Taped wires

Polyimide-Film insulated Winding Wires

- **Taped round or rectangular winding wires with outstanding thermal properties**
- **Temperature Index 240**

Description

Polyimide-film taped, round or rectangular winding wires, are copper conductors which are wrapped tightly with a Polyimide-tape, coated on one or both sides with a FEP (Teflon®)-adhesive. A suitable heat-treatment melts the thermoplastic FEP-coating and thus bonds firmly the overlapping film. This results in a non-porous, highly flexible insulation of superior thermal and chemical resistance.
The Temperature Index of the insulation is 240.[1)]

Conductor dimensions

Round copper acc. to IEC 60317-0-1. Rectangular copper acc. to IEC 60317-0-2 as well as any dimension up to 80 mm², with max. width of 20 mm and min. thickness of 0,50 mm. The recommended ratio width/thickness is 10:1 max.

Standards types

From among many possibilities, the most common types are listed below:

Type	Construction	Increase due to insulation
FO100	One side FEP-coated Polyimide-film, thickness 0,04 mm 50% overlap	0.15 ± 0.02 mm
2FO100	Two one side FEP-coated Polyimide-films, thickness 0,04 mm with 50 % overlap each	Width 0.31 ± 0.03 mm Thickness 0.30 ± 0.03 mm
TX200 G2 FO100	Grade 2 enamelled Thermex 200 one side FEP-coated Polyimide-film, thickness 0,04 mm, 50 % overlap	enamel acc. to IEC, 0.15 ± 0,02 mm
FO140	One side FEP-coated Polyimide-film thickness 0,06 mm, 50 % overlap	0.25 ± 0,03 mm
2FO200	Two FEP-coated Polyimide-films 1. layer: both sides coated 0,05 mm thick 2. layer: one side coated 0,04 mm thick with 50 % overlap each	Width 0.39 ± 0.04 mm Thickness 0.38 ± 0.04 mm

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Water-Resistant Types

In addition to all the excellent characteristics, the newly developed water-resistant Kapton® FWR is able to better restrain the hydrolytic degradation. The dissociation of organic compounds under the influence of elevated temperature in presence of water is considerably minimized by the use of Kapton® FWR.
The optimized properties increase the reliability of electrical machinery under severe conditions and thus open up new perspectives of construction.
All other properties are almost identical with the standard types.

Type	Construction	Increase due to insulation
FO150	FEP-coated on one side Special Polyimide-film (Kapton® FWR) Thickness 0,04 mm, overlap 50 %	0.15 ± 0.02 mm
2FO306	Two one side FEP-coated Special Polyimide-film (Kapton® FWR) Thickness 0,04 mm, overlap 66 % resp. 50 %	Width 0.38 ± 0.04 mm Thickness 0.36 ± 0.04 mm

Corona-Resistant Types

Winding wires insulated with corona-resistant Polyimide-film, have almost the same properties as those of the standard types. But in addition to their excellent properties, this type can withstand the damaging effects of corona. At high voltage, (>1 kV), corona can cause ionization and eventual breakdown of the insulation system. Furthermore, this Polyimide-film has a thermal conductivity that is twice that of standard Kapton®.
These superior properties increase the safe operation of electrical machines and open up new perspectives.

Currently available types:

Type	Construction	Increase due to insulation
FO190 **FO230**	FEP-coated on one side special corona-resistant Polyimide-film, thickness 0,04 mm, overlap 50%	0.15 ± 0.02 mm
FO192 **FO232**	FEP-coated on one side special corona-resistant Polyimide-film, thickness 0,04 mm, overlap 53-55 %	0.23 ± 0.02 mm
FO193 **FO233**	FEP-coated on one side special corona-resistant Polyimide-film, thickness 0,04 mm, overlap 66 %	0.23 ± 0.03 mm
FO195 **FO235**	FEP-coated on one side special corona-resistant Polyimide-film, thickness 0,04 mm, overlap 75 %	0.30 ± 0.03 mm
2FO190 **2FO230**	Two FEP-coated on one side special corona-resistant Polyimide-film, thickness 0,04 mm, with overlap 50% each	Width 0.32 ± 0.03 mm Thickness 0.30 ± 0.03 mm

