NGF EUROPE

the essential component




glass cord

for rubber drive belt reinforcement

QS 9000: 1998 BS EN ISO 9001: 1994

BS EN ISO 14001: 2004

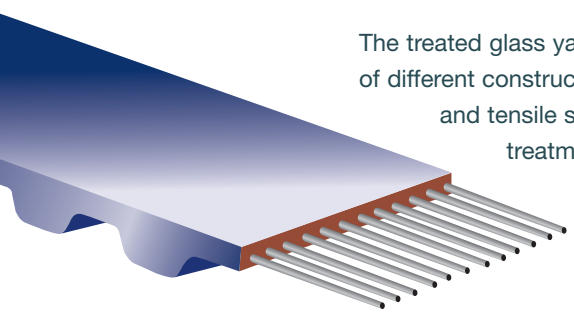
NGF EUROPE

01: manufacturing process

Glass Cord is manufactured by the complete coating of individual filaments of a multi-strand yarn with special resorcinol formaldehyde latex formulations (RFL) which are formulated to be compatible with a large number of rubber compounds. The benefits of this coating treatment are it:

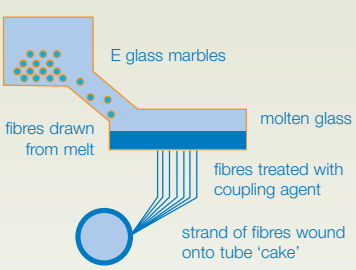
- **prevents inter-filament abrasion of the glass fibre yarn**
- **increases the end-product life**
- **provides the basis for a chemical bond between the glass filaments and the rubber compounds that the Glass Cord is designed to reinforce.**

At NGF EUROPE we have the in-house expertise to manufacture our own glass fibre. This ensures we are in full control of the whole manufacturing process and subsequent quality and performance of the Glass Cord.

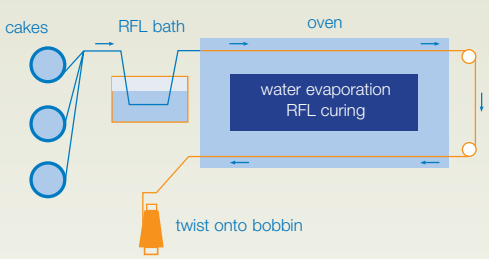


The treated glass yarns are twisted and plied together to produce Glass Cords of different constructions, in a variety of twist frequencies, weights, dimensions and tensile strengths. Glass Cord is supplied in a wide range of coating treatments for compatibility with CR, EPDM, NBR, PU, Silicone; HNBR and ACSM compounds for high temperature applications; and for thermoplastics and other specialised elastomers.

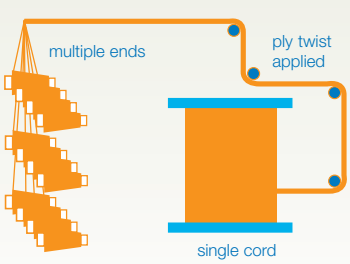
1. glass fibres at NGFE



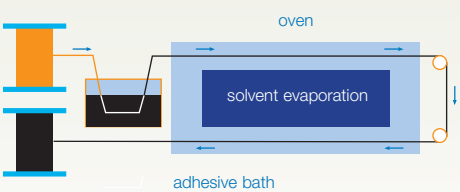
2. RFL impregnation process



3. cord plying



4. adhesive overcoat



02:

characteristics of glass fibre

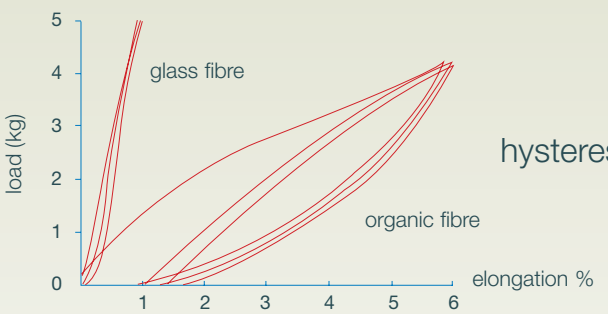
Weight for weight, glass is stronger than steel, and has better stress/strain properties than many other reinforcement media.

