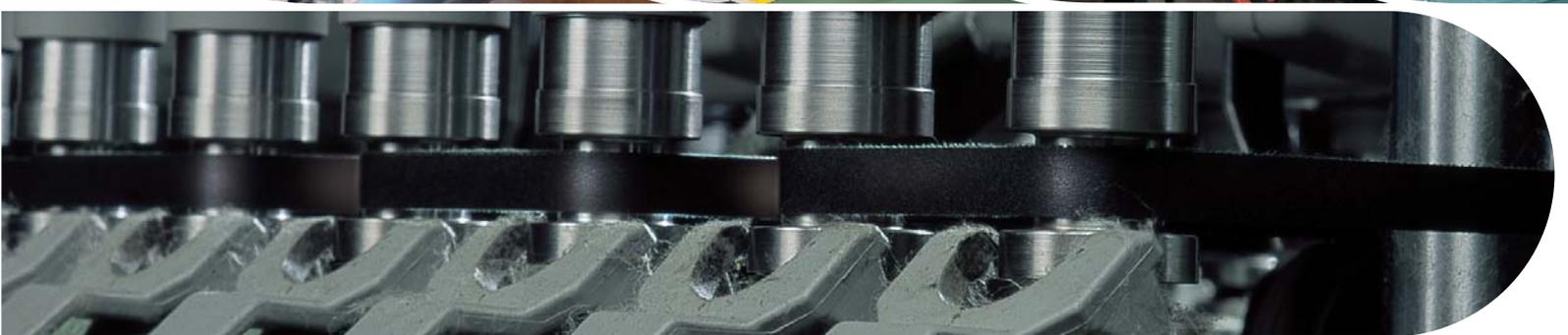


Power Transmission Belts Engineering Guide

Habasit – Solutions in motion



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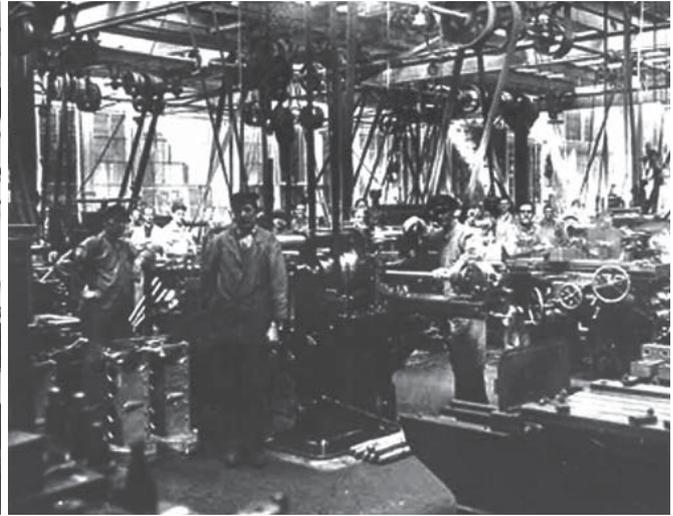
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The history of flat belt power transmission



Belts, ropes and chains have been used as traction devices for centuries. Babylonians and Assyrians used chains for the first time for water drawing machines. By 1430, endless rope haulage was used to drive grinding devices, and in the drawings of Leonardo da Vinci (1452 to 1519) link chains are shown.

During the course of industrialization, which started with the invention of the steam engine in the 18th century, the power transmission drive with flat belts made of chrome leather became the indispensable basis for industrial production. The power generated centrally by the steam engine was transmitted to individual production machines via long transmission shafts.

Leonhard Euler (mathematician, 1707–1783) authored the first theoretical essays on the traction mechanism. Based on these essays, the engineer Johann Albert Eytelwein (1764–1848) established his rope friction equation in 1808, an equation that is still indispensable for calculating frictionally engaged drives. At the same time, traction mechanisms continued to develop at a rapid pace.

Due to the introduction of the electric motor, its application as an individual drive, and the drawbacks of the leather belt (friction degradation; waning tension; vibration-stimulation, noise, and accident-prone mechanical joints), the power transmission belt was temporarily displaced.

The invention of polyamide in the Second World War presented an opportunity to Fernand Habegger (founder of Habasit AG Switzerland, 1921–1992) to create a flat belt with stable and predictable elastic characteristics which could be made endless by a glued joint. At that time, chrome leather was adhered to the polyamide traction layer as a friction cover.

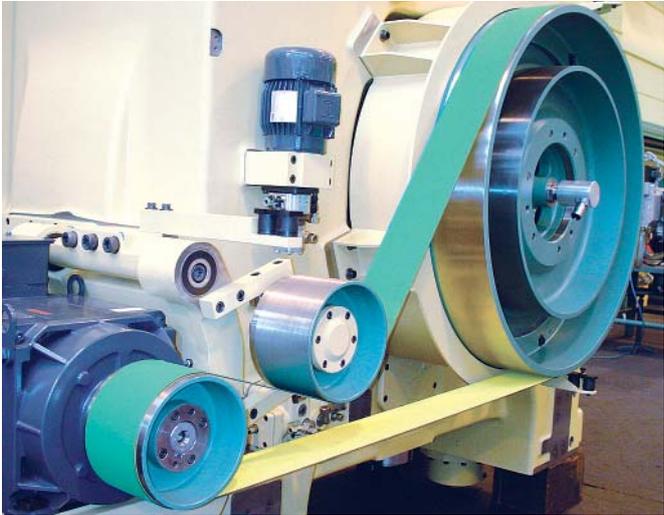
Today's modern, fully synthetic, high-duty power transmission flat belts are equipped with a strong and resilient traction layer made of polyamide, polyester or aramide, and with wear-resistant, oil and grease resistant friction covers made of NBR-rubber (elastomer) that provide a high degree of consistent friction between belt and pulleys.

High efficiency synthetic flat belts are currently being used in all areas of power transmission technology due to their versatility, energy saving properties, and outstanding reliability.

Introduction

The history of flat belt power transmission

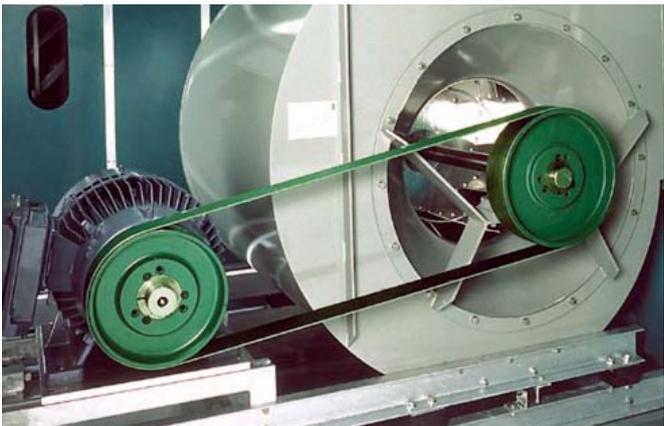
Examples of power transmission flat belt applications:



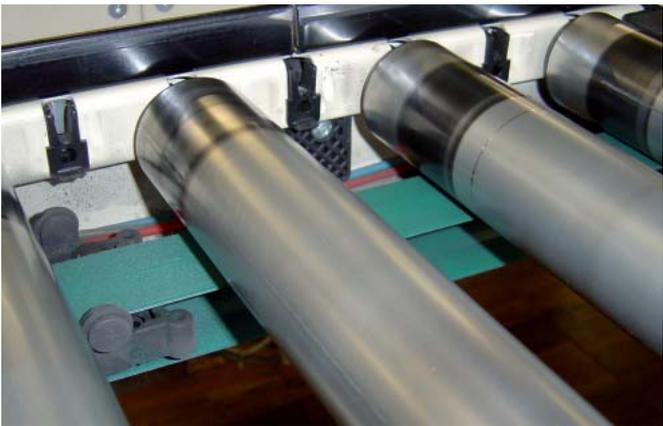
Flat belt driven 160 ton press



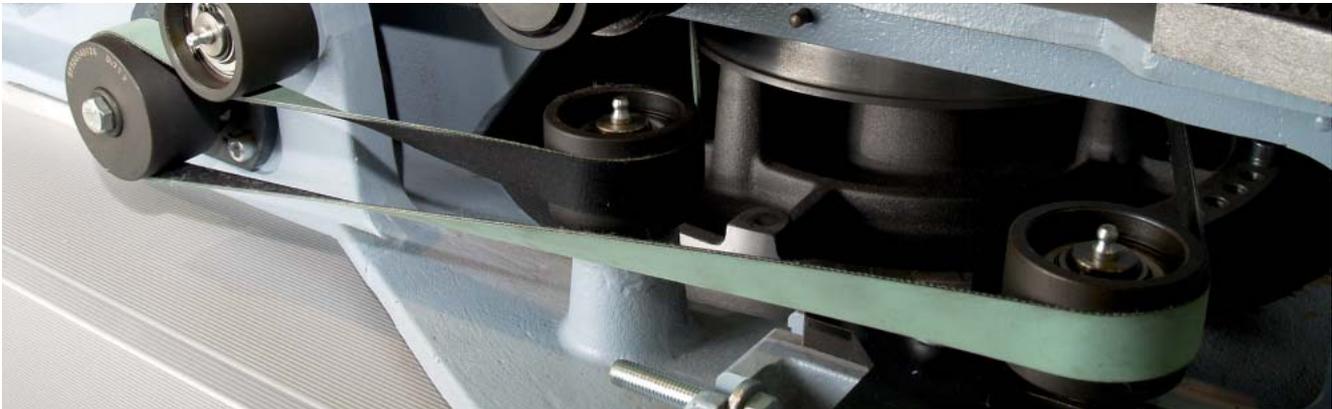
Tangential belt drives on spinning machines



Flat belt driven industry fan



Flat belt driven live roller conveyor

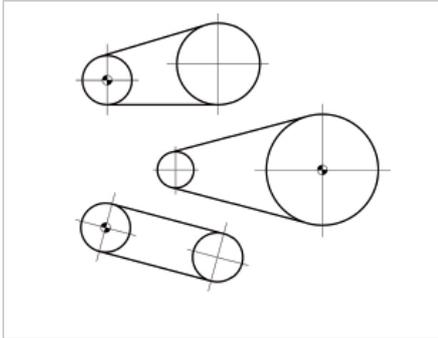


Twisted flat belt drive on a textile machine

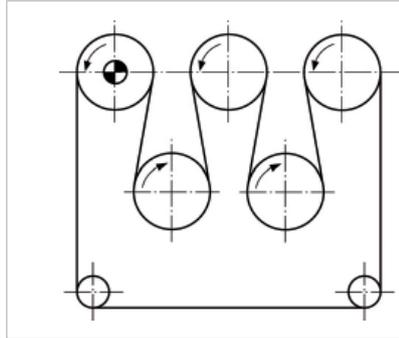
The flat belt as a versatile machine element

The power transmission flat belt can be used in many forms of power transmission. Basically it is known as a two pulley drive (open drive), consisting of a driving pulley, a driven pulley and the belt.

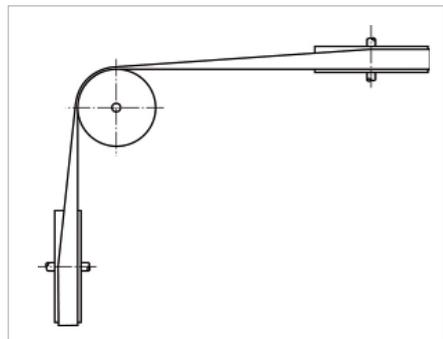
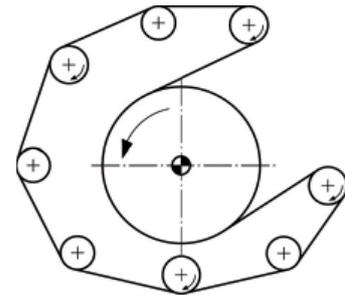
However, the flat belt can be used in a great number of design variations. Here some typical examples:



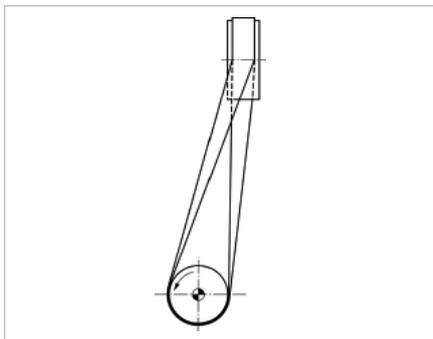
Two pulley drive (open drive)



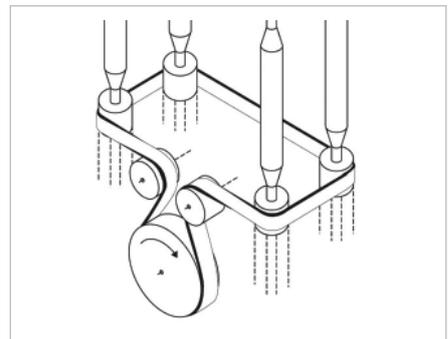
Multi pulley drive (power branching)



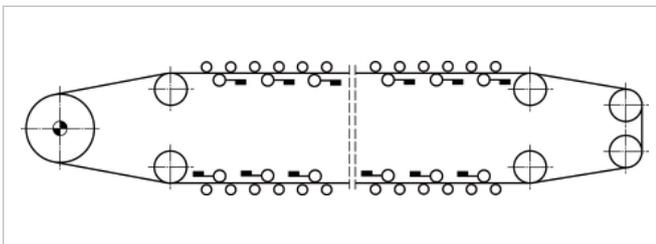
Angular drive



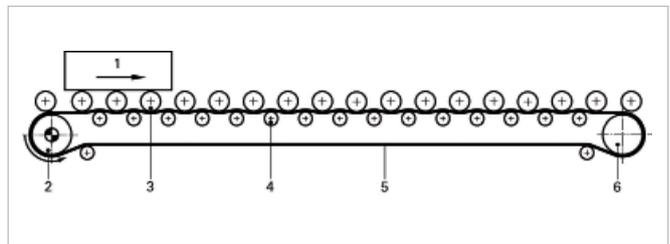
Half-cross drive



Spindle tape drive



Tangential belt drive



Live roller conveyor drive

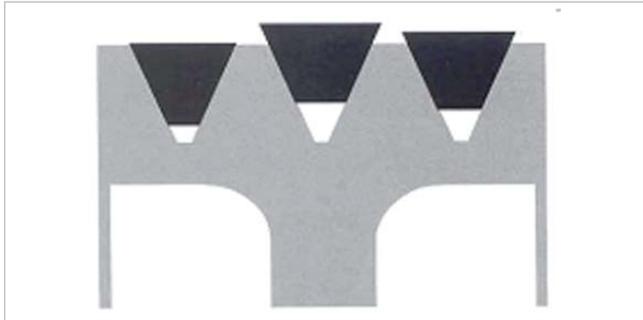
Details are available in the chapter on "Special flat belt drives" starting on page 26.

⊙ = driving pulley

The flat belt compared to the V-belt drive

Based on the fundamental technical differences, the flat belt drive offers considerable benefits compared to the V-belt drive.

The V-belt drive



Frictional engagement between the lateral wedge surfaces require a large cross-section and high stiffness of V-belts

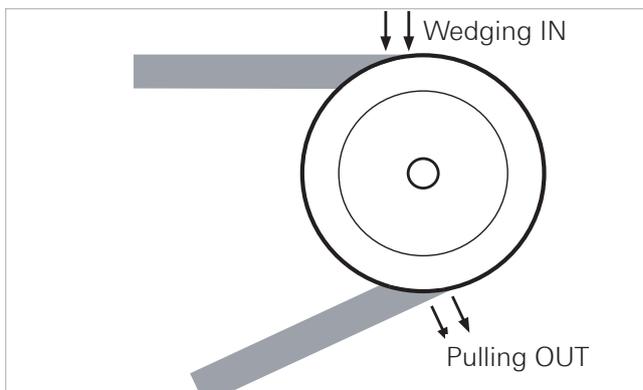
→ High energy loss due to cyclic bending

The flat belt drive



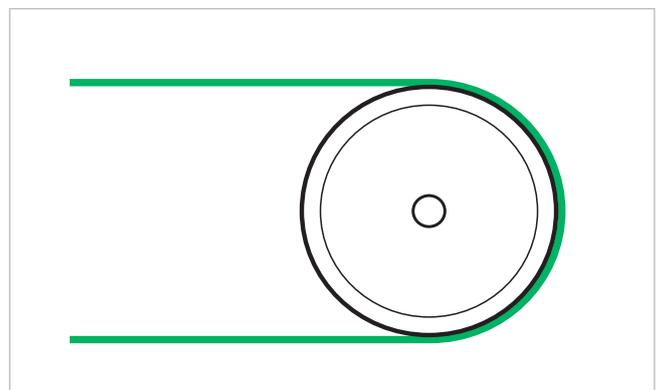
Frictional engagement on the outer pulley surface require only a small cross-section and make flat belts very flexible

→ Negligible energy loss due to cyclic bending



V-belts are wedging in grooves and pulling out from grooves

→ Energy loss and high wear



No grooves required, consequently no wedging in and pulling out from grooves

→ No energy loss and negligible wear

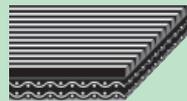
Consequential benefits of the flat belt drive:

- Higher efficiency, hence considerable energy savings
- Longer service life of belts and pulleys
- Cleaner operation, longer service life of air filters
- Longer service life means less down time and higher productivity
- Constant tension, no re-tension required, maintenance-free
- Smoother operation, lower noise generation

The belt concept

Habasit has developed the HabaDRIVE® range of power transmission belts to allow you to choose the most suitable belt for your specific application.