Definition of the type of tape: FO19X Rayitek FCR-38-S

FO23X Kapton® 150FCRC019

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Special Conductor Types
In addition to the mentioned rectangular and round copper conductors, the following conductors and dimensions can be taped with the currently available Polyimide-films:

- Enamelled wires round or rectangular
- Nickel-plated copper conductors
- Cables and Litz wires, bare or enamelled
- Superconductors (Polyimide-film without FEP)

To meet special requirements, overlap and other combinations of insulating materials can be chosen.

Standards
Polyimide-film insulated wires meet the requirements of:

- IEC-Publication 60317-43 for round wires and
- IEC-Publication 60317-44 for rectangular wires

Other national standards: NF C 31 616 E

Wherever applicable, the test methods are based on:

IEC 60851-1	General
IEC 60851-2	Determination of the dimensions
IEC 60851-3	Mechanical properties
IEC 60851-4	Chemical properties
IEC 60851-5	Electrical properties
IEC 60851-6	Thermal properties

Applications
Polyimide-film insulated winding wires are used especially where traditional wire insulations are inadequate. Their superior thermal, mechanical, dielectric and chemical properties allow them to be used extensively for:

Rotor and stator windings of:

- railway traction motors (conductor strands)
- heavy-duty d.c. motors, e.g. rolling mill and roller table drives
- mining machine motors
- drives for crane installations
- aircraft generators, marine engines, marine generators
- underwater motors
- asynchronous motors subjected to great thermal stress in the chemical and paper industry
- motors exposed to radioactive radiation
- drives for construction machines

- Nuclear industry
- Heavy-duty connection Litz wires / lead wires in motors
- Windings of dry-type transformers and reactance coils exposed to great thermal loading
- Windings of lifting magnets in steel works
- Stirring coils

Even though Polyimide-film insulated wires are relatively more expensive than wires with traditional insulations, their use often results in lower costs per kW of supplied power. Polyimide-film ensures an improved heat dissipation and a better copper space factor.

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Processing Instructions

Because of the excellent adherence of the insulation to the conductor, the low friction properties and mechanical toughness, such insulated wires round or rectangular, can be processed on all common types of coil-winding benches, automatic winding machines and coil-forming devices.

- Single taped rectangular wires may be bent edgewise on a mandrel with diameter as small as 2 x the width of the wire. For flatwise bending, the min. permissible diameter of the mandrel is 3 x the thickness of the wire.
- When forming coils, the use of hard or sharp-edged tools has to be avoid.
- The best method for stripping Polyimide-film insulated wires is the mechanical one, (using hand-cutting tools, or rotary knives for round wires).
- For the impregnation of entire coils and stators, we recommend to use the following impregnating resins, varnishes and protection-overcoats:
    - Polyester-Imide: Damisol 2053 (Repair) , 3340 or 3630 MEV
      (For the Polyester-Imide resin and varnish, we recommend applying Damicoat 2407 as protection overcoat).
    - Epoxy: Damisol 3418 API
    - Silicon: Damisol 3551

Order Data

Quantity, Designation, Supply form

The designation shall comprise:

Profile of the conductor	RD for round	FL for rectangular
Designation of the insulation	FO100	FO100
Nominal dimension in mm	1.25mm	
Dimensions (width x thickness) in mm		2.00x8.00mm
Reel type:	e.g. DIN 355	e.g. DIN 500