Glass Cord uses the unique properties of glass fibres to give strength and dimensional stability to polymeric products, particularly automotive timing belts, where there is a need for synchronous transfer of power from crankshaft to overhead camshaft without loss of inertia.

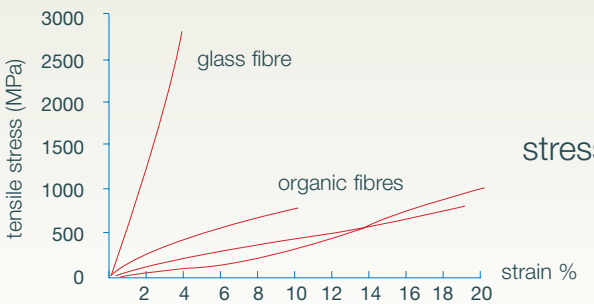
advantages of glass fibre over other forms of fibrous reinforcement are many:

- prevents stretching
- high Young's modulus
- good dimensional stability
- freedom from creep
- low extensibility
- good resistance to most forms of chemical and solvent attack
- moisture resistance
- good weathering properties
- high strength
- good fatigue resistance when impregnated
- low hysteresis

Glass fibre has excellent stress/ strain properties compared to many other reinforcement media.



hysteresis curve



stress : strain curve

03:

glass cord products: physical characteristics

Glass Cord Construction strand tex			Initial Twist TPI	Initial Twist TPM	Final Twist TPI	Final Twist TPM	Cord Weight g/1000m	Diameter mm	Tensile Strength kg	Ultimate Elongation %	Adhesion N/mm	Bobbin MBB	Bobbin DFB S	Bobbin DFB L
EC9	34.	3/0	–	–	3.6	142	135	0.23	8			X		
EC9	34.	3/3	2.0	80	3.0	118	400	0.50	27					X
EC9	34.	3/5	2.0	80	3.0	118	675	0.70	45					X
EC9	34.	3/8	2.0	80	2.0	80	1075	0.85	75					X
EC9	34.	3/11	2.0	80	2.0	80	1480	1.12	95					X
EC9	34.	3/13	2.0	80	2.0	80	1750	1.22	115					X
EC9	68.	1/2	2.5	98	2.5	98	168	0.34	12	2.5	10	X	X	
EC9	68.	1/2	5.0	197	2.5	98	168	0.34	11	2.5	10	X	X	
EC9	110.	1/0	–	–	1.5	59	135	0.23	9	2.6	8	X	X	
EC9	110.	1/0	–	–	3.6	142	135	0.23	8	2.6	8	X	X	
EC9	110.	1/0	–	–	4.2	165	135	0.23	8	2.6	8	X	X	
EC9	110.	1/2	3.6	142	3.6	142	270	0.45	18	2.6	15	X	X	
EC9	110.	1/3	3.6	142	3.6	142	400	0.55	26	2.8	23	X	X	
EC9	110.	1/3	3.6	142	6.0	236	410	0.55	25	2.8	23	X	X	
EC9	110.	1/6	2.1	83	2.1	83	800	0.80	50	2.8	25		X	X
EC9	110.	1/10	2.1	83	2.1	83	1350	1.05	80	2.8	34		X	X
EC9	110.	1/10	2.1	83	3.0	118	1350	1.05	80	2.8	34		X	X
EC9	110.	1/11	2.1	83	2.1	83	1500	1.10	85	2.8	35		X	X
EC9	110.	1/13	2.1	83	2.1	83	1775	1.20	105	3.1	40		X	X
EC9	110.	1/14	2.1	83	2.1	83	1910	1.25	110	2.8	40		X	X
EC9	140.	1/0	–	–	2.5	98	173	0.29	11	2.5	11	X	X	
EC9	140.	1/3	2.0	79	2.1	83	520	0.63	33	2.8	25	X	X	
EC9	140.	1/3	3.6	142	3.6	142	520	0.63	33	2.8	25	X	X	
EC9	140.	1/7	2.0	79	2.1	83	1210	0.95	70	2.8	30		X	
EC9	140.	1/10	2.1	83	2.1	83	1750	1.20	105	3.1	40			X
EC9	140.	3/6	2.0	79	1.0	39	3150	1.75	150	3.2	45		X	X
EC9	140.	3/12	2.0	79	1.0	39	6350	2.47	300	3.2	60		X	X

