HEXCEL®

HexTow®
Carbon Fiber

HexTow® carbon fiber is the preferred carbon fiber for the world's most advanced aerospace and industrial composite applications

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Carbon Fiber

- Stronger than steel, lighter than aluminum & as stiff as titanium
- High strength
- High strain
- PAN based fiber
- Successive surface treatment to improve bonding
- Sizing to improve handleability

Hexcel is

- The leading manufacturer of carbon fiber with over 45 years of experience and the most qualified positions on aerospace programs.
- Manufacturer of a broad range of high performance carbon fibers for both aerospace and industrial applications.
- The leading carbon fiber supplier to US Military applications.
- Committed to premiere customer service, technical support, and being the leader in providing global innovative carbon fiber material solutions.

Hexcel offers an unmatched breadth and depth of products and services to the composites industry. We manufacture the full spectrum of advanced material solutions including carbon fiber, reinforcement fabrics and pre-impregnated materials as well as honeycomb core, tooling materials and even finished aircraft structures. As a complete composites solutions provider, we are vertically integrated through all phases of our customers' composite needs.

With such an expansive portfolio, Hexcel's product lines are used in a variety of markets which spurs a constant drive for innovation and cost-competitive production. This culture of innovation allows us to embrace the exploration of new ideas, to challenge the impossible and succeed beyond expectations. We have been pioneers at the forefront of the composites industry for over 50 years and will continue to pave the way for the future.

HexTow® carbon fiber

The primary building blocks for carbon fiber composite materials begin with Hexcel's HexTow® carbon fiber which is the preferred carbon fiber for the world's most advanced aerospace and industrial applications.

HexTow® carbon fiber is produced in a continuous operation in which polyacrylonitrile precursor undergoes a series of precisely controlled oxidation and carbonization processes. Exposure to extremely high temperatures chemically changes the precursor which yields high strength-to-weight and high stiffness-to-weight properties. Successive surface treatment and sizing stages improve bonding and handleability.

The resulting carbon fiber is stronger than steel, lighter than aluminum and as stiff as titanium.

HexTow® carbon fiber can be supplied in two forms: continuous fiber and chopped fiber.

HexTow® Carbon Fiber

Continuous fiber can be combined with all thermoset and thermoplastic resin systems. They are used for weaving, braiding, filament winding applications, unidirectional tapes for ATL and AFP processes and prepreg tow for fiber placement.

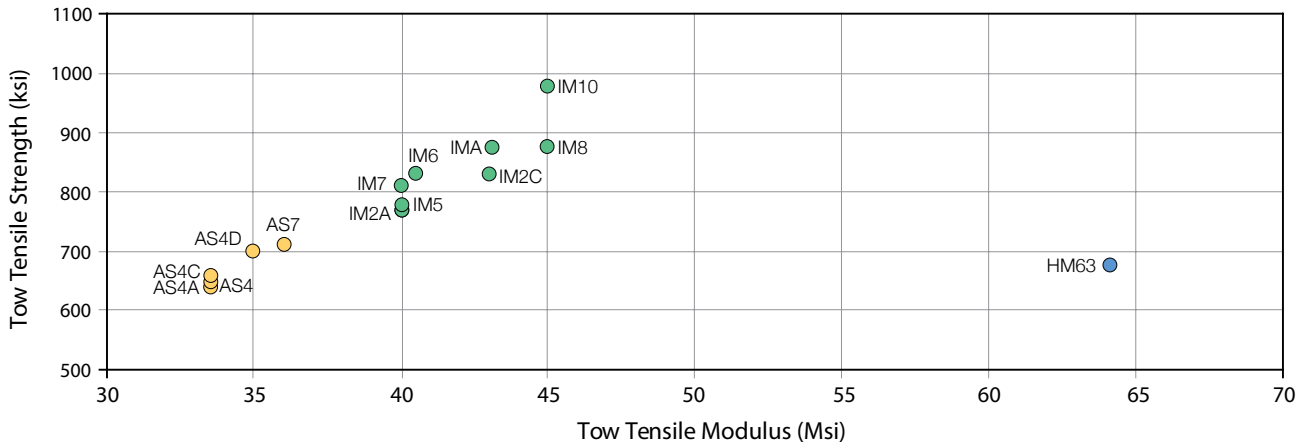
Hexcel's IM fibers have become an industry standard, particularly the HexTow® IM7 carbon fiber, but Hexcel continues to innovate and look for better ways to meet customer needs. Hexcel's HM or high modulus fiber line is the latest development released to the market.

