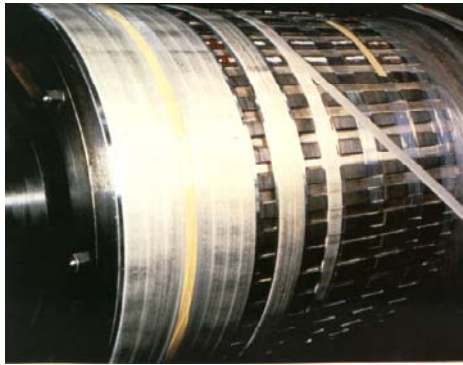


Polyglas® Banding Tapes



Construction and application

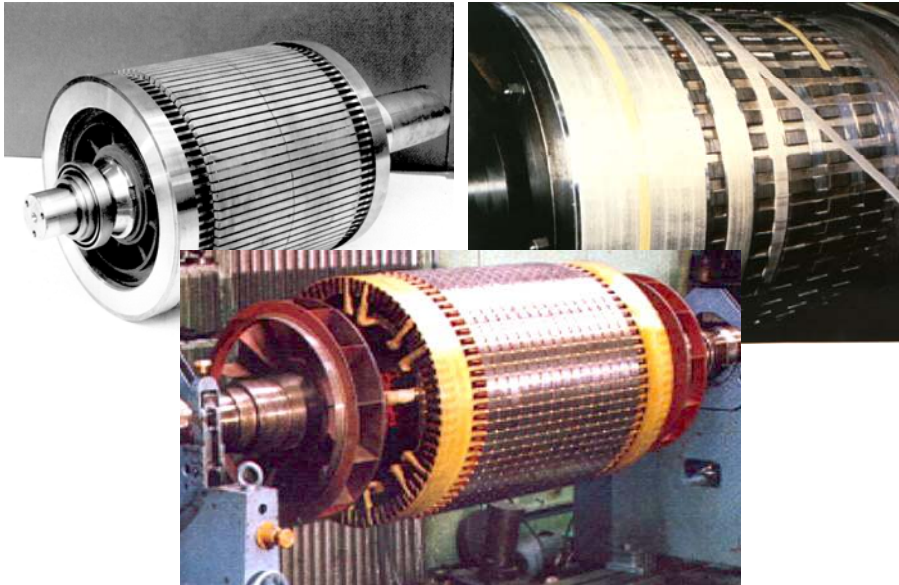
Construction

Parallel (unidirectional) twisted glass or Kevlar® yarns, preimpregnated with a special thermo-setting polyester / polyesterimide based resin.

Applications

- Banding of DC traction motor armatures
- Banding of DC motor armatures
- Banding of transformer cores
- Bracing of end windings of form wound motors and generators

Application



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Application

Fixation of endwindings of a 350 MVA turbo generator:



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Polyglas® products

Polyglas® P30 is a basic class F (155°C) banding tape, used for banding rotors, overhangs, collectors and dry and oil filled transformer.

Polyglas® H200 is a standard class H+ (200°C) moisture resistant banding tape, used mainly for banding rotors and overhangs.

Polyglas® H220 is an improved class C (220°C) moisture resistant banding tape, used mainly for banding traction rotors, collectors and overhangs.

Polyglas® K220 is the ultimate class C (220°C) moisture resistant banding tape, Kevlar® based, used mainly for banding permanent magnets rotors, high speed starters and whenever steep operative cycles or reduced spaces are required.

Main characteristics of Polyglas®

Characteristics as supplied		P30	H200	H220	K220	Test Norm
Thickness	mm	0.30 ± 0.03	0.30 ± 0.03	0.30 ± 0.03	0.33 ± 0.04	IEC 60371-2
Total weight	g/m ²	600 ± 60	600 ± 60	600 ± 60	600 ± 60	IEC 60371-2
Volatile content	%	0.9 ± 0.5	0.9 ± 0.5	0.9 ± 0.5	0.9 ± 0.5	ASTM D 2369-A
Resin content *	%	26 ± 2	26 ± 2	26 ± 2	26 ± 2	ASTM D 2408-6.2.2
Number of yarns/cm	n	30 ± 1	30 ± 1	30 ± 1	26 ± 1	ASTM D 902
Minimal Tensile strength	N/cm	2000	2000	2000	4000	IEC 60934-2
Pull in banding	N/cm	≤1000	≤1000	≤1000	≤2000	