The concept is based on the three traction layer materials used:

	Polyester power transmission belts		Polyamide power transmission belts		Aramide power transmission belts
	The versatile belt		The hard-working belt		The sophisticated belt
	Outstanding price-to-value ratio First choice of machine manufacturers and end users worldwide		Well known for its reliability and long service life Robust and highly resilient, copes with intermittent overload and high temperatures (up to 100 °C)		Best choice for long belts Short take-up and highest accuracy for numbers of revolutions (rpm) and belt speed
	TC-	TCF-xxEL	S-	A-	TF-
	<ul style="list-style-type: none"> • Low energy consumption • Highly flexible • Simple to join • Reliable performance 	<ul style="list-style-type: none"> • Low energy consumption • Grooves enable high grip • Highly flexible • Simple to join 	<ul style="list-style-type: none"> • Resilient • Shock resistant 	<ul style="list-style-type: none"> • Resilient • Shock resistant • Grooves enable high grip 	<ul style="list-style-type: none"> • Low energy consumption • Highly flexible • Simple to join • High E-modulus
Application as/for					
Tangential drive	●	—	●	—	●
Multiple pulley drive	●	●	●	●	●
Live roller drive	●	—	●	—	●
Double-sided power transmission	●	—	●	—	●
Design and materials	e.g.: TC-55ER 	e.g.: TCF-20EL 	e.g.: S-250H 	e.g.: A-2 	e.g.: TF-50 
Friction cover (Material)	NBR-Rubber	NBR-Rubber	NBR-Rubber	NBR-Rubber	NBR-Rubber ¹⁾
Traction layer (Material)	Polyester		Polyamide		Aramide
Reverse cover (Material)	NBR-Rubber	Hamid	NBR-Rubber	NBR-Rubber (protection cover)	NBR-Rubber ¹⁾
Operating temperature admissible (continuous)	-20 °C/70 °C -4 °F/158 °F		-20 °C/100 °C -4 °F/212 °F		-20 °C/65 °C -4 °F/149 °F
Fabrication/ joining system	Flexproof (adhesive-free)		Thermofix		Flexproof (adhesive-free)

¹⁾ except TF-15H (Hamid)

Product key data

The table below lists the key data of the most commonly used HabaDRIVE® belts.

For detailed and up-to-date product data, contact www.habasit.com

	Belt group	Belt code	Double-sided power transmission, tangential drives	Thickness [mm]	Pulley diameter minimum with counter flexion [mm]	Tensile force for 1% elongation per unit of width [N/mm] (k _{1%} after running in)	Nominal peripheral force per unit of width [N/mm]	
Polyester power transmission belts	TC-	TC-10EF	●	1.8	25	5	10	
		TC-20EF	●	2.0	25	10	21	
		TC-20/25EF	●	2.5	50	11	23	
		TC-35ER	●	2.5	50	18	38	
		TC-35/30ER	●	3.0	50	18	38	
		TC-35/35ER	●	3.5	70	18	38	
		TC-55ER	●	3.0	70	25	53	
	TCF-	TCF-20EL	○	2.6	80	10	21	
		TCF-35EL	○	3.0	100	18	38	
		TCF-55EL	○	3.5	150	25	53	
		TCF-20H	●	1.5	25	10	20	
		TCF-50H	●	2.0	60	24	48	
	Polyamide power transmission belts	S-	S-10/15	●	1.5	40	4.4	12
			S-18/20	●	2.0	60	8	22
S-18/30			●	3.0	60	8	22	
S-33/40			●	4.0	125	13	37	
S-33/50			●	5.0	125	13	37	
S-140H			●	1.7	40	4.8	13	
S-141H			●	2.3	40	4.8	13	
S-250H			●	2.3	100	11	29	
S-250HR			●	2.6	100	11	29	
S-251H			●	3.0	100	11	29	
S-321H			●	3.2	125	13	35	
S-390H			●	3.2	160	14	38	
S-391H			●	4.0	160	14	38	
A-		A-2	○	2.7	60	7.5	22	
		A-3	○	3.4	125	12	36	
		A-4	○	5.0	300	21	63	
		A-5	○	6.8	450	30	92	
Aramide power transmission belts		TF-	TF-10	●	1.7	25	10	10
			TF-15	●	2.0	30	15	15
	TF-15H		●	1.5	30	15	15	
	TF-22		●	2.4	60	22	22	
	TF-33		●	3.0	100	33	33	
	TF-50		●	3.9	125	50	50	
	TF-75T		○	4.4	200	75	75	
	TF-75TE		○	4.4	200	75	75	

● Applicable ○ Not applicable

All data are approximate values under standard climatic conditions: 23 °C/73 °F, 50% relative humidity (DIN 50005/ISO 554), and are based on the Habasit master joining method.

In order to guarantee problem-free running and to benefit from the features of a power transmission belt, the following three factors must be defined:

- Belt type
- Belt width
- Initial elongation

If one of the three factors changes, the belt must be re-calculated.

The professional specification of power transmission belts comprises the following steps:

1. Gathering the drive data
2. Selection of the optimal belt type
3. Calculation of the required belt dimensions

Gathering the drive data

In order to select the optimal belt type and to calculate the required belt dimensions it is crucial to have exact information on the application, the drive data and the operating conditions.

For the calculation of a common two-pulley power transmission belt the following data are required:

- P_M = motor power or power to be transmitted [kW]
 n_1 = number of revolutions of driving pulley [1/min]
 n_2 = number of revolutions of driven pulley [1/min]
 d_1 = diameter of driving pulley [mm]
 d_2 = diameter of driven pulley [mm]
 c = center distance [mm]

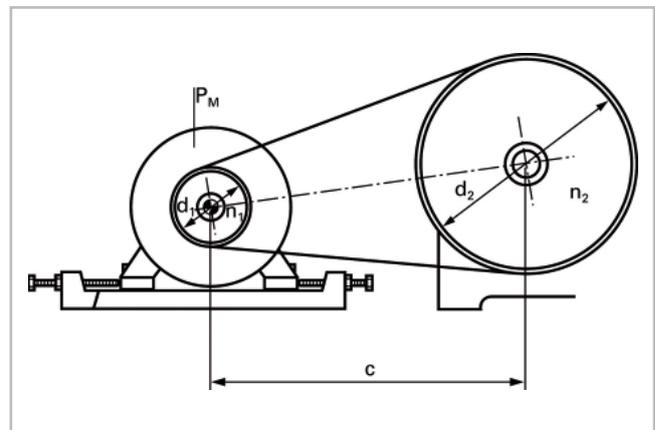
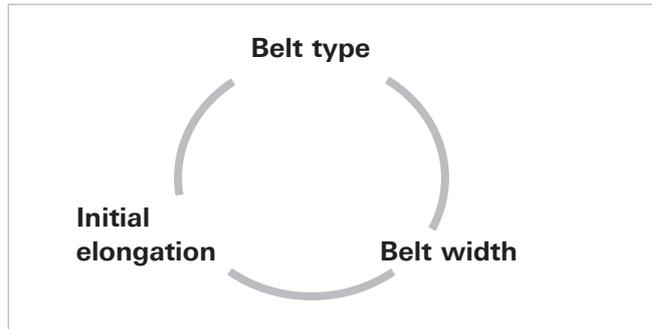
Please use the **Questionnaires** (see Appendix). These should be copied, completed and forwarded to the person responsible for belt selection and calculation.

Selection of the optimal belt type

The optimal belt type can be determined by reference to the **Belt selection chart** on the following page.

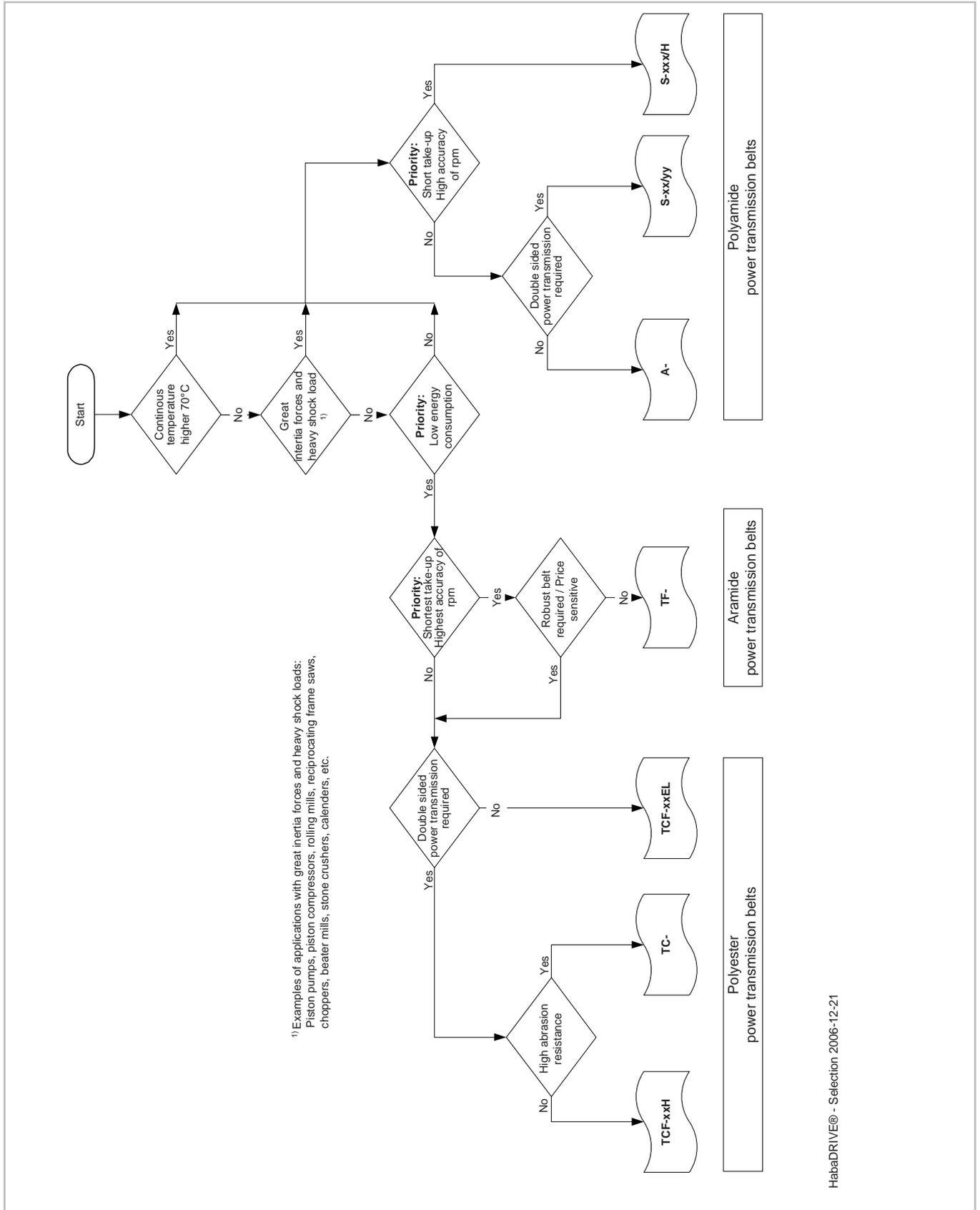
If the Habasit POWER-SeleCalc program is available, use the easy to handle Belt Selector in order to select the optimal belt type.

For further support please contact your Habasit partner.



Belt selection and calculation

Selection of the optimal belt type



HabaDRIVE® - Selection 2006-12-21

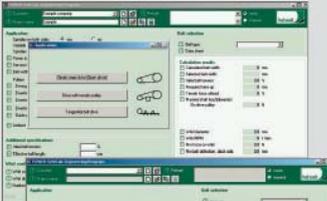
Belt selection and calculation

Calculation by POWER-SeleCalc

The Habasit POWER-SeleCalc program enables the user to perform a belt selection in terms of machine and environmental influences, and to calculate the technical drive data such as belt width, initial elongation, static and dynamic shaft load, effective belt length, etc. of two pulley drives, drives with tension pulley, and tangential belt drives, in a quick and easy way.

Single stage drive/open drive (two pulley drive)

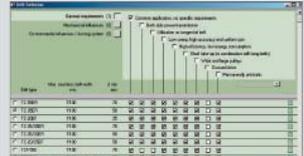
Selection /input mask



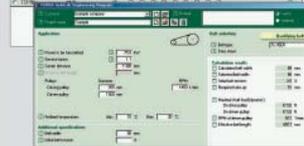
Further input mask



Belt selector mask



Result screen



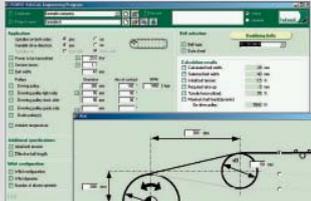
Result printout



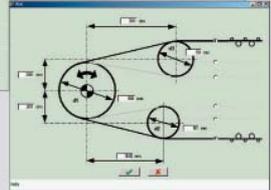
Option: Printout of Product Data Sheets

Tangential belt drive

Selection /input mask



Drive configuration input/selection mask



The Habasit POWER-SeleCalc program can be ordered free of charge via our website www.habasit.com, by e-mail info@habasit.com, or by contacting your Habasit partner.

In belting technology, there are a few special expressions and technical data which need a brief explanation.

Belt length

The length of power transmission flat belts can be expressed in three ways:

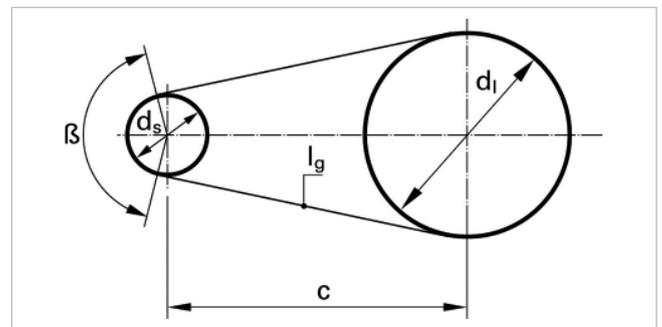
- Geometric belt length (l_g)
- Effective belt length (l_{eff})
- Shortened belt length (l_s)

For common two pulley drives, the difference between geometric and effective belt length is negligible. However, in specific applications, e.g. short centre distance and/or relatively thick belts, limited take-up etc., greater calculation accuracy is necessary.

Please note that the theoretical considerations below are automatically taken into consideration when using the POWER-SeleCalc calculation program.

Geometric belt length (l_g)

The geometric belt length means the inner circumference of an un-tensioned belt drive on the assumption that the belt is infinitely thin. The belt thickness and the position of the neutral layer are not considered.



Exact formula for the calculation of the geometric belt length of a two pulley drive:

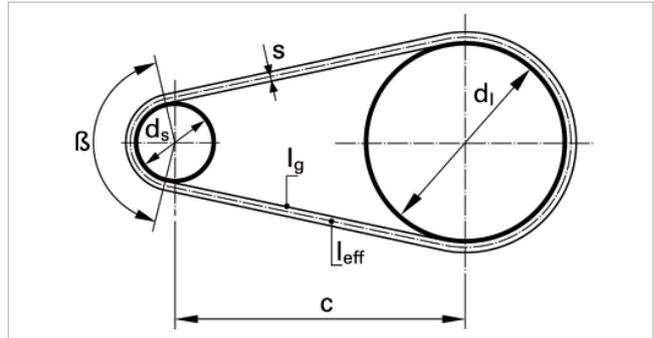
$$l_g = 2c \cdot \sin\left(\frac{\beta}{2}\right) + \frac{\pi}{2} \left[d_s + d_l + \frac{(d_l - d_s)(180 - \beta)}{180} \right] [\text{mm}]$$

- c = center distance [mm]
 d_s = diameter of small pulley [mm]
 d_l = diameter of large pulley [mm]
 β = arc of contact on small pulley [°]

$$\beta = 2 \arccos\left(\frac{d_l - d_s}{2c}\right) = \quad [^\circ]$$

Effective belt length (l_{eff})

The effective belt length is the length of the neutral layer of an **un-tensioned** belt. It is identical with the fabrication length.

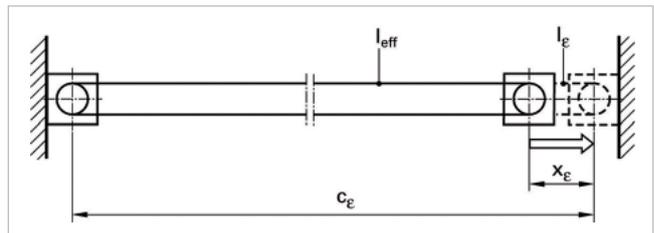


Exact formula for calculation of the effective belt length of a two pulley drive:

$$l_{\text{eff}} = 2c \cdot \sin\left(\frac{\beta}{2}\right) + \frac{\pi}{2} \left[d_s + d_l + 4s + \frac{(d_l - d_s)(180 - \beta)}{180} \right] \text{ [mm]}$$

- c = center distance [mm]
- d_s = diameter of small pulley [mm]
- d_l = diameter of large pulley [mm]
- s = position of the neutral layer measured from running side [mm]
- β = arc of contact on small pulley [°]

In machines with **defined take-up displacement**, where the belt is elongated to a fixed end position, usually the center distance for the tensioned belt (c_e) is known.



The effective length (fabrication length) of the un-tensioned belt has to be calculated accordingly:

$$l_{\text{eff}} = 2(c_e - x_e) \cdot \sin\left(\frac{\beta}{2}\right) + \frac{\pi}{2} \left[d_s + d_l + 4s + \frac{(d_l - d_s)(180 - \beta)}{180} \right] \text{ [mm]}$$

- c_e = center distance of tensioned belt [mm]
- x_e = take-up displacement [mm]

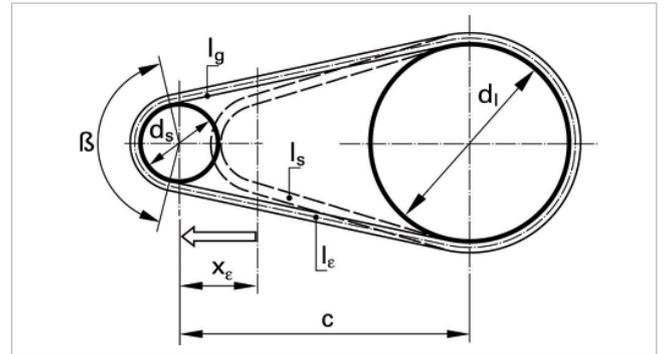
Formula for the calculation of the take-up displacement (x_e):

$$x_e = \frac{l_{\text{eff}} \cdot \epsilon_0}{2 \cdot 100}$$

- l_{eff} = effective length of the un-tensioned belt [mm]
- ϵ_0 = initial elongation [%]

Shortened belt length (l_s)

In applications without any tensioning device at all, the belt must be fabricated shorter by the amount equal to the required initial elongation.