The HexTow® HM63 fiber is ideal for high stiffness and high strength applications such as space, satellite, UAV, commercial aerospace, helicopters as well as premium sports and recreation applications such as Formula 1, marine, bikes, and fishing rods.

Fiber Type	Number of Filaments	Tensile Strength		Tensile Modulus*		Strain**	Weight/ Length	Density	Standard Spool Size
		(ksi)	(MPa)	(Msi)	(GPa)	(%)	(g/m)	(g/cm³)	(lb)
AS4A	12000	640	4413	33.5	231	1.8	0.858	1.79	8
AS4	3000	670	4619	33.5	231	1.8	0.210	1.79	6
	6000	640	4413	33.5	231	1.7	0.427	1.79	4
	12000	640	4413	33.5	231	1.7	0.858	1.79	10
AS4C	3000	675	4654	33.5	231	1.8	0.200	1.78	4
	6000	645	4447	33.5	231	1.7	0.400	1.78	4
	12000	650	4482	33.5	231	1.8	0.800	1.78	8
AS4D	12000	700	4826	35.0	241	1.8	0.765	1.79	8
AS7	12000	710	4895	36.0	248	1.7	0.800	1.79	8
IM5	12000	775	5343	40.5	276	1.8	0.740	1.79	8
IM2A	12000	770	5309	40.0	276	1.7	0.446	1.78	4
IM2C	12000	830	5723	43.0	296	1.8	0.446	1.78	7.5
IM6	12000	830	5723	40.5	279	1.9	0.446	1.76	4
IM7	6000	800	5516	40.0	276	1.9	0.223	1.78	5
	12000	820	5654	40.0	276	1.9	0.446	1.78	4, 8
IMA	12000	880	6067	43.1	297	1.8	0.445	1.79	7.5
IM8	12000	880	6067	45.0	310	1.8	0.446	1.78	4
IM10	12000	980	6757	45.0	310	2.0	0.324	1.79	2
HM63	12000	680	4688	64.0	441	1.0	0.418	1.83	3

