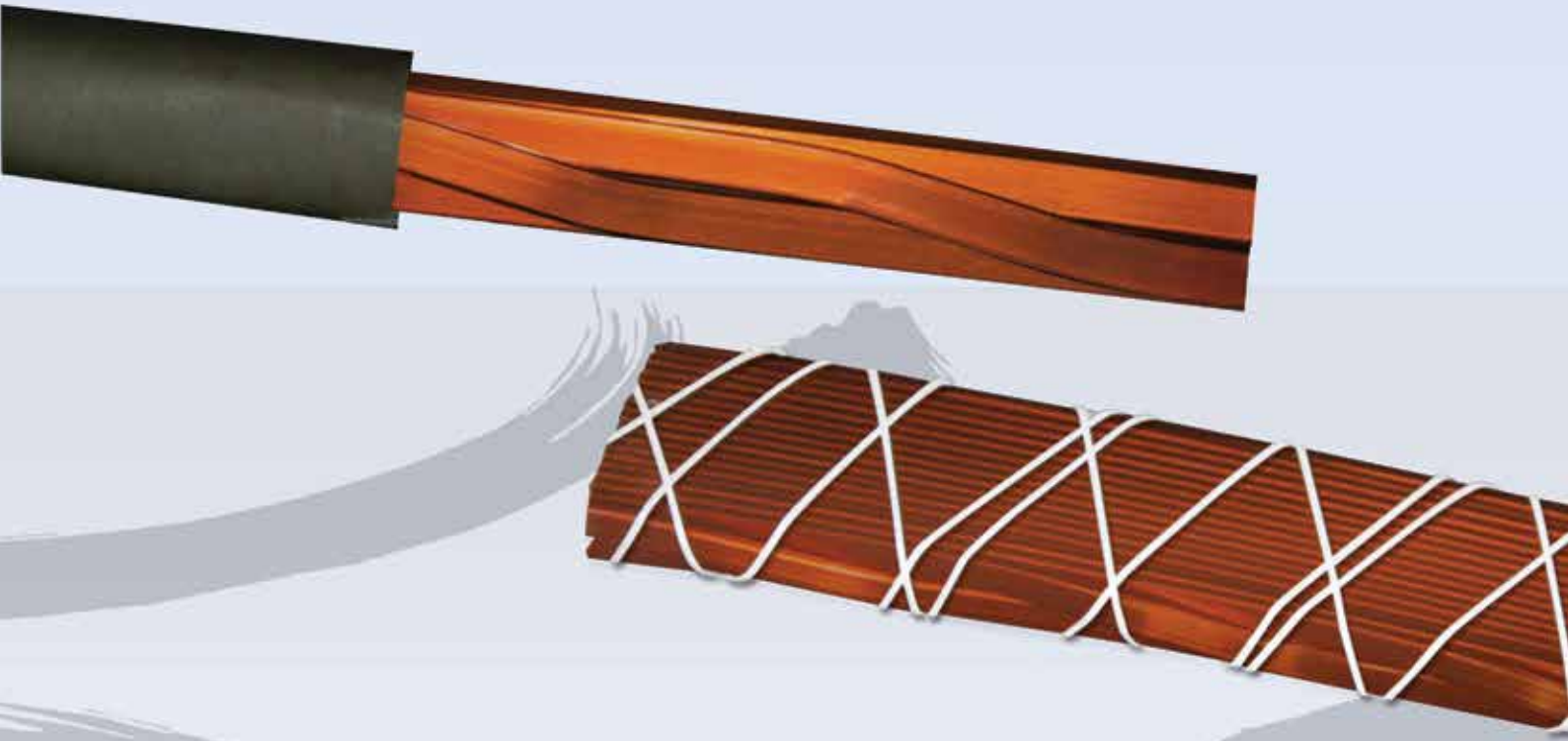
sarkuysan

ELEKTROLİTİK BAKIR SANAYİ VE TİCARET A.Ş.



Continuously Transposed Conductor **(CTC)**

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CONTINUOUSLY TRANSPOSED CONDUCTOR (CTC)

Continuously Transposed Conductor consists of a group of enamelled rectangular wires, generally of PVA or PVA-EPOXY with bonding layer type, which are connected up parallel to the ends. In this group each strand successively and repeatedly takes on every possible position inside the conductor cross-section. The strands as a whole are wrapped with pure cellulose paper tapes. This is used for manufacturing low loses winding for electric machines.

