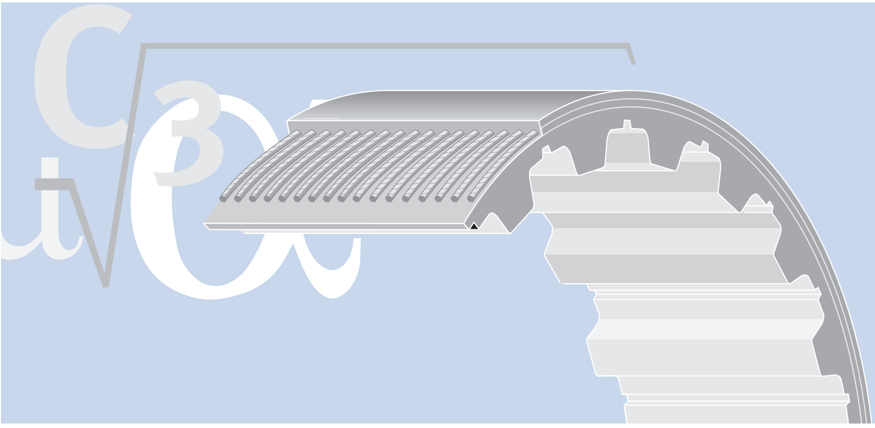
siegling proposition
timing belts

Calculation methods



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You can find detailed information on Siegling Proposition high quality timing belts in the overview of the range (ref. no. 245).

Formulae

1. Forces

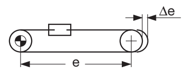
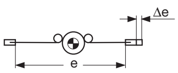
Symbol	Designation	Unit	Calculation/Remarks
Effective pull to be transmitted	F_U	N	$F_U = \frac{2 \cdot 10^3 \cdot T}{d_0} = \frac{19.1 \cdot 10^6 \cdot P}{n \cdot d_0}$ $= \frac{10^3 \cdot P}{v}$ [N] $F_U = F_A + F_H + F_R$ ... [N]
Accelerating force	F_A	N	$F_A = m \cdot a$ [N]
Lifting power	F_H	N	$F_H = m \cdot g \cdot \sin \alpha$ [N] (sin α for inclined conveying)
Frictional force (μ values table 4)	F_R	N	$F_R = m \cdot \mu \cdot g$ [N] ($g = 9.81$ m/s²)
Maximum effective pull	$F_{U\,max}$	N	$F_{U\,max} = F_U \cdot (c_2 + c_3)$ [N]
Specific effective pull required	$F'_{U\,req}$	N	$F'_{U\,req} = F_{U\,max}/c_1$ [N]
Specific effective pull	F'_U	N	from calculation sheet
Pretensioning force	F_V	N	$F_V \geq 0.5 \cdot F_{U\,max}$ [N] (2-pulley drives) $F_V \geq F_{U\,max}$ [N] (linear drives)
Force determining belt selection	F_B	N	$F_B = F_{U\,max} + F_V$ [N]
Permissible tension member load	F_{per}	N	Table value from calculation sheet
External force	F	N	
Static shaft load	F_{WS}	N	$F_{WS} = 2 \cdot F_V$ [N] (2-pulley drives)

2. Masses

Symbol	Designation	Unit	Calculation/Remarks
Mass to be moved	m	kg	$m = m_R + m_L + m_{Z\,red} + m_{S\,red}$ [kg]
Mass of belt	m_R	kg	$m_R = m'_R \cdot l/1000$ [kg];
Belt weight per metre	m'_R	kg/m	Table value from calculation sheet
Mass of linear slide	m_L	kg	
Mass of timing belt pulley	m_Z	kg	$m_Z = \frac{(d_k^2 - d^2) \cdot \pi \cdot b \cdot \rho}{4 \cdot 10^6}$ [kg]
Reduced mass of timing belt pulley	$m_{Z\,red}$	kg	$m_{Zred} = \frac{m_Z}{2} \cdot \left[1 + \frac{d^2}{d_k^2}\right]$ [kg]
Mass of take-up pulley	m_S	kg	$m_S = \frac{(d_S^2 - d^2) \cdot \pi \cdot b \cdot \rho}{4 \cdot 10^6}$ [kg]
Reduced mass of take-up pulley	$m_{S\,red}$	kg	$m_{Sred} = \frac{m_S}{2} \cdot \left[1 + \frac{d^2}{d_S^2}\right]$ [kg]

