HEXCEL®

HexForce® Reinforcements
Technical Fabrics Handbook

Woven & Unidirectional Fabrics

- Glass
- Carbon
- Aramid

Reinforcements for Composites

Manufacturing, Sales and Customer Service
Seguin, Texas
1913 N. King St.
Seguin, TX 78155
United States

Telephone: (830) 379-1580
Fax: (830) 379-9544
Customer Service Toll Free: 1 (866) 601-5430
Technical Service: 1 (830) 401-8180

Manufacturing
Les Avenieres, France
Z.I. Les Nappes
38630 Les Avenieres
France

Tel: +33 4 74 33 99 33

HiMax™ Multiaxial Reinforcements
Hexcel Reinforcements UK Ltd
Cutters Close
Narborough
Leicester, UK LE19 2FZ

Tel: +44(0) 1162 752 200

For European sales office numbers and a full address list, please go to: *www.hexcel.com/contact/salesoffices*

www.hexcel.com

Commercial Disclaimer

For Commercial Use Only - In determining whether the material is suitable for a particular application, such factors as overall product design and the processing and environmental conditions to which it will be subjected should be considered by the User. The following is made in lieu of all warranties, expressed or implied: Seller's only obligations shall be to replace such quantity of this product which has proven to not substantially comply with the data presented in this bulletin. In the event of the discovery of a nonconforming product, Seller shall not be liable for any commercial loss or damage, direct or consequential arising out of the use of or the inability to use the product. Before using, User shall determine the suitability of the product for his intended use and User assumes all risks and liability whatsoever in connection therein. Statements relating to possible use of our product are not guarantees that such use is free of patent infringement or that they are approved for such use by any government agency. The foregoing may not be changed except by an agreement signed by an officer of Seller.

Contents

Contents (cont.)

Company Profile

Hexcel Corporation is a leading advanced composites company. It develops, manufactures and markets lightweight, high-performance structural materials; including carbon fibers, reinforcements, prepregs, honeycomb, matrix systems, adhesives and composite structures, used in commercial aerospace, space and defense and industrial applications such as wind turbines.

As the most vertically integrated supplier in the industry, Hexcel is better able to control the cost, quality and delivery of its products. Vertical integration also means that we can offer enhanced design flexibility and support to our customers worldwide.

Hexcel's research and technology function supports our businesses worldwide with a highly developed expertise in materials science, textiles, process engineering and polymer chemistry.

Hexcel manufactures a wide range of reinforcements for the manufacture of structural composites, used in aerospace, military, transportation and industrial applications. Reinforcements in the form of fabrics or non-wovens are made using a variety of high performance fibers, including glass, carbon, aramids, and specialty reinforcements.

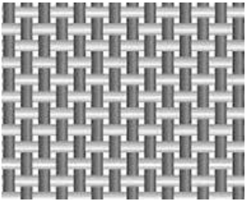
Parameters for Woven Fabric Selection

In selecting a woven fabric for industrial applications, a number of design parameters may be considered. These are broken down into four basic variables: yarn weight, thread count, weave pattern and fabric finish. The wide range of yarn weights provides the base for fabric design. Yarn weight, combined with thread count [the number of warp ends (lengthwise) and filling picks (widthwise) per inch] determines the strength, weight and thickness of the fabric.

Basic weaving concepts are utilized in the manufacture of fiber glass and high performance fabrics. The technology, however, is advanced to incorporate specialized precision equipment to meet the exacting demands of modern industry. Almost any weave can be woven; however, for industrial purposes there are six basic patterns as described below.

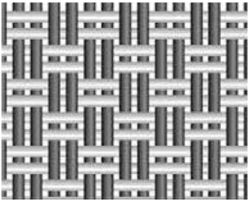
Plain

The plain weave consists of yarns interlaced in an alternating fashion one over and one under every other yarn. The plain weave provides good fabric stability but is generally the least pliable.



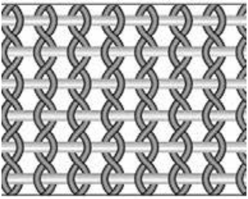
Basket

The basket weave is similar to the plain weave except that two or more warp yarns and two or more filling yarns are alternately interlaced over and under each other. The basket weave is more pliable, flatter and stronger than the plain weave, but is not as stable.



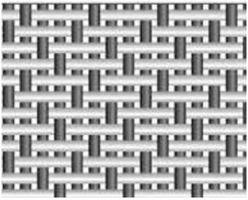
Leno

The leno weave is used where relatively low numbers of yarns are involved. The leno weave locks the yarns in place by crossing two or more warp threads over each other and interlacing with one or more filling threads.



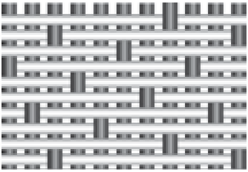
Four Harness Satin (Crowfoot)

The four harness satin weave is more pliable than the plain weave and is easier to conform to curved surfaces typical in reinforced plastics. In this weave pattern there is a three-by-one interfacing where a filling yarn floats over three warp yarns and under one.



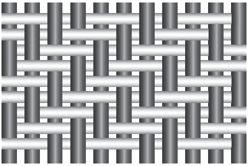
Eight Harness Satin

The eight harness satin is similar to the four harness satin except that one filling yarn floats over seven warp yarns and under one. This is a very pliable weave and is used for forming over curved surfaces.



2x2 Twill Weave

The twill weave is more pliable than the plain weave and has better drapability while maintaining more fabric stability than a four or eight harness satin weave. The weave pattern is characterized by a diagonal rib created by one warp yarn floating over at least two filling yarns.



Fiber Glass Fabrics

Physical Properties of Fiber Glass

The versatility of glass as a fiber makes it a unique industrial textile material. Fiber glass in fabric form offers an excellent combination of properties from high strength to fire resistance. Wide ranges of yarn sizes and weave patterns provide unlimited design potential, allowing the end user to choose the best combination of material performance, economics and product flexibility.

Dimensional Stability
Fiber glass is a dimensionally stable engineering material. Fiber glass does not stretch or shrink after exposure to extremely high or low temperature. The maximum elongation for “E” glass at break is 4.8 percent with a 100 percent elastic recovery when stressed close to its point of rupture.

Moisture Resistance
Glass fibers do not absorb moisture, and do not change physically or chemically when exposed to water.

High Strength
The high strength-to-weight ratio of fiber glass makes it a superior material in applications where high strength and minimum weight are required. In textile form, this strength can be unidirectional or bidirectional, allowing flexibility in design and cost.

Fire Resistance
Fiber glass is an inorganic material and will not burn or support combustion. It retains approximately 25 percent of its initial strength at 1,000 ºF.

Chemical Resistance

Most chemicals have little or no effect on glass fiber. The inorganic glass textile fibers will not mildew, rot or deteriorate. Glass fibers are affected by hydrofluoric, hot phosphoric acids and strong alkaline substances.

Electrical Properties

Fiber glass is an excellent material for electrical insulation. The combination of properties such as low moisture absorption, high strength, heat resistance and low dielectric constant makes fiber glass fabrics ideal as a reinforcement for printed circuit boards and insulating varnishes.

Thermal Conductivity

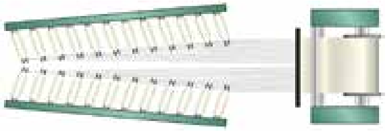
A low coefficient of thermal expansion combined with high thermal conductivity properties make glass fabrics a dimensionally stable material that rapidly dissipates heat as compared to asbestos and organic fibers.

Cure Ply Thickness

To accurately calculate the cure ply thickness, please visit our website at www.hexcel.com/resources/calculator and click on “CPT Calculator.”

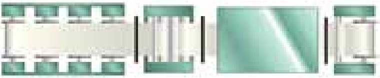
The Process of Converting Glass Yarn to Fabric

1. Warping



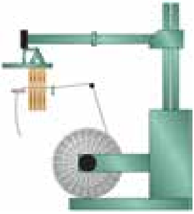
The first step in the warping stage is beaming, where purchased yarn is transferred from the bobbin creel to section beams. Most input yarn is in singles form; however, some yarn is twisted and plied together to yield unique properties. The section beams constitute the machine direction or thread sheet segment of yarn in the loom. Several section beams are produced and consolidated into a group called a set, which provides the input for the slashing process.

2. Slashing



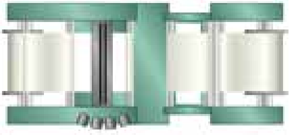
The slashing process combines the warp ends of the set's multiple section beams into a single beam for weaving called a warp or loom beam. Sizing is applied to the threadsheet filaments and to avoid abrasion of individual strands.

3. Entering



The final stage of preparation is entering, where the warp is set up for installation in the loom. A warp can contain over 4,500 individual ends, depending on the design of the style. Each warp end is drawn through a drop wire, heddles and a reed, either by hand or by machine. These parts work together to mechanically arrange and control the warp yarn spreadsheet during the weaving process on the loom.

4. Weaving



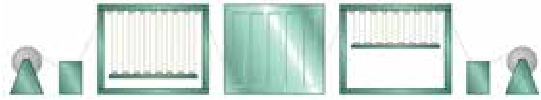
After the warp beam is installed in the loom, then either rapier technology for heavy fabrics, or air jet technology for lighter fabrics is used to interlace the filling yarns at 90 degree angles to the warp ends on the loom. The fabric, called greige or loom state, is then wound onto a roll or steel drums called mandrels, and the weaving process is complete.

5. Heat Cleaning

The next stage is batch oven cleaning, where the mandrels are placed on racks, loaded into large ovens, and exposed to high temperatures until all organic binders are removed and a pure clean glass fabric is produced. Organic, polymer-based fabrics are not exposed to this process (fabrics of Kevlar®/ Twaron® fibers).

6. Finishing

In the finishing stage a coupling agent (finish) or chemical treatment is applied to the fabric, and the finished glass is ready for use. The finish serves to provide optimum adhesion between the fiber surface and the matrix resin, to provide fabric stability and protection (weave set), or to provide chemical protection and resistance.



Woven Fiber Glass Applications

Fiber glass fabrics are used in a wide range of industrial applications. High strength, dimensional stability, design flexibility and excellent electrical properties are some of the characteristics that ensure optimum performance and economy with this highly engineered material.

Reinforced Plastics
Fiber glass fabrics used as reinforcement for plastics have replaced traditional materials such as wood, steel, and aluminum in a vast array of products. The inherent strength, light weight, dimensional stability and low tooling costs derived from fiber glass reinforced plastics help make many products more durable, attractive and maintenance free.

Electrical
Fiber glass fabrics offer outstanding performance to the electrical industry. High strength, dimensional stability, temperature resistance and excellent electrical properties provide the basis for use as the prime reinforcement in high pressure laminates for printed circuit boards. Fiber glass fabrics coated with chemistry such as epoxy, silicone, rubber, Teflon® and neoprene, as well as reinforcing mica products, provide the long term durability and reliability needed in insulating high voltage generators, transformers, switches and cables.

Coated and Laminated Fabrics
High strength, dimensional stability, fire resistance and low cost are some of the advantages of using fiber glass fabrics to reinforce foils, plastic film and coatings. Protective covers, vapor barriers, window shades, movie screens, packaging tapes, awnings, protective clothing, gaskets, wall covering and conveyor belts are just some of the products that are improved through the use of fiber glass fabrics.

Thermal Insulation
Strength retention at high temperatures, corrosion and fire resistance, and ease of handling make fiber glass fabrics an important material for thermal insulation. Both the U.S. Navy and commercial shipyards use fiber glass fabrics almost exclusively as pipe lagging and for thermal pad covers.

Construction
From pipe wrap to wallboard seaming tape, fiber glass fabrics can be found throughout the construction industry. Fiber glass scrim is used to reinforce paper and film for insulation facings and to provide dimensional stability to asphalt used on roofing, roadways and bridge decks. Fabric structures such as tennis courts, sports centers and football stadiums use coated fiber glass fabrics as an economical way to encapsulate space.

Surfboard and Recreation
Hexcel offers a variety of styles and finishes that should work in the surfboard and recreation markets for any of your needs.

Fiber Glass Yarn Nomenclature

The wide variety of fiber glass yarns produced requires a special system of nomenclature for identification. This nomenclature consists of two parts—one alphabetical and one numerical. In addition, although the final result is the same, there are differences between the customary U.S. Systems and the TEX/Metric System.