The number of component strands includes all numbers between 5 and 55, though an odd number can give a greater cross-section for the same stack size. Up to 24 paper tapes are applied as external insulation and this permits any increase of the overall insulation between 0.5 and 4.5 mm.

Transposed conductors of pure copper are available with controlled proof stress.

Regarding the different losses in the transformer, the use of CTC windings has improved this important characteristic of transformer design.

The adoption of CTC brings a great advantage in reduction of eddy current losses, particularly at the end of the winding. In addition it is possible to have a considerable increase in the space factor of the winding, due to the very small thickness of the insulation of the single conductors and getting a more uniform distribution of the temperature throughout the whole winding. The increased power demand on the transmission and distribution networks gave rise to an increase in the short circuits power due to their interconnection. The effects of short circuits due to this fact were intensified and many transformers broke down because of their inability to withstand to electrodynamic stresses. In response to these problems Sarkuysan produces also the CTC PVA-EPOXY CPR.

Epoxy bonded transposed conductors are made covering the enamelled rectangular wires with special epoxy resins at B-stage.

This technique enables the user to strongly bond together the conductors in the same strand thermal treatment used for drying the paper insulation of the windings.

Advantages

- Transformers against unstable electrical network and the risks of shorts.
- PVA-EPOXY enamelled rectangular wires used in transposed conductors provide exceptionally strong bond strength in the winding.
- Conductors in the winding become like a solid beam and can withstand strong electrodynamic stresses created during short circuit event.
- No special treatment is needed by the user.

CTC PVA-EPOXY CPR is characterised by the following properties:

- Copper with high mechanical characteristics (generally CPR with a proof stress 0.1% of 140 ÷ 250 MPa) – in order to withstand the electrodynamic stresses in case of short circuits.
- Rectangular wires enamelled with polyvinylacetal enamels resistant to transformer oils.
- Epoxy coating over the enamelled rectangular wires (PVA-EPOXY) – a thin layer of tack-free cresol-free epoxy B-stage that bond the strands together after the thermal treatment of the winding, getting a solid monolithic winding in order to withstand the electrodynamic stresses in case of short circuits.
- Wrapping the transposed conductors with special insulation papers (thermally upgraded, calendered, crepe) internally in contact with the strands and externally, in order to give the best geometry (well defined oil ducts) allowing good cooling performance of transformers.

CONTROLLED PROOF STRESS COPPER STRAND RANGE

The single strand is generally E-Cu58 copper.

When cold worked, the required minimum yield strength will be on the order document or it can be produced according to BS 1432 (CPR RP0.1% designation or Rp0.2%).

TEST METHODS: IEC 60851, IEC 60317-0-2 General Requirements, IEC 60317-18 (PVA and PVA-EPOXY), if not otherwise specified in the order.

Controlled Proof Stress Copper	Rp(0.2%) MPa
Annealed	60-100
CPR-A	100-120
CPR-B	120-150

Controlled Proof Stress Copper BS1432	Rp(0.2%) MPa
CPR1	140-170
CPR2	170-220
CPR3	220-260

ENAMELLED RECTANGULAR WIRES

Designation	Type of Enamel	Grade	Increase in Dimensions (mm)
Sarkuysan PVA	Polyvinylformal resins	1 2	0.10 ± 0.02 0.15 ± 0.02
Sarkuysan PVA-EPOXY	Polyvinylformal + B-stage epoxy resins	1 2	0.15 ± 0.03 0.20 ± 0.03

B-stage epoxy coating 0.02-0.05 mm allows good adhesion of the strands for treatment at 120 ^{0}C 24 h for storage at temperature not greater than 32 ^{0}C up to 8 months (or up to 6 months for treatment at 110 ^{0}C 48 h).

Good bonding is achieved in Lab specimens after treatment at 130 ^{0}C for 16 hours or 120 ^{0}C for 24 hours.

In the order form the insulation grade is to be specified as G1, G2, etc.