The basic formula for the calculation of the shortened belt length (l_s), that is the fabrication length, is:

$$l_s = \frac{100 \cdot l_\epsilon}{100 + \epsilon_0} \quad [\text{mm}]$$

l_ϵ = length of the tensioned belt [mm]
 ϵ_0 = initial elongation [%]

Usually the geometric belt length (l_g), this means the inner circumference of the tensioned belt, is known. The position of the neutral layer (s) has therefore to be considered in the formula for the calculation of the shortened belt length:

$$l_s = \frac{100 \cdot [l_g + (2s \cdot \pi)]}{100 + \epsilon_0} \quad [\text{mm}]$$

Note: If the drive is equipped with a tensioning device, but the available take-up displacement is not sufficient to obtain the effectively calculated take-up displacement (x_e), the belt may be **partially shortened**.

Tensile force for 1% elongation ($k_{1\%}$ value)

The $k_{1\%}$ value indicates the tensile force per unit of belt width that is required to elongate it by 1% [N/mm].

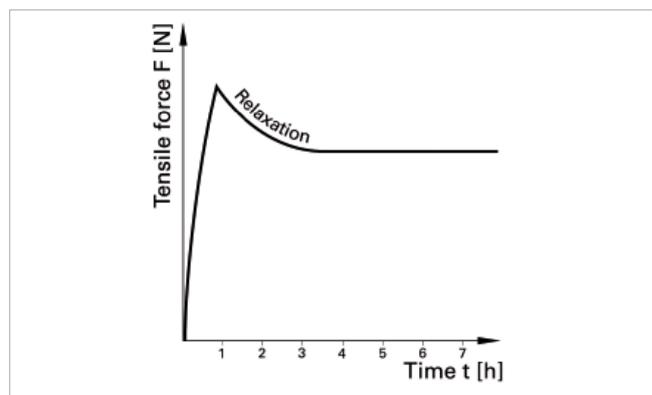
Tensile force for 1% elongation after running-in ($k_{1\%a.r.i.}$)

The correlation of force and elongation of synthetic material is influenced by the elapsed time after stretching, temperature and humidity. While the influence of temperature and humidity is quite complex (and will not be further discussed here), the influence of time on force/elongation behavior after stretching synthetic material cannot be neglected.

In the following it is described what happens when a synthetic material, like a power transmission belt, is elongated:

To achieve elongation a certain tensile force (F) is required. At the end of the elongation the tensile force immediately starts to decrease, first considerably, later moderately, until the force remains constant. The explanation for this is a microscopic displacement of molecular chains against each other. This viscoelastic phenomenon is called "relaxation".

Habasit considers the relaxation of power transmission belts by measuring the $k_{1\%}$ value **after the relaxation phase** or running-in time period.



This is why the value is called $k_{1\%}$ **after running-in**:

$k_{1\% a.r.i.}$ = tensile force for 1% elongation per unit of width after running-in [N/mm]

The $k_{1\% a.r.i.}$ is the decisive value for calculating the required belt width and the resulting shaft load after belt relaxation.

Technical belt data

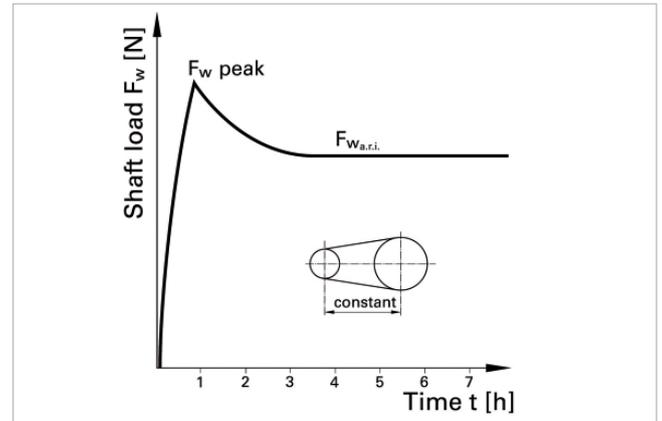
Shaft load – Nominal peripheral force

Shaft load

The described relaxation phenomena directly influence the shaft load.

If a power transmission belt is tensioned to the required initial elongation, the resulting shaft load will be at maximum (F_{Wpeak}) immediately after elongation.

Where the belt is tensioned to a **constant elongation**, the shaft load decreases over the course of time. While the shaft load reduction is relatively large at first (the main part of the belt relaxation takes place within the first 2–3 hours after tensioning), it gradually tapers off until the shaft load remains constant ($F_{Wa.r.i.}$).



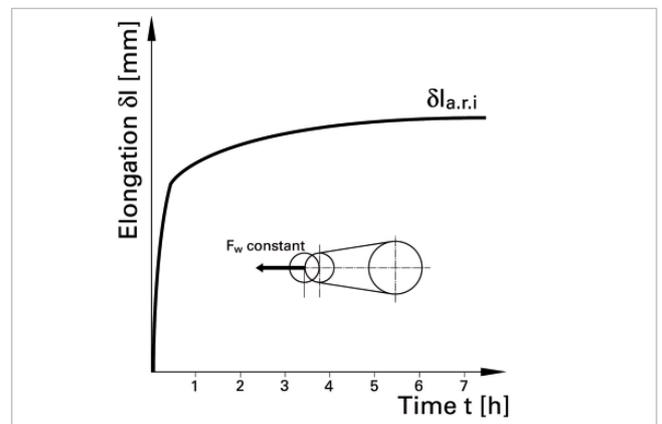
The highest shaft load (F_{Wpeak}), appearing immediately after elongation, is about 40% to 50% higher than the shaft load after relaxation or after running-in ($F_{Wa.r.i.}$), depending on belt type and elongation conditions.

This fact must be considered when specifying shafts and bearings (see the chapter on “Design guidelines, bearings”), in the engineering of the drive frame, as well as during belt installation (see the chapter on “Belt installation”).

Habasit’s shaft load indications refer to the situation after relaxation, after running-in respectively.

We distinguish between the static shaft load (at standstill F_{Ws}) and the dynamic shaft load (in operation F_{Wd}), where centrifugal forces are considered.

Note: Where the belt is tensioned by a **constant force**, mechanical force (hydraulic or pneumatic cylinder or spring) or by force of gravity, the shaft load remains constant, but the belt changes its length. This means it elongates after tensioning due to relaxation, until the length remains constant.



Nominal peripheral force

The nominal peripheral force (F'_{UN}) indicates the force which can be transferred from the circumference of the drive pulley to the belt in Newton per unit of belt width [N/mm].

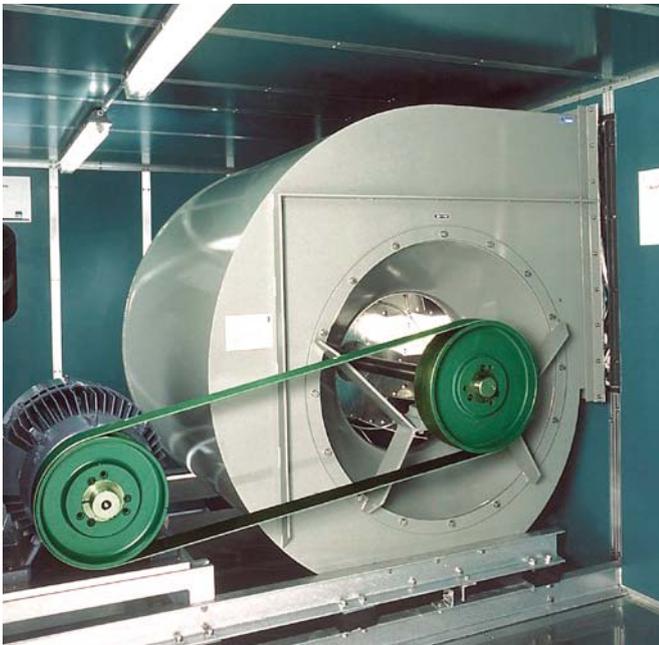
The F'_{UN} is the product of the $k_{1\%}$ after running-in ($k_{1\%a.r.i.}$) and the admissible elongation (ϵ_{adm}) of the belt, considering the coefficient of friction (μ) between belt and steel pulley.

The admissible elongation is determined by extensive tests for each belt type.

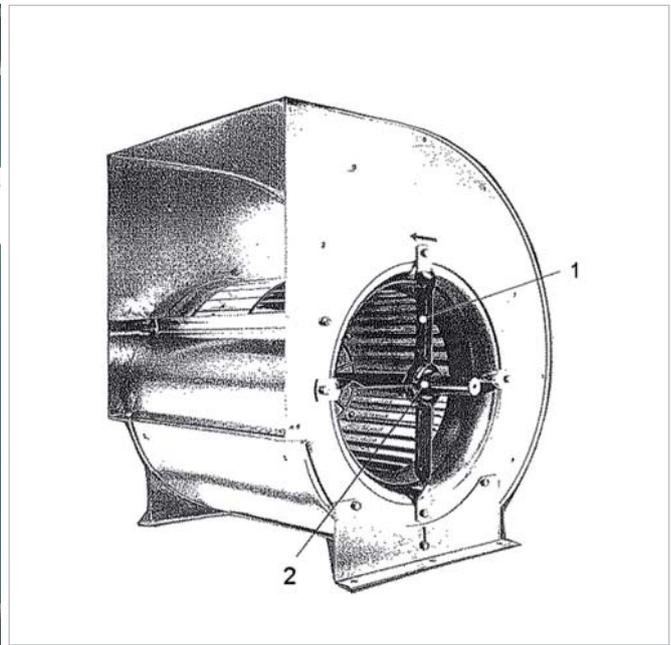
Note: The nominal peripheral force indicates the effective strength of a power transmission flat belt.

Flat belt drives transmit power by friction. This fact means that the belt needs to be pressed onto the periphery of the pulley with a certain force. This force creates a shaft load which has to be borne by the shafts and bearings. Finally, the installation has to take up all forces without appreciable distortion. This leads to the following conclusions:

- The drive structure must be rigid and distortion-resistant, i.e. machine frame, shaft bearings and motor mounting must be sized in accordance with the maximum developed tension forces and related shaft loads.
- All shaft and roller axes coming into contact with the belt must be perpendicular to the belt running axis.
- The installation must be grounded (electrically connected with the earth potential) in order to prevent an electrostatic charge. Exercise caution with synthetic-supported bearings or mobile installations on rubber wheels!



a) Example of an appropriate, distortion-resistant bearing support



b) Example of an **inappropriate** design

- 1 Weak and non-distortion-resistant design of the bearing support
- 2 Bearings supported by rubber rings (mechanically weak and cause electrostatic charge)

Pulley material

For peripheral speeds of $v \leq 35$ m/s, it is preferable to choose **cast iron** pulleys. For $v > 35$ m/s, use steel pulleys or cast iron pulleys of higher strength. The above data refer to solid pulleys and center disc pulleys.

Injection-molded pulleys of **duroplastic** material are becoming common for weight and cost reasons. In general it is not recommended to use duroplastic pulleys for driving or driven pulleys due to the low heat conductivity of synthetic material which can result in inadmissible temperatures of the pulleys and belt.

Aluminum pulleys and rollers have to be **anodized**. However, premature wear and “blackening” of the pulleys has been observed.

Pulley dimensions

Pulley diameter and width depends on the requirements and geometric data of the application.

Pulley width

The width of the pulleys should be at least 1.05 to 1.1 times belt width b_0 .

Pulley diameter

The required transmission ratio for the application must be observed.

The minimum pulley diameter according to the flat belt product data sheet must be respected.

The **maximum** diameter is usually limited by the size of the installation, often by the belt safety guard.

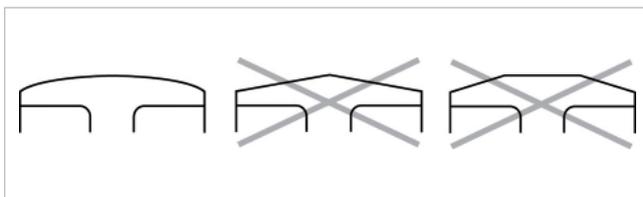
General rule: The larger the pulley diameters, the higher the belt speed and, consequentially, the lower the shaft load.

Basically, pulleys may have any dimensions. Whenever possible, however, pulleys with a standard diameter according to ISO 22 should be used.

Pulley crown

To prevent the flat belts from running off, **at least one of the pulleys has to be crowned**, preferably the larger pulley, or the pulley with the largest arc of contact.

It is recommended that the shape of the profile should be a regular, symmetrical curve. Do not use conical or cylindrical-conical shaped pulleys, and avoid sharp edges under all circumstances.



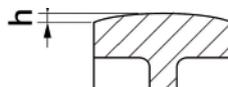
Commercial pulleys are usually crowned according to ISO 22. **If Habasit flat belts are used, the height of the crown can be reduced** because of their superior lateral rigidity and subsequent excellent tracking properties. Recommended crown heights see table on the following page.

Design guidelines

Flat belt pulleys

Recommended crown height:

Pulley diameter acc. to ISO 22 [mm]	Recommended crown height (h) [mm]					Crown height acc. to ISO 22 Not recommended [mm]	
	Pulley width b acc. to ISO 22 [mm]					Pulley width [mm]	
[mm]	20, 25, 32, 40, 50	63, 71, 80, 90, 100	112, 125, 140, 160	180, 200, 244, 250	280, 315, 355, 400	b ≤ 250	b ≥ 280
40	0.3	0.3	0.3	0.3	0.3	0.3	0.3
50							
63							
71							
80							
90							
100	0.4	0.4	0.4	0.4	0.4	0.4	0.4
112							
125							
140							
160							
180							
200	0.5	0.5	0.5	0.5	0.5	0.5	0.5
224							
250							
280							
315							
355							
400	0.6	0.6	0.6	0.6	0.6	0.6	0.6
450							
500							
560							
630							
710							
800	0.7	0.7	0.7	0.7	0.7	0.7	0.7
900							
1000							
1120							
1250							
1400							
1600	0.8	0.8	0.8	0.8	0.8	0.8	0.8
1800							
2000							
2000							



For recommendations regarding pulley diameters > 2000 mm, please contact your Habasit partner.

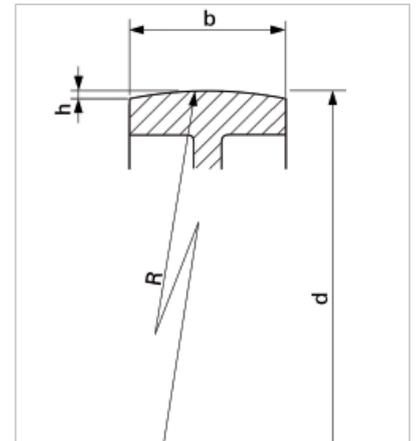
Crown heights greater than indicated in the table above may result in a loss of guiding effect, especially with laterally stiff belts.

Correlation of crown (h) and manufacturing radius (R)

$$R = \frac{h}{2} + \frac{b^2}{8h} \quad [\text{mm}]$$

$$h = \frac{b}{2} \operatorname{tg} \left(\frac{\arcsin \left(\frac{b}{2R} \right)}{2} \right) \quad [\text{mm}]$$

The higher the arc of contact, the better the tracking effect of crowned pulleys.



Pulley running surface

Clean and smooth running surfaces increase the efficiency and service life of power transmission belts.

The running surface of driving pulleys must not be too smooth, due to the risk of stick-slip and noise creation, and not too rough (no knurled surfaces!) as this can cause excessive belt wear and premature belt failure.

Habasit's recommendation for the roughness of the running surface:

$$R_a = 6.3 \text{ to } 3.2 \mu\text{m} \text{ (attainable by normal tooling on a lathe)}$$

R_a = arithmetical mean deviation of the profile according to ISO 4287

For small pulley and roller diameters (approx. 200 mm) a smoother surface is possible, but not necessary, e.g. $R_a = 1.6 \mu\text{m}$ (only attainable on a precision lathe with high accuracy).

Avoid smoother surface roughness than $R_a = 3.2 \mu\text{m}$ on large and wide driving and driven pulleys due to the risk of stick-slip.

Pulley balance quality

For peripheral speeds up to $v = 30 \text{ m/s}$ and diameter $d = 355 \text{ mm}$, pulleys are usually balanced in one plane, quality grade G 1.6, according to ISO 1940 (VDI 2060).

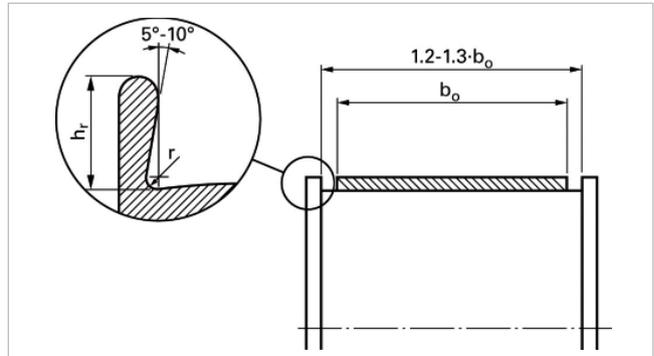
For higher peripheral speeds of $v > 30 \text{ m/s}$ and diameter $d > 355 \text{ mm}$, pulleys are best dynamically balanced in two planes.