U.S. System

Example: ECG 150-1/2

A. First Letter - "E" characterizes the glass composition (see Table I).

B. Second Letter - "C" indicates the yarn is composed of continuous filaments. "S" indicates staple filament. "T" indicates texturized continuous filaments.

C. Third Letter - Denotes the individual filament diameter: BC, D, DE, E, G, H, K (see Table II).

D. First Number - Represents 1/100 the normal bare glass yardage in one pound of the basic yarn strand. In the above example, multiply 150 by 100 which results in 15,000 yards in one pound (see Table II).

E. Second Number - Represents the number of basic strands in the yarn. The first digit represents the original number of twisted strands. The second digit separated by the diagonal represents the number of strands plied (or twisted) together. To find the total number of strands used in a yarn, multiply the first digit by the second digit (a zero is always multiplied as 1).

TEX/Metric System

Example: EC9 33 1X2

A. First Letter - “E” characterizes the glass composition (see Table I).

B. Second Letter - “C” indicates continuous filament. “T” indicates textured continuous filament. “D” indicates staple filament.

C. First Number - Denotes the individual filament diameter (see Table II) expressed in micrometers (microns).

D. Second Number - Represents the non-linear weight of the bare glass strand expressed in TEX. TEX is the mass in grams per 1,000 meters of yarn (see Table II).

E. Third Number - Indicates yarn construction or the basic number of strands in the yarn. The first digit represents the original number of twisted strands and the second digit after the “X” indicates the number of these strands twisted or plied together.

Table I

Glass Composition–By Weight

Composition	E Glass	S-2 Glass®
Silicon Dioxide	52-56%	64-66
Calcium Oxide	16-25%	
Aluminum Oxide	12-16%	24-26%
Boron Oxide	8-13%	
Sodium & Potassium Oxide	0-1%	
Magnesium Oxide	0-6%	9-11%

Fiber glass yarns are available in different formulations. “E” glass (electrical) is the most common all-purpose glass, while “S” Glass® (high strength) is used for special applications.

Table II

Basic Glass Yarn Stands

Filament Diameter			Strand Weight		
	U.S. Designation (inches)	Metric (microns)	U.S. x100= yd/lb	Designated TEX	Number of Filaments
BC	0.00017	4	150	33	1064
D	0.00023	5	1800	2.75	51
			900	5.5	102
			450	11	204
			225	2	408
DE	0.00025	6	300	16.5	204
			150	33	408
			100	50	612
			75	66	816
			50	99	1224
			37	134	1632
E	0.00029	7	225	22	204
			110	45	408
G	0.00036	9	150	33	204
			75	66	408
			50	99	612
			37	134	816
H	0.00043	10	25	198	816
K	0.00051	13	18	275	816

Fiber Glass Fabric Finishes

Fiber Glass Fabrics are available with a variety of finishes and treatments.

Greige: Loom state fabric that includes the organic binders and size applied to the yarn prior to weaving.

Finished: Fully heat cleaned fabric treated with the coupling agent which provides a chemical bond between the fiber glass surface and various matrix resins.

The following finish charts offer recommended Hexcel finishes based on compatibility with resin systems and include special finish processes.

Hexcel Finish	Recommended Matrix Resin(s)	Possible Matrix Resin(s)	Performance Features
F69	Epoxy Polyester		Silane finish for epoxy composites resins **BMS 9-3 Qualified**
F81	Epoxy Polyester Vinyl Ester Urethane Cyanate Ester	BMI Phenolic	Multifunctional silane for use with all major resin systems. Excellent wetting characteristics. Surfboard finish.
Z-6040/F46	Epoxy	Phenolic	Silane finish compatible with epoxy resins.
CS-767	Epoxy Polyimide BT Urethane Vinyl Ester	Cyanate Ester Polyester Phenolic	Unique multifunctional capability for use with all major resin systems. Excellent wetting characteristics. **BMS 9-3 Qualified**

Hexcel Fiber Glass Finishes (continued)

Hexcel Finish	Recommended Matrix Resin(s)	Possible Matrix Resin(s)	Performance Features
Greige	Loom state fabric. No additional fabric finish processing. Used for coating applications.		
CS-724	Epoxy		Specially developed finish for structural composites. **BMS 9-3 Qualified**
CS-310	Epoxy		Silane finish **BMS 9-3 Qualified**
CS-550/ Volan	Polyester Epoxy	Vinyl Ester Phenolic	Volan/Silane finish for structural polyester/ vinyl ester and phenolic resins. Fabric will have a green tint from the Volan. **BMS 9-3 Qualified**
F50	Polyester Epoxy	Vinyl Ester Cyanate Ester Phenolic	Volan/Silane finish. Fabric will have green tint from the Volan. **BMS 9-3 Qualified**
F3/F16	Polyester Vinyl Ester	Epoxy Phenolic	Volan finish compatible with structural epoxy, polyester/vinyl ester and phenolic resins. Fabric will have green tint from the Volan. **F3 is BMS 9-3 Qualified**
F43	Polyester	Vinyl Ester	Silane finish compatible with polyester and vinyl ester resin systems. Very good clarity
F72	Polyester		Silane finish

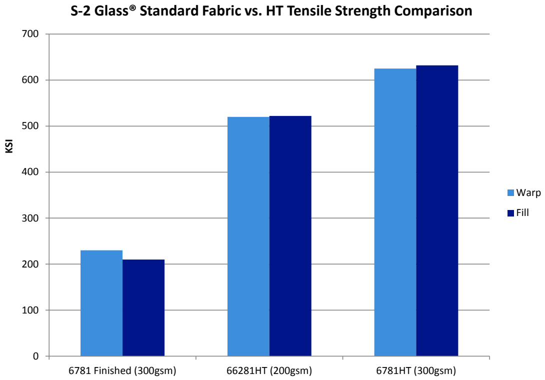
Other Finishes and Special Processes

Hexcel Finishes	Performance Features
Greige	Loom state fabric. No additional fabric finish processing. Used for coating applications.
F12	Heat cleaned fabric for silicone processes. **BMS 9-3 Qualified**
“HT”	Direct size S Glass fabric that is used in very high temperature applications and can be used in a wide variety of resins.

Ultra High Performance Glass Products

The HT fabrics are fashioned after the standard high volume E-glass aerospace 7781 300 gsm fabric and 200 gsm 3K carbon fabric styles. Complimenting these styles in fabric areal weight and weave pattern, 6781HT and 66281HT have similar characteristics in fabric hand, flexibility, and weight; with added benefit of superior impact resistance, tensile strength than standard S-2 Glass® fiber with a cost benefit over Carbon.

The dry fabric tensile strength for HT fabrics is dramatically higher than typical S-2 Glass® fabrics made with standard starch oil sizing. Starch oil size fabrics require heat cleaning prior to finishing, significantly reducing fiber tensile strength. The HT fabrics have a simple yet effective organic sizing compatible with high temperature Epoxy, BMI, Phenolic, Cyanate Esters, Thermoplastics, Polyamide, Polyimide, PEI, PEEK, PAI, LCP, and others.



Fiber Glass Fabric Shelf Life Recommendation

Finishes on fiber glass fabrics are generally very stable to environmental conditions. Most fabric/finish combinations, silane and Volan-type finishes included, will not lose performance under ambient storage conditions - <65% relative humidity and <120ºF. Fiber glass fabrics finished with Silane and/or Volan-type finishes are frequently used several years after shipment when stored at these conditions.

As every application for fiberglass fabric is different; with multiple resins, processes, as well as storage conditions, Hexcel cannot recommend a shelf life of a fiber glass fabric finish to our customers. Unless specified in an approved customer specification, it is up to the end user to determine the appropriate shelf life of a fiber glass fabric finish.

An exception to this is the F43 which may discolor and stiffen, should be used within 6 months of shipment.

Fiber Glass Fabric Technical Data

Hexcel reserves the right to use equivalent yarns in fiber glass styles. The use of such yarns is designed to maintain the physical properties of the woven cloth. The values listed for weight, thickness, and breaking strengths are typical greige values, unless otherwise noted.

Fiber Glass Fabrics

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
104	Plain	60	52	ECD 900 1/0	ECD 1800 1/0	0.57	19	1.1	0.03	60	20
106	Plain	56	56	ECD 900 1/0	ECD 900 1/0	0.73	25	1.5	0.04	60	55
108 ⬢	Plain	60	48	ECD 900 1/2	ECD 900 1/2	1.43	48	2.5	0.06	80	70
112 ⬢	Plain	40	39	ECD 450 1/2	ECD 450 1/2	2.10	71	3.2	0.08	120	90
116 ⬢	Plain	60	57	ECD 450 1/2	ECD 450 1/2	3.11	105	3.8	0.10	160	160
117 ⬢	Plain	54	39	ECD 450 1/2	ECD 450 1/2	2.40	81	2.6	0.07	160	90
120 ⬢	4H Satin	60	58	ECD 450 1/2	ECD 450 1/2	3.16	107	3.5	0.09	160	160
138	4H Satin	65	60	ECE 225 1/2	ECE 225 1/2	6.54	222	7.0	0.18	300	270
162	Plain	28	17	ECE 225 2/5	ECE 225 2/5	12.40	420	13.8	0.35	650	400
220 ⬢	4H Satin	60	58	ECE 225 1/0	ECE 225 1/0	3.22	109	3.5	0.09	200	185
232	4H Satin	48	30	ECG 37 1/0	ECG 75 1/2	12.75	432	14.0	0.36	550	450
332	4H Satin	48	32	ECG 37 1/0	ECG 37 1/0	12.75	432	14.0	0.36	550	450
333	4H Satin	48	32	ECDE 37 1/0	ECDE 37 1/0	13.00	441	14.0	0.36	600	425
341	4H Satin	32	49	ECD 450 1/2	ECE 225 3/2	8.64	293	8.2	0.21	50	300

Style		Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
							(oz/yd^2)	(g/m^2)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
403		4H Satin	54	50	ECG 75 1/0	ECG 150 1/2	8.40	285	8.9	0.23	440	350
477	●	4H Satin	55	48	ECDE 150 1/0	ECDE 150 1/0	4.11	139	4.7	0.12	300	250
520		Plain	18	17	ECG 75 1/3	ECG 75 1/3	8.70	295	9.1	0.23	330	310
993		Plain	38	67	ECD 900 1/0	ECD 900 1/0	0.71	24	1.2	0.03	30	23
1035		2/2 Twill	35	35	ECG 75 1/0	ECG 75 1/0	5.7	193	7.1	0.18	350	400
1037		Plain	70	73	ECC 1200 1/0	ECC 1200 1/0	0.73	25	1.3	0.03	45	40
1047		Plain	47	47	ECDE 100 1/0	ECDE 100 1/0	5.44	184	5.6	0.14	200	200
1064	●	Plain	18	22	ECG 75 1/2	ECG 150 1/2	4.62	157	5.7	0.14	220	150
1067		Plain	70	70	ECD 900 1/0	ECD 900 1/0	0.91	31	1.4	0.04	57	57
1070		Plain	60	35	ECD 450 1/0	ECD 900 1/0	1.05	36	2.0	0.05	100	25
1071		Plain	60	30	ECD 900 1/0	ECD 900 1/0	0.60	20	1.2	0.03	60	25
1076		Plain	60	25	ECD 450 1/0	ECD 900 1/0	0.96	33	1.8	0.05	120	22
1080		Plain	60	47	ECD 450 1/0	ECD 450 1/0	1.41	48	2.2	0.06	120	90
1125	●	Plain	40	39	ECD 450 1/2	ECG 150 1/0	2.65	90	3.6	0.09	120	190

● Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Fiber Glass Fabrics (cont.)