MOVEMENT SYSTEMS

3. Measurements

Symbol	Designation	Unit	Calculation/Remarks
Bore diameter	d	mm	
Pitch diameter	d_0	mm	$d_0 = z \cdot t/\pi$ [mm], catalogue value
Outside diameter	d_k	mm	Catalogue value of timing belt pulley supplier
Take-up pulley diameter	d_s	mm	
Width of timing belt pulley, take-up pulley	b	mm	
Belt width	b_0	mm	
Belt length untensioned for 2-shaft drives	l	mm	for $i = 1$: $l = 2 \cdot e + \pi \cdot d_0 = 2 \cdot e + z \cdot t$ [mm] for $i \neq 1$: $l = \frac{t \cdot (z_2 + z_1)}{2} + 2e + \frac{1}{4e}\left[\frac{t \cdot (z_2 - z_1)}{\pi}\right]^2$
Belt length general		mm	$l = z \cdot t$ [mm]
Clamping length per belt end	l_k	mm	for AdV 07
Centre distance (exact)	e	mm	is calculated from l
Centre distance (exact)	Δe	mm	Rotating 2-pulley drives and 2-pulley linear drives (AdV 07clamped): $\Delta e = \frac{F_V \cdot l}{2 \cdot c_{spec}}$ [mm]  Clamped belt (AdV 07)  $\Delta e = \frac{F_V \cdot l}{c_{spec}}$ [mm]
Positioning deviation under influence of external forces	Δs	mm	$\Delta s = \frac{F}{c}$ [mm]; $\Delta s_{min} = \frac{F}{c_{max}}$ [mm]
Belt pitch	t	mm	Centre distance of adjacent teeth

4. Constants and Coefficients

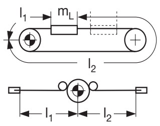
Symbol	Designation	Unit	Calculation/Remarks
Density	ρ	kg/dm^3	e.g. pulley material
Friction coefficient	μ		Depends on friction pairing; see table 4
Teeth in mesh factor; number of teeth involved in power flux	c_1		$i = 1$; $c_1 = z/2$ $i \neq 1$; $c_1 = \frac{z_1}{180} \cdot \arccos \frac{(z_2 - z_1) \cdot t}{2 \cdot \pi \cdot e}$ Note $c_{1\,max}$ table 1!
Operational factor	c_2		Table 2
Acceleration factor	c_3		Table 3

Formulae

5. Quantities of Motion

Symbol	Designation	Unit	Calculation/Remarks
Speed (RPM)	n	min^{-1}	$n = \frac{v \cdot 19{,}1 \cdot 10^3}{d_0}$ [min^{-1}]
Belt speed	v	m/s	$v = \frac{d_0 \cdot n}{19.1 \cdot 10^3} = \sqrt{\frac{2 \cdot s_a \cdot a}{1000}}$ [m/s]
Acceleration	a	m/s^2	
Acceleration due to gravity	g	m/s^2	g = 9.81 [m/s^2]
Travel total	s_v	mm	$sv = s_a + s'_a + s_c$ [mm]
Accelerating (braking) distance	s_a (s'_a)	mm	$s_a (s_a') = \frac{a \cdot t_a^2 \cdot 10^3}{2} = \frac{v^2 \cdot 10^3}{2 \cdot a}$ [mm]
Travel where v = constant	s_c	mm	$s_c = v \cdot t_c \cdot 10^3$ [mm]
Accelerating (braking) time	t_a (t'_a)	s	$t_a (t_a') = \frac{v}{a} = \sqrt{\frac{2 \cdot s_a}{a \cdot 1000}}$ [s]
Travel time where v = constant	t_c	s	$t_c = \frac{s_c}{v \cdot 10^3}$ [s]
Travel time total	t_v	s	$t_v = t_a + t_a' + t_c$ [s]
Gear ratio	i		