** Tensile Modulus Calculated as Chord (6000 - 1000) ** Strain at Failure*

Strength vs. Modulus



HexTow® Carbon Fiber

Typical Epoxy Composite Properties*

Property	Test Method	HM63 12k		IM10 12k		IM7 12k		IM5 12K		AS4 12k	
		US Units	SI Units	US Units	SI Units	US Units	SI Units	US Units	SI Units	US Units	SI Units
0˚ Tensile Strength	ASTM D3039	350-ksi	2413-MPa	480-ksi	3310-MPa	395-ksi	2723-MPa	391-ksi	2696-MPa	320-ksi	2205-MPa
0˚ Tensile Modulus		37.0-Msi	255-GPa	27.5-Msi	190-GPa	23.8-Msi	164-GPa	22.9-Msi	158-GPa	20.5-Msi	141-GPa
0˚ Tensile Strain		1.00%	1.00%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%
0˚ Flexural Strength	ASTM D790			241-ksi	1662-MPa	270-ksi	1862-MPa	200-ksi	1379-MPa	274-ksi	1889-MPa
0˚ Flexural Modulus				23.5-Msi	162-GPa	22.0-Msi	152-GPa	20.1-Msi	139-GPa	18.4-Msi	127-GPa
0˚ Short Beam Shear Strength	ASTM D2344	14.6-ksi	101-MPa	18.1-ksi	125-MPa	18.5-ksi	128-MPa	18.3-ksi	126-MPa	18.5-ksi	128-MPa
0˚ Compressive Strength	ASTM D695 Mod.	190-ksi	1310-MPa	260-ksi	1793-MPa	245-ksi	1689-MPa	269-ksi	1855-MPa	222-ksi	1530-MPa
0˚ Compressive Modulus		32.0-Msi	221-GPa	23.8-Msi	164-GPa	21.7-Msi	150-GPa	19.8-Msi	137-GPa	18.6-Msi	128-GPa
Open Hole Tensile Strength	ASTM D5766	66-ksi	455-MPa	86-ksi	593-MPa	62.1-ksi	428-MPa	61-ksi	421-MPa	63.5-ksi	438-MPa
Open Hole Compressive Strength	ASTM D6484	36-ksi	248-MPa	53-ksi	362-MPa	48.9-ksi	337-MPa	42-ksi	290-MPa	48-ksi	330-MPa
90˚ Tensile Strength	ASTM D3039	6.5-ksi	45-MPa	11.6-ksi	80-MPa	9.3-ksi	64.1-MPa	10.5-ksi	72-MPa	9.3-ksi	64-MPa

** 350˚F Cure (177˚C), Room Temperature, Dry Test Results. Data shown are normalized to 60% Fiber Volume where applicable*

Sizing Available with HexTow® Continuous Carbon Fiber Products

Designation	Size Compatibility*	Recommended Uses	Sizing Level
Unsized	Epoxy, Phenolic, Polycarbonate, Polyurethane, Polyester, Polysulfones, Cyanate Ester, Vinyl Ester, Nylon, BMI, PES, PEEK, PEKK, PES, PVC, Polyimide, Polypropylene	Prepreg Tape	0
G	Epoxy, Phenolic, Polyurethane	Weaving	0.8 - 1.2
		Prepreg Tape	0.2 - 0.4
GP	Epoxy, Phenolic, Vinyl Ester, Polyurethane, Cyanate Ester, BMI	Weaving & Filament Winding	0.8 - 1.2
		Prepreg Tape	0.2 - 0.4
H	Epoxy	Weaving	0.8 - 1.2
R	Epoxy, Polyester	Filament Winding	1.2 - 1.6
GS	Epoxy, Vinyl Ester, Polyurethane	Prepreg Tape	0.3 - 0.7

** Compatibility with these Matrices is considered theoretically compatible. Hexcel cannot guarantee their results.*

Recommended Storage and Shelf Life

The inherent properties of Hexcel's unsized carbon fiber include:

- Tow Tensile Strength
- Tow Tensile Modulus
- Tow Tensile Elongation
- Fiber Density
- Mass per Unit Length (yield)

To enable consumer processing of carbon fiber, proprietary sizing agents are typically applied by Hexcel, such as G, GP, and GS Sizes. It has been found that the original processing characteristics of G Sized carbon fiber will essentially remain constant for at least one year from the date of manufacture while GP and GS Sized carbon fibers will essentially remain constant for at least five years from date of manufacture.

Carbon fiber should be stored indoors, in original containers, under recommended storage conditions of <95°F (35°C) and < 50% RH. Direct exposure to sunlight or excessive moisture should be avoided. Shrink wrap should not be removed until immediately prior to use.

If carbon fiber is stored at high temperatures and/or high humidity conditions, or for time frames in excess of those recommended above, difficulty in processing may result. Therefore, it is strongly recommended that carbon fiber which has stiffened as a result of extended storage should undergo a thorough evaluation of processing characteristics (i.e. resin wet out, spreadability, etc.) relative to the customer's operation before use.