All figures are nominal values

notes

1. **Glass Cord** constructions are available in S or Z final twist.
2. 34 strand tex constructions are HNBR compatible and should be used for higher flex conditions such as HNBR timing belts
3. 34, 68, 110 and 140 strand tex cords are normally black, but can be supplied brown.
4. 330 tex cords are also available in a wide variety of constructions from NGF CANADA.
5. **Glass Cords** consist of continuous glass fibres of various constructions, with a nominal latex content from 18% to 19.5%.

Full product specifications are available on request

6. Catenary: **Glass Cords** are manufactured to give low catenary values, nominally less than 2%.
7. Tensile strength: Values quoted are an indication of breaking strength only, and do not take into account different cord cross-sectional areas.
8. Adhesion: Values are measured by the 'T' Test (pull-through method) using a 10mm square block of polychloroprene rubber compound.
9. Bobbin: MBB = Milk Bottle Bobbin
   DFB = Double Flanged Bobbin, Small or Large

The above table represents a typical range of constructions but others are available on request.

packaging

Glass Cord is wound onto one of three types of strong plastic bobbins:

- **Milk Bottle Bobbins (MBB)** Glass Cord net weight, 3kgs max
- **Double Flanged Bobbins, Small (DFBS)** Glass Cord net weight, 5kgs max
- **Double Flanged Bobbins, Large (DFBL)** Glass Cord net weight, 19kgs max

Bobbins are sealed in black plastic for protection from light and protected from moisture. Bobbins are then packed and palletised on four-way pallets. The loaded pallets are secured with strong plastic webbing and are suitable for shipment by air, sea or road. Full packaging specifications can be supplied on request.

04:

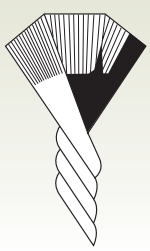
glass cord nomenclature

Different glass cords and yarns are usually described by one of the two widely acknowledged nomenclature systems: the SI System or the US Customary System.

These systems describe the type of glass, the nature of the filament, and the linear density or yardage of glass which makes up a basic strand. They also describe the construction of the finished cord. i.e. the number of twisted strands in the yarn, the number of plied yarns, the level of twist and the final direction of twist.

For example, the same cord can be described using the two systems as follows:

	SI System Glass Cord construction EC9 34.3/13 80 S		US Customary System Glass Cord construction ECG 150.3/13 2.0 S
Glass type	E Electrically resistant	E	Electrically resistant
Type of glass filament	C Continuous filament	C	Continuous filament
Filament diameter	9 9 micrometres (micrometre = 10^{-6} metre)	G	Filament designation (Average diameter of 0.00036")
Strand tex	34 Weight in g/1000m of a bundle of filaments	150	Strand Count (x 100 = yds/lb)
Yarn	3 Number of twisted strands	3	Number of twisted strands
Cord	13 Number of twisted yarns plied together	13	Number of twisted yarns plied together
Twist level	80 Number of turns per metre in the twist of the finished glass cord	2.0	Number of turns per inch in the twist of the finished glass cord
Twist direction	S Final twist direction	S	Final twist direction



S Twist: When twisted together, the yarns have a descending configuration from left to right as in the letter S.

Z Twist: When twisted together, the yarns have an ascending configuration from left to right as in the letter Z.