6. Other Values/Abbreviations

Symbol	Designation	Unit	Calculation/Remarks
Angle of incline	α	°	for inclined conveying
Specific spring rate	c_{spec}	N	Table value from calculation sheet
Spring rate of a belt Spring rate of a linear drive	c	N/mm	generally: $c = \frac{c_{spec}}{l}$ [N/mm] $c = \frac{l}{l_1 \cdot l_2} \cdot c_{spec}$ [N/mm]
Determine from extreme positions of linear drive c_{min} for $l_1 = l_2$	c_{min}/c_{max}	N/mm	 $l = l_1 + l_2$ [mm] $c_{min} = \frac{4 \cdot c_{spec}}{l}$ [N/mm]
Natural frequency	f_e	s^{-1}	$f_e = \frac{1}{2\pi} \cdot \sqrt{\frac{c \cdot 1000}{m_L}}$ [s^{-1}]
Exciter frequency	f_0	s^{-1}	$f_0 = \frac{n}{60}$ [s^{-1}]
Tooth base service factor	S_{tooth}		$S_{tooth} = F'_U/F'_{U\,req}$
Tension member service factor	S_{tm}		$S_{tm} = F_{per}/F_B$
Number of teeth	z		where i = 1
Number of teeth on small pulley	z_1		where i ≠ 1
Number of teeth on large pulley	z_2		where i ≠ 1
Minimum number of teeth	z_{min}		Table value from calculation sheet
Minimum take-up pulley diameter	$d_{s\,min}$	mm	Table value from calculation sheet
Power to be transmitted	P	kW	$P = \frac{F_U \cdot n \cdot d_0}{19.1 \cdot 10^6} = \frac{F_U \cdot v}{10^3}$ [kW]
Torque to be transmitted	T	Nm	$T = \frac{F_U \cdot d_0}{2 \cdot 10^3}$ [Nm]
Timing belt open	AdV 07		
Timing belt welded endless	AdV 09		

Calculation method for B 92 timing belts

Effective pull F_U [N] to be transmitted | **1**

$$F_U = \frac{2 \cdot 10^3 \cdot T}{d_0} = \frac{19.1 \cdot 10^6 \cdot P}{n \cdot d_0} = \frac{10^3 \cdot P}{v} \quad [N]$$

and $v = \frac{d_0 \cdot n}{19.1 \cdot 10^3}$ [m/s] with $d_0 = \frac{z \cdot t}{\pi}$ [mm]

or: Sum of all forces $F_U = F_R + F_H + F_A \ldots$ [N]

in which: $F_R = m \cdot \mu \cdot g$ [N] frictional force

$F_H = m \cdot g$ or $m \cdot g \cdot \sin \alpha$ [N] lifting power

$F_A = m \cdot a$ [N] accelerating force

Maximum effective pull $F_{U\,max}$ [N] | **2**

Operational and acceleration factor c_2 and c_3 take from tables 2 and 3

$F_{U\,max} = F_U \cdot (c_2 + c_3)$ [N]

Teeth in mesh factor c_1 for the driving (smaller) pulley | **3**

$c_1 = z/2$ for $i = 1$

$$c_1 = \frac{z_1}{180} \cdot \arccos \frac{(z_2 - z_1) \cdot t}{2 \cdot \pi \cdot e} \quad \text{for } i \neq 1$$

Always round down calculated values for c_1 to the smaller round figure.
Note maximum values in table 1!
Estimate number of teeth if not given and determine n.

Specific effective pull required $F'_{U\,req}$ [N] | **4**

$$F'_{U\,req} = \frac{F_{U\,max}}{c_1} \quad [N]$$

Belt selection from graphs

Find $F'_{U\,req}$ in the belt overview graph and move horizontally to the right to the point of intersection with the speed in question. All belt pitches which lie above this point can be used in principle.