Flanged pulleys

Avoid flanged pulleys and flanged rollers because there is a risk of belt damage if the belt runs onto the flanges

In exceptional cases, e.g. where long tangential belts have to be kept in the right position during installation, flanged pressure rollers may be acceptable. However, the belt should not touch the flanges during normal operation.

The width of the running surface should be 20% to 30% wider than the belt width (b_o). The flange height (h_f) should be about the same as the belt thickness and should be undercut to minimize the contact area with the belt.



Bearing selection and specification

Selection and specification of bearings according to the manufacturers' guidelines.

Bearing load

It is a prerequisite for the determination of the bearing load to know the **shaft load** created by the tensioned belt (see the chapter on "Technical belt data, Shaft load").

When using the POWER-SeleCalc calculation program, both the static shaft load (F_{Ws}) and the dynamic shaft load (F_{Wd}), are determined while calculating the belt.

Please consider when specifying the bearings that the highest shaft load (F_{Wpeak}), appearing for a short time immediately after elongation, is about 40% to 50% higher than the indicated shaft load F_{Ws} or F_{Wd} .

Note: In rare cases, e.g. if a very strong belt is unusually fast elongated, the shaft load appearing for a short time immediately after the first elongation can be up to 100% higher than the indicated shaft load in the POWER-SeleCalc calculation program.

If the basis for the calculation of the bearing load, the shaft load (F_W), is known, the actual bearing load can be calculated as follows:

• One-side bearing arrangement

$$\text{Load on bearing A} = F_W \cdot \frac{c_1 - c_2}{c_2} \quad [\text{N}]$$

$$\text{Load on bearing B} = F_W \cdot \frac{c_1}{c_2} \quad [\text{N}]$$

• Two-side bearing arrangement

$$\text{Load on bearing A} = F_W \cdot \frac{c_2 - c_1}{c_2} \quad [\text{N}]$$

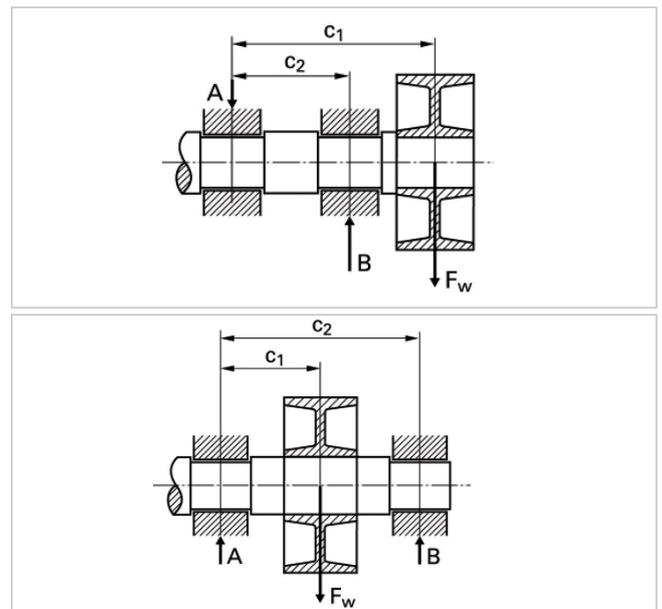
$$\text{Load on bearing B} = F_W \cdot \frac{c_1}{c_2} \quad [\text{N}]$$

It goes without saying that the resulting bearing load must not exceed the admissible bearing load indicated in the bearing data sheet.

If the calculated maximal bearing load that appears is close to the limit or exceeds the admissible load of the bearings used, the following measures can be taken:

- If possible increase pulley diameters in order to reduce the shaft load
- Choose a belt tension system using mechanical force (hydraulic or pneumatic cylinder or spring) or force of gravity (constant shaft load).
- Tension the belt in two steps when installing (see the chapter on "Belt installation, two step tensioning" on page 50).

Note: Contrary to the wide-spread opinion, the shaft load and the resulting bearing load of power transmission flat belts are not higher, but about the same as in other non-positive driving elements such as V-belts and poly-V-belts, provided that they are installed properly.

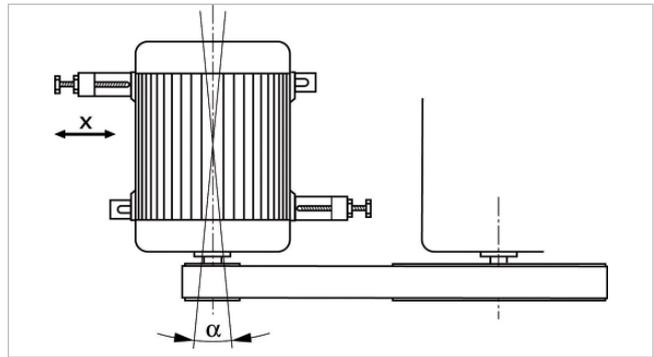


Correct and sufficient initial elongation is a pre-requisite for trouble-free operation of power transmission flat belts. The calculated initial elongation (ϵ_0) must be observed!

One has to distinguish between drive systems with variable centre distance, systems with defined take-up, systems with tensioning pulley, and systems with no tensioning device.

Systems with variable centre distance

The most common system for two pulley drives. Usually the motor is mounted on an adjustable base. The belt is tensioned by moving the base. After tensioning, the base is fixed with screws.



Sufficient tensioning length in the direction of x must be provided corresponding to installation and belt length tolerance due to the influences of temperature and humidity on the belt length (namely the polyamide traction layer) etc. Further-more, the shaft has to be adjusted square to the belt running axis by adjusting the α angle.

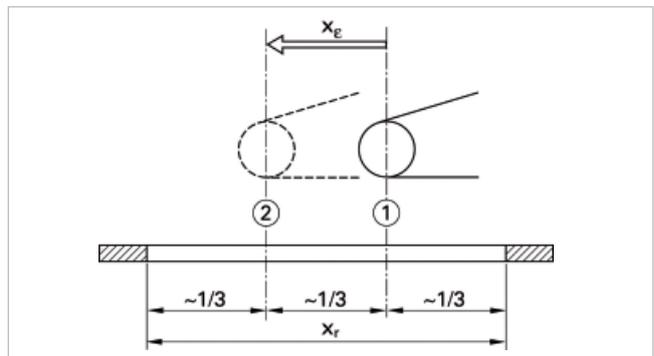
Recommended take-up of the tensioning device:

$$x_r \cong 3 \cdot x_\epsilon$$

- ① Position of the pulley with un-tensioned belt
- ② Position of the pulley after tensioning to initial elongation ϵ_0

x_ϵ Effective required take-up displacement [mm]

x_r Recommended take-up of the tensioning device [mm]



Systems with defined take-up

Due to the well-defined take-up displacement (the belt is elongated to a fixed end position), improper adjustment of the required initial elongation during installation can be avoided.

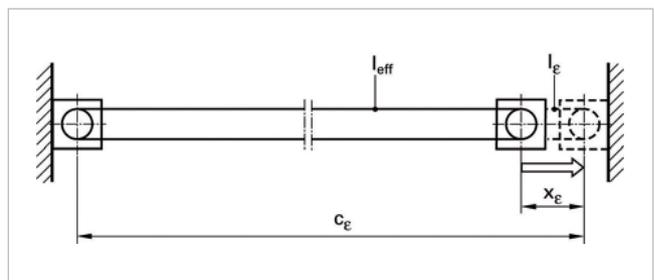
l_{eff} = effective length (fabrication length) of the un-tensioned belt [mm]

l_ϵ = length of tensioned belt [mm]

c_ϵ = center distance of tensioned belt [mm]

x_ϵ = take-up displacement [mm]

Machines with defined take-up displacement appear to be an intelligent and user-friendly solution. However, the system has some drawbacks:



1. The effective belt length (fabrication length, l_{eff}) must be produced with a high level of accuracy. Small differences in length may cause considerable deviations in belt tension. This is especially true with a short belt length and/or belts with a high modulus of elasticity (high $k_{1\%}$ value).

Observing the exact belt fabrication length is highly important with this system! Recommended fabrication length tolerance: **0/-** yy mm.

Deviations in belt length cannot be compensated for on such a machine design. Re-tensioning is impossible. Problems including slip and premature belt wear result if the belt is too long.

2. Influences on the belt dimension due to temperature or humidity changes (polyamide belts) cannot be compensated for and may lead to an increase or decrease in the shaft load.
3. Tensioning can be done by a hand-driven spindle, which is quite a slow process that allows the belt to relax. Other methods, such as a knee-lever or pneumatic or hydraulic cylinder, tension the belt very fast, causing high belt stress and high shaft load before the belt relaxes, leading to excessive bearing and shaft load.

Abrupt tensioning, e.g. provided by hydraulic or pneumatic cylinders, may damage aramide belts (TF-range).

4. This kind of tensioning device is often designed for one particular belt type. Changing later to another belt type can lead to problems.

Systems with tensioning pulley

In this system, the center distance between the driving and the driven pulley is fixed. A tensioning pulley, preferably placed on the slack side (less tensioning forces required), pushes the belt and thus provides the required initial elongation. The required pushing force can be provided by a hydraulic or pneumatic cylinder, spring load, or by a gravity system.

The Habasit POWER-SeleCalc calculation program automatically determines the shaft load of all three pulleys and the required take-up.

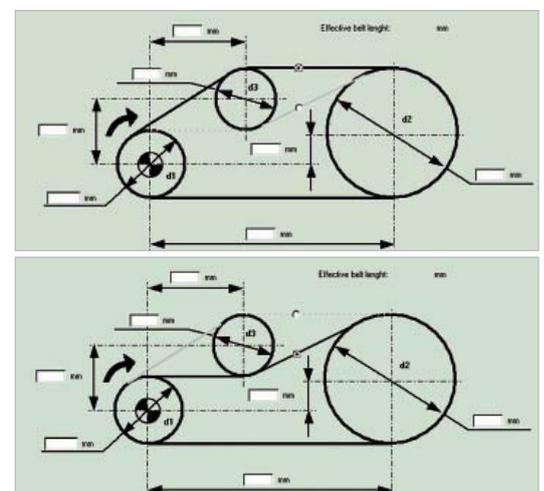
Systems without tensioning device

Old drive designs sometimes have no tensioning device at all. In this case the belt has to be forced onto the pulleys by hand.

In systems without tensioning device the required initial elongation (ϵ_0) is determined by reducing the length to the shortened belt length (l_s), which is the fabrication length.

It is important to pay attention when installing the belt. Twisting and excessive lateral forces to the belt, etc. must be avoided.

Aramide belts (TF-range) are not recommended for use in such applications due to the risk of damaging the traction layer during installation.



Overview

In addition to the classical two pulley drive, there are many different drive applications where the flat power transmission belt is the ideal solution.

The following drive systems are presented in this chapter:

- Tangential belt drive
- Spindle tape drive
- Live roller drive
- Multi pulley drive (power branching)
- Mule drive
- Half-cross drive

Introduction to the tangential belt drive

The tangential belt drive is mainly used in the textile industry for driving spindles on ring spinning, open-end spinning, twisting and texturizing machines.

In principle, this is a tangential drive where the power is not transmitted to a single driven pulley but to an array of spindles or rotors. The spindles (rotors) are arranged in a linear manner with the belt pressed against them by pressure rollers to drive them tangentially.

This is why it is referred to as a “tangential belt drive”.

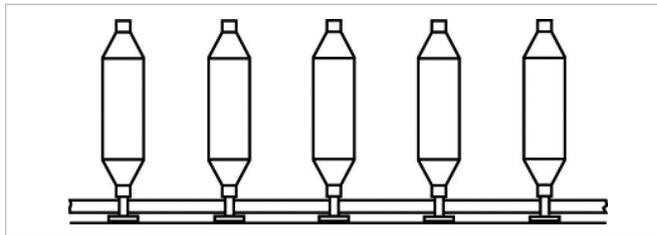
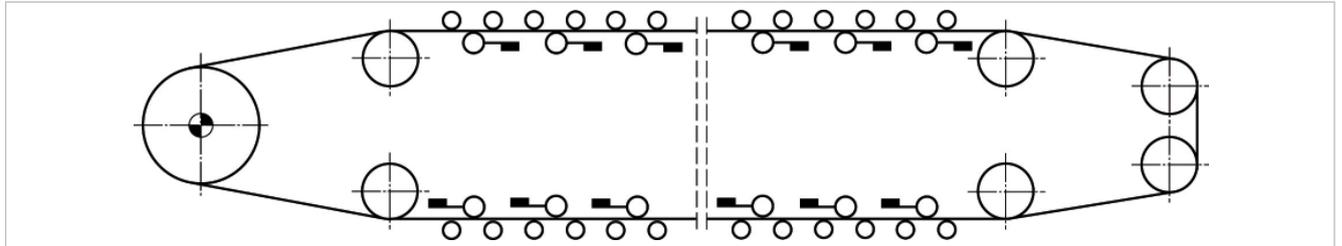
Tangential belt drives may have various arrangements, depending on the machine manufacturer, type and size of machines, etc. The most important systems are described in the following, without claim to completeness. The advantages and weaknesses described are general statements, which can be compensated for by special machine designs or special belt types, depending on the situation.

Special flat belt drives

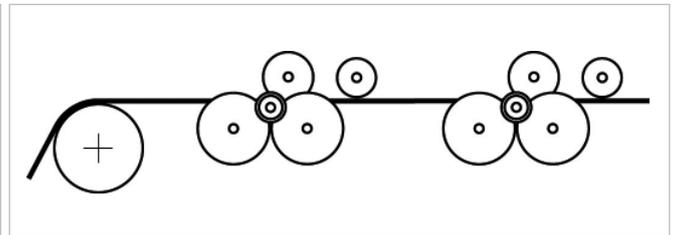
Tangential belt drive

Single belt/single drive system

The tangential belt is driven on one end of the machine by a drive pulley and on the other end diverted by one or two rollers to return to the drive. The belt is normally driven on its inner side; on the outer side it drives hundreds of spindles or rotors.



Ring spinning



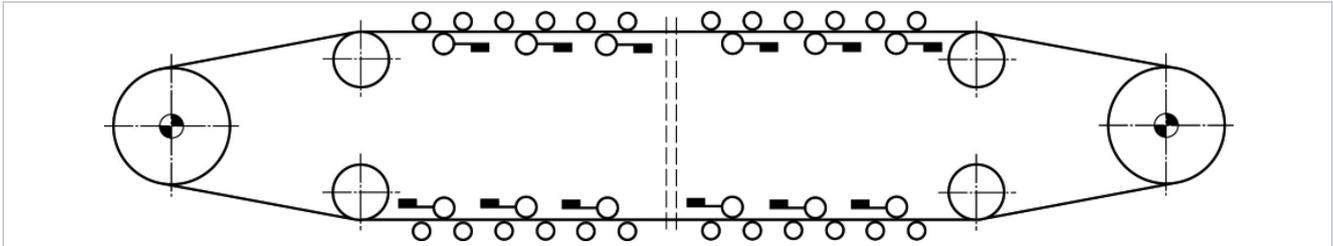
Open-end spinning

Advantages of the system	Weaknesses of the system
<ul style="list-style-type: none"> • Simple drive principle • Large pulleys, few flections, no counter flection → long belt service life • Easy belt installation 	<ul style="list-style-type: none"> • Strong belts required, thus → high shaft and bearing load → heavy machine design → long take-up displacement ¹⁾ • Significant deviation of spindle rpm from first to last spindle ¹⁾ • Demanding belt tracking • Efficiency not optimal • If belt fails all spindles (rotors) are out of production

¹⁾ Can be compensated by using TF- belts with aramide traction layers

Single belt/dual drive system

The tangential belt is driven by two motors placed at both ends of the machine. This reduces the power to be transmitted per motor and belt to 50% compared with the "one-belt-one-drive" system.

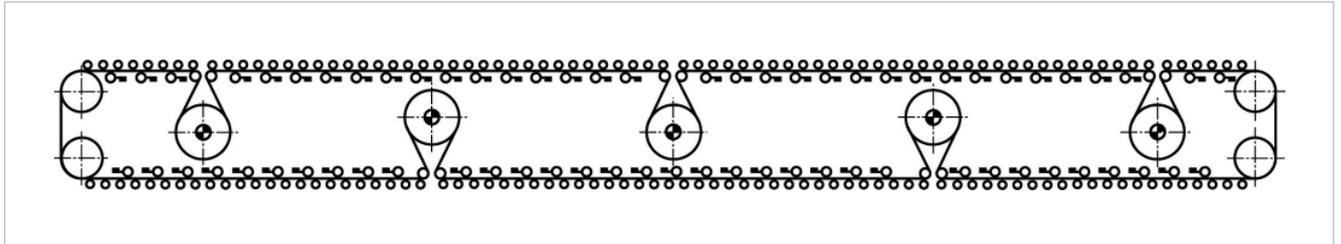


Advantages of the system	Weaknesses of the system
<ul style="list-style-type: none"> • Lower strength belts required compared with the → single belt / single drive system, thus → smaller shaft and bearing load → lighter machine design • Automatic speed control and adjustment of variable speed motors is less demanding compared with "multi drive" systems • Large pulleys, few flexions, no counter flexion → long belt service life • Easy belt installation 	<ul style="list-style-type: none"> • Deviation of spindle rpm from first to last spindle conderable ¹⁾ • Demanding belt tracking • Greater efficiency compared with the "single belt / single drive", but still not optimal • If belt fails, all spindles (rotors) are out of production

¹⁾ Can be compensated by using TF- belts with aramide traction layers

Single belt/multi drive system

With the multi motor drive, the tangential belt is driven by several motors arranged in regular intervals around the machine. As a consequence, lower strength tangential belts can be used. Machines with such a group drive have been produced to 60 meters in length, containing as many as 1500 spindles.



The number of revolutions of the individual motors must be perfectly synchronized and the diameter of the driving pulleys have to be in a narrow tolerance, otherwise the belt assumes the stresses of equalizing the speed, resulting in premature belt wear and reduced belt service life.

