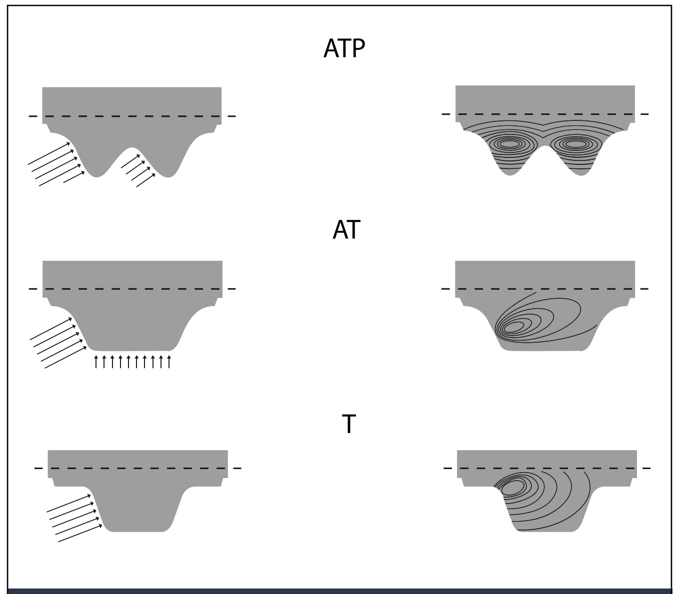


Force distribution | Load distribution

Providing the following conditions of tooth strength (1st), tension member tensile strength (2nd) and flexibility (3rd) are met, then a maintenance-free timing belt operation can be expected.

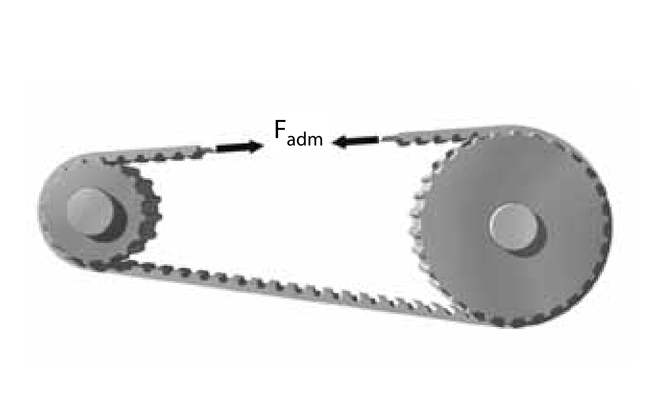
1. Tooth shear strength
Specific tooth shear strength

The specific tooth shear strength depends on the rotational speed. The maximum specific tooth shear strength is the limit load the belt tooth can bear in continuous operation. The values are stated in tables for each timing belt type. The timing belt drive is correctly designed, when not exceeding the admissible tooth shear strength. Generally, a special safety surplus is not necessary, see chapter „Safety factors“.

The high specific tooth shear strength of the ATP profile, for example, is achieved by the optimised force and load distribution. The effective force is distributed to two tooth faces.

The working loads can be distributed the more effective the more belt teeth are meshing in the pulley. Maximum number of teeth in mesh (BRECOFLEX® timing belts): z_{emax}=12

Due to the high pitch accuracy of BRECOFLEX® timing belts generally, it can be calculated with 12 belt teeth in mesh, should the number of teeth in mesh be respectively high enough.



Tensile strength

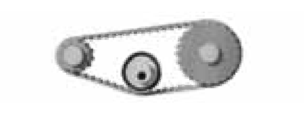
2. Tension cord tensile strenght
Admissible tensile load on belt cross section

The timing belt is designed correctly, when the maximum admissible tensile load in the steel cord tension members is not exceeded under operation conditions. The table values for F_{adm} refer to the constant loading.

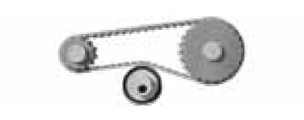
3. Flexibility
Minimum number of teeth, minimum pulley diameter

The recommended minimum number of teeth and/or the minimum diameter for a malfunction-free operation depends on the selected belt type. Take especially into consideration that the minimum number of teeth and/or the minimum diameter is higher when using a belt arrangement „with contraflexure“ (e.g. due to a tension roller).