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
1131	Plain	120	52	ECD 450 1/0	ECG 150 1/0	3.65	124	5.0	0.13	160	210
1142	Plain	31	21	ECG 37 1/0	ECG 37 1/0	8.37	284	10.3	0.26	400	300
1161	Plain	100	42	ECD 450 1/0	ECDE 100 1/0	3.85	131	5.0	0.12	150	350
1165	Plain	60	52	ECD 450 1/2	ECG 150 1/0	3.70	125	4.2	0.11	160	210
1167	Plain	60	55	ECD 450 1/2	ECG 150 1/0	3.77	128	4.2	0.11	160	250
1188	4H Satin	44	30	ECH 25 1/0	ECG 150 1/0	11.83	401	12.0	0.30	750	130
1280/1086	Plain	60	60	ECD 450 1/0	ECD 450 1/0	1.60	54	2.4	0.06	120	120
1297	Plain	50	20	ECD 450 1/0	ECD 900 1/0	0.81	27	2.0	0.05	100	18
1299	Plain	50	20	ECD 450 1/0	ECD 450 1/0	0.92	31	2.2	0.06	100	40
1311	Plain	32	21	ECE 225 3/2	ECE 225 3/2	8.48	288	9.7	0.25	469	338
1500	Plain	49	42	ECE 110 1/0	ECE 110 1/0	4.95	168	5.3	0.13	220	220
1501	Plain	46	45	ECE 110 1/0	ECE 110 1/0	4.95	168	5.3	0.14	220	220
1507	Leno	20	10	ECG 75 1/3	ECG 37 1/3	10.30	349	25.0	0.64	300	310
1520	Plain	24	20	ECG 150 1/2	ECG 75 1/0	3.7	125	4.3	0.11	150	170

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
1522 ⬣	Plain	24	22	ECG 150 1/2	ECG 150 1/2	3.67	124	5.3	0.12	160	150
1523	Plain	28	20	ECG 150 3/2	ECG 150 3/2	11.50	392	13.6	0.35	680	525
1526	Plain	34	34	ECG 150 1/2	ECG 150 1/2	5.30	180	6.2	0.15	225	200
1527	Plain	17	17	ECG 150 3/3	ECG 150 3/3	12.15	412	14.3	0.36	500	485
1528	Plain	43	32	ECG 150 1/2	ECG 150 1/2	6.03	204	7.0	0.18	250	200
1530	Plain	20	18	ECG 150 3/3	ECG 150 3/3	13.20	448	15.0	0.38	500	475
1543 ⬣	4H Satin	48	30	ECG 75 1/2	ECE 225 1/0	8.69	295	7.8	0.20	625	90
1557 ⬣	4H Satin	57	30	ECG 150 1/2	ECE 225 1/0	5.42	184	5.5	0.14	350	90
1562	Leno	30	16	ECG 150 1/0	ECG 150 1/0	1.82	62	4.5	0.11	100	50
1564 ⬣	Plain	20	18	ECG 37 1/2	ECG 37 1/2	12.40	420	15.0	0.38	500	450
1568	Leno	16(8)	8	ECH 25 1/0	ECG 37 1/3	7.97	270	16.5	0.42	237	374
1576	12H Satin	120	24	ECG 150 1/2	ECG 150 1/0	10.60	359	11.1	0.28	600	100
1579	Plain	30	16	ECG 150 1/2	ECG 75 1/0	3.68	125	4.5	0.11	200	110
1581 ⬣	8H Satin	57	54	ECG 150 1/2	ECG 150 1/2	8.79	298	8.5	0.22	450	380

⬣ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Fiber Glass Fabrics (cont.)

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
1582	8H Satin	60	56	ECG 150 1/3	ECG 150 1/3	13.63	462	12.7	0.32	575	550
1583 ●	8H Satin	54	48	ECG 75 1/2	ECG 75 1/2	16.52	560	16.2	0.41	980	850
1584	8H Satin	44	35	ECG 150 4/2	ECG 150 4/2	26.00	882	24.6	0.62	1000	900
1597 ●	Plain	30	30	ECG 37 1/4	ECG 37 1/4	38.57	1308	37.8	0.96	1300	1400
1608	Plain	30	26	ECG 150 1/0	ECG 150 1/0	2.22	75	3.5	0.09	160	130
1609	Plain	32	10	ECG 150 1/0	ECD 450 1/0	1.48	50	2.6	0.07	160	15
1610	Plain	32	28	ECG 150 1/0	ECG 150 1/0	2.37	80	4.0	0.10	160	130
1611	Plain	32	28	ECG 150 1/0	ECDE 150 1/0	2.42	82	4.0	0.10	160	152
1614	Leno	30	14	ECG 150 1/0	ECG 75 1/0	2.33	79	5.0	0.13	100	110
1620	Plain	20	20	ECG 150 1/0	ECG 150 1/0	1.58	54	3.2	0.08	100	100
1628	Plain	40	28	ECDE 150 1/0	ECDE 150 1/0	2.69	91	3.4	0.09	190	142
1632	Plain	30	32	ECG 150 1/0	ECG 75 1/0	3.75	127	4.7	0.12	160	260
1636	Plain	40	24	ECDE 150 1/0	ECDE 150 1/0	2.60	88	4.0	0.09	190	130
1652	Plain	52	52	ECG 150 1/0	ECG 150 1/0	4.15	141	4.5	0.11	220	210

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
1658	Plain	20	10	ECG 150 1/0	ECG 75 1/0	1.60	54	4.0	0.10	100	100
1659	Leno	20	10	ECG 150 1/0	ECG 75 1/0	1.60	54	4.2	0.11	70	100
1669	Plain	60	12	ECG 150 1/0	ECD 450 1/0	2.50	85	3.2	0.09	300	20
1674	Plain	40	32	ECG 150 1/0	ECG 150 1/0	2.85	97	4.0	0.10	200	160
1675 ⬣	Plain	40	32	ECDE 150 1/0	ECDE 150 1/0	2.85	98	4.3	0.11	190	162
1676	Plain	55	48	ECDE 150 1/0	ECDE 150 1/0	4.10	139	4.8	0.12	250	190
1678	Plain	40	40	ECG 150 1/0	ECG 150 1/0	3.20	108	4.3	0.11	200	200
1680	8H Satin	72	70	ECDE 150 1/0	ECDE 150 1/0	5.70	193	6.1	0.15	320	260
1692	Plain	40	22	ECG 150 1/0	ECG 75 1/0	3.18	108	5.2	0.12	200	210
1694	Plain	40	24	ECG 150 1/0	ECG 75 1/0	3.54	120	5.1	0.12	200	220
1695	Plain	40	24	ECDE 150 1/0	ECDE 75 1/0	3.59	122	5.4	0.14	190	180
1800 ⬣	Plain	16	15	ECK 18 1/0	ECK 18 1/0	9.33	316	11.1	0.28	530	460
1884	8H Satin	44	35	ECK 18 1/0	ECK 18 1/0	25.40	861	26.0	0.66	950	800
1938	8H Satin	45	36	ECK 18 1/0	ECG 37 1/2	26.80	909	26.6	0.68	1000	900

⬣ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Fiber Glass Fabrics (cont.)

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
2025	Plain	20	14	ECDE 37 1/3 Text	ECDE 37 1/3 Text	17.05	578	26.2	0.67	575	340
2112	Plain	40	39	ECE 225 1/0	ECE 225 1/0	2.10	71	3.0	0.08	120	120
2113	Plain	60	56	ECE 225 1/0	ECD 450 1/0	2.34	79	2.8	0.07	220	100
2114	Plain	56	48	ECE 225 1/0	ECE 225 1/0	2.69	91	3.3	0.08	190	160
2116	Plain	60	58	ECE 225 1/0	ECE 225 1/0	3.12	106	3.5	0.10	200	185
2125	Plain	41	38	ECE 225 1/0	ECE 225 1/0	2.60	88	3.5	0.09	120	120
2157	Plain	60	35	ECE 225 1/0	ECG 75 1/0	4.32	146	5.9	0.15	185	280
2165	Plain	60	52	ECE 225 1/0	ECG 150 1/0	3.62	123	4.2	0.10	195	210
2166	Plain	60	38	ECE 225 1/0	ECG 75 1/0	4.80	163	6.0	0.15	185	300
2313	Plain	60	64	ECE 225 1/0	ECD 450 1/0	2.40	81	3.0	0.08	220	120
2523	Plain	28	20	ECH 25 1/0	ECH 25 1/0	11.47	389	13.0	0.33	525	375
2532 ●	Plain	16	14	ECH 25 1/0	ECH 25 1/0	6.89	234	10.0	0.25	300	280
3070	Plain	70	70	ECDE 300 1/0	ECDE 300 1/0	2.74	93	3.4	0.09	180	160
3313	Plain	61	62	ECDE 300 1/0	ECDE 300 1/0	2.43	82	3.2	0.08	170	154

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd^2)	(g/m^2)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
3434	5H Satin	34	34	ECG 37 1/0	ECG 37 1/0	10.77	365	10.9	0.28	550	550
3582	8H Satin	60	56	ECG 50 1/0	ECG 50 1/0	13.70	465	14.4	0.37	700	600
3731	Plain	17	15	ECG 37 1/0	ECG 37 1/0	5.21	177	5.5	0.14	350	300
3733 ⬣	Plain	18	17	ECG 37 1/0	ECG 37 1/0	5.80	197	8.0	0.20	350	350
3734	Plain	16	11	ECG 37 1/2	ECG 37 1/3	10.38	352	14.4	0.37	393	400
3743	4H Satin	48	30	ECG 37 1/0	ECE 225 1/0	8.45	287	8.0	0.20	600	90
3780	Plain	22	16	ECG 37 1/0	ECG 75 1/2	5.93	201	7.9	0.20	300	250
3783	8H Satin	54	48	ECG 37 1/0	ECG 37 1/0	16.08	546	15.7	0.40	750	560
3784	8H Satin	44	35	ECG 37 1/2	ECG 37 1/2	25.79	874	24.2	0.61	1150	925
3788	12H Satin	42	36	ECG 37 1/4	ECG 37 1/4	52.30	1773	48.7	1.24	1900	1600
3884	8H Satin	46	36	ECDE 37 1/2	ECDE 37 1/2	27.00	915	26.0	0.66	950	800
4180	8H Satin	80	100	SCD 450 1/0	SCD 450 1/0	2.41	82	3.0	0.08	180	200
4450	Plain	18	17	SCG 75 1/2 493	SCG 75 1/2 493	5.57	189	8.9	0.23	450	435
4522 ⬣	Plain	24	22	SCG 150 1/2	SCG 150 1/2	3.64	123	5.1	0.13	125	125

⬣ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Fiber Glass Fabrics (cont.)

Style		Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
							(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
4526		Basket 2x2	36	34	SCG 75 1/0 493	SCG 75 1/0 493	5.60	190	6.0	0.15	350	350
4527		Plain	24	22	SCG 75 1/0 493	SCG 75 1/0 493	3.70	125	4.0	0.10	300	300
4533	⬢	Plain	18	17	SCG 75 1/2	SCG 75 1/2	5.60	190	7.4	0.19	300	300
4579		Plain	30	16	SCG 150 1/2	SCG 75 1/0	3.59	122	5.4	0.14	300	300
4700	⬢	Plain	14	13	ECG 37 1/0	ECG 75 1/2	4.40	149	4.7	0.12	240	240
4797		Leno	28	14	ECG 75 1/0	ECG 75 1/2	4.63	157	7.4	0.19	168	172
4985		Plain	18	22	SCG 75 1/2	SCG 150 1/2	4.70	159	6.2	0.16	300	115
6060		Plain	60	60	ECDE 600 1/0	ECDE 600 1/0	1.19	40	1.9	0.05	75	75
6080		Plain	60	47	SCD 450 1/0	SCD 450 1/0	1.44	49	2.0	0.05	150	110
6543	⬢	4H Satin	48	30	SCG 75 1/2	ECE 225 1/0	8.50	288	9.1	0.23	700	90
6557		4H Satin	57	30	SCG 150 1/2	ECE 225 1/0	5.40	183	5.8	0.15	250	90
6580		8H Satin	72	72	SCG 150 1/0	SCG 150 1/0	5.60	190	5.6	0.15	350	300
66281HT		4H Satin	38	37	SCG 75 1/0 933	SCG 75 1/0 933	5.91	200	7	0.18	520	522
6725HT		2/2 Twill	57	57	SCG 75 1/0 933	SCG 75 1/0 933	9.02	306	9.6	0.24	660	650

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
6781 HT	8H Satin	57	57	SCG 75 1/0 933	SCG 75 1/0 933	9.02	306	9.6	0.24	660	650
7255	Plain	37	37	ECG 75 1/0	ECG 75 1/0	6.00	203	7.0	0.18	300	300
7500 ⬢	Plain	16	14	ECG 37 1/2	ECG 37 1/2	9.41	319	11.8	0.30	420	400
7520 ⬢	Plain	18	17	ECG 75 1/3	ECG 75 1/3	8.37	284	11.4	0.29	330	310
7532 ⬢	Plain	16	14	ECG 75 1/3	ECG 75 1/3	7.25	246	10.0	0.25	300	280
7533 ⬢	Plain	18	17	ECG 75 1/2	ECG 75 1/2	5.63	191	7.3	0.20	250	250
7544 ⬢	2 End Plain	28	14	ECG 37 1/2	ECG 37 1/4	18.00	612	19.1	0.49	700	700
7547	8H Satin	54	46	ECG 75 1/2	ECG 75 1/2	16.24	551	15.5	0.39	815	600
7562	Plain	30	18	ECG 75 1/3	ECG 75 1/3	11.58	393	12.5	0.32	615	375
7579	Plain	26	20	ECG 75 1/0	ECG 150 1/2	3.61	122	5.2	0.13	200	125
7580 ⬢	Plain	24	14	ECG 75 1/2	ECG 37 1/0	6.20	210	7.8	0.20	300	200
7581	8H Satin	57	54	ECG 75 1/0	ECG 75 1/0	8.94	303	9.0	0.23	460	460
7587	Mock Leno	40	21	ECG 37 1/2	ECG 37 1/2	19.70	668	27.2	0.69	750	450

⬢ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Fiber Glass Fabrics (cont.)