SPECIAL PAPERS INSULATION

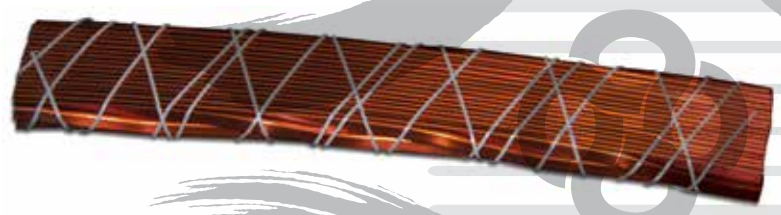
Type of Paper	Recomm. Thickness (mm)	Applications	Main Properties
Kraft Natural Paper	0.065 - 0.080	General Purposes	High purity 5A2 - 1M3
Calendered Kraft		General Purposes	High density and dielectric stress
Calendered Crepe Dennison	0.075	Inner and outermost layers	High mechanical characteristics, high thermal properties
Thermally Upgraded HD	0.065 - 0.075 - 0.105	Inner and outermost layers	High thermal properties
Cottrel Clupak	0.125		High mechanical characteristics, high density and thermal stress
Epoxy Coated Kraft		Inner and outermost layers	Bonding purposes and reducing bagging effect
Aramid	0.05	Thermal Class 200	High temperature resistant
Polyester Film		Gas Transformers	
Glass Tape		External Protection	
Prepreg Paper	0.10 - 0.30	Interleaving layer	

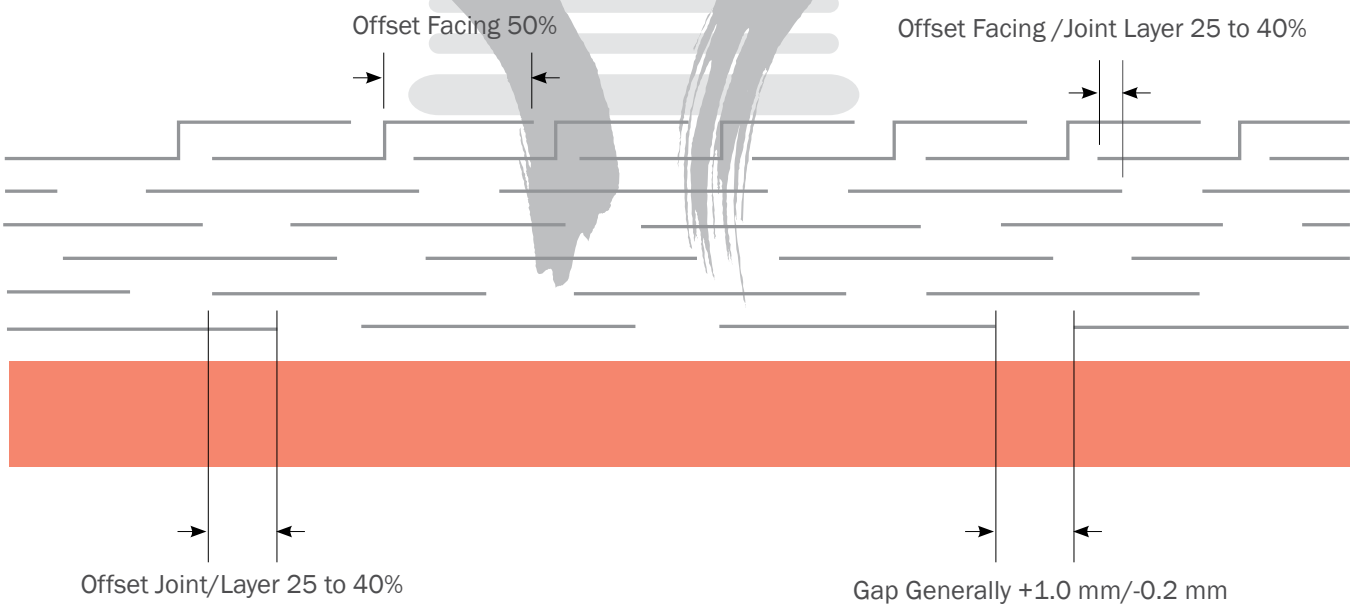
All papers for electrical applications are according to IEC554. Other types of papers are available on request.

PAPERS ARRANGEMENT

Unless otherwise agreed with customer, the insulation shall consist of at least three layers of 80µm kraft paper or dennison paper. The paper shall be applied according to the following arrangement:

- Papers are wound.
- Up to 8 papers in opposite direction, in groups of maximum 4 papers.
- Above 8 papers in opposite direction, in groups of maximum 8 papers.
- The inner layers papers shall be butt lapped or overlapped 15% and staggered from 25% to 40%. The two final exterior layers shall be wound interlocked by 50%.
- Agreement with the customer will be required in case of change of thickness of one or more papers or the type of arrangement in order to reach the required paper insulation thickness.





