HEXCEL®

HexTow®
Carbon Fiber

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

HexTow® Carbon Fiber

- Stronger than steel, lighter than aluminum and 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 more than 50 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 U.S. military applications.
- Committed to providing premiere customer service and technical support as 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 a 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, spurring 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 to succeed beyond expectations. We have been pioneers at the forefront of the composites industry for more than 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 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 is supplied as continuous fiber.

Aerospace-Grade
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 offers standard, intermediate and high modulus carbon fibers. While our IM fibers have become an industry standard, particularly HexTow® IM7 carbon fiber, we continue to innovate and look for better ways to meet the growing needs of our customers.

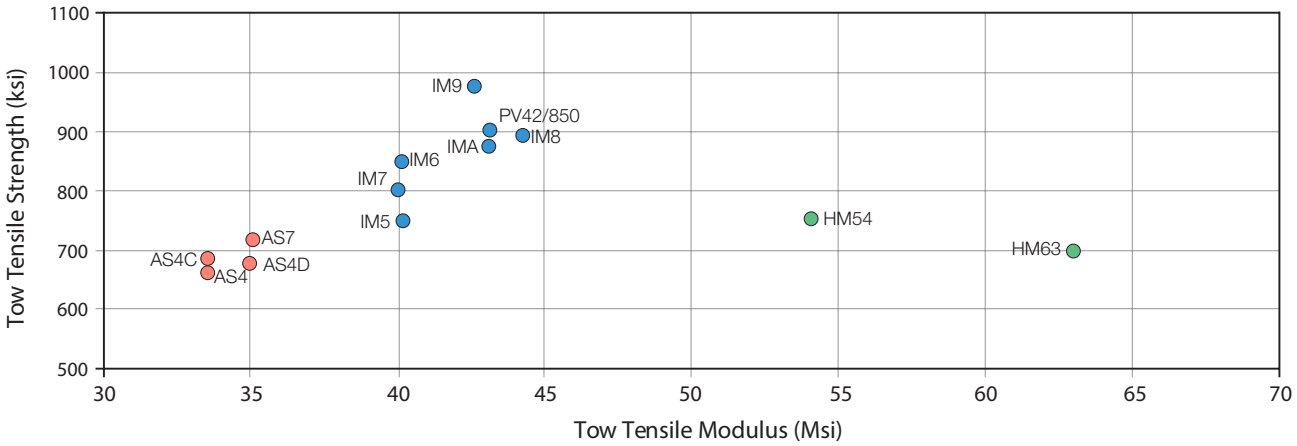
Fiber Type	Number of Filaments	Weight/ Length	Tensile Strength		Tensile Modulus[1]		Strain[2]	Density
		(g/m)	(ksi)	(MPa)	(Msi)	(GPa)	(%)	(g/cm³)
AS4	3000	0.210	650	4501	33.5	231	1.8	1.79
	6000	0.427						
	12000	0.858						
AS4C	1000	0.067	675	4646	33.5	231	1.8	1.78
	3000	0.200						
	6000	0.400						
	12000	0.800						
AS4D	12000	0.765	685	4723	35.0	241	1.8	1.79
AS7	12000	0.800	715	4930	35.3	243	1.7	1.79
IM5	12000	0.735	750	5171	40.5	279	1.7	1.79
	24000[3]	1.470						
IM6	12000	0.446	850	5860	40.5	279	1.9	1.76
IM7	6000	0.223	820	5670	40.0	276	1.8	1.78
	12000	0.446						
IMA	12000	0.446	880	6067	43.2	298	1.9	1.79
IM8	12000	0.446	895	6170	44.1	304	1.9	1.79
IM9	24000	1.020	915	6200	42.0	290	2.0	1.79
PV42/850	12000	0.446	900	6205	43.2	298	1.9	1.79
HM54	12000	0.422	750	5171	54.0	372	1.3	1.76
HM63	6000	0.210	700	4889	63.0	434	1.0	1.83
	12000	0.422						

Refer to specific product data sheets for more details on each product.
[1] Tensile modulus calculated as Chord (6000 - 1000) [2] Strain at Failure [3] Provisional Data

Fiber Type	Number of Filaments	Weight/Length	Density	Carbon Content
HexTow® 85	24000	1.78 g/m	1.78 g/cm³	85%

HexTow® 85 carbon fiber is designed for ablative applications.