* content of 22% on request

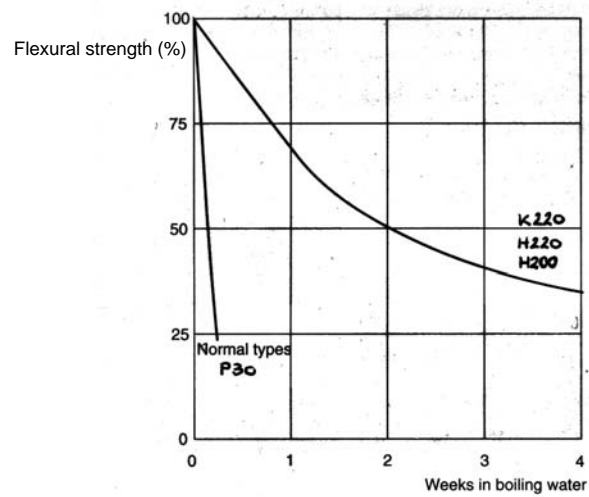
Shelf life as supplied

at 10°C	Months	24	24	24	24	before removing cool material from plastics bag let the tape reach room temperature
at 15°C	Months	18	18	18	18	
at 20°C	Months	12	12	12	12	
at 30°C	Months	8	8	8	8	

Characteristics after application and curing		P30	H200	H220	K220	Test Norm
Thermal Class	°C	155 (F)	200 (H+)	220 (C)	220 (C)	IEC 60085
Cured Thickness	mm	0.25 ± 0.02	0.25 ± 0.02	0.25 ± 0.02	0.31 ± 0.02	
Minimal Tensile Strength referred to one tape layer at 20 °C	N/cm	2500	2500	2500	3500	
one tape layer at thermal class	N/cm	1800	1800	1800	2500	
Modulus of Elasticity						
at 20 °C	N/mm ²	62000	62000	62000	80000	
at thermal class	N/mm ²	50500	52000	50500	65000	
Elongation at break at 20°C	%	1.6	1.6	1.6	0.6	
Elongation at break at thermal class	%	1.4	1.4	1.4	0.5	
Breaking load at -35 °C	N/cm	2700	2700	2700	2700	
Coefficient of Linear Expansion	1/°C	6,5 E-6	6,5 E-6	6,5 E-6	6,5 E-6	
Thermal conductivity	W/(m °C)	0.53	0.53	0.53	0.53	
Radiation Index at 10 ⁵ Gy/h		> 8	> 8	> 8	> 8	IEC 544-4
Tracking Index CTI		600	600	600	600	IEC 60112
Arc Resistance	s	180	180	180	180	ASTM D 495
Vertical Fire resistance over 12 mm	V1	V1	V0	V0	V0	UL94
Breakdown Voltage in oil at 20 °C						
natural conditions	KV/cm	28 ± 2	28 ± 2	28 ± 2	28 ± 2	IEC 60243-1
after 24 h in water at 23 °C	KV/cm	8 ± 2	13 ± 2	13 ± 2	13 ± 2	IEC 60243-2

Polyglas® moisture resistance

Percentage change in flexural strength after standing in boiling water (100 °C)
Specimen thickness of 3 mm.



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Polyglas® K220



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Application of Polyglas® K220

Low voltage automotive starter motor (12 V, 4 kW)



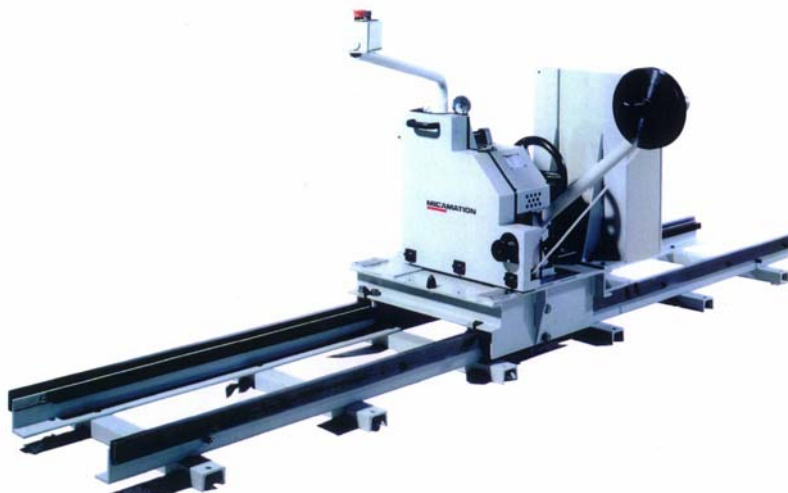
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Polyglas® banding machine