Product Nomenclature Comparison

Filament Diameter Designation		Strand Count		
			US Customary System	
SI Micrometres	US Customary Letter	SI tex (g/1000m)	100yd cuts/lb	yds/lb
7	E	22	225	22,500
9	G	34	150	15,000
9	G	68	73	7,300
9	G	110	45	4,500
9	G	140	35	3,500
11	H	330	15	1,500

conversions

Yards per lb is obtained by dividing 496,053 by the tex strand count.

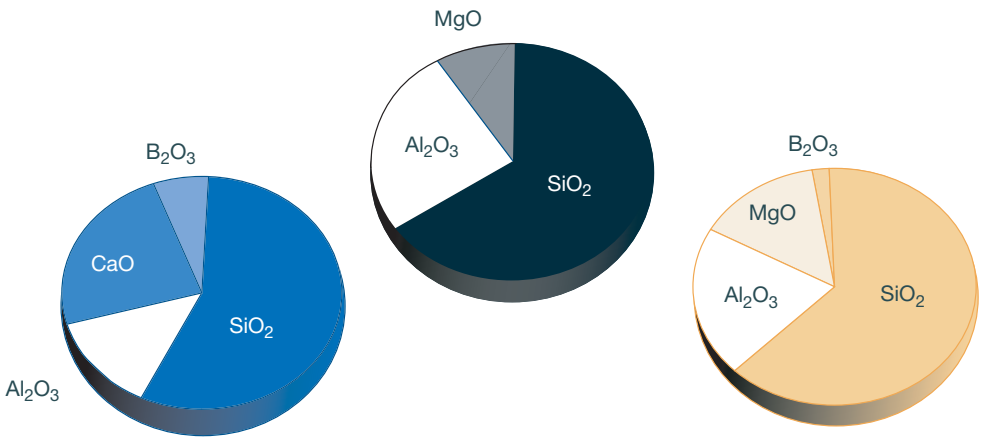
Grams per 1000m is obtained by dividing 496,053 by the yards per pound.

05: high tensile strength glass cord (HTS)

High Tensile Strength Glass Cord (HTS) is manufactured from either K or U glass filament, as opposed to E glass. The difference in formulation of the glass produces glass fibre with improved physical characteristics.

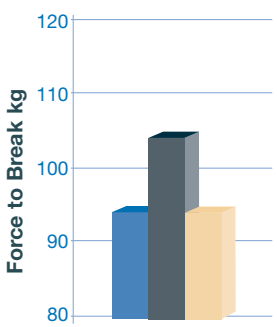
KEY

- **E GLASS**
- **U GLASS**
- **K GLASS**

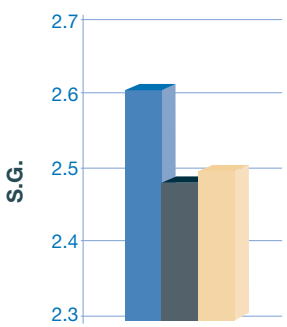


physical characteristics

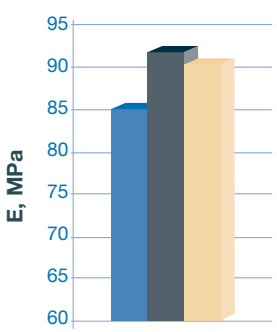
Tensile Strength of 11 Ended Cord



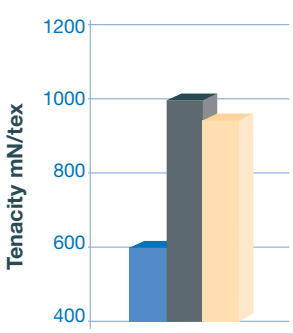
Specific Gravity – Variations with Glass Type



Elastic Modulus – Variations with Glass Type

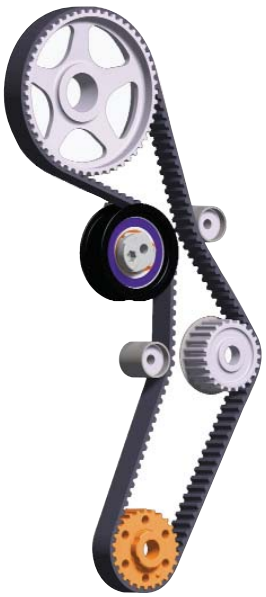


Tenacity – Variations with Glass Type



06:
design options

The use of High Tensile Strength Glass Cord (HTS) gives two options for improving the performance of a belt in comparison with E glass.