Strength vs. Modulus



Industrial-Grade
HexTow® Carbon Fiber

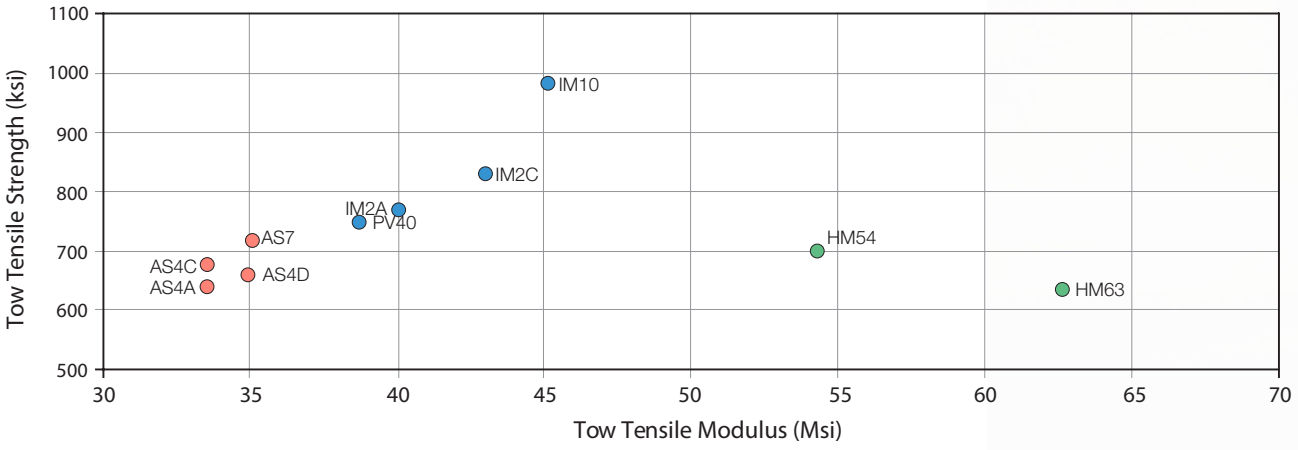
HexTow® carbon fiber is widely used in a number of leading-brand, high-performance recreational sports equipment including performance bikes, tennis racquets, fishing rods, skis, snowboards, hockey sticks, baseball bats, and golf shafts.

HexTow® standard and intermediate modulus carbon fiber is selected for winning Formula 1 cars, competition racing boats, high-performance cars, and composite tooling material. In the field of civil engineering, HexTow® is used for concrete reinforcement and infrastructure repair. Carbon fiber is also opening new possibilities for high strength and performance in the fields of energy generation and high-performance pressure vessels.

Fiber Type	Number of Filaments	Weight/ Length	Tensile Strength		Tensile Modulus[1]		Strain[2]	Density
		(g/m)	(ksi)	(MPa)	(Msi)	(GPa)	(%)	(g/cm³)
AS4A	12000	0.858	640	4413	33.5	231	1.7	1.79
AS4C	1000	0.067	650	4463	33.5	231	1.8	1.78
	3000	0.200						
	6000	0.400						
	12000	0.800						
AS4D	3000	0.200	665	4586	34.9	241	1.8	1.79
	12000	0.765						
AS7	12000	0.800	680	4690	35.2	243	1.8	1.79
PV40	12000	0.735	750	5171	40.5	279	1.8	1.79
	24000[3]	1.470						
IM2A	12000	0.446	775	5343	40.0	276	1.7	1.78
IM2C	12000	0.446	830	5723	43.0	296	1.8	1.78
IM10	12000	0.324	990	6826	45.4	313	2.0	1.79
HM54	12000	0.424	700	4826	54.0	372	1.3	1.76
HM63	12000	0.422	630	4344	63.0	435	1.0	1.83

Refer to specific product data sheets for more details on each product.
[1] Tensile modulus calculated as Chord (6000 - 1000) [2] Strain at failure [3] Provisional Data