The selection of the minimum number of teeth and/or minimum diameter of the pulleys as well as tension and return rollers is based on a large number of different parameters. In the applications of the belt is to taken into consideration the belt versions and the flexibility of the tension members.

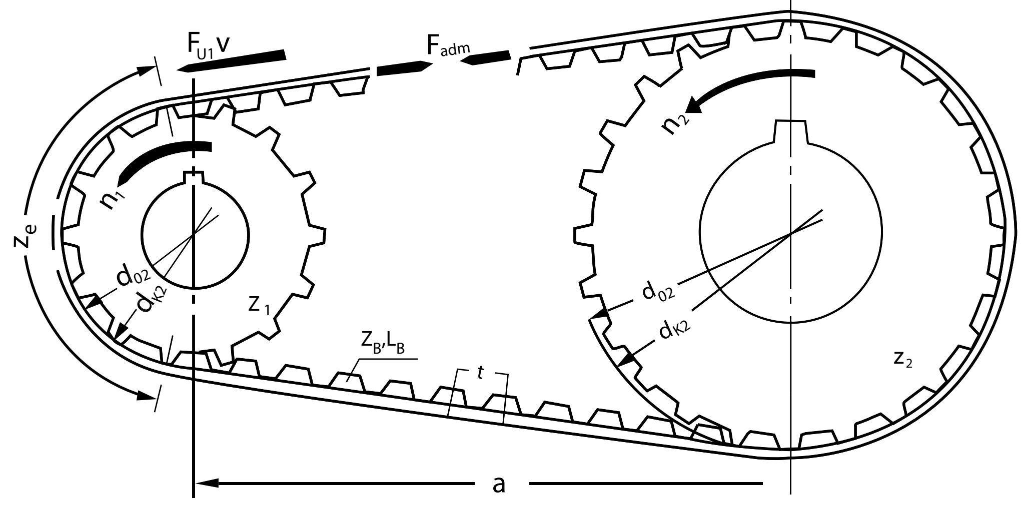


Drive layout without contraflexure



Drive layout with contraflexure

Terms, definitions



Circumferential force	F_U	[N]	Centre distance	a	[mm]
specific tooth force	F_{Uspec}	[N/cm]	Belt length	L_B	[mm]
admissible tensile load	F_{adm}	[N]	Belt width	b	[mm]
Pre-tension force	F_V	[N]	Pulley width	B	[mm]
Shaft force	F_W	[N]	Bore, pulley	d	[mm]
Torque	M	[Nm]	Pitch circle diameter	d_o	[mm]
Acceleration torque	M_B	[Nm]	Crown diameter	d_K	[mm]
specific torque	M_{spec}	[Ncm/cm]	Span length	L_T	[mm]
Power	P	[kW]	Pitch	t	[mm]
specific power	P_{spec}	[W/cm]	Number of belt teeth	z_B	
Load bearing torque	J	[kgm²]	Number of teeth with i = 1	z	
Load	m	[kg]	Number of teeth in mesh	z_e	
Density	ρ	[kg/dm³]	No. of teeth, small pulley	z_1	
Speed	v	[m/s]	No. of teeth, large pulley	z_2	
Rotational speed	n	[min⁻¹]	Transmission	i	
Angular speed	ω	[s⁻¹]	Acceleration time	t_B	[s]
Frequency	f_e	[s⁻¹]			

Circumferential force

$$F_U = \frac{2 \cdot 10^3 \cdot M}{d_0} = \frac{19.1 \cdot 10^6 \cdot P}{n \cdot d_0} = \frac{10^3 \cdot P}{v}$$

Torque

$$M = \frac{d_0 \cdot F_U}{2 \cdot 10^3} = \frac{9.55 \cdot 10^3 \cdot P}{n} = \frac{d_0 \cdot P}{2 \cdot v}$$