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd²)	(g/m²)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
7594	Triple Plain	48	24	ECG 37 1/2	ECG 150 1/2	17.83	605	16.5	0.42	1070	150
7597 ⬢	Double Satin	30	30	ECG 37 1/4	ECG 37 1/4	38.00	1289	40.2	1.02	1000	1100
7624	Plain	44	24	ECG 75 1/0	ECG 75 1/0	5.50	186	6.9	0.16	325	175
7626	Plain	34	32	ECG 75 1/0	ECG 75 1/0	5.40	183	6.0	0.15	225	260
7627	Plain	44	24	ECG 75 1/0	ECG 75 1/0	5.58	189	6.2	0.16	325	175
7628	Plain	44	31	ECG 75 1/0	ECG 75 1/0	6.09	206	6.8	0.17	350	260
7629	Plain	44	34	ECG 75 1/0	ECG 75 1/0	6.25	212	7.0	0.18	350	270
7630	Plain	31	30	ECG 75 1/0	ECG 75 1/0	4.83	164	5.5	0.15	230	230
7635	Plain	44	29	ECG 75 1/0	ECG 50 1/0	7.09	240	8.5	0.22	350	400
7637	Plain	44	23	ECG 75 1/0	ECG 37 1/0	7.08	240	9.6	0.24	350	470
7642	Plain	44	20	ECG 75 1/0	ECG 37 1/0 Tex	6.84	232	11.0	0.28	350	170
7645	8H Satin	46	42	ECG 75 1/2	ECG 75 1/2	14.31	485	13.4	0.34	600	525
7652	Plain	32	32	ECG 50 1/0	ECG 50 1/0	7.50	254	8.3	0.21	400	400

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness		Strength	
						(oz/yd^2)	(g/m^2)	(mils)	(mm)	W(lbf/in)	F(lbf/in)
7715 ⬢	Modified Plain	82	18	ECG 75 1/0	ECG 150 1/0	7.30	248	7.7	0.20	650	70
7725 ⬢	2/2 Twill	54	18	ECG 75 1/0	ECH 25 1/0	8.80	298	9.3	0.24	440	360
7781 ⬢	8H Satin	57	54	ECDE 75 1/0	ECDE 75 1/0	8.81	299	8.6	0.22	570	450
8700	4H Fancy Leno	16(8)	8	ECG 150 1/0-ECG 371/2	ECG 37 1/2	5.46	185	14	0.35	60	70
8800 ⬢	4H Fancy Leno	17(8)	8	ECG 150 1/0-ECG 37 1/3	ECG 37 1/3	8.23	279	17.8	0.45	425	450
76290	Plain	44	31	ECG 75 1/0	ECG 67 1/0	6.27	213	7.0	0.18	350	350

⬢ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Glass Fabric Weight Index

Style	Weight		Style	Weight		Style	Weight		Style	Weight	
	(oz/yd²)	(g/m²)		(oz/yd²)	(g/m²)		(oz/yd²)	(g/m²)		(oz/yd²)	(g/m²)
104	0.57	19	1609	1.48	50	4180	2.41	82	120	3.16	107
1071	0.60	20	1620	1.58	54	1611	2.42	82	1692	3.18	108
993	0.71	24	1658	1.60	54	3313	2.43	82	1678	3.20	108
106	0.73	25	1659	1.60	54	1669	2.50	85	220	3.22	109
1037	0.73	25	1280/1086	1.60	54	1636	2.60	88	1520	3.52	119
1297	0.81	27	1562	1.82	62	2125	2.60	88	1694	3.54	120
1067	0.91	31	112	2.10	71	1125	2.65	90	1695	3.59	122
1299	0.92	31	2112	2.10	71	1628	2.69	91	4579	3.59	122
1076	0.96	33	1608	2.22	75	2114	2.69	91	7579	3.61	122
1070	1.05	36	1614	2.33	79	3070	2.74	93	2165	3.62	123
6060	1.19	40	2113	2.34	79	1674	2.85	97	4522	3.64	123
1080	1.41	48	1610	2.37	80	1675	2.85	98	1131	3.65	124
108	1.43	48	117	2.40	81	2116	3.12	106	1522	3.67	124
6080	1.44	49	2313	2.40	81	116	3.16	107	1579	3.68	125

Style	Weight		Style	Weight		Style	Weight		Style	Weight	
	(oz/yd²)	(g/m²)		(oz/yd²)	(g/m²)		(oz/yd²)	(g/m²)		(oz/yd²)	(g/m²)
1165	3.70	125	7630	4.83	164	6580	5.60	190	2532	6.89	234
4527	3.70	125	1500	4.95	168	7533	5.63	191	7637	7.08	240
1632	3.75	127	1501	4.95	168	1680	5.70	193	7635	7.09	240
1167	3.77	128	3731	5.21	177	1035	5.7	193	7532	7.25	246
1161	3.85	131	1557	5.26	178	3733	5.80	197	7715	7.30	248
1676	4.10	139	1526	5.30	180	3780	5.93	201	7652	7.50	254
477	4.11	139	6557	5.40	183	7255	6.00	203	1568	7.97	270
1652	4.15	141	7626	5.40	183	1528	6.03	204	8800	8.23	279
2157	4.32	146	1047	5.44	184	7628	6.09	206	1142	8.37	284
4700	4.40	149	7624	5.50	186	7580	6.20	210	7520	8.37	284
1064	4.62	157	4450	5.57	189	7629	6.25	212	403	8.40	285
4797	4.63	157	7627	5.58	189	76290	6.27	213	3743	8.45	287
4985	4.70	159	4526	5.60	190	138	6.54	222	1311	8.48	288
2166	4.80	163	4533	5.60	190	7642	6.84	232	6543	8.50	288

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Glass Fabric Weight

Style	Weight (oz/yd²)	Weight (g/m²)	Style	Weight (oz/yd²)	Weight (g/m²)	Style	Weight (oz/yd²)	Weight (g/m²)	Style	Weight (oz/yd²)	Weight (g/m²)
341	8.64	293	3734	10.38	352	8000	13.09	444	3784	25.79	874
1543	8.69	295	1576	10.60	359	1530	13.20	448	1584	26.00	882
520	8.70	295	3434	10.77	365	1582	13.63	462	1938	26.80	909
6581	8.75	297	2523	11.47	389	3582	13.70	465	3884	27.00	915
1581	8.79	298	1523	11.50	392	7645	14.31	485	7597	38.00	1289
7725	8.80	298	7562	11.58	393	3783	16.08	546	1597	38.57	1308
7781	8.81	299	162	12.00	407	7547	16.24	551	3788	52.30	1773
6781	8.92	302	1188	12.00	407	1583	16.52	560	8700	5.46	185
7581	8.94	303	1527	12.15	412	2025	17.05	578	66281 HT	5.91	200
6781 HT	9.02	306	1564	12.40	420	7594	17.83	605			
1800	9.33	316	232	12.75	432	7544	18.00	612			
7500	9.41	319	332	12.75	432	7587	19.70	668			
1507	10.30	349	333	13.00	441	1884	25.40	861			

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Glass Fabric Thickness Index

Style	Thickness		Style	Thickness		Style	Thickness		Style	Thickness	
	(mils)	(mm)		(mils)	(mm)		(mils)	(mm)		(mils)	(mm)
104	1.1	0.03	332	14.0	0.36	1067	1.3	0.03	1188	12.0	0.30
106	1.5	0.04	333	14.0	0.36	1070	2.0	0.05	1297	2.0	0.05
108	2.5	0.06	341	8.2	0.21	1071	1.2	0.03	1299	2.2	0.06
112	3.2	0.08	403	8.9	0.23	1076	1.8	0.05	1311	9.7	0.25
116	3.8	0.10	477	4.7	0.12	1080	2.2	0.06	1500	5.3	0.13
117	2.6	0.07	520	9.1	0.23	1125	3.6	0.09	1501	5.3	0.14
120	3.5	0.09	993	1.2	0.03	1131	5.0	0.13	1507	25.0	0.64
138	7.0	0.18	1035	7.1	0.18	1142	10.3	0.26	1520	4.3	0.11
162	13.8	0.35	1037	1.3	0.03	1161	5.0	0.12	1522	5.3	0.12
220	3.5	0.09	1047	5.6	0.14	1165	4.2	0.11	1523	13.6	0.35
232	14.0	0.36	1064	5.7	0.14	1167	4.2	0.11	1526	6.2	0.15

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Glass Fabric Thickness Index (cont.)

Style	Thickness		Style	Thickness		Style	Thickness		Style	Thickness	
	(mils)	(mm)		(mils)	(mm)		(mils)	(mm)		(mils)	(mm)
1527	14.3	0.36	1597	37.8	0.96	1674	4.0	0.10	2114	3.3	0.08
1528	7.0	0.18	1608	3.5	0.09	1675	4.3	0.11	2116	3.5	0.10
1530	15.0	0.38	1609	2.6	0.07	1676	4.8	0.12	2125	3.5	0.09
1543	7.8	0.20	1610	4.0	0.10	1678	4.3	0.11	2157	5.9	0.15
1557	5.5	0.14	1611	4.0	0.10	1680	6.1	0.15	2165	4.2	0.10
1562	4.5	0.11	1614	5.0	0.13	1692	5.2	0.12	2166	6.0	0.15
1564	15.0	0.38	1620	3.2	0.08	1694	5.1	0.12	2313	3.0	0.08
1568	16.5	0.42	1628	3.4	0.09	1695	5.4	0.14	2523	13.0	0.33
1576	11.1	0.28	1632	4.7	0.12	1800	11.1	0.28	2532	10.0	0.25
1579	4.5	0.11	1636	4.0	0.09	1884	26.0	0.66	3070	3.4	0.09
1581	8.5	0.22	1652	4.5	0.11	1938	26.6	0.68	3313	3.2	0.08
1582	12.7	0.32	1658	4.0	0.10	2025	26.2	0.67	3434	10.9	0.28
1583	16.2	0.41	1659	4.2	0.11	2112	3.0	0.08	3582	14.4	0.37
1584	24.6	0.62	1669	3.2	0.09	2113	2.8	0.07	3731	5.5	0.14