Option 1: If the cord is required to have the same tensile strength properties as E glass then the cord diameter can be reduced. By using less glass, bending strains are lowered, and less hysteresis energy generated within the glass.

These reduce the level of heat build-up within the belt. Thus, a high strength glass belt will run at a lower temperature, and have a longer life.

Option 2: If the cord is required to keep the same diameter, then the high strength glass increases the load bearing capability of the belt, allowing the belt to cope with very high shock loads. Changing from 9 micron to 7 micron filament diameter gives a greater number of filaments per cord, these increase load sharing between filaments, extending fatigue life.

This table quantifies the benefits that High Tensile Strength Glass Cord gives two belts of similar tensile properties: one by using cords of reduced diameter, and one by using narrower belt width

Basic Parameters	Increased Belt Life by Reduced Cord Diameter		Increased Design Freedom by Reduced Belt Width	
	E	HTS	E	HTS
Number of ends	13	11	11	11
Cord diameter mm	1.20	0.95	1.10	0.95
Inter-cord gap mm	0.170	0.170	0.170	0.170
Cord tensile kg	123	105	95	105
Belt width	25	25	25	22
Cords per belt width	18.3	22.3	19.7	19.6
Available tensile kg	2245	2344	1870	1842
Glass cord density tex	1750	990	1480	990
Glass cord wt/m of belt g	31.9	22.1	29.1	19.5
REDUCTION IN CORD WEIGHT		**30.8%**		**33.3%**

High Tensile Strength Glass Cords are designed to suit customers' individual needs

07: new cords for improved performance

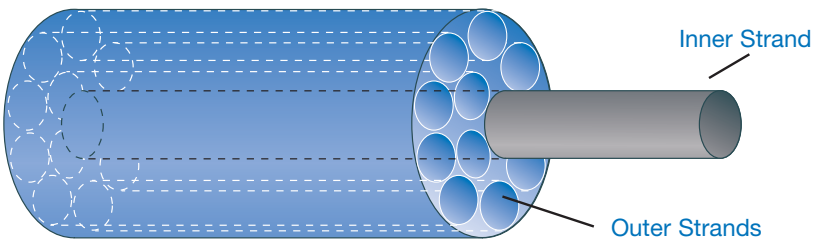
7.1 hybrid cord technology

Concept

Inside and outside of the cord have different functions:

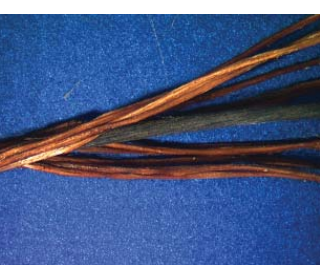
Inside:
- Load bearing tension member
- Controls elastic extension
- Controls viscous extension

Outside:
- Sees high strain during bending
- Protects the central fibres
- Adhesion to external matrix



Hybrid cord allows the use of:
- Strands twisted in opposite directions
- Materials of different strengths
- Materials of different modulus
- By using two materials, each can be used in the environment where it will perform best

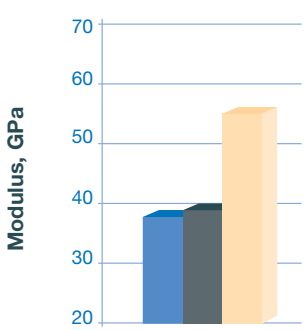
Hybrid cord benefits:
- Longer belt life
- Stronger belts
- Stiffer belts
- Narrower belts