Power

$$P = \frac{M \cdot n}{9{,}55 \cdot 10^3} = \frac{F_U \cdot d_0 \cdot n}{19{,}1 \cdot 10^6} = \frac{F_U \cdot v}{10^3}$$

Belt length for i =1

$$L_B = 2a + \pi \cdot d_0 = 2a + z \cdot t$$

Pitch circle diameter

$$d_0 = \frac{z \cdot t}{\pi}$$

Angular speed

$$\omega = \frac{\pi \cdot n}{30}$$

Rotational speed

$$n = \frac{19.1 \cdot 10^3 \cdot v}{d_0}$$

Peripheral speed

$$v = \frac{d_0 \cdot n}{19{,}1 \cdot 10^3}$$

Apply all equations with the dimensions mentioned here.

Acceleration torque

$$M_B = \frac{J \cdot \Delta n}{9.55 \cdot t_B}$$

Load bearing torque

$$J = 98.2 \cdot 10^{-15} \cdot B \cdot \rho \cdot (d_k^4 - d^4)$$

Calculation example power transmission

Calculation power transmission

Task: A roll table drive must be designed for heavy conveying duties. Under start-up conditions the 2.5 times the running torque is exerted on the timing belt.

The application conditions are:

Given:

Power	P	=	10	kW
Nominal speed	n	=	800	min^{-1}
Start-up torque	M	=	300	Nm
Transmission, number of teeth	i	=	1, $z = z_1 = z_2 = 25$	
Centre distance	a	=	625	mm

Required: The timing belt pitch is to be determined and the belt width is to be designed.

Formulae:

$$b = \frac{100 \cdot M}{z_1 \cdot z_e \cdot M_{spec}} \quad M[Nm]$$

$$b = \frac{1000 \cdot P}{z_1 \cdot z_e \cdot P_{spec}} \quad P[kW]$$

$$F_U = \frac{2 \cdot 10^3 \cdot M}{d_0} \quad F_U\,[N]$$

$$d_0 = \frac{z \cdot t}{\pi} \quad [mm]$$

$$L = 2 \cdot a + z \cdot t \quad [mm]$$

How to proceed

Belt length: Profile preselection: AT10. Calculation of the belt length with formula:

$$L = 2 \cdot a + z \cdot t = 2 \cdot 625 + 25 \cdot 10 = \underline{1500\ mm}$$

Calculation of the belt width: **1. Tooth shear strength**
In the calculation it will be used $z_e = 12$ (see basis of calculation).
Calculation of the belt width with the nominal speed of the power equations.

$$b = \frac{1000 \cdot P}{z_1 \cdot z_e \cdot P_{spec}} = \frac{1000 \cdot 10}{25 \cdot 12 \cdot 6{,}96} = 4{,}79\ cm = \underline{47{,}9\ mm}$$

Calculation of the belt width under start-up torque when rotational speed n = 0.

$$b = \frac{100 \cdot M}{z_1 \cdot z_e \cdot M_{spec}} = \frac{100 \cdot 300}{25 \cdot 12 \cdot 11{,}70} = 8{,}54\ cm = \underline{85{,}4\ mm}$$

The belt width is to be determined from the least favourable load conditions.
Selected: the next larger standard belt width $\underline{b = 100\ mm}$.

2. Tension cord strength
The corresponding circumferencial force can be calculated from the general data supplied:

$$F_U = \frac{2 \cdot 10^3 \cdot M}{d_0} = \frac{2 \cdot 10^3 \cdot M}{79{,}58} = \underline{7539\ N < 16000\ N}$$

The tabular value F_{adm} for AT 10 with 100 mm belt width is 16000 N. Thus, there is a sufficient tension member safety factor.