Micamation Bandex 125-01 (9614)



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Features of Polyglas® banding tapes

- A high level of resistance to moisture in storage and in use under wet conditions (tropical environments)
- Easy application, which reduces scrap and other processing cost
- Lay-flat characteristics which avoid defects caused by curing at the edges of tape
- A degree of elasticity during and after winding on the rotor, sufficient to provide dynamic banding reinforcement against the centrifugal forces produced by rotation
- High tensile strength, equivalent to that of steel banding wire
- Good tracking resistance, meets ASTM D-2303
- A high level of heat dissipation, resulting from the intimate contact with the underlying winding, because of the excellent resin flow during the cure cycle
- Non-conducting - no dangers from generation of eddy currents or corrosion compared to steel bands. Elimination of flashover among windings and steel bands.
- Outstanding properties of breaking through fatigue

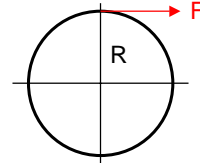
Tensile strength of cured Polyglas® banding tape

Polyglas®	Type 30	Type H200	Type H220	Type K220
at 20°C	250 kg/cm	250 kg/cm	250 kg/cm	350 kg/cm
at 155°C	180 kg/cm	-	-	-
at 200°C	-	180 kg/cm	-	-
at 220°C	-	-	180 kg/cm	250 kg/cm

Calculation of number of turns of banding tape to be applied to armatures (1)

Determine the tangential force F which the banding will have to withstand by using the formula :

$$F \text{ [kg]} = \frac{P \cdot R \cdot N^2}{5.6 \cdot 10^6}$$



where

P = weight of windings in kg exposed to the centrifugal force; normally this is only end winding of the rotor/armature

R = maximum distance, in mm between windings and axis of rotation

N = number of revolutions per minute at the maximum speed of rotation reached by motor

Calculation of number of turns of banding tape to be applied to armatures (2)

The number of turns of Polyglas® tape to be *applied* is obtained from the following formula:

$$n = \frac{F \cdot K_s}{C \cdot L}$$

where

F = the force in kg determined above

K_s = the safety factor normally used (e.g. K_s = 5)

C = tensile breaking stress of the tape, in kg/cm
(180 / 250 kg/cm at operating temperature)

L = width, in cm of the Polyglas® tape being used

Effect of application parameters on residual stress retained in band (1)

Residual pull values measured on bands made with 15 turns of 10 mm wide Polyglas® tape applied at a speed of 10 metres per minute. Values measured at 20°C.

Tension during application	Residual pull values				Tensile strength
	Hot application (80 -100°C)		Cold application (20 - 25°C)		Measured at 20°C
kg/cm	kg/cm	%	kg/cm	%	kg/cm
50	30 - 35	60 - 70	5	10	≈ 280
75	45-52.5	60 - 70	9	12	≈ 280
100	60 - 70	60 - 70	15	15	≈ 280

➡ Recommended temperature during application: 80 - 100°C

Effect of application parameters on residual stress retained in band (2)

Effect of speed of application (m/min.) and banding tension (kg/cm tape width):

Speed of application	Tension during application		
	50 kg/cm	75 kg/cm	100 kg/cm
	Residual tension		
9 m/min.	32.5 kg/cm (65 %)	46.5 kg/cm (62 %)	71.5 kg/cm (71.5 %)
15 m/min.	20.5 kg/cm (41 %)	34.5 kg/cm (46 %)	46.5 kg/cm (46.5 %)
25 m/min.	-	31.5 kg/cm (42 %)	41.5 kg/cm (41.5 %)
42 m/min.	-	-	30 kg/cm (30 %)

➡ Recommended speed of application: 10 m/min. maximum

Recommended application parameters of Polyglas®

Summary:

Polyglas® should be applied with the following parameters:

- Temperature: 80 - 100°C
- Banding speed: 10 m/min. maximum
- Banding tension: 80 - 100 kg per cm width of tape

This procedure is strongly suggested for those applications in which the purpose is to obtain at least the 60% of pull as residual tension in the cured bandage.



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Cure cycles of Polyglas® banding tapes

Number of hours to fully cure			
Cure temperature	Polyglas® 30	Polyglas® H200	Polyglas® H220 / K220
115°C	10 h	20 h	48 h
120°C	5 h	14 h	24 h
135°C	3 h	5 h	10 h
150°C	1.5 h	3 h	5 h
160°C		2.5 h	3.5 h

The above times do not include the time for the workpiece to reach the curing temperature.