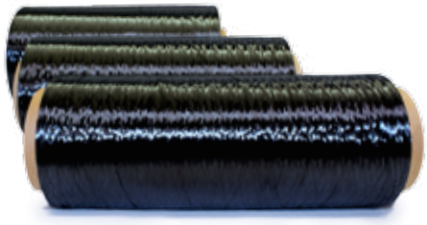
Selecting Carbon Fiber

The appropriate carbon fiber for an application is selected based on a number of criteria.

Does the application require a fully certified, aerospace grade fiber or is an industrial grade fiber the right choice?
Hexcel manufactures fibers that are certified to meet specific aerospace and industrial specifications. Contact a Hexcel representative to find out which particular fiber is suited to your application.

What is the mechanical performance required for the composite product being produced?
Carbon fibers are grouped by their tensile modulus and tensile strength. Standard Modulus is the term given to fibers with a tensile modulus in the 33 Msi to 38 Msi range. Intermediate Modulus fiber (or IM fiber) is in the 40 Msi to 44 Msi range. And High Modulus fiber (HM) are fiber with tensile modulus above 50 Msi. As you can see from our product descriptions, Hexcel has a variety of fiber offerings across each of these ranges.

What tow size or the number of individual filaments in the yarn bundle are required?
Here, the manufacturing process to be used with the fiber usually dictates the tow size preferred. For example, the smaller tows such as 3K (3000 filaments in the bundle) or 6K (6000 filaments) might be used for woven materials or very thin prepreg tapes while the larger tow sizes (12K) are used for tapes, filament winding and heavier stitched and woven products.



What sizing should be applied to the fiber?
The majority of composites are thermoset such as epoxy or BMI and Hexcel's standard sizings such as GP or GS are compatible with those matrix systems. Hexcel also supplies most grades of fiber unsized (no sizing applied at all) which works well in thermoplastic composites. When in doubt, contact your Hexcel representative for further guidance on the most appropriate HexTow® carbon fiber for your application.

Chopped Fiber

Chopped fiber is used in compression and injection molding compounds to produce parts as varied as machine parts, gears and chemical valves. The finished products exhibit high strength and modulus, excellent fatigue and creep resistance, low thermal expansion, electrical and thermal conductivity, excellent friction and wear resistance, and low shrinkage.

HexTow®, PAN based carbon fiber is available in 1/4 inch chopped fiber lengths, sized for compatibility with various resin matrix systems and processes. The chopped product is small, thin, rectangular flake, 1/4 inch long by 1/8 to 1/4 inch wide. The individual filaments are lightly held together by the sizing and will break apart during subsequent processing.

The specially formulated sizing systems, in addition to improving bonding, produce a higher bulk density that aids in blending operations and in the flow through mechanical feed systems.

HexTow® Chopped Carbon Fiber Products

		Chopped Carbon Fiber Type			
Property	Units	1	2	3	4
IM Carbon Fiber	%	100	50 - 100	0 - 100	0
AS Carbon Fiber	%	0	0 - 50	100 - 0	100
Fiber Length*	in	0.25	0.25	0.25	0.25
	mm	6.4	6.4	6.4	6.4
Standard Packaging	lbs	40	40	40	40
	kg	18.1	18.1	18.1	18.1

** Other fiber lengths available on request*

Sizing Available with HexTow® Chopped Carbon Fiber Products

Sizing Type	**Units**	1900	1925	BR102
Sizing Content	wt. %	3 - 7%	3 - 7%	4 - 8%
Size Compatibility**		Polyamide (nylon)	Polyamide (nylon), Polycarbonate, Polyphenylene sulfide, Polyurethane, PEI, Polyester	Polycarbonate, Polysulfone, Epoxy

*** Compatibility with these Matrices are considered theoretically compatible. Hexcel cannot guarantee their results.*

Glossary

AFL
Automated fiber layup

ATL
Automated tape layup

AS
Standard modulus fiber in the 33 Msi to 38 Msi range

Filament
The individual threads in a tow. Filaments can vary in diameter.