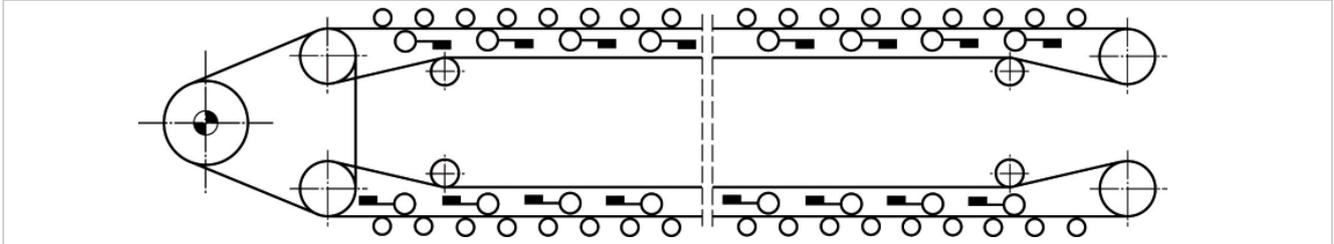
Advantages of the system	Weaknesses of the system
<ul style="list-style-type: none"> • Lower strength belts required compared with the single belt / single drive system, thus <ul style="list-style-type: none"> → smaller shaft and bearing load → lighter machine design • High efficiency, low energy consumption • Minimal difference in spindle rpm 	<ul style="list-style-type: none"> • Automatic speed control and adjustment of variable speed motors is <ul style="list-style-type: none"> → technically demanding → expensive → sensitive • Premature belt wear, reduced service life and irregular yarn quality result if motors are not perfectly synchronized • If belt fails, all spindles (rotors) are out of production • Reduced service life due too small pulleys, a high number of reverse bending cycles and because only one side of the belt is used

Special flat belt drives

Tangential belt drive

Dual belt drive system

Two separately-driven tangential belts, one located on each side of the machine, each drives half of all the spindles, thus reducing the power to be transmitted per belt to 50%. This permits the use of lower strength belts and lower belt tension.



Advantages of the system	Weaknesses of the system
<ul style="list-style-type: none">• Lower strength belts required compared with the single belt/single drive system, thus → smaller shaft and bearing load → lighter machine design• Relatively large pulleys, few flexions and counter flexions → long belt service life• If one belt fails, production can still run at 50% until repair is made	<ul style="list-style-type: none">• Different initial elongation and running conditions for the two belts• Difference in spindle rpm between left and right side (due to creep of the main drive) ¹⁾• Demanding belt tracking• Demanding belt specification• Additional time required to replace all belts

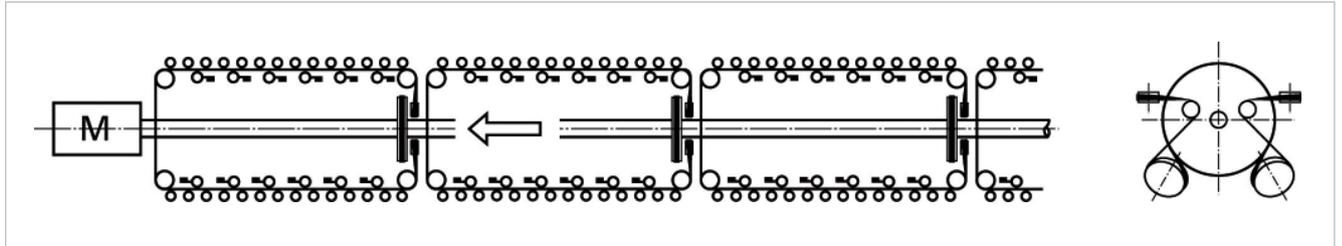
¹⁾ Can be reduced by using TF- belts with aramide traction layers

Special flat belt drives

Tangential belt drive

Section (segmented) drive system

With the section drive (also called segmented or group drive) a single motor drives a central shaft, which is oriented along the length of the machine. Driving pulleys are fixed on the shaft and drive multiple tangential belts. Each tangential belt drives a small group of spindles, e.g. 24 spindles on each side.



Advantages of the system	Weaknesses of the system
<ul style="list-style-type: none">• Lower strength belts required• Small difference in spindle rpm between left and right side of the machine• High efficiency, low energy consumption• Time-saving belt installation of endless belts• If one belt fails, only limited loss to production until repair is made	<ul style="list-style-type: none">• Extensive drive system• Small pulley diameters, high numbers of reverse bending cycles and belt twists → reducing belt service life• Accurate belt length required due to defined take-up

Technical requirements on tangential belts

The demands on tangential belts are many and may have different priority, depending on the type of application, machine type, belt speed, operating conditions, maintenance capabilities, etc.

- **Energy saving**

Modern, flexible belts with a high modulus of elasticity, such as polyester fabric (TC-range) and aramide fabric (TF-range), can produce a high degree of efficiency and as a consequence, realize considerable savings in energy costs.

- **Long service life, low down-time**

This highly stressed machine element can still deliver a long service life provided that the belt is selected, installed and maintained according to these guidelines.

- **Easy, fast and reliable joining method**

If belts have to be joined on the machine, an easy joining method – producing a uniform, reliable splice – is important in order to optimize up-time. The joint (splice) must not lead to belt vibrations.

- **Suitable and constant force/elongation-ratio**

An optimal force/elongation-ratio (E-modulus, k_1 %-value), which remains constant throughout the belt's service life ensures highly consistent and superior yarn quality, low belt maintenance, and long belt life.

- **High and constant coefficient of friction**

Tangential belts must transmit the necessary peripheral force without slipping under all operating conditions. This requires a high coefficient of friction of the cover that will remain constant during the entire service life. The normal influence of humidity, batching oil, fibers and other debris must not lead to slipping problems.

- **Vibration-free running**

For reasons of noise control and yarn quality, as well as with regard to achieving a high service life of the tangential belt, spindle bearings and other machine parts, the belt should provide quiet, vibration-free operation, particularly at the highest running speed. Uniform belt thickness and a homogeneous joining area are, therefore, important belt features.

- **Minimum run-up time**

After splicing of the thread, the spindle (rotor) brake is released and the spindle (rotor) is again accelerated to its normal operating speed. The run-up time has to be within a time frame of few seconds. This is attainable with a high E-modulus (k_1 %-value) and a high and consistent friction tangential belt.

- **Perfect tracking, no maintenance**

To ensure optimum, maintenance-free belt performance and service life, tangential belts must not run off the pulleys and/or whirls during operation. Therefore, proper component alignment and belt tension must be ensured

- **Short take-up**

The considerable length of today's textile machines should not be additionally increased by the need for a long take-up mechanism. A high E-modulus (k_1 %-value) of the tangential belt is, therefore, desirable.

- **High accuracy of spindle revolutions**

Consistent yarn quality is a function of spindle speed accuracy. A high E-modulus (k_1 %-value) produces less creep in the belt drive, which means a smaller speed difference between the first and the last spindle, thereby improving yarn quality.

- **Resistant to chemicals**

Belts must be resistant to typical lubricating chemicals (oil, fat, batching oil, avivage) to ensure consistent performance and optimum service.

Special flat belt drives

Tangential belt drive

Recommended product range

For new machines with a high focus on low energy consumption:

- **TC-range**

For highly demanding applications regarding shortest take-up, lowest energy consumption and highest accuracy of rpm:

- **TF-range**

For older machines, flanged pulleys and very warm environments:

- **S-range**

Belt calculation

If the machine data is known (complete the questionnaire in the appendix), the required belt data can be calculated exactly by means of the POWER-SeleCalc program.

Note: The calculation of tangential belts is quite demanding, even with the POWER-SeleCalc program, and specific know-how is required. In case of doubt we recommend to contact your Habasit partner to perform or check your calculation.

Design recommendations

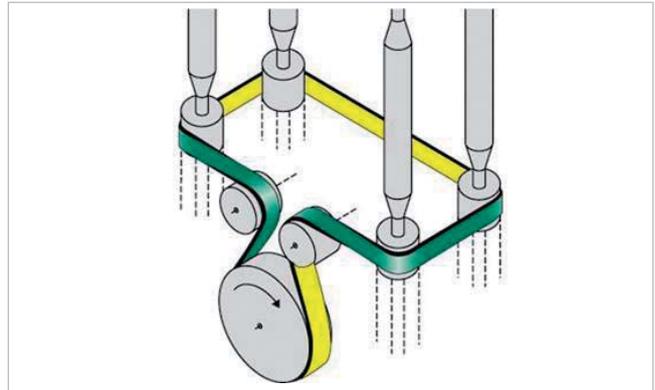
The general statements in the chapter “Design guidelines”, starting on page 18, should be observed. Use crowned pulleys and rollers, and avoid flanged pulleys! It is always good to contact your Habasit partner for detailed support.

Installation and maintenance

The general statements in these chapters (pages 47–53) should be observed.

Introduction

The spindle drive is an alternative to the tangential belt. It is used in the textile industry for driving spindles on ring spinning and twisting machines. The spindle tape touches the whirls with an arc of contact of at least 90°.



Technical requirements on spindle tapes

High quality spindle tapes must have specific properties such as:

- **Energy saving**

Modern, flexible spindle tapes have a high degree of efficiency. As a consequence, considerable energy cost savings can be realized.

- **Easy, fast and reliable joining method**

Considering that hundreds of spindle tapes per machine have to be made endless, an easy (preferably adhesive-free) and reliable joining method is required.

- **Highest spindle revolution (rpm)**

Spindle tapes for modern spinning machines must be designed for spindle speeds up to 20,000 rpm and higher.

- **High accuracy of spindle revolution**

A high modulus of elasticity produces less creep, which means that a smaller speed difference results between the first and the last spindle, which in turn improves yarn quality.

- **No fiber / fluff accumulation**

Spindle tapes must have sharp, clean, smooth edges, and must not accumulate static charges, so that no fibers or debris is attracted and sticks to the tape surface, thus reducing friction.

- **Long service life, low down-time**

A long service life of this highly stressed machine element can be expected.

- **Low speed loss of running spindles when neighbor spindles are stopped**

When a spindle is braked, it is expected that the adjacent spindles continue to run with negligible loss of speed (objective: uniform yarn quality).

- **High temperature resistance**

At thread breakage, the spindle will be stopped by a mechanical break. The spindle tape, however, continues to run on the stopped whirl. The resulting temperatures of up to 60 °C must be overcome by the spindle tape without any damage.

- **Minimum run-up time**

After automatic or manual splicing of the thread, the spindle brake is released and the spindle is again accelerated to its nominal number of revolutions. The run-up time must be within a time frame of a few seconds.

Available spindle tapes products

W-8	The best energy-saving spindle tape in the world (adhesive-free joint)
W-16	Stronger version of W-8 (adhesive-free joint)
TS-5	The most popular spindle tape in the world (polyamide type); excellent heat resistance, very robust, long lasting
TS-55	Stronger alternative to TS-5
TS-10	Suitable when lubricants are present; not applicable for applications requiring the braking (stopping) of spindles.
HS-5/HS-55	Economical alternatives to TS-5 and TS-55 (polyamide type)

Belt selection and calculation aids

Belt selection is according to the requirements of the machine and customer preferences. Contact your Habasit partner to provide calculations for special requests.

Design recommendations

The general statements in the chapter “Design guidelines”, starting on page 18, should be observed.

Installation and maintenance

The general statements in these chapters and the following additional statement must be observed (pages 47–53).

All spindle tapes have two different friction covers. In order to ensure trouble-free, efficient performance of the tapes, it is essential to follow the following rules during installation:

- High coefficient of friction on driving pulley
- Low coefficient of friction on spindle whirl

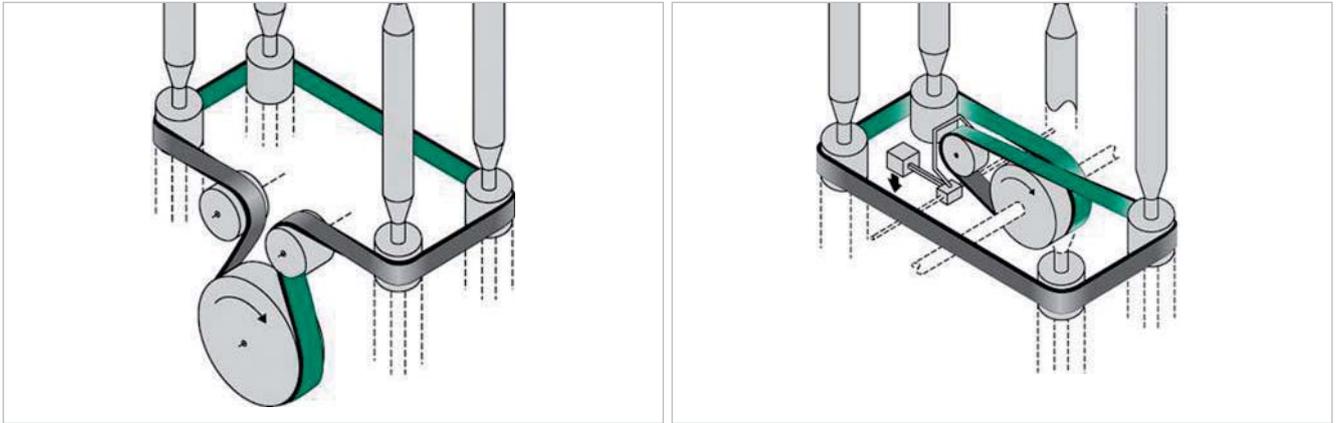
Special flat belt drives

Spindle tape drive

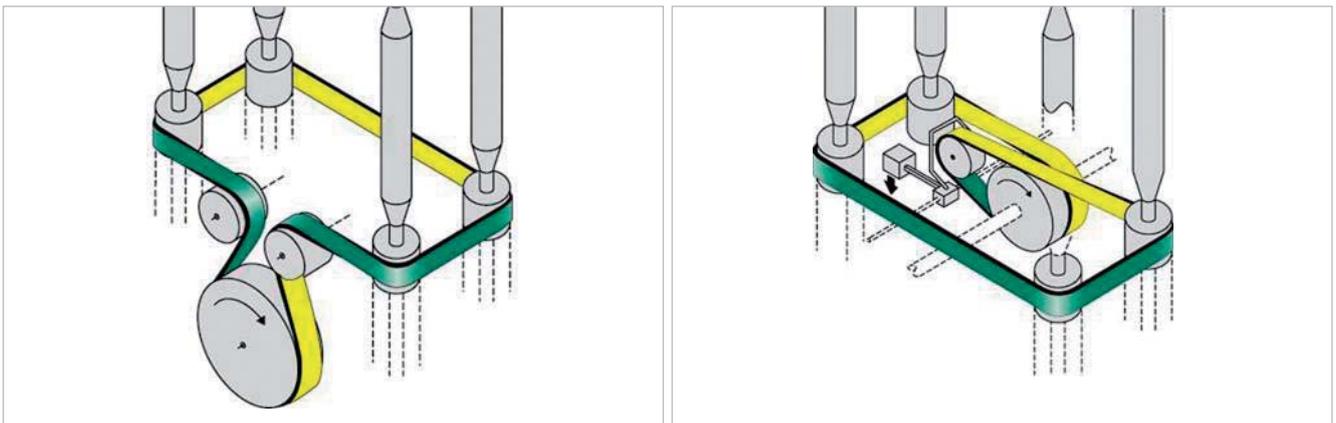
Correlation of material color and coefficient of friction:

Spindle tape type	High coefficient of friction on driving pulley side	Low coefficient of friction on whirl side
W-8, W-16	Black	Green
TS-5, TS-55, TS-10	Green	Yellow
HS-5, HS-55	Green	Beige

Correct installation of W-8 and W-16:



Correct installation of TS-5 (HS-5), TS-55 (HS-55) and TS-10:

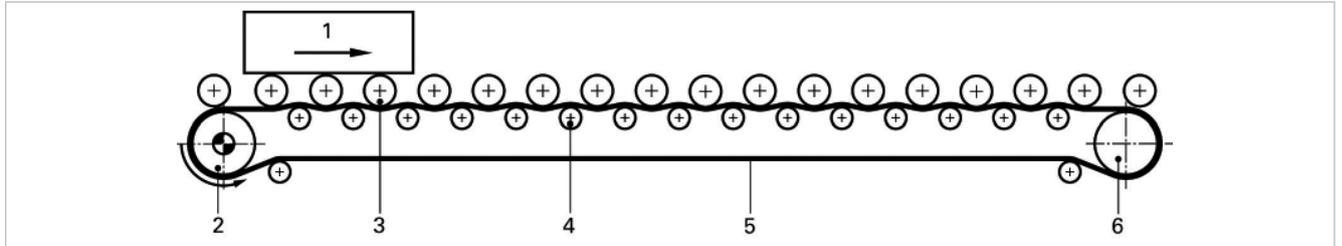


Special flat belt drives

Live roller conveyor drive

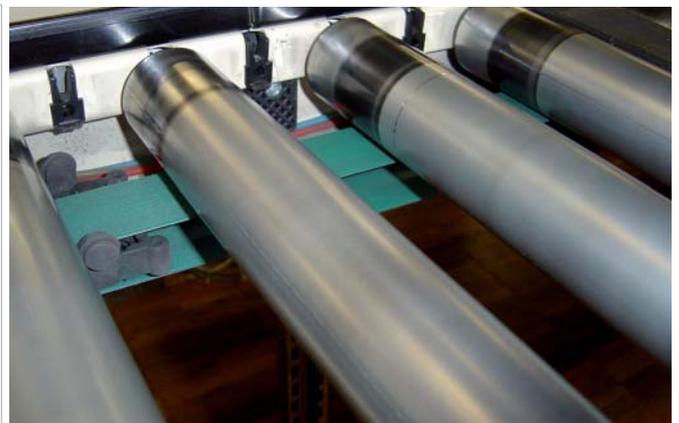
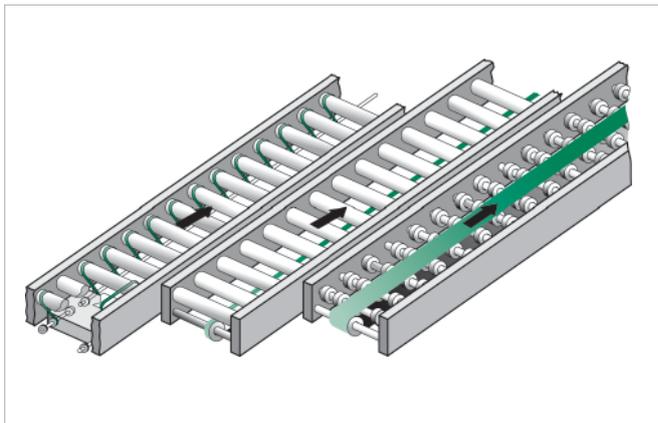
Introduction

Live roller conveyors (LRC) play an important role in modern materials handling engineering. Piece goods in a broad range of sizes can be carried over shorter or longer distances, in a straight line as well as through curves, with relatively low energy consumption. Transport usually takes place horizontally, although slight inclines are also possible.