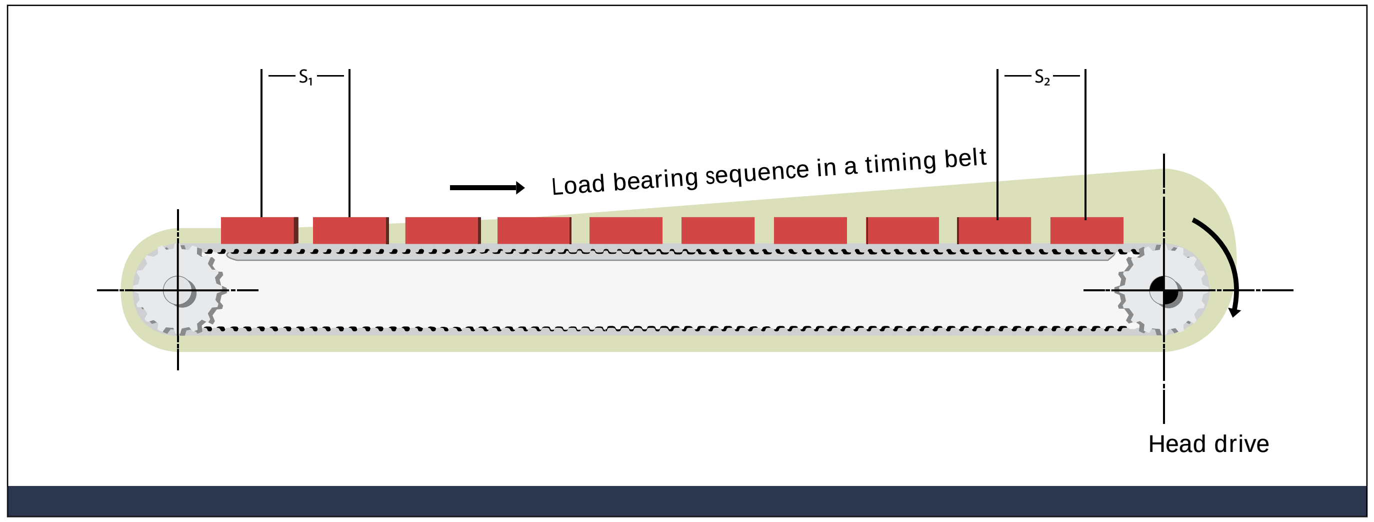
3. Flexibility
The design is a drive „without contraflexure“. The minimum number of teeth according to the table is adhered to.

Result: The drive is correctly designed with a belt width of 100 mm. A maintenance-free operation can be expected.
Ordering code: BRECOFLEX® timing belt 100 AT 10 / 1500

Calculation example transport technology

BRECO® and BRECOFLEX® timing belts used for transportation

Transport timing belts are to be designed preferably as head drive. The goods to be transported can consist of one or more individual loads. A lot of individual loads can be seen as line load.



Calculation of the circumferencial force F_U

From the overall transport load, the required haul-off force or the circumferential force F_U for the drive pulley assemblies can be derived:

$$F_U = 9{,}81 \cdot m \cdot \mu$$

Circumferential force in the drive pulley station	F_U	[N]
Mass of the items to be transported	m	[kg]
Friction factor of the timing belt in relation to the bed plate	µ	

As friction factor µ (slide friction), the following values can be assumed:

Steel/PUR 92 Shore A	0,6 - 0,7
Steel/PAZ	0,2 - 0,4
PE/PUR	0,3 - 0,4

In general, friction factors show large ranges. Trials should be carried out, if necessary. Information without obligation.

Information on the force/ elongation behaviour

The grid surface in the picture shows the force/elongation behaviour in the timing belt under operating conditions. The individual spacing between the transported products increase towards to the drive pulley assembly.

Space $s_1 < s_2$

Pre-tension force

We recommend to set the pre-tension force in the transport timing belt such that a residual pre-tension force is always maintained on the slack span side under operating conditions. The following pre-tension force is required:

$$F_V > 0{,}5 \cdot F_U$$

Calculation of the belt width b

$$b = \frac{F_U}{z_e \cdot F_{Uspez}} \qquad F_U[N]$$

F_U: Circumferencial force (calculated)

F_{Uspec}: Specific load of the belt teeth

z_e: Number of teeth in mesh

z_{emax}: Maximum number of teeth in mesh for endless joined BRECO timing belts (V): $z_{emax} = 6$