Style	Thickness		Style	Thickness		Style	Thickness		Style	Thickness	
	(mils)	(mm)		(mils)	(mm)		(mils)	(mm)		(mils)	(mm)
3733	8.0	0.20	4533	7.4	0.19	7500	11.8	0.30	7624	6.9	0.16
3734	14.4	0.37	4579	5.4	0.14	7520	11.4	0.29	7626	6.0	0.15
3743	8.0	0.20	4700	4.7	0.12	7532	10.0	0.25	7627	6.2	0.16
3780	7.9	0.20	4797	7.4	0.19	7533	7.3	0.20	7628	6.8	0.17
3783	15.7	0.40	4985	6.2	0.16	7544	19.1	0.49	7629	7.0	0.18
3784	24.2	0.61	6060	1.9	0.05	7547	15.5	0.39	7630	5.5	0.15
3788	48.7	1.24	6080	2.0	0.05	7562	12.5	0.32	7635	8.5	0.22
3884	26.0	0.66	6543	9.1	0.23	7579	5.2	0.13	7637	9.6	0.24
4180	3.0	0.08	6557	5.8	0.15	7580	7.8	0.20	7642	11.0	0.28
4450	8.9	0.23	6580	5.6	0.15	7581	9.0	0.23	7645	13.4	0.34
4522	5.1	0.13	6581	10.4	0.26	7587	27.2	0.69	7652	8.3	0.21
4526	6.0	0.15	6781	9.5	0.24	7594	16.5	0.42	7715	7.7	0.20
4527	4.0	0.10	7255	7.0	0.18	7597	40.2	1.02	7725	9.3	0.24

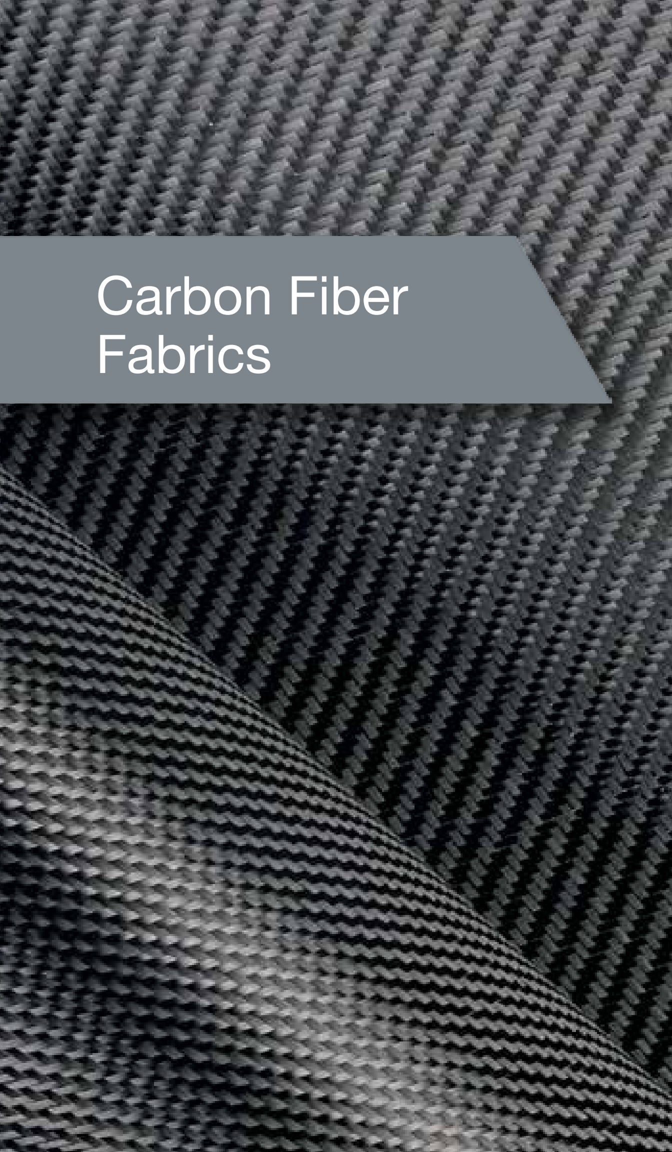
The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Glass Fabric Thickness Index (cont.)

Style	Thickness		Style	Thickness	
	(mils)	(mm)		(mils)	(mm)
7781	8.6	0.22	76290	7.0	0.18
8000	11.9	0.30	1280/1086	2.4	0.06
8700	14	0.36	6725HT	9.6	0.24
8800	17.8	0.45	6781 HT	9.6	0.24
66281	7	0.18			

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Carbon Fiber Fabrics



Carbon Fabrics Overview

Hexcel manufactures the most complete line of carbon fabrics and specialty reinforcements for the composite industry and offers a thorough line of globally certified aerospace products.

Carbon fiber reinforcements, when properly engineered into the appropriate matrix, can achieve one of the strongest and most rigid composite structures available with significant weight savings when compared to metals and other materials.

In addition to the high strength-to-weight ratio, carbon fiber reinforcements are thermally and electrically conductive, have very low CTE and excellent fatigue resistance.

Hexcel Corporation can provide users with a wide variety of commercially available fabrics and specialty reinforcements with different ranges of tensile strength, modulus, and thermal/electrical conductivities.

Our fabric product line includes traditional 0/90 fabrics, +/-45 degree fabrics, flat-tow 12K fabrics, heat-set uni-directional fabrics, multi layered stitch bonded fabrics, lightning strike (LS) fabrics, double-weave fabrics, and hybrid (multiple fibers) fabrics woven with standard modulus or IM fibers. Many of these fabrics are qualified to major aerospace programs with listings on specifications such as BMS9-8, BMS9-17, 5PTMCT01, LMAC001, etc. and are available with our enhanced surface treatments such as PrimeTex® ZB and FDS™.

Our Specialty Reinforcements product line includes a number of different technologies that produce an endless variety of carbon-reinforced designs for preform products and your composite needs. (See “Specialty Reinforcements Materials” in this section)

Hexcel’s staff, with expertise in the areas of textile development, finishing technology, resin chemistry, composite technology, and applications engineering, is readily available to investigate development requirements for engineered fabrics, coated fabrics, and specialty composite-reinforced structures.

Often a process is limited by the use of “off-the-shelf” textile reinforcements. Hexcel offers the development consultation services required to best tailor the textile component to the final product. Throughout Hexcel’s history our product development staff has worked closely with our customers to create innovative solutions to unique requirements. For Technical questions, dial (830) 401-8180.

Carbon Fabrics Applications

Aerospace
A world leader in carbon fiber and composite materials for commercial and defense aircraft, helicopters, engines, satellites and launchers, Hexcel is also a specialist in lightweight composite components. Hexcel has the greatest number of aerospace qualified products of any composite materials manufacturer worldwide.

Hexcel's carbon fiber reinforcements are widely qualified by all major aircraft manufacturers - in both dry and prepreg form. These fabrics use fibers that are produced under stringently controlled conditions, extensive testing and documentation.

Hexcel's unique capability to weave carbon on a 45 degree bias helps our customers reduce scrap.

Space and Defense
Hexcel is currently qualified to supply materials to a broad range of over 100 military aircraft and rotorcraft programs.

Automotive
As an innovator in advanced composites, Hexcel supplies design-enabling technologies to high performance car manufacturers. Hexcel's PrimeTex® patented technology has recently added a new dimension to the visual quality of interior features.

Beyond performance, Hexcel is adapting high quality composite materials to respond to the future demands of the fast evolving automotive industry in other ways. With an increasing focus on energy saving and reducing CO2 emissions, the opportunities for weight-saving and reducing fuel consumption by using composites are in the spotlight. In addition to saving weight, Hexcel materials offer possibilities for enhanced safety features, by integrating safety functions - or completely redesigning the vehicle structure - while complying with the manufacturers expectations for efficient production processes.

Recreation
Hexcel's leading edge technology and advanced structural materials have played a key role in the evolution of sports and recreation equipment, providing lightness, stiffness and strength. From performance bikes to tennis racquets, golf shafts, fishing rods and surfboards, Hexcel is proud to supply the "top of the range" with cutting edge materials that provide amateurs and professionals with the performance edge.

Hexcel's involvement in sports equipment began back in 1971 when the company brought a number of materials and technologies together to produce the Hexcel brand of snow skis. The fast lightweight durable skis quickly became a status symbol on slopes the world over. Hexcel no longer manufactures skis, but we are "the strength within" all leading brands of skis and snowboards on the market today. Other winter sports applications include ice hockey sticks and bobsleighs.

Carbon Fabrics Nomenclature

Carbon fabrics from Hexcel have a specific nomenclature which enables us to know the fiber used and the weave style as well as any tracers, tracer fiber and the tracer spacing if in the fabric. This nomenclature is referred to as the “description” on our fabric label that is placed on each box of carbon fabric. Here are some examples of the nomenclature for the US and Europe:

US EXAMPLES:

SGP203CSDL means:

S = IM7 Type Fabric
GP = GP sizing
203 = 203 gsm fabric
CS = Crowfoot Satin (4 Harness Satin Weave)
D = SCG 75 1/0 0.7z 933
L = Tracer yarn every 12” in warp, 6” in fill

F3B282(GP) means:

F = Fabric
3B = 3K AS4C
28 2= Style 282 (193 gsm)
(GP) = GP sizing
(This style has no tracers)

AGP280-5HAB means:

A = AS4 Type Fabric
GP = GP sizing
280 = 280 gsm fabric
5H = 5 Harness Satin Weave
A =195d. 1.7s t.965 Kevlar®
B = Tracer yarn every 3” in warp, none in fill

For items outside of these examples, contact technical services.

EUROPEAN EXAMPLES:

48193S-P means:

4 = Carbon
8 = 12K
193 = Weight of fabric in gsm
S = 12K AS4CGP FLAT TOW
P = Plain

48370S-2T means:

4 = Carbon
8 = 12K
370 = Weight of fabric in gsm
S = 12K AS4CGP FLAT TOW
2T = 2/2 Twill

43193 S 1070 TCT means:

4 = Carbon
3 = 3K
193 = Weight of fabric in gsm
S = 3K AS4 GP
1070 = 1070mm width
T = Tracers
C = Tracers in warp
T = Tracers in fill

PAN Carbon Fibers Data

Producer	Fiber Name	Availability (filaments/tow)	Tensile Strength (ksi)	Tensile Modulus (Msi)	Strain (%)	Density (g/cm^3)
Hexcel	AS4	3K, 6K, 12K	638-650	33.5	1.80	1.79
	AS4C	3K, 6K, 12K	640-674	33.5	1.80	1.78
	AS4D	12K	696	35.5	1.80	1.79
	AS7	12K	700	35.0	1.80	1.79
	IM2	12K	800	40	1.8	1.78
	IM6	12K	827	40.5	1.90	1.76
	IM7	6K, 12K	795-808	40.0	1.8-1.9	1.78
	IM9	12K	890	44.0	1.90	1.80
	IM10	12K	1010	45	2	1.79
	HM63	12K	680	64	1	1.83
Solvay	T300	1K, 3K, 6K, 12K	545	33.5	1.40	1.76
	T650/35	3K, 6K, 12K	620	37.0	1.70	1.77

Producer	Fiber Name	Availability (filaments/tow)	Tensile Strength (ksi)	Tensile Modulus (Msi)	Strain (%)	Density (g/cm^3)
Toray	T300	1K, 3K, 6K, 12K	512	33.4	1.50	1.76
	T600	24K	600	33.4	1.80	1.79
	T700	6K, 12K, 24K	711	33.4	2.10	1.79
	T800	6K, 12K	796	42.7	1.90	1.81
Toho Tenax	HTA40	3K	570	34.0	1.68	1.77
	HTA40	6K H13/E13	570/620	34.0	1.65/1.85	1.76/1.75
	HTA40	12K H13/E13	570/620	34.0	1.65/1.85	1.76/1.75
	UTS50	12K, 24K	700/740	35.0	2.00/2.10	1.78/1.79
	IMS60	24K	810	42.0	1.95	1.79
	HMA35	12K	480	52.0	0.92	1.78
	HTA40	3K	570	34.5	1.7	1.76
	HTS40	12K, 24K	625	34.5	1.8	1.76
	STS40	24K	590	34.9	1.7	1.75

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Fiber Carbon Fabric Technical Data