Strength vs. Modulus



HexTow® Carbon Fiber
Composite Properties & Sizing Options

Typical Epoxy Composite Properties*

Property	Test Method	HM63 12k		IM8 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	361 ksi	2491 MPa	430 ksi	2963 MPa	395 ksi	2723 MPa	365 ksi	2514 MPa	310 ksi	2137 MPa
0˚ Tensile Modulus		35.7 Msi	246 GPa	26.2 Msi	181 GPa	23.8 Msi	164 GPa	24.3 Msi	168 GPa	19.6 Msi	135 GPa
0˚ Tensile Strain		1.0 %		1.5 %		1.6 %		1.4 %		1.6 %	
0˚ Flexural Strength	ASTM D790					270 ksi	1862 MPa	200 ksi	1379 MPa	274 ksi	1889 MPa
0˚ Flexural Modulus						22.0 Msi	152 GPa	20.1 Msi	139 GPa	18.4 Msi	127 GPa
0˚ Short Beam Shear Strength	ASTM D2344	14.5 ksi	100 MPa	18.5 ksi	128 MPa	19.9 ksi	137 MPa	17.3 ksi	120 MPa	18.5 ksi	128 MPa
0˚ Compressive Strength	ASTM D695 Mod.	196 ksi	1350 MPa	258 ksi	1781 MPa	245 ksi	1689 MPa	236 ksi	1627 MPa	222 ksi	1531 MPa
0˚ Compressive Modulus		32.0 Msi	221 GPa			21.7 Msi	150 GPa	19.8 Msi	137 GPa	18.6 Msi	128 GPa
Open Hole Tensile Strength	ASTM D5766	66.4 ksi	458 MPa	61.8 ksi	426 MPa	62.1 ksi	428 MPa	56.8 ksi	392 MPa	63.5 ksi	438 MPa
Open Hole Compressive Strength	ASTM D6484	36.0 ksi	248 MPa	42.6 ksi	293 MPa	48.9 ksi	337 MPa	45.0 ksi	310 MPa	47.8 ksi	330 MPa
90˚ Tensile Strength	ASTM D3039	6.5 ksi	45 MPa			9.3 ksi	64 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)

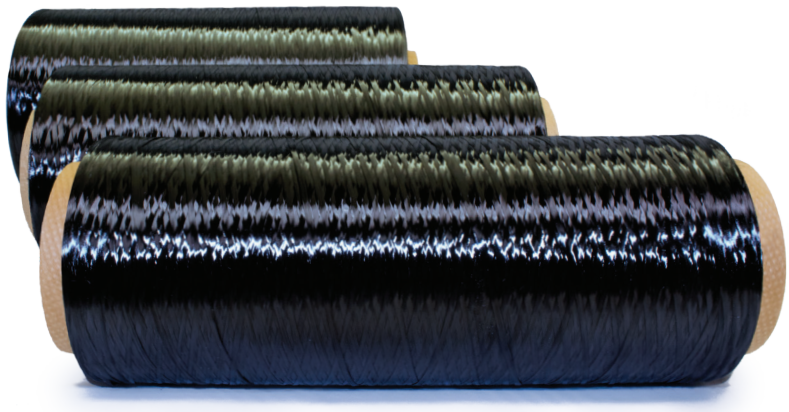
To enable consumer processing of carbon fiber, proprietary sizing agents are typically applied by Hexcel, such as G, GP, and GS Sizes. It has been found that the original processing characteristics of G Sized carbon fiber will essentially remain constant for at least one year from the date of manufacture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

Carbon fiber should be stored indoors, in original containers, and 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 before use.

If carbon fiber is stored at high temperatures and/or high humidity conditions, or for time frames in excess of those recommended, 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 fibers (HM) are fibers with tensile modulus above 50 Msi. Hexcel has a variety of fiber offerings across each of these ranges.

What tow sizes 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 and 24K) 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 thermosets 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.

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, 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®-i Molding Composite

HexForce® Reinforcements

Polyspeed® Laminates

HexWeb® Honeycomb Core

HiTape® Advanced Reinforcements

Modipur® Polyurethane

HexWeb® Engineered Core

HexPly® Prepregs

HexBond® Adhesives

HexTool® Tooling Material

HiMax® Multiaxial Reinforcements

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® honeycomb
- Acousti-Cap® sound attenuating honeycomb
- Engineered core
- Engineered products
- Polyspeed® laminates

For U.S. 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:

https://www.hexcel.com/contact

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