EPOXY BONDED TRANSPOSED CONDUCTORS

Epoxy bonded transposed conductors are made by coating one special epoxy resin at B-stage (PVA-EPOXY wire) on the enamelled rectangular wires.

This technique enables the user to strongly bond together the conductors in the same standard thermal treatment used for drying the paper insulation of the windings.

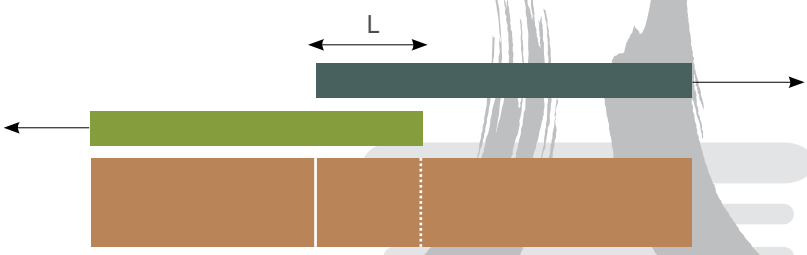
Characteristics
Epoxy is thermosetting resin.

Enamelled wires are covered by a thin layer of epoxy tack-free cresol-free resin at B-stage.

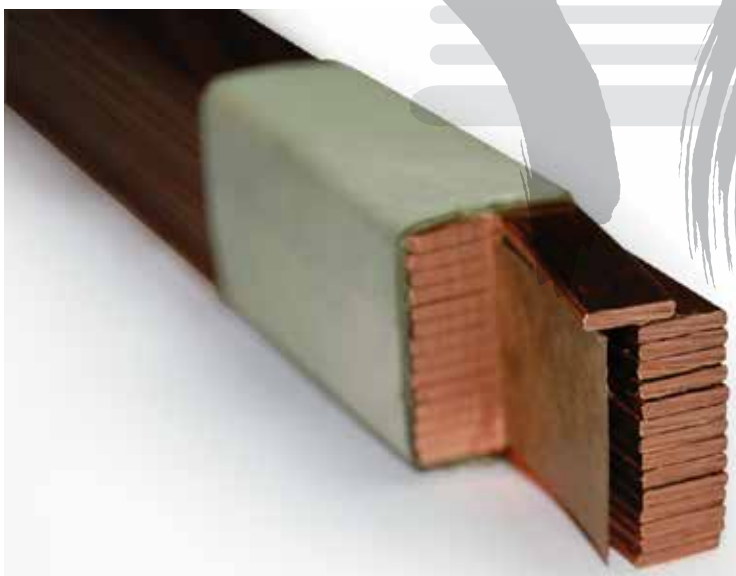
Epoxy system is characterised by the following properties:
- Uniform melting.
- High grade curing.
- Stability of B-stage (more than 6 months at 32 ^{0}C).
- Suitable for the insulation system of oil transformers.

Benefits
- Suitable for the insulation system of oil transformers.
- Reduction of risks of shorts.
- Exceptionally strong bond strength in the winding.
- Epoxy resin cure in the same thermal treatment for drying paper (100-120 ^{0}C).
- Better insulation of each single strip.
- Conductors in the winding become like a solid beam and can withstand strong electrodynamic stresses created during short circuits event.
- Small thickness of coating needed in order to achieve very strong bonding (0.02-0.05 mm).
- Improve the windability of the CTC.
- No-pollution because the B-stage resin doesn't contain residues of harmful solvents.

Epoxy Bonding Test



This test is applied to epoxy coated enamelled rectangular wires used in CTC. Specimens are prepared like shown above, put in oven and then bonding test is done.