Aerospace Carbon Fabric Construction Data

Style		Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness	
							(oz/yd^2)	(g/m^2)	(mils)	(mm)
ACGP124-P-ZB	⬢	Plain	8	8	AS4CGP 3K	AS4CGP 3K	3.65	124	5	0.13
AGP185-P		Plain	11	11	AS4GP 3K	AS4GP 3K	5.4	185	9.4	0.24
AGP193-P	⬢	Plain	11.5	11.5	AS4GP 3K	AS4GP 3K	5.70	193	8.5	0.22
AGP280-5H		5H Satin	17	17	AS4GP 3K	AS4GP 3K	8.40	285	12.7	0.32
AGP370-5H	⬢	5H Satin	11	11	AS4GP 6K	AS4GP 6K	11.10	376	16.6	0.42
AGP370-8H	⬢	8H Satin	22	23	AS4GP 3K	AS4GP 3K	11.00	373	16.5	0.42
SGP145-P-ZB		Plain	8.2	8.2	IM7GP 6K	IM7GP 6K	3.65	145	6.4	0.16
SGP193-P	⬢	Plain	11	11	IM7GP 6K	IM7GP 6K	5.70	193	8.5	0.22
SGP196-P	⬢	Plain	11	11	IM7GP 6K	IM7GP 6K	5.80	196	8.6	0.22
SGP203-CS		4H Satin	11.5	11.5	IM7GP 6K	IM7GP 6K	6.00	203	9.0	0.23
F3T245		2/2 Twill	15.7	15.7	T300 3K	T300 3K	7.20	245	11.0	0.28
RGP175-P-ZB	⬢	Plain	5	5	IM2C 12K	12MC 12K	5.16	175	8.3	0.21
F3A282		Plain	12.5	12.5	AS4GP 3K	AS4GP 3k	5.80	195	8.7	0.22
F3C282		Plain	12.5	12.5	HTA40 3K	HTA40 3K	5.80	195	8.7	0.22

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness	
						(oz/yd^2)	(g/m^2)	(mils)	(mm)
F3G282	Plain	12.5	12.5	T300 3K	T300 3K	5.80	195	8.7	0.22
F3GR282 ⬢	Plain	12.5	12.5	T300 3K	T300 3K	5.80	195	8.7	0.22
F3T282	Plain	12.5	12.5	T300 3K	T300 3K	5.80	195	8.7	0.22
F4G282	Plain	12.5	12.5	T650 3K	T650 3K	5.80	195	8.7	0.22
F4M282	Plain	12.5	12.5	IM7GP 6K	IM7GP 6K	5.80	195	8.7	0.22
F3C433 ⬢	5H Satin	18	18	HTA40 3K	HTA40 3K	8.40	285	12.6	0.32
F4G433	5H Satin	18	18	T650 3K	T650 3K	8.40	285	12.6	0.32
F4M466	5H Satin	16	16	IM7GP 6K	IM7GP 6K	8.40	285	12.6	0.32
F3C584	8H Satin	24	24	HTA40 3K	HTA40 3K	11.00	373	16.5	0.42
F3G584	8H Satin	24	24	T300 3K	T300 3K	11.00	373	16.5	0.42
F3GR584 ⬢	8H Satin	24	24	T300 3K	T300 3K	11.00	373	16.5	0.42
F3T584	8H Satin	24	24	T300 3K	T300 3K	11.00	373	16.5	0.42
F4G584	8H Satin	24	24	T650 3K	T650 3K	11.00	373	16.5	0.42
XC1400	±45° 4H Satin	12	12	IM7GP 6K	IM7GP 6K	6.00	203	9.0	0.23

⬢ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Aerospace Carbon Fabric Construction Data (cont.)

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness	
						(oz/yd^2)	(g/m^2)	(mils)	(mm)
X8T196	±45° Plain	11.2	11.2	T800H 6K	T800H 6K	5.80	196	8.6	0.22
282X	±45° Plain	12	12	3K Carbon, 33MSI	3K Carbon, 33MSI	5.80	195	8.7	0.22
XSGP196-P ⬣	±45° Plain	11	11	IM7GP 6K	IM7GP 6K	5.88	196	8.6	0.22
HMGP200-P-ZB ⬣	Plain	6	6	HM63 GP 12K	HM63 GP12K	5.89	200	9	0.23
TGP196-P-ZB	Plain	7.5	7.5	IM10GP 12k	IM10GP 12K	5.8	196	8.1	0.2

⬣ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Industrial Carbon Fabric Construction Data

Style		Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness	
							(oz/yd²)	(g/m²)	(mils)	(mm)
84		Plain	16	16	1K Carbon, 33MSI	1K Carbon, 33MSI	2.48	84	5.3	0.13
130		Plain	24	24	1K Carbon, 33MSI	1K Carbon, 33MSI	3.74	127	5.6	0.14
160		Plain	12	12	3K Carbon, 33MSI	1K Carbon, 33MSI	3.92	133	5.9	0.15
262		Plain	12	8	3K Carbon, 33MSI	3K Carbon, 33MSI	4.79	163	7.3	0.19
282	⬣	Plain	12	12	3K Carbon, 33MSI	3K Carbon, 33MSI	5.80	195	8.7	0.22
284	⬣	2/2 Twill	12	12	3K Carbon, 33MSI	3K Carbon, 33MSI	5.80	197	8.7	0.22
286	⬣	4H Satin	12	12	3K Carbon, 33MSI	3K Carbon, 33MSI	5.80	197	8.7	0.22
433	⬣	5H Satin	18	18	3K Carbon, 33MSI	3K Carbon, 33MSI	8.40	285	12.6	0.32
444		2/2 Twill	18	18	3K Carbon, 33MSI	3K Carbon, 33MSI	8.40	285	12.6	0.32
463		2/2 Twill	9	9	6K Carbon, 33MSI	6K Carbon, 33MSI	8.40	285	12.6	0.32
584	⬣	8H Satin	24	24	3K Carbon, 33MSI	3K Carbon, 33MSI	11.00	373	16.5	0.42

⬣ Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Industrial Carbon Fabric Construction Data (cont.)

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness	
						(oz/yd²)	(g/m²)	(mils)	(mm)
613	5H Satin	12	12	6K Carbon, 33MSI	6K Carbon, 33MSI	11.10	376	16.6	0.42
670 ⬣	2/2 Twill	11	11	12K Carbon, 33MSI	12K Carbon, 33MSI	19.80	671	29.7	0.75
690	Basket 2X2	10	10	12K Carbon, 33MSI	12K Carbon, 33MSI	18.70	634	28.0	0.71
48193	Plain	3	3	12KCarbon, 33MSI	12KCarbon, 33MSI	5.70	193		
48280	Plain	4	4	12KCarbon, 33MSI	12KCarbon, 33MSI	8.26	280		
48350	Plain	5	5	12KCarbon, 33MSI	12KCarbon, 33MSI	10.20	350		

⬣ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Industrial Carbon Fabric Construction Data (cont.)

Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness	
						(oz/yd²)	(g/m²)	(mils)	(mm)
Hybrid Composite Fabrics non US									
716	Plain	16	16	3K Carbon, 30 MSI	ECG 75 1/0	5.00	170	7.0	0.18
717	Plain	16	16	3K Carbon, 30 MSI	SCG 75 1/0	5.00	170	7.0	0.18
790	Plain	12.5	13	3K Carbon, 30 MSI	Kevlar® 49, 2160 d.	6.60	224	12.1	0.31
1168	2/2 Twill	7.25	7.25	3K Carbon, 30 MSI	3K Carbon, 30 MSI	7.40	251	12.5	0.32
		7.25	7.25	Kevlar® 49, 2160 d.	Kevlar® 49, 2160 d.				
1119	Plain	20	22	SCG 150 1/2	SCG 150 1/2	3.70	125	4.2	0.11
		4		1K Carbon, 33MSI					
1320	Modified Plain	12.5	25	ECG 37 1/0x2	ECG 37 1/0x2	7.30	247	8.3	0.21
		6.25		3K Carbon, 30 MSI					

● *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

Heatset Uni Construction Data

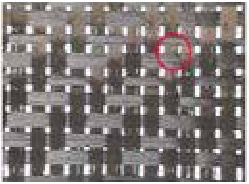
Style	Weave	Count Warp	Count Fill	Warp Yarn	Fill Yarn	Weight		Thickness	
						(oz/yd^2)	(g/m^2)	(mils)	(mm)
GA030	Plain Heatset	13	4	3K Carbon, 33MSI	Proprietary	3.30	112	5.0	0.13
GA045 ⬢	Plain Heatset	9.5	4	6K Carbon, 33MSI	Proprietary	4.40	149	6.7	0.17
GA060 ⬢	Plain Heatset	6.5	4	6K Carbon, 33MSI	Proprietary	6.70	227	10.1	0.26
GA090 ⬢	Plain Heatset	9.5	4	6K Carbon, 33MSI	Proprietary	8.90	302	13.4	0.34
GA130	Plain Heatset	14	4	12K Carbon, 33MSI	Proprietary	13.60	461	19.9	0.51
RGS045	Plain Heatset	8	4	12K Carbon, 40MSI	Proprietary	4.7	160	8.5	0.22
RGS090	Plain Heatset	16..5	4	12K Carbon, 40MSI	Proprietary	9.5	322	12.9	0.33

⬢ *Denotes common styles which are standard stock The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.*

PrimeTex® Reinforcements

PrimeTex® reinforcements are a range of carbon fabrics which have been processed for a smooth, closed weave and uniform cosmetic appearance. The fiber tows are spread in both the warp and weft direction for unique aesthetic appeal. PrimeTex® fabrics are more uniform as the filaments in each tow are spread out creating a thinner and more closely woven fabric that provides better mechanicals and less porosity in a composite. It can also be used to lower the mass in a composite where lighter weight is the key characteristic. This technology allows a nearly infinite range of light weight fabrics, down to 75 gsm (with 3K fiber) with the same or better closure than standard 3K 193 gsm fabrics.

PrimeTex® Closure Comparison



HexForce® 193 gsm, Twill 2/2, HS12K
Open factor: 5%

PrimeTex® 193 gsm, Twill 2/2, HS12K
Open factor: 0.3%

Typical Applications

- Aircraft and helicopter sandwich structures and thin monolithic parts
- UAV/Light Aircraft market targeted by cost to weight
- Automotive structures
- Sports equipment (e.g. skis, hockey sticks, bikes, helmets)

HiMax™ Multiaxial Reinforcements

HiMax™ multiaxial reinforcements, also known as non-crimp fabrics (NCF), are multiple layers of unidirectional fibers, with each ply placed in a different orientation or axis. These layers are then typically stitchbonded to form a fabric. The range includes fabrics manufactured by Hexcel in Leicester, UK at the site that was formerly Formax and was acquired by Hexcel in 2016. Multiaxial reinforcements provide strength and stiffness in multiple directions depending on the controlled orientation of the fibers. The weight distribution in the fabric is optimized and it is possible to mix fiber types.

HiMax™ reinforcements offer several advantages over traditional fabric forms:

- The reinforcing fibers can be placed in different axis to optimize the performance of the finished laminate
- The avoidance of resin-rich areas means it is easy to achieve a higher weight fraction (wf)
- Non-crimped fibers give higher tensile and flexural properties in the finished laminate
- There is reduced print-through - especially important on boat hulls and automotive applications
- Fabrics are easier to cut and handle as the stitching holds the material together
- Heavier combinations are possible, meaning higher deposition rates
- The straight uncrimped fibers allow good resin penetration and flow which is ideal for infusion and light-RTM, while the stitching aids resin migration through the layers (Z-direction) which is perfect for maximizing infusion rates

For more information on HiMax™ products contact our Hexcel Reinforcements UK Ltd office in Leicester, UK.
Tel: +44(0) 1162 752 200 - Email: HRUK@hexcel.com

FDS™ (Fabric De-Size) Process

Carbon fibers are typically produced with a sizing (binder) on them which aids in processing the fibers later with less broken filaments. In some markets and for some resin systems, it is preferred not to have this chemistry on the carbon fiber surface. Hexcel has developed a proprietary de-sizing process to remove this chemical from the carbon fiber surface. Please contact a Technical Service Representative at (830) 401-8180 if you need information on a style.

Dry Uni-Directional Material

Hexcel's unidirectional reinforcements are non-woven carbon fabrics that have 99% of the areal weight in the 0 direction and are stabilized by a thin proprietary warp thread. These fabrics are ideal as a wet lay-up or resin infusion alternative to unidirectional prepreg tapes. Hexcel produces carbon unidirectional reinforcements in an areal weight range of 156 to 1200 gsm.

Bias Weave Process

Hexcel has developed a patented bias weave process to manufacture continuous rolls of carbon fiber fabric in which the warp and weft yarns are oriented on the bias at +/- 45° in standard plain or crow foot satin weaves.