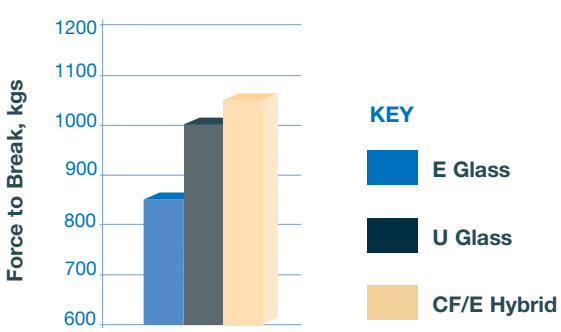
Photograph showing example of untwisted cord

Hybrid cords have a different inner portion to the outer portion. The simplest hybrid is one where the inner strands of the plied structure have different (strand) twist to those of the outer strands. The inner and outer strands do not have to be made with the same fibre material. One example is to use glass strands for the centre of the cord, and aramid strands for the outside of the cord. Another example is to use a high modulus material (carbon fibre, PBO, aramid and others) in the middle and lower modulus glass (or other material) around the outside. This last combination has been demonstrated to give good performance for rubber adhesion and flex fatigue life. Some of these property improvements are shown below:-

Cord Modulus Properties

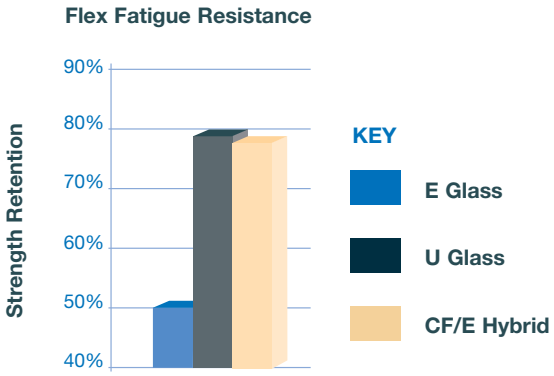


Cord Tensile Properties



new cords for improved performance (continued)

Timing belts with hybrid cords can be produced for enhanced performance in hot, cold, dry and wet (including oil) environments. This gives the potential for high modulus narrow timing belts with good environmental performance to replace equivalent metal parts, such as timing chains.

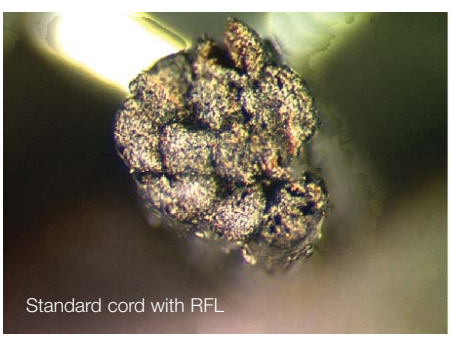


Fatigue Test: Load 20N, 10mm pulley diameter, 100,000 cycles, 1.8 Hz, 140°C

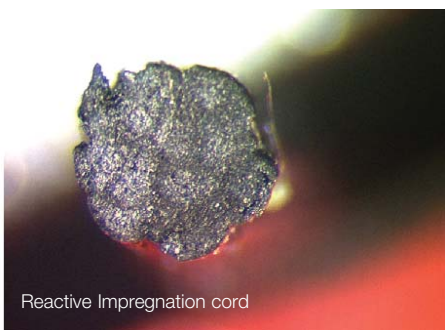
7.2 reactive impregnation technology

Traditionally, glass cord is manufactured by the impregnation of glass filament with resorcinol-formaldehyde latex. The latex is cured as the strand is passed through an oven. The strand is then twisted. Several strands can be plied together into a cord. During the rubber moulding process the rubber matrix reacts with the cord to enhance the adhesive bond. There is no bonding between strands – they are simply pulled together. This can lead to weakness within the cord structure and areas of fatigue due to crack formation.