Example for round: 250 kg RD FO100 1.25mm D355

Example for flat: 600 kg FL FO100 2.00x8.00mm D500

Characteristics of Polyimide Taped Wires		Round				Rectangular			
Standards		**IEC 60317-43**				**IEC 60317-44**			
Tape		**FEP coated Polyimide Film**				**FEP coated Polyimide Film**			
Dimensions		**Available Dimensions**				**Available Dimensions see conductor dimensions on page 1**			
	FO100	0.40 ... 5.00 mm Ø				> 1.5 mm^2			
	2FO100	0.80 ... 5.00 mm Ø				> 1.5 mm^2			
	TX200 G2 FO100	0.40 ... 5.00 mm Ø				> 1.5 mm^2			
	FO140	-				> 3.0 mm^2			
	2FO200	-				> 3.0 mm^2			
	FO150	0.80 ... 5.00 mm Ø				> 6.0 mm^2			
	2FO306	-				-			
	FO190 / FO230	0.71 ... 5.00 mm Ø				> 3.0 mm^2			
	FO192 / FO232	0.71 ... 5.00 mm Ø				> 3.0 mm^2			
	FO193 / FO233	0.71 ... 5.00 mm Ø				> 3.0 mm^2			
	FO195 / FO235	-				> 3.0 mm^2			
	2FO190 / 2FO230	0.80 ... 5.00 mm Ø				> 3.0 mm^2			
Properties of standard types	**Test Method**	**Units**	**Results for 1.00 mm Ø e.g.**			**Units**	**Results for Rectangular Wire**		
			FO100	**2FO100**	**TX200 G2 FO100**		**FO100**	**FO140**	**2FO200**
Mechanical:									
Elongation	**IEC 60851- 3, Test 6**	%	min. 33	min. 33	min. 33	%	Thickness < 2.5 mm: min. 30 Thickness > 2.5 mm: min. 32		
Springback Angle	**IEC 60851- 3, Test 7**	Deg.	max. 42	max. 42	max. 42	Deg.	Thickness < 1.5 mm: max. 5.5 1.5mm < Thickn.< 3.0 mm: max. 4.5 Thickness > 3.0 mm: max. 4.0		
Flexibility and Adherence	**IEC 60851- 3, Test 8**								
	Mandrel Winding	Mandrel-Ø	3xd	3xd	3xd				
	Adherence by Elongation	%	min. 20	min. 20	min. 20	%	min. 20	min. 20	min. 10
	Bend Test					Width of cond. < 12 mm: 2 x width / 2 x thickn. Width of cond. > 12 mm: 3 x width / 3 x thickn.			
Electrical:									
Nominal	**IEC 60851- 5, Test 5**								
Resistance D.C. a 20°C		Ohm/m	0.0218	0.0218	0.0218	Ohm· mm^2/m	0.017241	0.017241	0.017241

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Breakdown Voltage	**IEC 60851- 5, Test 13**	**V**				**V**			
	round wire: 3xd coils /	min	3500	6000	6000	min	3500	4000	6000
	flat wire: straight sample	mean	5500	8000	8000	mean	5500	6000	8000
	bent edgewise 2xwidth					min	2500	3000	5000
						mean	3500	4000	6000
	bent flat wise 3xthickn.					min	2500	3000	5000
						mean	3500	4000	6000
Thermal:									
Heat shock	**IEC 60851- 6, Test 9**	visual	crack free	crack free	crack free	visual	crack free	crack free	crack free
at 240°C / 30 min.			(mandrel-Ø 3xd)			Width of cond. < 12 mm: Width of cond. > 12 mm:		2 x width / 2 x thickn. 3 x width / 3 x thickn.	
Thermoplastic Cut-through	**IEC 60851- 6, Test 10**	°C	min. 450	min. 450	min. 450				
Thermal Long-time Behaviour									
	IEC 60851- 6, Test 15	TI[1)]	240	240	240	TI[1)]	240	240	240
	IEC 60172								
Thermal Resistance		°C	[2)]	[2)]	[2)]	°C	[2)]	[2)]	[2)]
Resistance to Cold		K	10	10	10	K	10	10	10
Chemical:									
Saltwater		resistant							
Solvents of Impregnating Varnishes		resistant to				Sangajol, Xylene, Solvent Naphtha			
Cleansing Solvents		resistant to				Trichloroethylene, Perchlorethylene			
Mineral oils		resistant							
Hardeners in solvent free Impregnating Resins		resistant to				Anhydrics			

[1]) The Temperature Index is derived from the tests carried out according to IEC 60172. It gives an indication of the behaviour of the wires when exposed to heat, but it does not necessarily equal the service temperature at which the wires can be used.
[2]) At temperatures above 220°C the formation of CuO/Cu2O takes place in the boundary layer between conductor and insulation causing adherence losses, we therefore suggest the use of Nickel-plated Copper.