Benefits

- Reduced prepreg waste (up to 60% savings)
- Prepregged fabrics can be slit to an optimum width for automated manufacturing
- Kitting waste from cutting of standard 0/90° to +/- 45° is eliminated
- Reduced labor
- Pattern cutting and lay-up is simplified
- Increased design allowables as the warp and fill will have the same properties due to an equal amount of crimp (unlike standard 0/90 fabrics)
- Elimination of fabric or prepreg splices in parts
- This continuous fabric provides constant thickness along the length of the part by eliminating seams

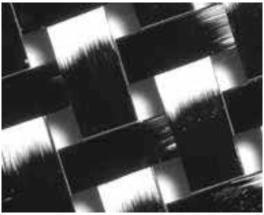
Typical Applications

Ideal for high aspect ratio parts that need bias reinforcement:

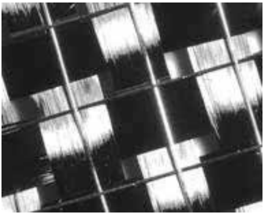
- Ribs, stringers, spars
- Helicopter blades
- Engine nacelles
- Secondary structures
- Barrel sections of aircraft

Conductive Reinforcements for Lightning Strike

Hexcel has carbon fabrics with interwoven wires for lightning strike applications where both structural integrity and lightning protection are required in a single ply. Standard plain weave designs are available (IWWF) where the wire is woven inside the weave next to an adjacent carbon tow, as well as the more elaborate pattern designs like our patented “double weave”, where the woven wire is 92 percent on the surface of the carbon weave.



Plain Weave
70 g wire interwoven
193 g 6K fabric



92% of wire positioned
on top of carbon

Conductive Reinforcements for Lightning Strike

Style	Weave	Warp Yarn(1)	Warp Yarn(2)	Fill Yarn(1)	Fill Yarn(2)	Construction	Total Fabric Weight
AGP193PBLS	Plain	AS4GP 3K	Phos/Bnz	AS4GP 3K	Phos/Bnz	11.5:11.5 X 11.5:11.5	260 g/m^2
XLS9101	Plain	T800HB 6K	Phos/Bnz	T800HB 6K	Phos/Bnz	11.2:11.2 x 11.2:11.2	260 g/m^2
XLS9102	Dbl Plain	T800HB 6K	Phos/Bnz	T800HB 6K	Phos/Bnz	11.2:11.2 x 11.2:11.2	260 g/m^2
XLS9103	Plain	IM7GP 6K	Phos/Bnz	IM7GP 6K	Phos/Bnz	11.2:11.2 x 11.2:11.2	260 g/m^2
XLS9104	Dbl Plain	IM7GP 6K	Phos/Bnz	IM7GP 6K	Phos/Bnz	11.2:11.2 x 11.2:11.2	260 g/m^2
XLS9113	Plain	T800HB 6K	NiCu	T800HB 6K	NiCu	11.2:11.2 x 11.2:11.2	260 g/m^2
XLS9114	Dbl Plain	T800HB 6K	NiCu	T800HB 6K	NiCu	11.2:11.2 x 11.2:11.2	260 g/m^2
XLS9123	Plain	AS4GP 3K	Phos/Bnz	AS4GP 3K	Phos/Bnz	11.5:11.5 x 11.5:11.5	260 g/m^2
TEF7	5H Satin	Thorstrand	ECG 150 1/0	Thorstrand	ECG 450 1/0	32:32 x 30:30	291 g/m^2

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Aramid Fiber Fabrics

Historic styles are included as reference only. Aramid fabrics are obsolete in US production, contact EU sales offices for more information on their aramid offerings.

Physical Properties of Aramid Fibers

Aramids – Kevlar®, Twaron®

High Strength

Aramid fibers are 43 percent lighter than fiber glass, with a density of 1.44 g/cc compared to 2.55 g/cc for fiber glass. Aramids are twice as strong as E-Glass, ten times as strong as aluminum and approach the strength of high strength carbon on a specific tensile strength basis.

Dimensional Stability

Aramids display excellent dimensional stability with a slightly negative coefficient of thermal expansion (-2.4 X 10-6/°C).

Chemical Resistance

Aramids resist chemicals with the exception of a few strong acids and alkalis.

Thermal Stability

Aramids display excellent stability over a wide range of temperatures for prolonged periods. They show essentially no embrittlement or strength loss at temperatures as low as -320ºF (-196ºC). Aramids do not melt or support combustion but will start to carbonize at approximately 800ºF (427ºC).

Applications of Aramid Fabrics

Aerospace
Hexcel manufactures aramid fabrics for use in aerospace applications. Aramid fabrics are used in aerospace ducting where low weight and strength are important. They are also used for secondary structures and containment cases where impact resistance is key.

Marine, Tooling and Recreational Products
Hexcel's aramid fabrics, exhibiting the properties of high strength and durability, are used in the recreational industry in a variety of applications ranging from boating to skiing. The market for recreational products is a dynamic market driven by strength, durability, clarity and cost. Hexcel's products are used in the manufacture of kayaks, boats, hydroplanes, canoes and a wide range of other recreational products where strength and low weight are essential.

Aramid Fibers Nomenclature

Aramid Fibers are typically designated by denier, tex or decitex (dtex). Each is described below.

Denier
The denier system is used internationally to measure the size of silk and synthetic filaments and yarns. Denier number indicates the weight in grams of 9,000 meters of filament or filament yarn. For example, if 9,000 meters of yarn weigh 100 grams, it is a 100-denier yarn. The smaller the denier number, the finer the yarn.

$$\text{Denier} = \text{dtex} \times 0.9$$

Tex
The tex system is also applicable to the measurement of filament yarns. It is based on the weight in grams of one kilometer 3,300 feet) of yarn. Decitex (dtex), is defined as ten times tex.

$$\text{Tex} = \text{dtex}/10 \quad \text{Dtex} = \text{Tex} \times 10 = \text{denier}/0.9$$

For example, 840 denier yarn may also be designated as 933 dtex.

Aramid Fabric Finishes

Hexcel Finish	Performance Features
CS-800/F100	Scour finish for Aramid fabric.

Aramid Fiber Technical Data

Historic styles are included as reference only. Aramid fabrics are obsolete in US production, contact EU sales offices for more information on their aramid offerings.

Aramid Fabric Styles

Discontinued - For Reference Only

Hexcel Style	AMS Style	Weave	Count		Warp Yarn	Fill Yarn	Weight		Thickness		Breaking Strength	
			Warp	Fill			(oz/yd^2)	(g/m^2)	(mils)	(mm)	(lbf/in)	(lbf/in)
328	328	Plain	17	17	Kevlar 49 1420 denier	Kevlar 49 1420 denier	6.4	217	12.0	0.30	700	750
345	124	4H Satin	34	34	Kevlar 49 195 denier	Kevlar 49 195 denier	1.7	58	3.0	0.08	210	210
348	181	8H Satin	50	50	Kevlar 49 380 denier	Kevlar 49 380 denier	4.9	166	8.7	0.22	660	650
350	120	Plain	34	34	Kevlar 49 195 denier	Kevlar 49 195 denier	1.7	58	3.0	0.08	260	260
351	220	Plain	22	22	Kevlar 49 380 denier	Kevlar 49 380 denier	2.2	75	4.0	0.10	294	298
352	281	Plain	17	17	Kevlar 49 1140 denier	Kevlar 49 1140 denier	5.1	173	9.3	0.24	624	643
353	285	Crowfoot	17	17	Kevlar 49 1140 denier	Kevlar 49 1140 denier	5.1	173	9.0	0.23	680	670
354		Plain	13	13	Kevlar 49 1420 denier	Kevlar 49 1420 denier	4.9	166	10.0	0.25	568	600
372		Twill 4x4	72	72	Kevlar 49 195 denier	Kevlar 49 195 denier	3.8	129	7.2	0.18	550	575

Hexcel Style	AMS Style	Weave	Count		Warp Yarn	Fill Yarn	Weight		Thickness		Breaking Strength	
			Warp	Fill			(oz/yd²)	(g/m²)	(mils)	(mm)	(lbf/in)	(lbf/in)
383		5H Satin	16	16	Kevlar 49 2160 denier	Kevlar 49 2160 denier	9.4	319	13.0	0.33	104	104
384	1050	Basket 4x4	28	28	Kevlar 49 1420 denier	Kevlar 49 1420 denier	10.7	363	19.0	0.48	1360	1300
386		Basket 4x4	27	22	Kevlar 49 2160 denier	Kevlar 49 2160 denier	13.6	461	25.0	0.64	1826	1473
388	1033	Basket 8x8	40	40	Kevlar 49 1420 denier	Kevlar 49 1420 denier	15.3	519	26.9	0.68	1830	1790
1629		Plain	14	14	Kevlar 100 1500 denier	Kevlar 100 1500 denier	5.2	176	10.3	0.26	775	785
5328	328	Plain	17	17	Twaron 2200 1580 dtex	Twaron 2200 1580 dtex	6.4	217	12.0	0.30	700	750
5348	181	8H Satin	50	50	Twaron 1055 405 dtex	Twaron 1055 405 dtex	4.9	166	8.0	0.20	660	650
5351	220	Plain	22	22	Twaron 1055 405 dtex	Twaron 1055 405 dtex	2.2	75	4.0	0.10	295	300
5352	281	Plain	17	17	Twaron 2200 1270 dtex	Twaron 2200 1270 dtex	5.0	170	10.0	0.25	624	643

Aramid Fabric Styles (cont.)

Discontinued - For Reference Only

Hexcel Style	AMS Style	Weave	Count		Warp Yarn	Fill Yarn	Weight		Thickness		Breaking Strength	
			Warp	Fill			(oz/yd²)	(g/m²)	(mils)	(mm)	(lbf/in)	(lbf/in)
5353	285	Crowfoot	17	17	Twaron 2200 1270 dtex	Twaron 2200 1270 dtex	5.0	170	9.0	0.23	623	635
5354		Plain	13	13	Twaron 2200 1580 dtex	Twaron 2200 1580 dtex	4.9	166	10.0	0.25	568	600

Reference Appendix

Technical Reference - US Standard

Fiber	Density (lb/in^3)	Tensile Strength (ksi)	Tensile Modulus (msi)	Strain to Failure (%)	Specific Tensile Strength (10^6 in)	Specific Tensile Modulus (10^8 in)	Coefficient of Thermal Expansion (10^{-6}/°F)	Decomposition Temperature (°F)
E-Glass	0.095	500	10.5	4	5.28	1.11	3.00	11346
S-2 Glass®	0.090	665	12.5	5.5	7.42	1.40	0.90	1562
Carbon Fiber Standard Modulus PAN	0.064	530	33.5	1.5	8.33	5.27	-0.33	6332
Carbon Fiber Intermediate Modulus PAN	0.064	770	42.3	1.8	11.97	6.58	-0.33	6332
Carbon Fiber High Modulus PAN	0.066	610	63.3	1	9.18	9.52	-0.61	6332
Carbon Fiber Low Modulus Pitch	0.070	230	27	0.8	3.30	3.87	-0.33	6332
Carbon Fiber High Modulus Pitch	0.077	380	92	0.4	4.96	12.01	-0.81	6332
Kevlar® 49 1420 denier	0.052	424	15.8	2.5	8.15	3.04	-1.50	842
Kevlar® 29 1500 denier	0.052	424	15.8	2.5	8.15	3.04	-1.50	842

Fiber	Density (lb/in^3)	Tensile Strength (ksi)	Tensile Modulus (msi)	Strain to Failure (%)	Specific Tensile Strength (10^6 in)	Specific Tensile Modulus (10^8 in)	Coefficient of Thermal Expansion (10^{-6}/°F)	Decomposition Temperature (°F)
Kevlar® 129 840 denier	0.02	479	13.6	3.3	9.21	2.61	-1.22	842
Kevlar® KM2 850 denier	0.052	497	10.8	3.5	9.55	2.08	-1.22	842
Kevlar® LT 400 denier	0.052	497	13.6	3.4	9.5	2.61	-1.22	842
Kevlar® KM2 600 denier	0.052	497	11.8	3.6	9.55	2.27	-1.22	842
Spectra® 900 650 denier	0.035	348	11.4	3.6	9.93	3.25	-	302
Spectra® 1000 375 denier	0.035	410	14.9	3.1	11.70	4.25	-	302
Spectra® 2000 195 denier	0.035	465	16.4	2.9	13.27	4.68	-	302
Twaron® 1000	0.052	507	9.4	3.7	9.74	1.81	-1.22	842
Twaron® 2000	0.052	479	12.9	3.3	9.21	2.50	-1.22	842
Twaron® HM	0.052	507	14.7	2.1	9.69	2.85	-1.33	842