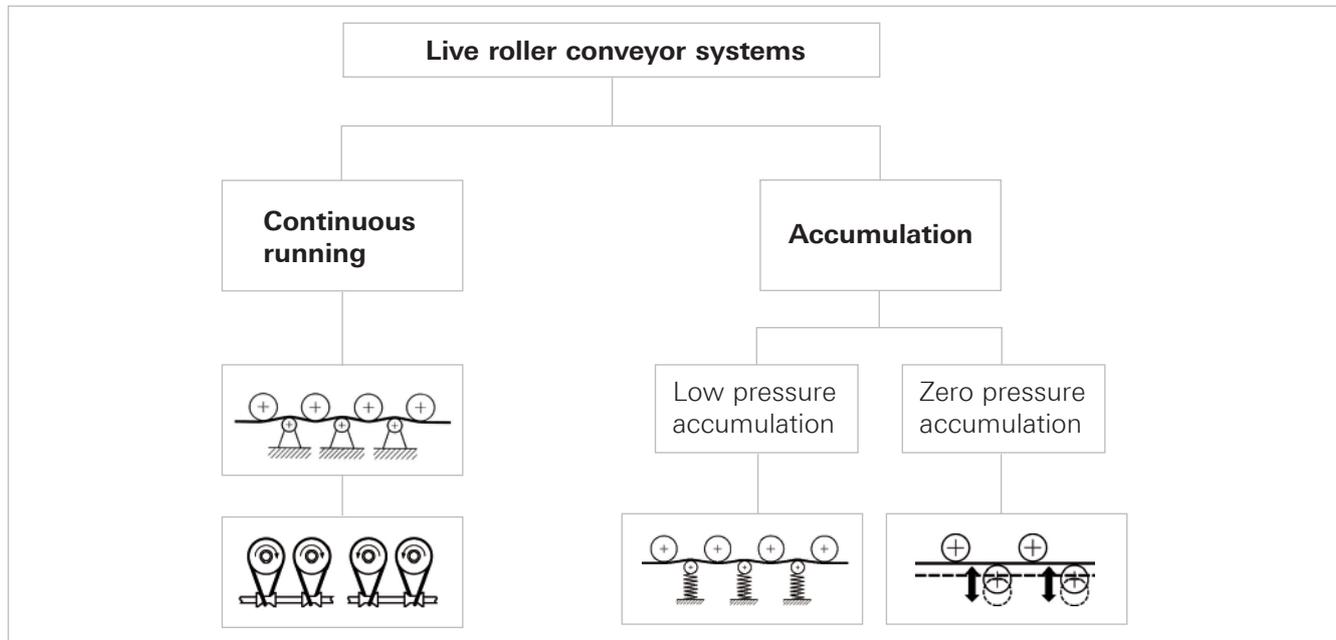


- 1 Transported piece good
- 2 Driving pulley
- 3 Carrying rollers
- 4 Pressure rollers
- 5 Driving belt
- 6 Return pulley

The goods are transported by a roller conveyor. The rollers are driven by a strong and therefore relatively narrow flat belt. The power transmission between belt and rollers is accomplished by the use of pressure rollers. The transported goods move in the opposite direction to that of the drive belt.



Flat belt driven LRC are particularly well suited for goods accumulation and subsequent singulation processes. For the selection of the flat belt it is important to know exactly which LRC system will be used.



Continuous running system

In a continuous running system, the carrying rollers are driven continually. There is no accumulation of goods and thus no stopping of the rollers. Pressure rollers can be fitted therefore in a fixed position. Flat belts with friction covers (NBR) on both sides are used as driving element. Rollers in continuous running systems may also be driven by Polycord round belts – a solution that is particularly suited for curves.

Accumulation system

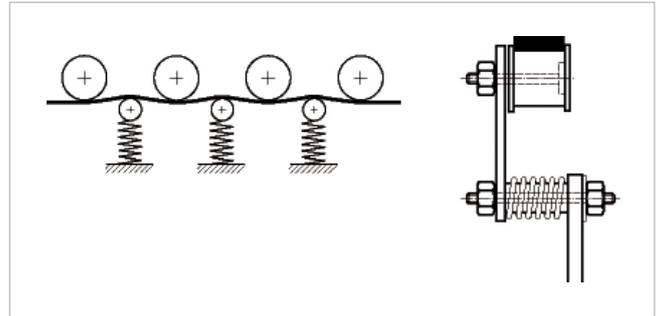
Where products need to be accumulated on the LRC for subsequent controlled retrieval, a distinction is made between systems where the continuous running belt remains in contact with the rollers while they are blocked by the accumulated goods (low pressure accumulation), and systems where the belt is separated from the rollers (zero pressure accumulation).

Special flat belt drives

Live roller conveyor drive

- **Low pressure accumulation**

On the relatively simple low pressure accumulation system, the belt is pressed against the rollers by a spring-loaded mechanism. If the carried goods are accumulated, e.g. by means of a mechanical stop or gate, the rollers in question stop while the belt continues to run. The surface touching the carrying rollers must be formed so that it can slip with minimum resistance on the stationary rollers, but at the same time have sufficient friction to continue driving the other carrying rollers reliably. On the driving pulley side, the belt must have a high coefficient of friction (preferably NBR rubber cover).

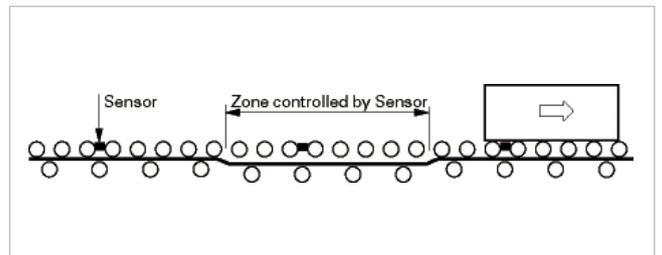
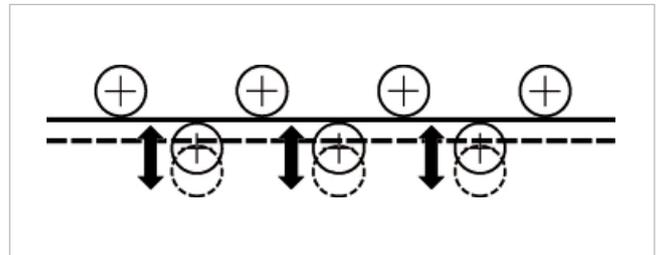


- **Zero pressure accumulation**

On the more sophisticated zero pressure accumulation system, the pressure rollers are separated from the carrying rollers by mechanical devices during the accumulation process.

The goods being carried will stop moving once the rollers are disconnected from the drive. However, if they are to be conveyed further, the pressure rollers are simply returned to their operating position, pressing the drive belt back onto the rollers.

In this fashion, different sections of the roller conveyor can be engaged and disengaged from the drive completely independently of each other. The pressure roller lifting device itself can be mechanically, pneumatically or electromechanically operated, while the control sensors are mechanical, electrical, pneumatic or optical.



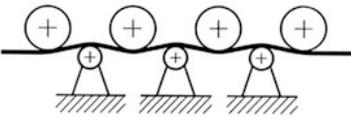
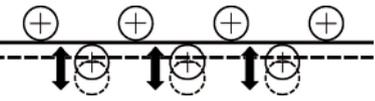
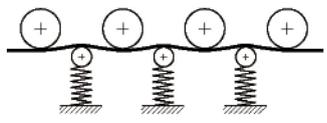
Since in the zero pressure accumulation system there is absolutely no contact between the driving belt and the carrying rollers during accumulation, drive belts with friction covers on both sides (NBR rubber) can be used. This results in increased transport reliability and belt service, and reduced power consumption compared with the low pressure system.

Technical requirements on live roller driving belts

Due to their relatively low belt speeds, the demands regarding running properties are relatively low. However, the belts still have to be robust, because they are often exposed to strong mechanical loads, e.g. due to start-stop operation, relative movement on stationary rollers, lateral contact on flanged pulleys, etc.

Belt selection

Habasit can provide the optimal belt type for every LRC system:

LRC system	Required belt design	Belt recommendations
<p>Continuous running system</p> 	<p>Carrying roller side: Adhesive surface *</p> 	<p>Power transmission belts: TC-range TCF-20H, TCF-50H TF-range S-range</p>
<p>Zero pressure accumulation</p> 	<p>Driving pulley side: Adhesive surface *</p>	<p>Other possibilities (examples): MAM-5E CM-18/30F</p>
<p>Low pressure accumulation</p> 	<p>Carrying roller side: Non-adhesive surface</p>  <p>Driving pulley side: Adhesive surface *</p>	<p>Power transmission belts: TF-75T, TF-75TE</p> <p>Other possibilities (examples): MAM-5P FAB-xxE EMB-12EMCH, EMB-20EMCH ENU-20EXBD EMB-27EHBT</p>

* NBR rubber by preference

Further belt types are available for special requirements, such as use in cold environments, etc. As an alternative to flat belts, LRC are often equipped with round belts (Polycord®, Habicord). For further information please contact your Habasit partner.

Calculation aids

For driving belt calculations for special requests please contact your Habasit partner.

Design recommendations

The general statements in the chapter on “Design guidelines” should be observed.

Belt installation and maintenance

The general statements in these chapters should be observed.

Alternative: HabasitLINK® modular belt conveyor

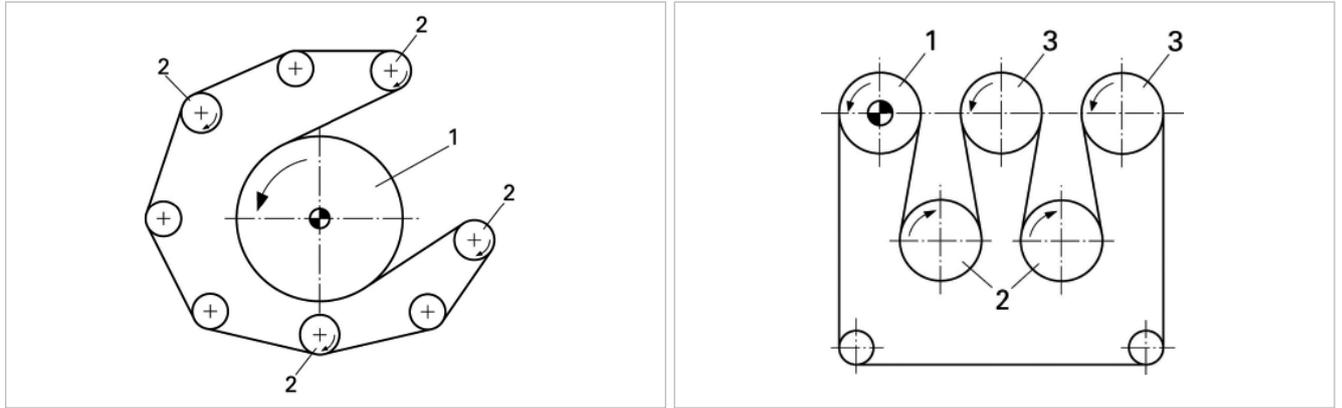
As an alternative to the belt driven live roller conveyor system, the HabasitLINK® modular belt conveyor can be considered for new installations. For further information see www.habasit.com or contact your Habasit partner.

Special flat belt drives

Multi pulley drive (power branching)

Introduction

One drive pulley powers several pulleys via one belt, whereby at least two driven pulleys transmit power to energy-consuming machine parts. Power branching often includes the reverse rotation of driven pulleys (double side power transmission).



- 1 Driving pulley
- 2 Driven pulleys, change of rotating direction
- 3 Driven pulleys, same rotating direction as driving pulley

Belt selection

Selection of the optimal belt type has to be made according to the requirements of the application, customer preferences and cost considerations.

Single sided power transmission:

- **A and TCF-xxEL-range**
Also possible TC-, TF- and S-range

Double sided power transmission:

- **TC-, TF- and S-range**

See also Belt Selection Chart on page 11 or contact your Habasit partner.

Belt calculation

Please note that multi pulley drives with power branching cannot be calculated by the POWER-SeleCalc program.

We recommend that you send the drive data to your Habasit partner for exact calculation.

Design recommendations

The general statements in the chapter "Design guidelines" should be observed.

Belt installation and maintenance

The general statements in these chapters should be observed.

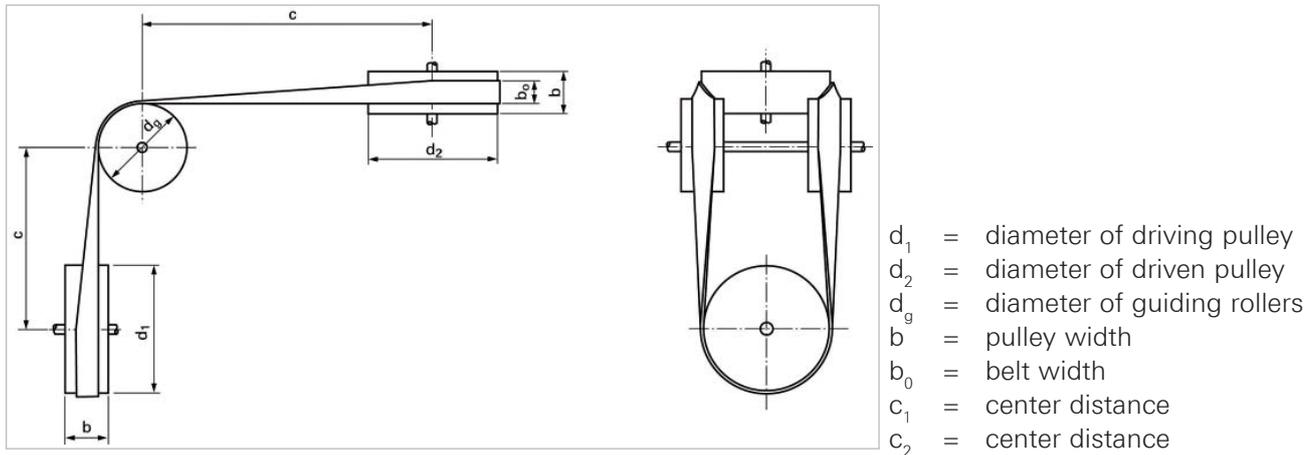
The largest circumference circles of all crowned pulleys must be precisely aligned in the same plane to ensure a proper belt tracking response.

Special flat belt drives

Angular drive (mule drive)

Introduction

In an angular drive the driving and the driven pulley can be arranged in rectangular position.



Recommended product range

- TC- or TCF-xxEL range
Also possible A- and S-range

Non-recommended product range

Do **not** use TF-belts (aramide is sensitive regarding twisting and buckling).

Belt calculation

If the machine data are known, the required belt data can be calculated by the POWER-SeleCalc program.

Design recommendations

The general statements in the chapter "Design guidelines", starting on page 18, should be observed. The following additional recommendations for angular drives are based on experience:

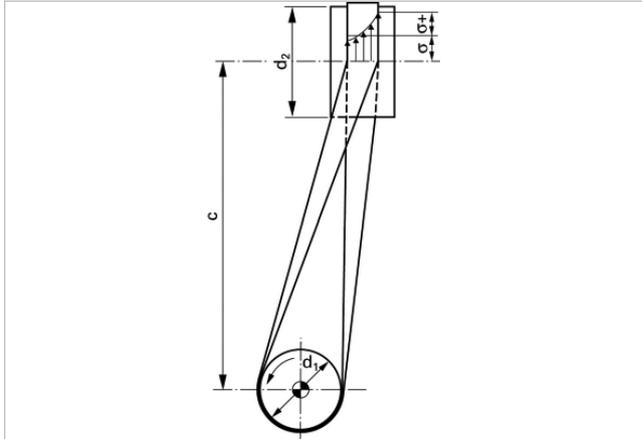
- The greater the center distance (c_1, c_2), the better.
It should be at least 10 times the belt width.
- The width of the driving and driven pulley must be 1.5 to 2 times the belt width
- Crown both the driving and the driven pulley
- The guiding roller width must be at least 2 times the belt width
- The guiding rollers must be cylindrically

Belt installation and maintenance

The general statements in these chapters should be observed (pages 47–53).

Introduction

The half-cross drive serves to transmit power between two shafts, the axes of which cross at an angle of 1° to 90° .



d_1 = diameter of driving pulley
 d_2 = diameter of driven pulley
 c = center distance

Preconditions

The belt must run parallel onto the pulleys (perpendicular to the axis). Running in reverse direction is not possible.

Recommended product range

- TC-range

Also possible S-range

Not recommended product range

Do **not** use TF-belts

(Aramide is sensitive regarding twisting and buckling).

