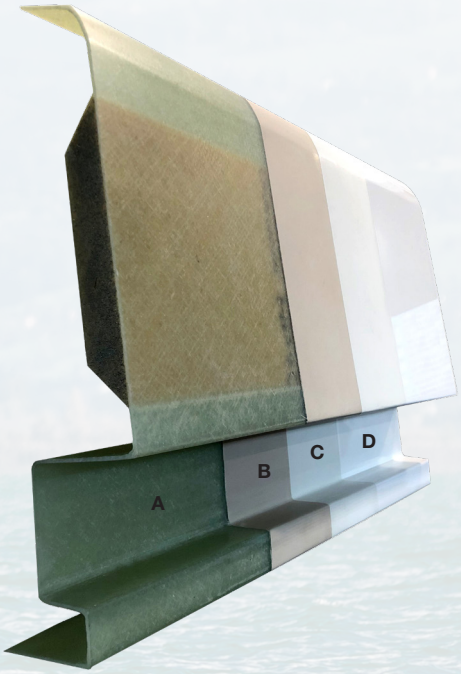


Hexcel's recommended resin for SuperFIT™ prepregs is low temperature curing HexPly® M79. HexPly® M79 SuperFIT™ is ideal for boat builders looking for alternative technologies and new materials in order to reduce the manufacturing cycle time. It is easy to process, can be used in conjunction with conventional prepregs, and is suitable for automated layup processes (requiring no decontamination of equipment).

New HexPly® XF2 Surfacing Prepreg Technology

Another new technology has been developed by Hexcel to help reduce yacht-building cycle times. HexPly® XF2 is a surfacing prepreg that is easy to handle, providing good drapability and tack to adhere to the mold tool, for a highly efficient lay-up process. HexPly® XF2 prepreg also gives an excellent surface finish, with no pin holes or visible overlaps, providing excellent out-of-mold quality that greatly reduces post-processing operations, saving time and labor costs.

HexPly® M79 SuperFIT™ can be used in conjunction with HexPly® XF2 surfacing prepreg for a simplified ply book and lay-up process, with a single layer solution that is low in final solution costs and provides a competitive edge.



Section	Surface finish
A	Out-of-mold surface finish using XF2
B	Paint primer
C	Color paint
D	Clear finish

Specialized Structural Adhesives

Hexcel formulates and manufactures a comprehensive range of structural film adhesives for the marine market. HexBond™ 609 is an elevated temperature curing modified epoxy film adhesive. Curing can be achieved over a range of temperatures from 100°C to 180°C with cure times from 5 to 240 minutes. This high-performance structural adhesive is suitable for bonding a variety of substrates. It is commonly used for the manufacture of strong, lightweight, metal and composite honeycomb sandwich structures. HexBond™ ST1035 is an epoxy film designed for the manufacture of sandwich structures by composite or metallic skins and cores and for bonding a wide range of substrates. The adhesive also offers very flexible processing methods and cure temperatures from 90°C to 160°C as well as good tack for easy adhesive joint assembly.

Product	Applications				Product Performance			Product Performance				Key Features
	Composite		Metal to Metal	Honeycomb	Maximum Service Temperature °C (°F)	Typical Cure Temperature °C (°F)	Cure Time (minutes)	Lap shear at 25°C (77°F) MPa (psi)	Honeycomb Climbing drum peel at 25°C (77°F) (N/76mm)	Flatwise Tensile at 25°C (77°F) MPa (psi)	Tg Dry by DMTA °C (°F)	
	Surfacing	Bonding										
Epoxy Film Adhesive												
HexBond™ 609	-	-	✓	✓	85 (185)	120 (250)	60	33 (4800)	200	7 (1000)	105 (220)	Ideal for industrial bonding applications such as: building panels, rail carriage doors, flooring partitions. Flexible cure cycle from 100 - 150°C (212 - 300°F).
HexBond™ 312	-	✓	✓	✓	100 (212)	120 (250)	30-60	40 (5800)	650	9 (1300)	105 (220)	Short cure cycle: 30 minutes at 120°C (250°F) for faster applications and good composite to composite bonding.
HexBond™ ST1035	-	-	-	✓	100 (212)	120 (250)	60	40 (5775)	400	-	110 (230)	Excellent bonding for industry and leisure sport. Widely use for sandwich panels: foam and honeycomb.
HexBond™ EA9686 STRUCTIL	-	-	-	✓	110 (230)	120 (250)	120	39 (5600)		-	130 (265)	Excellent for structural applications as leading edge bonding. High peel strength with high shear strength.
HexBond™ 319	-	✓	✓	✓	150 (300)	175 (350)	60	36 (5200)	600	9 (1300)	120 (250) 200 (390)	High peel performance for automotive and aerospace (engine nacelles, flaps, aileron bonding) applications.
HexBond™ ST1480	-	-	-	✓	170 (340)	180 (355)	90	28 (4060)		-	195 (385)	Low weight film adhesives used for space applications. Ideal for assembly composite/composite and sandwich composite structure.

For more information

Hexcel is a leading worldwide supplier of composite materials to aerospace and industrial markets. Our comprehensive range includes:

- HexTow® carbon fibers
- HexForce® reinforcements
- HiMax™ multiaxial reinforcements
- HexPly® prepregs
- HexMC®-i molding compounds
- HexFlow® RTM resins
- HexBond™ adhesives
- HexTool® tooling materials
- HexWeb® honeycombs
- Acousti-Cap® sound attenuating honeycomb
- Engineered core
- Engineered products
- Polyspeed® laminates & pultruded profiles
- HexAM™ additive manufacturing

For US quotes, orders and product information call toll-free 1-866-601-5430. For other worldwide sales office telephone numbers and a full address list, please go to visit http://www.hexcel.com/contact.

For any other infomation, please email marine@hexcel.com.