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Technical Reference - Metric

Fiber	Density (g/cm^3)	Tensile Strength (MPa)	Tensile Modulus (GPa)	Strain to Failure (%)	Specific Tensile Strength (10^6 MPa)	Specific Tensile Modulus (10^8 GPa)	Coefficient of Thermal Expansion (10^{-6}/°C)	Decomposition Temperature (°C)
E-Glass	2.50	5600	72	4	13.42	2.82	1.6	730
S-2 Glass®	2.48	4800	85	5.5	18.86	3.55	0.48	850
Carbon Fiber Standard Modulus PAN	1.76	3657	231	1.5	21.18	13.38	-0.60	3500
Carbon Fiber Intermediate Modulus PAN	1.78	5313	292	1.8	30.42	16.71	-0..60	3500
Carbon Fiber High Modulus PAN	1.84	4209	347	1	23.31	24.19	-1.10	3500
Carbon Fiber Low Modulus Pitch	1.93	1587	186	0.8	8.38	9.84	0.60	3500
Carbon Fiber High Modulus Pitch	2.12	2622	635	0.4	12.60	30.52	-1.45	3500
Kevlar® 49 1420 denier	1.44	2926	109	2.5	20.71	7.72	-2.70	450
Kevlar® 29 1500 denier	1.44	2926	75	3.4	20.71	5.32	-2.20	450

Fiber	Density (g/cm^3)	Tensile Strength (MPa)	Tensile Modulus (GPa)	Strain to Failure (%)	Specific Tensile Strength (10^6 MPa)	Specific Tensile Modulus (10^8 GPa)	Coefficient of Thermal Expansion (10^{-6}/°C)	Decomposition Temperature (°C)
Kevlar® 129 840 denier	1.44	3305	94	3.3	23.39	6.64	-2.20	450
Kevlar® KM2 850 denier	1.44	3429	75	3.5	24.27	5.27	-2.20	450
Kevlar® LT 400 denier	1.44	3429	94	3.4	24.6	7.52	-2.20	450
Kevlar® KM2 600 denier	1.44	3429	81	3.6	24.27	5.75	-2.20	450
Spectra® 900 650 denier	0.97	2401	79	3.6	25.23	8.26	-	150
Spectra® 1000 375 denier	0.97	2829	103	3.1	29.72	10.80	-	150
Spectra® 2000 195 denier	0.97	3209	113	2.9	33.71	11.89	-	150
Twaron® 1000	1.44	3498	65	3.7	24.76	4.59	-2.20	450
Twaron® 2000	1.44	3305	90	3.3	23.39	6.35	-2.20	450
Twaron® HM	1.45	3498	103	2.1	24.59	7.23	-2.40	450

The physical properties listed are typical for greige (untreated) fabrics. Actual values may vary. For additional information, please contact a Technical Service Representative at 830-401-8180.

Specifications

AMS 3824
This specification covers the basic forms of finished glass fabrics used by themselves or as components of other materials.

AMS 3902
This specification covers cloth woven from high-modulus, continuous, multifilament aramid yarn.

AMS-C-9084
This specification replaces MIL-C-9084 and covers the requirement for glass fabrics that have been woven, cleaned and finished for further fabrication into glass fabric base resin laminates and sandwich materials.

ASTM-D-579
Standard specifications for Greige Woven Glass Fabrics. This specification includes the basic forms of greige woven glass fabrics and their testing.

ASTM-D-1668
This specification covers open mesh woven glass fabrics used for membrane waterproofing and built up roofing (Type II).

ASTM-D-4029
Standard specifications for finished woven glass fabrics. This specification includes finished fabrics woven from "E" glass fiber yarns intended as a reinforced material in laminated plastics for structural use.

MIL-C-20079
This specification covers glass and tape used as lagging material over thermal insulation and as a facing material for hull insulation board.

MIL-C-22787
Vinyl coated glass fabrics. The base cloth is glass fabric.

MIL-I-24244
This specification covers thermal insulation with special corrosion and chloride requirements.

MIL-P-25515
Phenolic Laminates. Glass fabrics used as supports for phenolic resin laminates.

MIL-Y-1140
This specification covers the basic forms of untreated glass yarns and fabrics used by themselves or as components of other materials. The materials are generally used as electrical insulation, mechanical support or as structural members.

MIL-R-7575
Resin, Polyester, Low Pressure Laminates, Fiber Glass Base. Glass fabrics used as supports for polyester resin laminates.

MIL-R-9300
Resin, Epoxy, Low Pressure Laminates, Fiber Glass Base. Glass fabrics used as supports for polyester resin laminates.

AMS 3824
This specification covers the basic forms of finished glass fabrics used by themselves or as components of other materials.

AMS 3902
This specification covers cloth woven from high-modulus, continuous, multifilament aramid yarn.

AMS-C-9084
This specification replaces MIL-C-9084 and covers the requirement for glass fabrics that have been woven, cleaned and finished for further fabrication into glass fabric base resin laminates and sandwich materials.

Specifications (cont.)

ASTM-D-579
Standard specifications for Greige Woven Glass Fabrics. This specification includes the basic forms of greige woven glass fabrics and their testing.

ASTM-D-1668
This specification covers open mesh woven glass fabrics used for membrane waterproofing and built up roofing (Type II).

ASTM-D-4029
Standard specifications for finished woven glass fabrics. This specification includes finished fabrics woven from "E" glass fiber yarns intended as a reinforced material in laminated plastics for structural use.

MIL-C-20079
This specification covers glass and tape used as lagging material over thermal insulation and as a facing material for hull insulation board.

MIL-C-22787
Vinyl coated glass fabrics. The base cloth is glass fabric.

MIL-I-24244
This specification covers thermal insulation with special corrosion and chloride requirements.

MIL-P-25515
Phenolic Laminates. Glass fabrics used as supports for phenolic resin laminates.

MIL-Y-1140
This specification covers the basic forms of untreated glass yarns and fabrics used by themselves or as components of other materials. The materials are generally used as electrical insulation, mechanical support or as structural members.

MIL-R-7575
Resin, Polyester, Low Pressure Laminates, Fiber Glass Base. Glass fabrics used as supports for polyester resin laminates.

MIL-R-9300
Resin, Epoxy, Low Pressure Laminates, Fiber Glass Base. Glass fabrics used as supports for polyester resin laminates.

MIL-C-44050A
This specification covers cloth woven from high-modules, continuous, multifilament yarn.

U.S.C.G. Subpart 164-009
Non-combustible material for merchant vessels. Woven glass cloth containing not more than 2.5 percent lubricant is automatically considered non-combustible.

BMS 9-3
This specification covers the Boeing Commercial Airplane Company's requirements for woven, cleaned, and finished E-Glass fiber glass fabrics. End fabric uses are high performance structural prepreg for aircraft structure and wet lamination of tooling and structural composite repair.

BMS 9-8
This specification establishes requirement for woven and non-woven carbon reinforcements in a Boeing application.

BMS 9-17
This specification establishes requirements for intermediate modulus carbon fibers and fabric in a Boeing application.

Conversions

Areal Weight
oz/yd^2 x 33.9057 = g/m^2
g/m^2 x 0.0295 = oz/yd^2

Mass
oz: ounce, lb: pound
1 oz = 28.35 g · 1 g = 0.035 oz
1 lb = 0.454 kg · 1 kg = 2.205 lb

Force
N: Newton, daN: decaNewton
1 N = 0.102 kgf ≈ 0.1 kgf · 1 daN = kgf ≈ 1kgf
1 kgf = 9.81 N ≈ 10 N or 1 daN
1 lbf = 4.4482 N = 0.4536 kgf

Strength
Pa: Pascal, MPa: megaPascal
1 MPa = 1 N/mm^2
1 MPa = 10bars = 0.1 hbar ≈ 10 kgf/cm^2 or 0.1 kgf/mm^2
1 bar = 0.1 MPa =10^5 Pa ≈ 1daN/cm ≈ 1 kgf/cm^2
1 hbar = 10 MPa = 10^7 Pa ≈ 1kgf/mm^2
100 psi (lbf/in^2) = 0.69 MPa · 1 MPa = 145 psi
1 psi (lbf/in^2) = 6894.76 Pa ≈ 0.0703kgf/cm^2

Length
yd: yard, ft: foot, in: inch
UK mile: 1 mile = 1.609 km · 1 km = 0.62 mile
Nautical Mile: 1 mile = 1.852 km
1 yd = 0.91 m · 1 m =1.09 yd
1 ft (1/3 yd) = 0.3048 m · 1 m = 3.281 ft
1 in (1/12 ft) = 2.54 cm · 1 cm = 0.39 in

Surface
1 sq in = 6.45 cm^2 · 1 cm^2 = 0.15 sq in
1 sq yd = 0.83 m^2 · 1m^2 = 1.19 sq yd
1 sq ft = 0.093 m^2 · 1 m^2 = 10.76 sq ft
1 sq mile = 2.59 km^2 · 1 km^2 = 0.30 sq mile
1 acre = 0.40 ha · 1 ha = 2.47 acre

Volume
1 cu in = 16.39 cm^3 · 1 cm^3 = 0.06 cu in
1 cu yd = 0.76 m^3 · 1 m^3 = 1.31 cu yd
1 cu ft = 28.31 dm^3 · 1 dm^3 = 0.035 cu ft

Density
1 lb/in^3 = 27.68 g/cm^3 · 1 g/cm^3 = 0.036 lb/in^3
1 lb/ft^3 = 0.016 g/cm^3 · 1 g/cm^3 = 62 lb/ft^3

Capacity
(US) Gallon: 1 gal = 3.781 · 1 liter = 0.26 gal
(UK) Gallon: 1 gal = 4.541 · 1 liter = 0.21 gal

Consumption
(US) 0 miles/gal = 23.50/100 km · 10 l/100 km = 23.8 miles/gal
(UK) 10 miles/gal = 28.21/100 km · 10 l/100 km = 29.5 miles/gal

Velocity
1 km/h = 0.2778 m/s · 1mph = 1.609 km/h = 0.4470 m/s

Yarn Conversions
Tex = 496,055/(yd/lb)
Dtex = Tex X 10 = Denier/.9
Denier = dtex X .9 = 9 tex
Denier = g/9000m
Tex = dtex/10 = g/1000m

Energy and Power
J: Joule, cal: calorie, th: thermal unit, W: watt

Density
1 W = 1 J/s
1 Wh = 3 600 J = 0.860 kcal · 1 kcal = 4 185.5 J = 1,1626 Wh
1 kJ = 0.2389 kcal · 1 cal = 4.185 J = 0.2389 cal
1 th = 1,000 kcan

tep: ton (metric) equivalent fuel oil

tec: tonne (metric) equivalent coal

1 tep = 10,000 th = 11,626 kWh = 11.6 MWh = 1.5 tec 1 100

Nm^3 natural gas

Specific Heat
kj/kgK: kilojoule per kilogram Kelvin

Thermal Conductivity
1 W/mK or W/mºC = 0.860 kcal/mhºC

Coefficient of Thermal Loss:
1 W/m^3K or W/n^3C = 0.8m60 $kcal/m^3hºC$

Temperature
K: Kelvin, °C: degree Celsius, °F: degree Fahrenheit

TK = °C + 273.18°
°F = 9/5°C + 32

Notes

Notes

Notes

Notes

HEXCEL®

U.S. Operations

Seguin, Texas

1913 N. King St.
Seguin, TX 78155
United States

Telephone: (830) 379-1580
Fax: (830) 379-9544
Customer Service Toll Free: 1 (866) 601-5430
Technical Service: 1 (830) 401-8180

For European sales office numbers and a full address list, please go to: *www.hexcel.com/contact/salesoffices*

www.hexcel.com

bsi. AS/EN 9100 Series Aviation, Space and Defense

bsi. ISO 9001 Quality Management

WTU 392 FB17