Appearance

Slight color variations are raw material or process-related and have no influence on the technical properties of the wire.

Properties of water- and corona-resistant types	Test Method	Units	Results for 1.00 mm Ø e.g.			Units	Results for Rectangular Wire					
			FO150	FO190 FO230	FO193 FO233		FO150	2FO306	FO190 F 230	FO192 FO232	FO195 FO235	2FO190 2FO230
Mechanical:												
Elongation	**IEC 60851- 3, Test 6**	%	min. 33	min. 33	min. 33	%	Thickness ≤ 2.5 mm: min. 30 Thickness > 2.5 mm: min. 32					
Spring-back Angle	**IEC 60851- 3, Test 7**	Deg.	max. 42	max. 42	max. 42	Deg.	Thickness < 1.5 mm: max. 5.5 1.5mm < Thickn.< 3.0 mm: max. 4.5 Thickness > 3.0 mm: max. 4.0					
Flexibility and Adherence	**IEC 60851- 3, Test 8**											
	Mandrel Winding	Mandrel Ø	3xd	3xd	3xd							
	Adherence by Elongation	%	min. 20	min. 20	min. 20	%	min. 20	min. 10	min. 20	min. 20	min. 20	min. 10
	Bend Test	-					Width of cond. < 12 mm: 2 x width / 2 x thickn. Width of cond. > 12 mm: 3 x width / 3 x thickn					
Electrical:												
Nominal Resistance D.C. at 20°C	**IEC 60851- 5, Test 5**	Ohm/m	0.0218	0.0218	0.0218	Ohm· mm²/m	0.01724	0.01724	0.01724	0.01724	0.01724	0.01724
Breakdown Voltage	**IEC 60851- 5, Test 13**	V				V						
	round wire 3xd coils /	min	3500	3000	5000	min	3500	6000	3000	5000	8000	8000
	flat wire straight sample	mean	5500	5000	7000	mean	5500	8000	5000	7000	10000	10000
	bent edgewise 2xwidth					min	2500	5000	2000	4000	6000	6000
						mean	3500	6000	3000	5500	7000	7000
	bent flat wise 3xthickn.					min	2500	5000	2000	4000	6000	6000
						mean	3500	6000	3000	5500	7000	7000
Thermal:												
Heat shock	**IEC 60851- 6, Test 9**	visual	crack free	crack free	crack free	visual	crack free	crack free	crack free	crack free	crack free	crack free
at 240°C / 30 min			(mandrel-Ø 3xd)				Width of cond. < 12 mm: 2 x width / 2 x thickn. Width of cond. > 12 mm: 3 x width / 3 x thickn.					
Thermoplastic Cut-through	**IEC 60851- 6, Test 10**	°C	min. 450	min. 450	min. 450							
Thermal Long-time Behaviour,												
	IEC 60851- 6, Test 15 IEC 60172	TI[1)]	240	240	240	TI[1)]	240	240	240	240	240	240
Thermal Resistance		°C	[2)]	[2)]	[2)]	°C	[2)]	[2)]	[2)]	[2)]	[2)]	[2)]

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Resistance to Cold	K	10	10	10	K	10	10	10	10	10	10	
Chemical:												
Saltwater	resistant											
Solvents of Impregnating Varnishes	resistant to				Sangajol, Xylene, Solvent Naphtha							
Cleansing Solvents	resistant to				Trichloroethylene, Perchlorethylene							
Mineral oils	resistant											
Hardeners in solvent free Impregnating Resins	resistant to				Anhydrics							

[1]) The Temperature Index is derived from the tests carried out according to IEC 60172. It gives an indication of the behaviour of the wires when exposed to heat, but it does not necessarily equal the service temperature at which the wires can be used.

[2]) At temperatures above 220°C the formation of CuO/Cu2O takes place in the boundary layer between conductor and insulation causing adherence losses, we therefore suggest the use of Nickel-plated Copper.

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