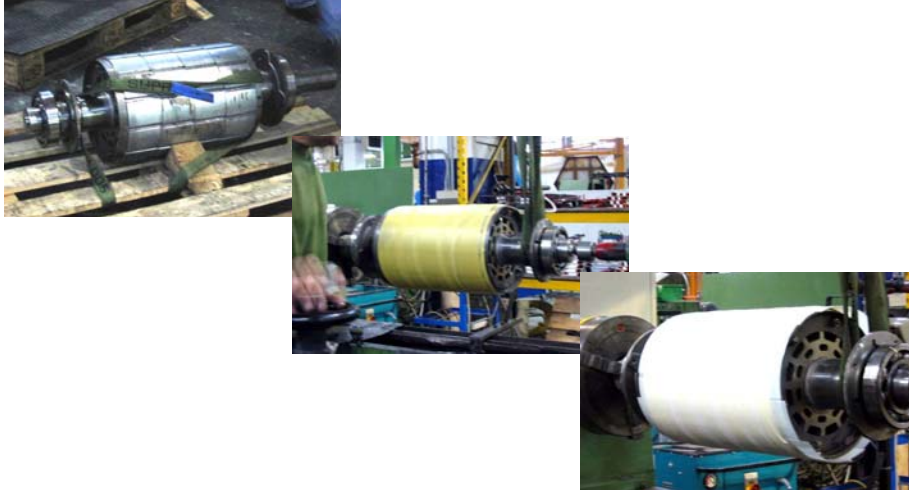
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Surface processing

To obtain a shiny surface after curing it's suggested a masking procedure with normal or shrinkable polyester foil. It allows even a controlled flowing of the resin during curing avoiding any bubble or lump on the surface.



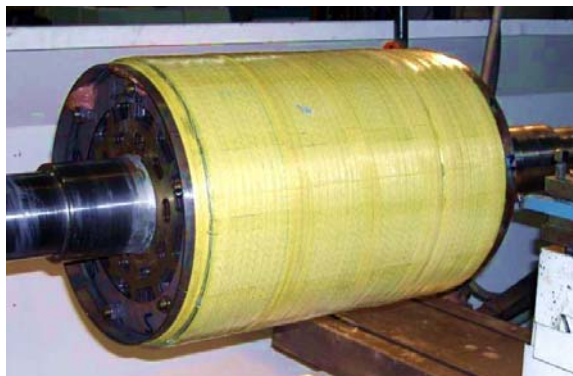
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Surface processing

Once removed any masking material, the grinding operations must be strictly limited to external surface of banding and regarding a thickness of few tenths of mils. It's strongly recommended to enquire specialised suppliers and manufacturers of tooling for boring, grinding and shaping the surface, especially when using Kevlar® based tapes.



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Form of delivery

Polyglas® is normally supplied in polyethylene bags which shouldn't be tampered with until time of use.

- Type A packing Flat pancakes plastic core ID 83 mm
- Type B packing Spools, flange OD 160 mm, L 200 mm
- Type C packing Spools, flange OD 290 mm, L 280 mm

All widths available from 4 mm to 51 mm in type A packing 100 or 200 m long and in spools as per table below.

Width	mm	10	15	20	25	30
Packing	-	B	B	C	C	C
Content	m	750	500	1800	1500	1200
Net Weight	kg	4.2	4.2	21	22	21

Calculation comparison between Polyglas® H200 and K220

Example: Rotor banding

P = 40 kg Weight of rotor windings
R = 200 mm Maximum distance between windings and rotation axis
N = 5'000 rpm Maximum number of revolutions per minute
K_S = 3 Safety factor

Calculation of tangential force F:

$$F = \frac{P \cdot R \cdot N^2}{5.6 \cdot 10^6} = \frac{40 \cdot 200 \cdot 5'000^2}{5.6 \cdot 10^6} \text{ kg} = 36'000 \text{ kg}$$

Calculation comparison between Polyglas® H200 and K220

Polyglas® H200 0.3 x 20 mm

Number of turns to be applied:

$$n = \frac{F \cdot K_s}{C \cdot L}$$

$$n_1 = \frac{36'000 \cdot 3}{180 \cdot 2} = 300$$

Polyglas® K220 0.3 x 20 mm

Number of turns to be applied:

$$n_2 = \frac{36'000 \cdot 3}{250 \cdot 2} = 216$$