Belt calculation

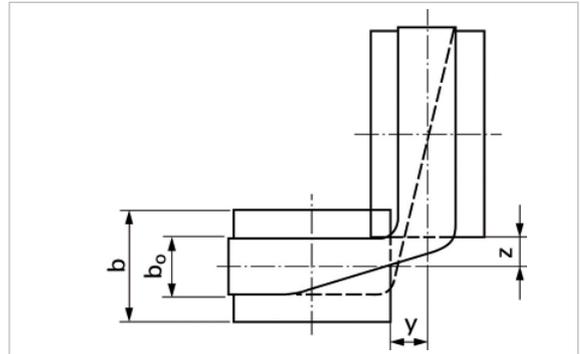
If the machine data are known, the required belt data can be calculated by the POWER-SeleCalc program.

Note: One belt edge experiences, depending on the center distance c , additional tensile stress (σ_+ , see figure) through distortion. Belts in half-cross drives must therefore be stressed only up to 80% of their performance. This can be taken into consideration by making the center distance as big as possible (see recommendations on page 44) and increasing the indicated belt width by approx. 20%.

Design recommendations

The general statements in the chapter “Design guidelines” should be observed. The following additional recommendations for half-cross drives are based on experience:

- The ratio of the small to the large pulley must not exceed 0.4
- It is an advantage to make the distance between the axes as big as possible and to choose a narrow belt
- The greater the center distance (c) the better. It should be at least 10 times the belt width
- The pulley width must be at least twice the belt width
- Both pulleys must be designed cylindrically
- At least one pulley has to be designed in a way that it can be pivoted in plane parallel to its own axis and perpendicular to the other pulley axis.
- The pulleys must be displaced by the amounts:
 $y \cong 0.5 \cdot b_0$
 $z \cong (0.1-0.2) \cdot b_0$
- The displacements must be made in such a way that the belt at the driving end is less laterally buckled than at the slack end



Belt installation and maintenance

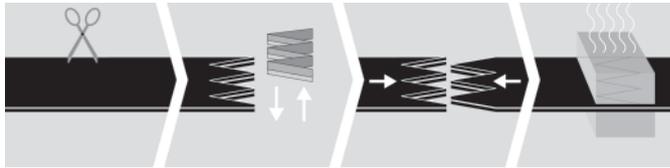
The general statements in these chapters should be observed (pages 47–53).

Fabrication

Flexproof joining system

Flexproof joining system (finger joint)

Flexproof is a fusion joint used **without** the addition of adhesive. It ensures simple joining and quick installation.

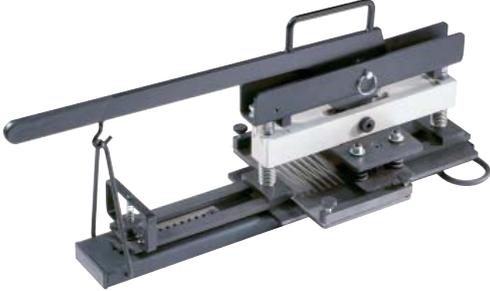


Advantages	Limitations
<ul style="list-style-type: none"> • Longitudinal flexibility, no stiffening of the joint • No stiffening over the joint, low vibration running • Good appearance; quality is easily assessed by visual inspections 	<ul style="list-style-type: none"> • Temperature resistance, not for high operating temperatures (limit 60° to 80 °C)

Process data

See "Joining data sheets" on www.habasit.com

Recommended joining tools (examples)

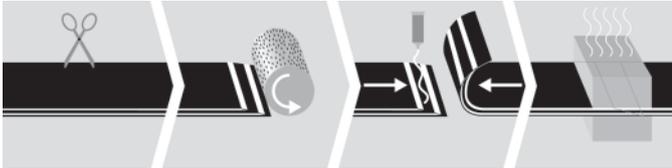
Preparing devices	Pressing devices
 <p>AF-605</p>	 <p>PF-61</p>
 <p>AF-100/US</p>	 <p>PM-309</p>

Fabrication

Thermofix joining system

Thermofix joining system

Thermofix is an adhesive bonded joint. A variety of procedures and adhesives are employed, which are dependent upon belt type.



Advantages	Limitations
<ul style="list-style-type: none"> • Admissible operating temperature up to 100 °C 	<ul style="list-style-type: none"> • Belt is slightly stiffer at the joint • Quality of joint skills depends on fabricator

Process data

See "Joining data sheets" on www.habasit.com

Recommended joining tools (examples)

Preparing devices	Pressing devices
 <p>AT-305</p>	 <p>PT-100</p>
	 <p>PM-309</p>

Belt installation

In order to guarantee problem-free running and to benefit from the features of the flat belt drive, the power transmission belts must be selected and installed correctly. Safety regulations and installation hints must be followed thoroughly.

Safety regulations

If touched, running belts can catch parts of the body and objects e.g. clothing, tools, etc. and cause serious bodily injury and machine damage.

Switch off the machine using the main switch and ensure that it cannot be switched on again before installation, adjustment or maintenance work is carried out.

Power transmission belts should only be installed on the equipment for which they have been selected and calculated according to Habasit documentation.

Only qualified personnel who are authorized to perform the required installation and equipment maintenance may perform this work. They must possess the requisite knowledge and skills to effectively perform such work in accordance with the necessary provisions and accident-prevention regulations.



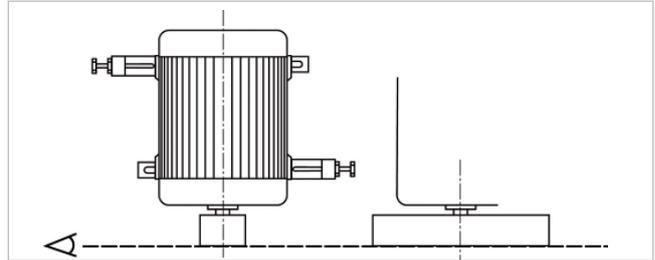
Belt installation

First-time installation

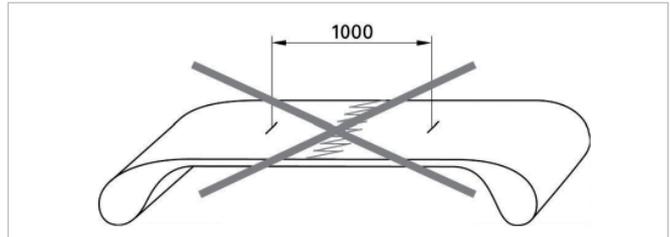
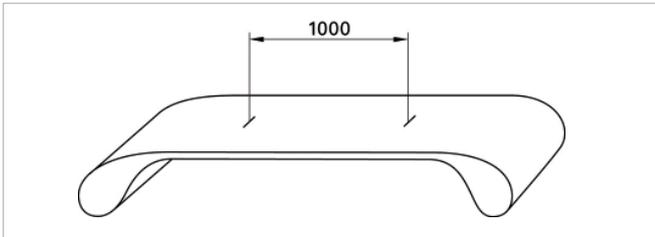
The following recommendations apply to the first installation of endless belts.

Proceed as follows:

1. Make sure that the tensioning device is in the innermost position.
2. Check that the shafts are parallel and the pulleys aligned perpendicular to the belt running axis.



3. The running surfaces of the pulleys must be clean and free from grease, soil and dust.
4. Before installing, trace small measuring marks at a distance of e.g. 1000 mm (recommendation) on the un-tensioned belt. Use a ball-point pen and mark as accurately as possible! Do not place the measuring distance over the joining area.



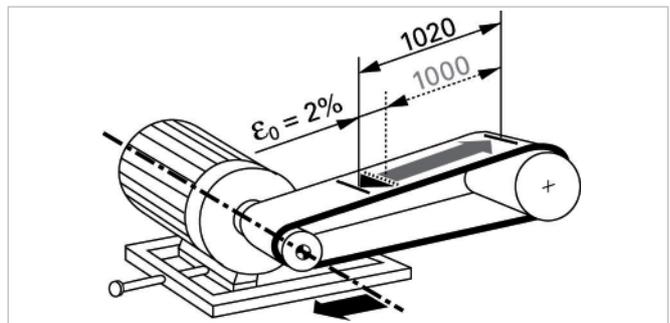
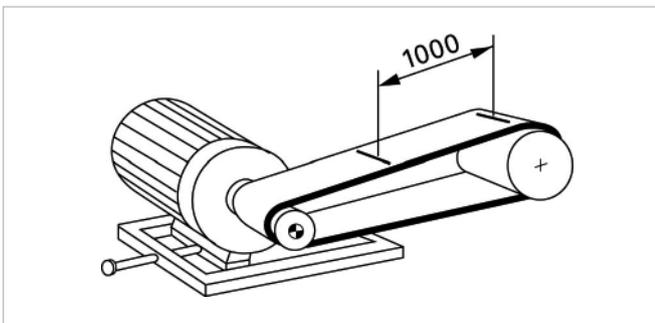
For short belts or if the control distance on the machine is shorter, choose a shorter measuring mark distance, e.g. 500 mm.

The longer the distance between the measuring marks, the higher the tensioning accuracy.

5. Install the belt carefully. Lay it first on the small pulley, then on the large pulley. Do not force the belt over the pulley edges. Do not use unsuitable tools such as screwdrivers, hammers, etc.

Special care has to be taken when installing belts with an aramide traction layer (TF-belts). These belts are sensitive to twisting and buckling.

6. Tension flat belt by enlarging the center distance until the distance between the measuring marks has increased by the value of the required (calculated) **initial elongation** (ϵ_0)



Example:

Required initial elongation $\epsilon_0 = 2.0\%$

Measuring mark distance of un-tensioned belt: 1000 mm

Measuring mark distance of tensioned belt: 1020 mm

If the initial measuring mark distance of an un-tensioned belt is not 1000 mm as recommended, adapt the tensioning accordingly. For examples see the table below:

Initial measuring mark distance (un-tensioned belt) [mm]	Measuring mark distance of tensioned belt [mm]				
	Calculated initial elongation ϵ_0 [%]				
	0.5	1.0	1.5	2.0	2.5
200	201	202	203	204	205
500	502.5	505	507.5	510	512.5
750	753.8	757.5	761.3	765	768.8
1000 (recommended)	1005	1010	1015	1020	1025
1500	1507.5	1515	1522.5	1530	1537.5
2000	2010	2020	2030	2040	2050

Never tension a power transmission belt by guesswork; always observe the calculated initial elongation ϵ_0 !

If the correct initial elongation is not known, calculate it with the POWER-SeleCalc program or call Habasit application support.

In exceptional cases, if no indication is available at all, observe the approximate values:

Traction layer	Belt range	Initial tension [%]	
		min.	Average range
Polyamide (PA)	S, A	0.5	1.5 – 2.5
Polyester (PET)	TC, TCF	0.3	1.0 – 2.0
Aramide	TF	0.2	0.5 – 0.8

7. Rotate the belt once or twice by hand. The flat belt must not drift or run off even when the direction of rotation is changed.
8. Check the distance of the measuring marks again. If necessary, tension the belt to the required initial elongation.
9. Fix the screws of the tensioning device.
10. Secure the original protective casing before starting the motor.
11. Make sure that the belt data (type, dimensions, quoted initial elongation, date of installation and maintenance instructions) are stored near the machine, e.g. in a self-adhesive envelope stuck on the machine).

Installation of aramide belts

Power transmission belts with an aramide traction layer (TF-range) must be installed with special care.

Do not twist belts with an aramide traction layer and do not tension the belts with sudden or excessive force!

The high modulus of elasticity of aramide fibres in the TF-belts leads to two special features:

- The required take-up displacement is extremely short
- Even a small increase in the initial elongation may lead to a considerable increase in the tensile force and shaft load. Extensive shaft deflection or early breakdown of bearings may be the result.

Installation of strong belts and re-installation

Installation of strong belts (two-step tensoning)

In applications where a relatively strong belt is being installed on an inappropriately **weak drive design** we recommend tensoning in two steps:

1st step: Tension the belt to 60% to 70% of the required initial elongation ($\epsilon_{1st\ step} = \epsilon_{70\%}$) only.
Let it relax for 3 to 6 hours

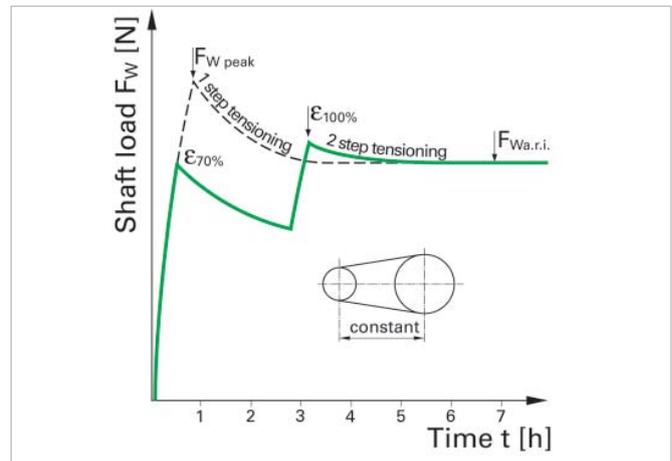
2nd step: Re-tension the belt to the required initial elongation ($\epsilon_{2nd\ step} = \epsilon_{100\%}$)

Conclusion:

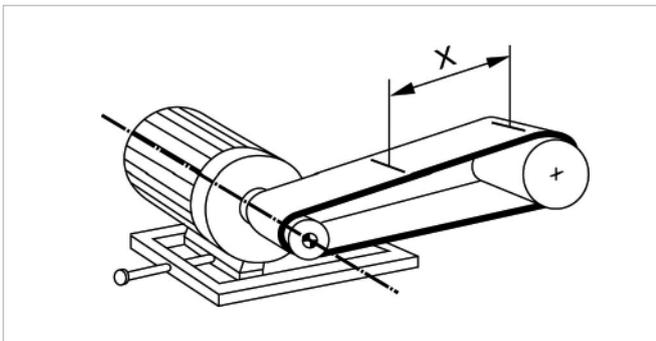
Using the two-step tensoning method avoids the maximum peak value of the shaft load ($F_{W\ peak}$) appearing when the belt is tensoned in one step to the required initial elongation (ϵ_0).

The shaft load after relaxation ($F_{Wa.r.i.}$) is equal with 1st step tensoning and 2nd step tensoning.

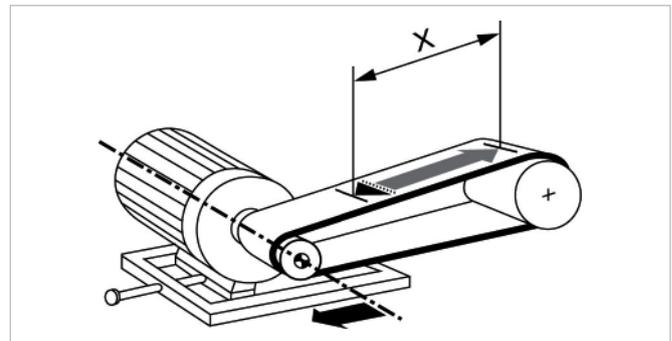
The shaft load after relaxation ($F_{Wa.r.i.}$) is not influenced in a negative way by the two-step tensoning method.



Re-installation of used belts



Before (!) releasing the belt, measure and note the distance between two existing or newly-applied measuring marks.



When re-installing the same used belt, tension it until the initial distance between the measuring marks comes up.

Follow the directions for first-time installation starting on page 48.

Provided there has been correct dimensioning and professional installation, Habasit's power transmission belts do not usually need to be maintained or re-tensioned.

However, regular checks are recommended in order to guarantee problem-free performance of the drive.

Cleaning

The running surfaces of pulleys must be clean and free from grease and accumulated dust. Dirty belts can be cleaned easily with lukewarm water and soap.

Check

Look out for changes in the friction cover and joint. Replace the belt if changes are considerable or in the event of damage. Check pulleys for excessive wear.

Re-tensioning

If the power transmission flat belt no longer transmits the capacity it was calculated for, clean the pulleys and belt and if necessary re-tension it carefully.

Prerequisites for trouble free operation

Power transmission flat belts are very reliable and long lasting if the following prerequisites are met:

- The belt should be specified and calculated according to its application
- The belt type, belt dimensions (width and length) and calculated **initial elongation** are known
- The belt joint is made carefully in line with Habasit's joining data sheets
- The belt is carefully installed in accordance with Habasit guidelines, and initial elongation is exactly applied
- The actual operating conditions correspond to the initial specifications
- There is no mechanical damage to the belts

The most common problems with power transmission flat belts, their possible causes and recommended action to solve the problems are listed below.

If the problem still remains, please contact your Habasit representative.