Flexural Modulus:
A number referring to a material's stiffness. It is used to calculate how far a bar will bend when a bending load is applied. Units are normally millions of pounds per square inch. (106 psi) – Giga Pascals (gPa). In two materials of equal thickness, the one with a higher number is more resistant to deflection.

Flexural Strength:
Also known as bending strength. Describes how much non-moving load can be applied to a bar before it yields or breaks. Units are normally thousands of pounds per square inch. (103 psi) – Mega Pascals (mPa). Higher numbers indicate stronger materials that can withstand a heavier load.

HM
High modulus. This is a stiffer fiber with a with tensile modulus above 50 Msi.

IM
Intermediate modulus fiber is a mid-range modulus fiber in the 40 Msi to 44 Msi range.

PAN (Polyacrylonitrile)
A polymer which when spun into fiber is used as a precursor material in the manufacture of certain carbon fibers.

Prepreg
Fiber or fabrics that are preimpregnated with resin.

Resin
A hardening agent that is applied as a liquid to fibers or fabrics to hold them in place and is then hardened at high temperatures to produce final structures.

Size
A coating put on the fibers to protect them from damage during winding or weaving,

Surface Treatment
Adhesion between the matrix resin and carbon fiber is crucial in a reinforced composite. During the manufacture of carbon fiber, surface treatment is performed to enhance this adhesion and improve interlaminar shear strength (ILSS).

Tensile Modulus:
When a bar is pulled in tension, it gets longer. Tensile modulus calculates how much longer it will get when a certain load is applied. Units are normally millions of pounds per square inch. (10 6 psi) – Giga Pascals (gPa). Higher numbers indicate materials that do not elongate as much as others under equal tensile loading conditions.

Tensile Strength:
The amount of non-moving load a bar can withstand before it breaks due to elongation. Units are normally thousands of pounds per square inch. (103 psi) – Mega Pascals (mPa). Higher numbers indicate materials that can withstand a stronger pull before breaking.

Tensile Stress:
Normal stress caused by forces directed away from the plane on which they act.

Thermoplastic
Capable of being repeatedly softened by an increase of temperature and hardened by a decrease in temperature. Applicable to those materials whose change upon heating is substantially physical rather than chemical, and that in the softened stage, they can be shaped by flow into articles by molding or extrusion.

Thermoset
A material that undergoes a chemical reaction caused by heat, catalyst or other condition, which results in the formation of a solid. Once it becomes a solid, it cannot be reformed.

Tow
Carbon fiber tow is the packaged form of individual spools as produced in the carbon fiber making process. The tow comes in a wide variety of tow sizes, from 1k, 3k, 6k, 12k, 24k etc. The k value indicates the number of individual filaments within the tow. for instance, the 12k tow has 12,000 filaments in it.

Unidirectional tape
A narrow carbon fiber fabric that is laid up in a single direction where all fibers are positioned at the same angle.

Hexcel Product Family

HexTow® Carbon Fiber

HexFlow® Resins

HexMC® Molding Composite

HexForce® Reinforcements

Polyspeed® Laminates

HexWeb® Honeycomb Core

HiTape® Advanced Reinforcements

Modipur® Polyurethane

HexWeb® Engineered Core

HexPly® Prepregs

Redux® & Hexbond™ Adhesives

HexTool® Tooling Material

HiMax™ Multiaxial Reinforcements

HexAM™ Additive Manufacturing

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
- HexAM™ additive manufacturing
- HexMC® molding compounds
- HexFlow® RTM resins
- Redux® adhesives
- HexTool® tooling materials
- HexWeb® honeycombs
- Acousti-Cap® sound attenuating honeycomb
- Engineered core
- Engineered products
- Polyspeed™ laminates

For US quotes, orders and product information call toll-free 1-866-556-2662 or 1-800-688-7734. For other worldwide sales office telephone numbers and a full address list, please go to:

http://www.hexcel.com/contact/salesoffice

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