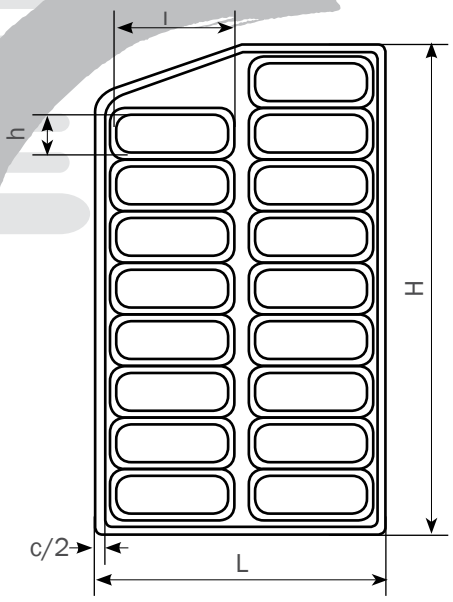
EPOXY BONDED TRANSPOSED CONDUCTORS

CONTINUOUSLY TRANSPOSED CONDUCTOR - DATA SHEET

Enamelled Rectangular Wire		Transposed Conductor	
Number of Strands	From 5 to 55	Separator Thickness	0.10 ÷ 0.30
Min. Width	2.8	Min. Radial Dim.	4
Max. Width	12.5	Max. Radial Dim.	75 (1)
Min. Thickness	1.20 (2)	Min. Axial Dim.	5.5
Max Thickness	3.25	Max. Axial Dim.	25
Preferred Ratio L/H	2.5 - 6.5		Radial/Axial Ratio ≤ 8

All dimensions are in mm.
(1) Dimension without insulation paper.
(2) Depending on the preferred ratio value.

Continuously Transposed Conductor Dimensional Data



External Dimensions of Cable

Maximum dimension in axial direction:

1) $L = 2 \times (1 + ie) + ip + ic + Kl$

Maximum dimension in radial direction:

2) $H = \left[\left(\frac{n+1}{2}\right) \times (h + ie)\right] + ic + Kh$

Where:
L = Axial cable dimension; H = Radial cable dimension
l = Axial strand dimension; h = Radial strand dimension
Kl = Maximum plus tolerance 0.10 mm for axial dimension
Kh = Maximum plus tolerance for radial dimension (values in table)
n = Number of strands in the cable
ie = Increase in dimensions due to enamel (nominal 0.11 for PVA and 0.15 for PVA + EPOXY)
ip = Thickness of separator between the strands stacks
ic = paper covering

Table: Kh values

Number of Strands	P/I ≥7 and h < 2 mm and Rp02 < 180 Mpa	All Other Cases
from 5 to 19	0.18	0.27
from 21 to 25	0.25	0.45
from 27 to 35	0.35	0.65
from 37 to 55	0.70	1.00

P = Transposing distance (Transposing pitch), distance between two transpositions.

Interleaving Paper

An interleaving paper between the two stacks is inserted if required by the customer. We suggest 0.13 mm paper thickness that should be inserted if:

$$iw = \frac{(n - 3) \times (h + ie)}{2} > 10 \qquad \text{For PVA}$$

$$iw = \frac{(n - 3) \times (h + ie)}{2} > 25 \qquad \text{For PVA + EPOXY}$$

Standard Thicknesses are 0.10 - 0.20 - 0.30 mm.

Width of the paper is the W value with approximation to the lowest pair unit (example: if iw = 7.50 we choose 6 mm paper, but this is the minimum value that we suggest using). For paper with width less than 6 mm, according to agreement with the customer.

External Dimensional Tolerances

External dimensions, obtained by formulas (1 and 2), are tested under pressure of 10 kg/cm^2 or the value required by the customer.

CTC CHARACTERISTICS

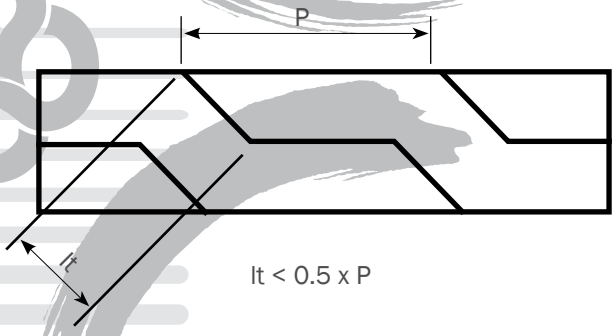
The first property to satisfy is the windability of CTC on the transformer core. Generally the length in which there is a complete transposition of one strand (called stranding pitch) should be less than the circumference of the core. This requirement is due to the flexibility of the CTC in order to avoid any damage of the CTC structure.

We define 3 elements: transposition pitch, transposition length, stranding pitch. **Minimum winding diameter** is in relationship with the dimensional characteristics and the stranding pitch by the following formula:

$P = (\pi \times Di)/n$ $P = M \times l$ Transposing Pitch

Where:
P = Transposing distance, distance between two transpositions
M = P/l = proportionality coefficient – we suggest 10 ÷ 20 transposing factor (if less than 5, k' shall be agreed during the contract review).