Problem	Possible causes	Remedies
<p>Poor tracking: Belt runs to one side</p> <p>Belt runs from one to the other pulley side and backwards</p>	<ul style="list-style-type: none"> • Pulleys or rollers out of alignment • Pulleys or rollers covered with dirt • Improper pulley or roller crown (usually crowned too high) or no crown at all • Pulleys or rollers covered with dirt 	<p>→ Check that all shafts are parallel and that the pulleys are exactly aligned perpendicular to the belt running axis</p> <p>→ Clean pulley surfaces</p> <p>→ Retooling of the pulley shape according to Habasit recommendations</p> <p>→ Clean pulley surfaces</p>
Belt edges wear out	<ul style="list-style-type: none"> • Belt is running over pulley edges, caused by poor tracking • Belt is touching flanges or machine parts, even if it runs straight on 	<p>→ See “Poor tracking”</p> <p>→ Avoid allowing belt edges to come into contact with flanges or other machine parts</p> <p>→ Avoid flanged pulleys</p> <p>→ Increase pulley width or chose a stronger but smaller belt (new belt calculation necessary)</p>
Belt running surface wears out	<ul style="list-style-type: none"> • Slip between driving or driven pulley(s) and belt • Knurled or too rough pulley surface 	<p>→ See “Belt slip”</p> <p>→ Reduce roughness according to Habasit recommendations ($R_a = 6.3$ to $3.2 \mu\text{m}$)</p>
Belt failure immediately after motor start up	<ul style="list-style-type: none"> • Bad joint quality • Heavy, unconsidered shock load or overload 	<p>→ Use a new belt with appropriate joint quality</p> <p>→ Check drive data, as well as belt design and calculation</p>
Belt service life does not fulfill customer expectations	<ul style="list-style-type: none"> • High bending frequency over small pulley diameter • Power to be transmitted [kW] higher or operating conditions more demanding than indicated • Extraordinary influence of temperature and humidity • Belt tension too high or too low • Unrealistic customer expectations 	<p>→ Increase pulley diameter or choose a more flexible belt</p> <p>→ Check drive data, as well as belt specification and calculation</p> <p>→ Check drive data, as well as belt specification and calculation</p> <p>→ Observe calculated initial elongation (ϵ_0)</p> <p>→ Inform customer about realistic belt service life</p>

Problem	Possible causes	Remedies
Layer separation on polyamide belts or cracks in the PA-layer	<ul style="list-style-type: none"> • Compression of the PA-layer due to a combination of small pulley diameter, thick traction layer and too low initial elongation 	<ul style="list-style-type: none"> → Observe the calculated initial elongation! Re-tension the belt if necessary → Use a belt type with fabric traction layer, e.g. TC- or TF-type
Belt slip	<ul style="list-style-type: none"> • Initial elongation too low • Power to be transmitted [kW] higher or operating conditions more demanding than indicated • Dirty, greasy, oily or wet pulley or belt surfaces • Important: Slip on power transmission belt drives must not be eliminated by increasing the friction or the surface roughness of the driving pulley: Premature belt wear would be the consequence! 	<ul style="list-style-type: none"> → Observe the calculated initial elongation! Re-tension the belt carefully if necessary → Check drive data, re-calculate the belt → Clean pulley and belt surfaces → Never use lagged driving pulleys → Avoid knurled surfaces
Excessive noise/rattling	<ul style="list-style-type: none"> • Stick-slip effect, mainly appearing with wide belts on big (> 2000 mm), very smooth, polished pulleys with a large arc of contact 	<ul style="list-style-type: none"> → Use a belt with a higher modulus of elasticity ($k_{1\%}$-value) → Use a belt with a lower coefficient of friction, e.g. leather coated belts → Reduce coefficient of friction with talcum powder or with a water-spirit mixture (2 dl spirit to 10 l water) → Reduce friction by roughening the pulley surface to $R_a = 6.3$ to $3.2 \mu\text{m}$
Joining area “kicks out” periodically on running belt	<ul style="list-style-type: none"> • Joint partially damaged • Joint slightly aslant, not absolutely parallel 	<ul style="list-style-type: none"> → Change belt → No danger for belt or drive, as long the belt does not run over pulley edges. → No action necessary
Belt shows a wiggly line	<ul style="list-style-type: none"> • Belt not cut absolutely straight (“banana”) 	<ul style="list-style-type: none"> → No danger for belt or drive, as long the belt does not run over pulley edges. → No action necessary

Unfavorable storage conditions or improper handling result in changes in the physical characteristics of synthetic power transmission belts. The main effects of improper storage conditions are on the coefficient of friction and the service life of the products.

Proper storage conditions in brief:

- Protect belts from sunlight/UV-radiation/dust and dirt
- Store spare belts in a cool (recommended 15 °C to 25 °C) and dry place
- Store the belts if possible in their original packaging

Storage location

The storeroom should be cool, dry, dust-free and moderately ventilated. Belts and tapes maybe stored outside only if they are covered to provide protection from the weather.

Temperature

Belts should not be stored at temperatures below -10 °C (14 °F) or above +25 °C (77 °F), except for very short periods of time.

When exposed to lower temperatures during storage or transport, products may stiffen. Before putting them into operation or further processing, these products should be conditioned at room temperature over a period of at least 48 hours. This is best carried out while the items are still in their packaging, to prevent the formation of condensation on the product itself.

Heating

In heated storerooms, belts must be shielded from the heat source. There must be a distance of more than 1 meter between a radiant heat source and an unshielded product. A greater distance from the heat source is necessary in rooms with forced-air heating systems.

Humidity

Storage in damp conditions should be avoided. Relative humidity of between 40% and 65% is recommended.

Lighting

Products should be protected from light, in particular from the direct rays of the sun and from strong artificial light with a high ultraviolet component.

Ozone

Belts should not be stored close to ozone-producing equipment such as UV lamps, AC arc welding machines, laser printers, etc.

Chemicals

Solvents, fuels, lubricants, chemicals, acids, alkalis, and disinfectants should not be kept together with belts in the same storeroom.

Handling

Care is to be taken that products, when stored, are not subject to stress, i.e. with no excess tension, pressure or other deformation, since stress can promote permanent distortion and crack formation.

Contact between belts of different compositions or colors should be avoided.

With long-term storage, ensure that recently received products are stored separately from products already in stock (first in, first out!).

Packaging

Belts must be protected by suitable packaging against soiling. Products containing polyamide should always be wrapped airtight, to avoid undesirable absorption of humidity or drying out.

Covering materials should contain no additives that are harmful to the products, e.g. plasticizers, benzene, oil or similar agents. Suitable packaging, for example, is anti-static black film or polyethylene or polyamide bags. Habasit belts should be stored preferably in their original packaging.

Should moisture, nevertheless, accumulate inside due to damage to the packaging materials, the packaging must be removed to prevent mold formation.

Symbol	Metric unit	Imperial unit	Explanation
a	mm	<i>in.</i>	Belt thickness
b	mm	<i>in.</i>	Pulley width
b₀	mm	<i>in.</i>	Belt width
c	mm	<i>in.</i>	Center distance of un-tensioned belt (corresponds to l_{eff})
c_ε	mm	<i>in.</i>	Center distance of tensioned belt (corresponds to $l_ε$)
d_l	mm	<i>in.</i>	Diameter of large pulley
d_s	mm	<i>in.</i>	Diameter of small pulley
d₁	mm	<i>in.</i>	Diameter of driving pulley
d₂	mm	<i>in.</i>	Diameter of driven pulley
E	N/mm ²	<i>ksi</i>	Modulus of elasticity
F'_{UN}	N/mm	<i>lbs./in.</i>	Nominal peripheral force per unit of width
F_{Wadm}	N	<i>lbs.</i>	Admissible shaft load
F_{W_s}	N	<i>lbs.</i>	Static shaft load (after relaxation)
F_{W_d}	N	<i>lbs.</i>	Dynamic shaft load (after relaxation)
h	mm	<i>in.</i>	Pulley crown height
h_r	mm	<i>in.</i>	Pulley flange height
k_{1%a.r.i.}	N/mm	<i>lbs./in.</i>	Tensile force for 1% elongation per unit of width after running-in
l_g	mm	<i>in.</i>	Geometric belt length (belt thickness not considered)
l_{eff}	mm	<i>in.</i>	Effective length of un-tensioned belt (length of the neutral layer, fabrication length)
l_s	mm	<i>in.</i>	Shortened belt length for fixed center distance or no take-up (length of the neutral layer, fabrication length)
l_ε	mm	<i>in.</i>	Length of tensioned belt (elongated to $ε_0$)
n₁	1/min	<i>rpm</i>	Number of revolutions of driving pulley
n₂	1/min	<i>rpm</i>	Number of revolutions of driven pulley
P	kW	<i>HP</i>	Power to be transmitted
P_M	kW	<i>HP</i>	Motor power
R	mm	<i>in.</i>	Pulley crown manufacturing radius
s	mm	<i>in.</i>	Position of the neutral layer measured from the running side
v	m/s	<i>fpm</i>	Belt speed
x	mm	<i>in.</i>	Available take-up displacement of tensioning device
x_r	mm	<i>in.</i>	Recommended take-up of tensioning device
x_ε	mm	<i>in.</i>	Effective take-up displacement, required to elongate the belt to $ε_0$
β	°	°	Arc of contact
ε₀	%	%	Initial elongation
ε_{adm}	%	%	Admissible elongation
μ	–	–	Coefficient of friction

Habasit always strives to support you in your selection.

Please find the following questionnaires to facilitate this process.

- Power transmission belts on page 58
- Tangential belts on pages 59 and 60

Make a copy, fill it in and send it to your local Habasit representative for further information; you'll find us on www.habasit.com

With several affiliated companies and many representatives and service partners, the Habasit distribution network is highly responsive to your individual needs.



Selection parameters

General requirements

- Common application, no specific requirements
- Both sides power transmission
- Utilisation as tangential belt
- Low creep, high accuracy and uniform number of revolution
- High efficiency, low energy consumption
- Short take-up (in combination with long belts)
- Wide and large pulleys
- Crossed drive
- Permanently antistatic

Mechanical influences

- Heavy shock loads
- Small pulleys, high bending cycle frequency
- High belt speed, low vibration required
- Transverse bending and / or twist
- Rough belt handling (during installation etc.)

Environmental influences

- Very wet, dirty and / or dusty conditions
- Considerable oil and / or grease influence
- Changing climat (humidity, temperature)
- Operating temperature > 60 °C/140 °F (continuous)

Joining system

- Skived and glued joint (Thermofix)
- Adhesive free joint (Flexproof)
- Seamless

Calculation parameters

Power to be transmitted

kW or PS

Service factor

1)

Center distance

mm or effective belt length mm

Pulleys

Driving pulley

mm

Width

mm

Arc of contact

°

Number of revolution

rpm

Driven pulley

mm

mm

°

rpm

Tension pulley

2) mm

mm

°

Ambient temperature

Minimum

°C

Maximum

°C

Alternative parameters

1) Start up:

- Smooth starting
- Medium starting
- Abrupt starting

Operating conditions:

- Uniform operation
- Medium inertia forces
- Heavy shock loads

Environmental influences:

- Very wet
- Oil or grease
- Dusty conditions

2) Drive with tension pulley

- Tension pulley on slack side
- Tension pulley on tight side

Measurements

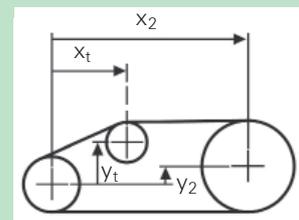
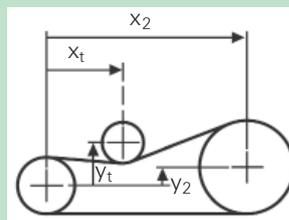
- Tension pulley outside
- Tension pulley inside

x_2 mm

y_2 mm

x_t mm

y_t mm



Selection parameters

General requirements

- Common application, no specific requirements
- Low creep, high accuracy and uniform number of revolution
- High efficiency, low energy consumption
- Short take-up (in combination with long belts)
- Wide and large pulleys
- Crossed drive
- Permanently antistatic

Mechanical influences

- Heavy shock loads
- Small pulleys, high bending cycle frequency
- High belt speed, low vibration required
- Transverse bending and / or twist
- Rough belt handling (during installation etc.)

Environmental influences

- Very wet, dirty and / or dusty conditions
- Considerable oil and / or grease influence
- Changing climat (humidity, temperature)
- Operating temperature > 60 °C/140 °F (continuous)

Joining system

- Skived and glued joint (Thermofix)
- Adhesive free joint (Flexproof)
- Seamless

Calculation parameters

Configuration

- Spindles on both sides
- Spindles on one side



Variable drive direction

- Yes
- No
- Spindles on tight side
- Spindles on slack side

Power to be transmitted

kW or PS

Service factor

1)

Belt width

mm

Effective belt length

mm

Pulleys

Driving pulley d_1

2) mm

Arc of contact

°

Number of revolution

rpm

Diverting pulley tight side d_t

2) mm

°

Diverting pulley slack side d_s

2) mm

°

Diverting pulley guide side d_m

2) mm

°

Guide pulley(s) d_u

2) mm

°

Ambient temperature

Minimum

°C

Maximum

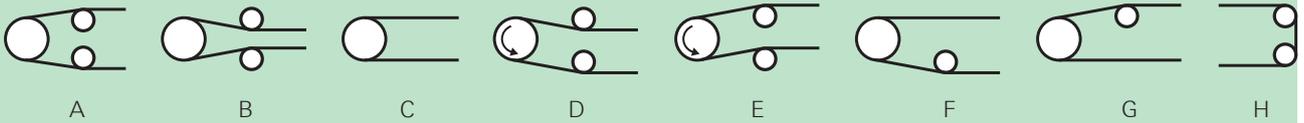
°C

Please fill-in the reverse side as well

Alternative parameters

- 1) Start up: Smooth starting Medium starting Abrupt starting
 Operating conditions: Uniform operation Medium inertia forces Heavy shock loads
 Environmental influences: Very wet Oil or grease Dusty conditions

2) Configuration

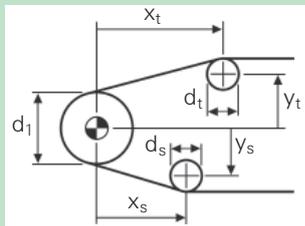


Driving side configuration (A,B,C,D,E,F,G)

Guiding side configuration (A,B,C,D,E,F,G,H)

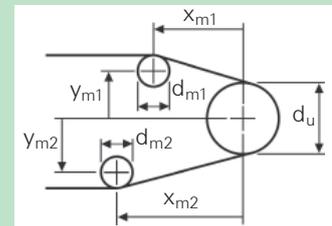
Measurements

x_t mm
 y_t mm
 x_s mm
 y_s mm



Measurements

x_{m1} mm
 y_{m1} mm
 x_{m2} mm
 y_{m2} mm



Whirl calculation parameters

Whirl configuration One pressure roller per 2 spindles One pressure roller per spindle No pressure rollers



Spindle pitch mm

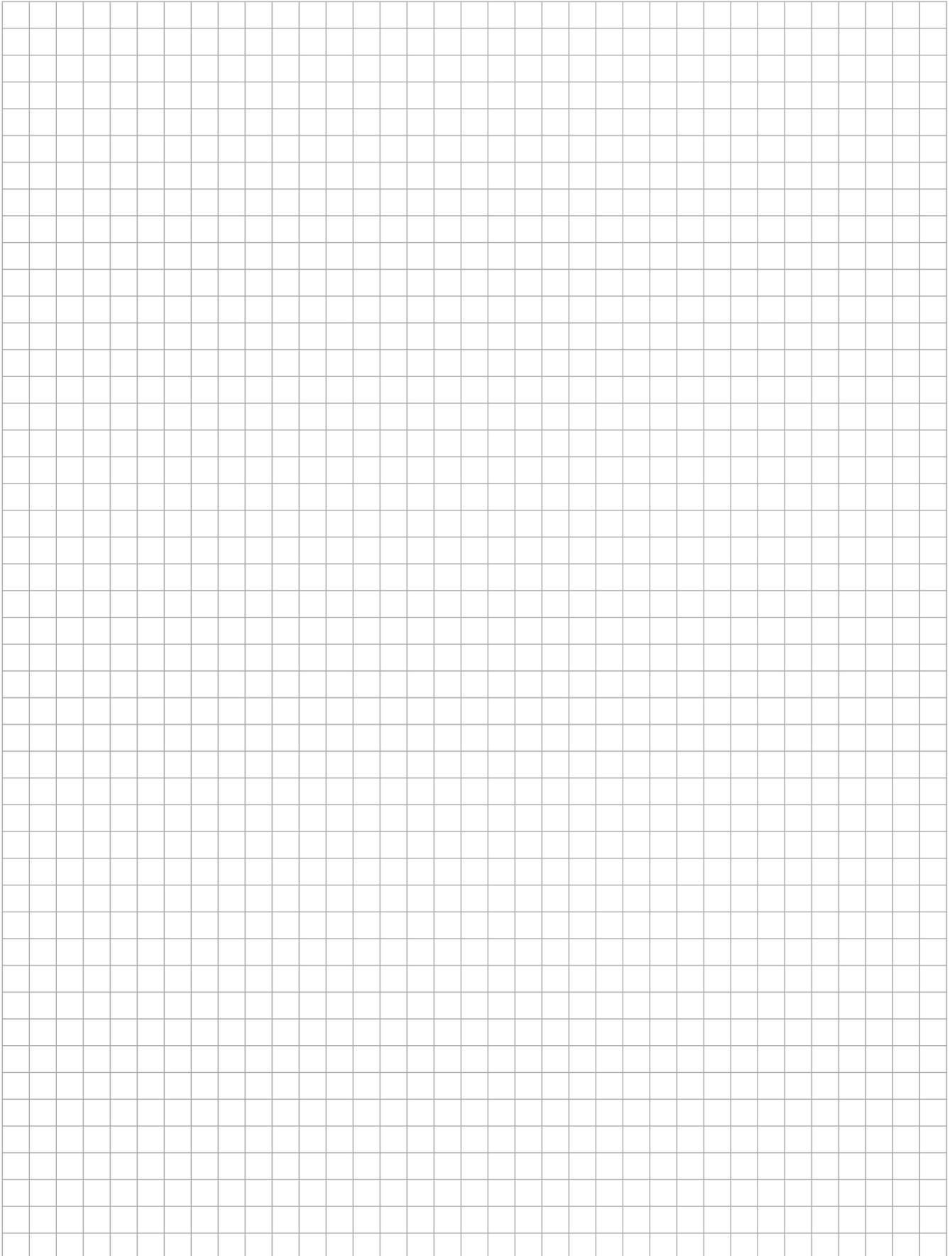
Whirl diameter mm or number of revolutions rpm

Number of spindles

Notes



Notes



The Habasit solution



Customers first

At Habasit we understand that our success depends on your success. This is why we offer solutions, not just products; partnership, not just sales. Since our foundation in 1946, Habasit has brought this understanding of customer needs to life every day and for every application. That's why we're the No. 1 in belting today. Worldwide. Learn more on www.habasit.com

Committed to innovation

Because our customers' belting challenges and needs never cease, we consistently dedicate a substantial percentage of our employees and resources to the research and development of new products and solutions.

Certified for quality

We deliver the highest quality standards not only in our products and solutions, but also in our employees' daily work processes. Habasit AG is certified according to ISO 9001:2008.



Worldwide leading product range

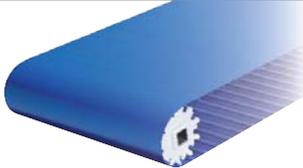
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