Reactive Impregnation technology does not use resorcinol-formaldehyde. Instead, a mixture of reactive chemicals is used. These are dried not cured around each glass filament. When the cord is moulded inside a rubber article, the impregnation inside the cord reacts at the same time as the external rubber.


Standard cord with RFL

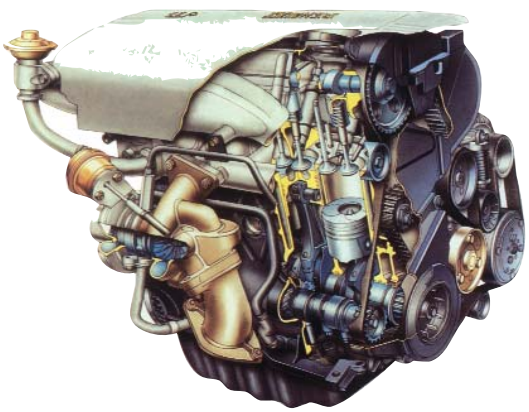
The net result is to create one network throughout the cord of both rubber inside the cord and the bulk rubber matrix. The individual strands are now fully bonded. This is shown in the photographs opposite:


Reactive Impregnation cord

new cords for improved performance (continued)

Reactive Impregnation cord features:

- Impregnation crosslinks form during rubber vulcanisation
- Can be used without an external adhesive overcoat
- Allows use of latex with high temperature and strong chemical resistance
- Can be applied to any filament material or hybrid
- Family of reactive impregnations are available for different applications
- Enhance belt integrity



Benefits available for rubber articles:

- Longer life
- Better heat resistance
- Better chemical and oil resistance
- Lower growth
- Lower pop-out

These new cords give belt designers greater opportunities to overcome the the ever-increasing demands of automotive engines, and to progress the technology of synchronous belts in a cost-effective manner.

7.3 polyurethane cords

Cords for direct bonding to polyurethane are available. These are particularly good for reinforcing small PU belts for office goods such as ink-jet printers, scanners and photo-copiers. These cords are also capable of reinforcing large goods such as PU or PVC conveyor belts.

08: glass cord applications

- **Automotive -** Passenger Cars and Commercial Vehicles
- **Textile Machinery -** Spinning, Weaving, Plying Machines
- **Laundry Equipment -** Washing Machines, Dryers
- **Household Appliances -** Food Mixers, Slicers
- **Power Tools**
- **Agriculture/Horticulture -** Combine Harvesters, Lawn Mowers, Edge Trimmers
- **Office Equipment -** Computer Printers, Typewriters, Copiers
- **Handling -** Hoists, Door Movements, Seat Adjusters

Suggested Glass Cord constructions for reinforcement of various belt types

Belt Classification	Pitch mm / inches	Glass Cord Construction
MXL	2.032/0.080	EC9 68.1/2, EC9 110.1/0
L, XL	9.525/0.375	EC9 110.1/3, EC11 330.1/0
H	12.7/0.5	EC9 110.1/13, EC11 330.1/4
XH	22.225/0.875	EC9 140.3/12, EC11 330.3/5
XXH	31.75/1.25	EC9 140.3/12, EC11 330.3/5

These classifications refer to different belt pitches as detailed in ISO 5296 part 1:1989. The cord constructions shown are intended only as a guide. Glass Cord selection is left to the discretion of the belt designer, and depends on the belt diameter and strength required.

design service

Our coating and yarn impregnation expertise can be applied to other synthetic continuous fibres, such as aramid and carbon.

Our Glass Cords can be designed to suit customers' individual needs and belt application. Glass constructions can be varied to give cords of different tensile strengths, weights, dimensions, twist levels and dynamic characteristics.
The chemical formulations of our RFL treatments can be adjusted to optimise compatability with customers' compounds and secondary adhesive overcoats when necessary can also be designed to give enhanced adhesion in more demanding conditions. Cord can be designed to satisfy requirements for:

- Stiffness
- Strength
- Degree of bending (smallest pulley)
- Operating temperature range
- Chemical resistance
- Geometric constraints

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