Transposition Length - lt
It is the length measured on the CTC between the two points where the strand goes from one side to the other side of the CTC stack. The transposition length should be less than 50% of the transposition pitch to increase the slip among the strands in the transposition area and in order to reduce the value of the radial coefficient Kh.



lt < 0.5 x P

DRUMS FOR CTC

Standard wooden drums.

Type	Max. Content	Dimensions (mm)				
	kg	Flange	Barrel	Bore	Width	Traverse
Sarkuysan 1350	700	1,350	900	82	445	290
Sarkuysan 1351	1,600	1,350	900	82	640	480
Sarkuysan 1650	2,900	1,650	900	82	840	680
Sarkuysan 2000	4,000	2,000	1,400	82	1,020	860

All dimensions are in mm.

Drums type Sarkuysan 1350 - Sarkuysan 1351 - Sarkuysan 1650 - Sarkuysan 2000 may be fitted with separators to permit parallel winding of 2 or more cables. Other types of non returnable drums are available on request.

ORDERING

When ordering Continuously Transposed Conductors the following requirements are necessary:

- Number of strands and their nominal dimensions,
- Type of copper wires and type of enamelling (epoxy or not),
- Minimum winding diameter,
- Total paper and its thickness,
- Interleaving paper and its thickness,
- Required length and type of drum.

Please use our form that is available by Sarkuysan Sales Department.

CONTINUOUSLY TRANSPOSED CONDUCTOR (CTC)

SİPARİŞ FORMU / ORDER FORM

Müşteri *Customer*	Sipariş No *Order No*		Şartname *Specification*		
CTC Ölçüsü *Size of CTC*	Adet *Number*	//	X		
Yassı Tel Köşe Yarı Çapı *Corner Radius Conductor*	mm				
Mekanik Özellikler *Mechanical Properties*		☐ Tavlı *Annealed*	☐ CPR1 ☐ CPRA	☐ CPR2 ☐ CPRB	☐ CPR3 Değer_____N/mm²
Kağıt Tipleri *Paper Types*	İç/*İnner*	☐ Kraft	☐ T.Upgraded Kraft	☐ Dennison	☐ Other
	Dış/*Outer*	☐ Kraft	☐ T.Upgraded Kraft	☐ Dennison	☐ Other
Kağıt Kalınlığı *Paper Increase*	mm				
Kağıt Sayısı *Number Papers*	Adet *Number*				
Kağıt Dizilişi *Papers Arrangement*		☐ Aynı Yönde *Same Direction*		☐ Ters Yönde *Opposite Direction*	
Emaye Tipi *Type of Enamel*	120 C°	☐ PVA		☐ PVA+EPOXY EPOXY_____mm	
Emaye Kalınlığı *Enamel Increase*	mm	☐ Gr1:_____mm		☐ Gr2:_____mm	
Ayırıcı Kağıt Tipi *Type of Interleaving Paper*		☐ Evet /*Yes* ☐ Hayır/*No*	☐ Prespan	☐ Diğer/*Other*_____	
Ayırıcı Kağıt Kalınlığı *Thickness of Interleaving Paper*	mm				
İç Sarım Çapı *Inner Winding Diameter*	mm				
Maks. Boyutlar *Max. Dimensions*	L=	mm	H=	mm	
Standart Boyutlar: 100 N/cm² basınç altında ölçülmüştür. *Standard Dimensions: Are tested under pressure 100 N/cm²*					

Makara Sayısı *Number of Reels*	Uzunluk *Length (m)*	Ayırıcı *Separator*	CTC Sayısı *Number of CTC*	Ağırlık *Weight (kg)*	Makara Tipi *Reel Type*
Toplam Boy: *Total Length (m):*				Toplam Ağırlık: *Total Weight (kg):*	

Makara Tipi *Reel Type*	Maks. Miktar *Max Content*	Ölçüler *Dimensions* (mm)						
	Kg	Flanş *Flange*	Sarım Çapı *Barrel*	Göbek Çapı *Bore*	Genişlik *Width*	İç Genişlik *Internal Width*	Mak. Tutucu Delik *Hole Lathe Carrier*	Delik Merkez Uzaklığı *Distance Between Center*

İSİM *NAME*	İMZA *SIGNATURE*

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