F'_U [N] of selected belt type

Select belt type and find point of intersection on the calculation sheet for that particular type. The curve above the point of intersection gives the belt width b_0 [mm]. The point where speed and width curve intersect gives the transmittable effective pull F'_U [N].

Belt length l [mm] | **5**

$l = 2 \cdot e + z \cdot t = 2 \cdot e + \pi \cdot d_0$ [mm] for $i = 1$

$$l = \frac{t \cdot (z_2 - z_1)}{2} + 2e + \frac{1}{4e}\left[\frac{t \cdot (z_2 - z_1)}{\pi}\right]^2 \quad [mm] \quad \text{for } i \neq 1$$

l must always be an integral multiple of the belt pitch t in mm. Equations are valid for rotating 2-pulley drives. Calculate other designs according to their geometry.

Belt mass m_R [kg]

$m_R = m'_R \cdot l/1000$ [kg]; $m_{R'}$ from calculation sheet

Reduced mass of timing belt pulley and take-up pulleys $m_{Z\,red}$, $m_{S\,red}$ [kg].

For calculation see formulae.
Timing belt pulley measurements from catalogue.

Calculation method for B 92 timing belts

6 Check F_U with F_A

including m_R, $m_{Z\,red}$ and $m_{S\,red}$

Repeat steps 1 – 4 if the influence of the belt mass must not be neglected; e.g. on linear drives with high acceleration.

7 Determining tooth base

$$S_{tooth} = \frac{F'_U \cdot c_1}{F_{U\,max}} = \frac{F'_U}{F_{U\,req}}$$

Demand: $S_{tooth} > 1$

8 Pretensioning force [N]

$F_V > 0{,}5 \cdot F_{U\,max}$ [N] for 2-pulley drives

$F_V > F_{U\,max}$ [N] for linear drives

Force determining belt selection F_B [N]

$F_B = F_{U\,max} + F_V$ [N]

Determining tension member service factor S_{tm}

$$S_{tm} = \frac{F_{per}}{F_B}$$

Demand: $s_{tm} > 1$

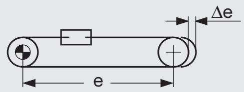
F_{per} from calculation sheet

9 Take-up range Δe [mm]

(For endless belts:
Elongation at fitting
ε approx. 0.1 %
For open material:
Elongation at fitting
ε approx. 0.2 %)

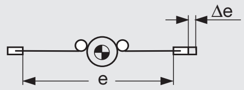
Rotating 2-pulley drives and 2-pulley linear drive (AdV 07 clamped)

$$\Delta e = \frac{F_V \cdot l}{2 \cdot c_{spec}} \text{ [mm]}$$



Clamped belt (AdV 07)

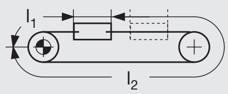
$$\Delta e = \frac{F_V \cdot l}{c_{spec}} \text{ [mm]}$$



Steps 10 – 12 of calculation method only for linear drives as a rule!

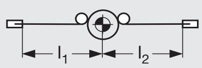
10 Spring rate of entire system c [N/mm] and c_{min} [N/mm]

$$c = \frac{l}{l_1 \cdot l_2} \cdot c_{spec} \text{ [N/mm]; } l = l_1 + l_2$$



c_{min} and c_{max} as per extreme right and left positions of slide.

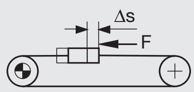
$$c_{min} = \frac{4 \cdot c_{spec}}{l} \text{ [N/mm] for } l_1 = l_2$$



11 Positioning deviation under influence of external force Δs [mm]

$$\Delta s = \frac{F}{c} \text{ [mm]}$$

$$\Delta s_{max} = \frac{F}{c_{min}} \text{ [mm]}$$



12 Resonance behaviour: Natural frequency: f_e [s^{-1}]

$$f_e = \frac{1}{2\pi} \cdot \sqrt{\frac{c \cdot 1000}{m}} \text{ [}s^{-1}\text{]}$$

$f_e \neq f_0$
There is then no danger of resonance.

Exciter frequency: f_0 [s^{-1}]

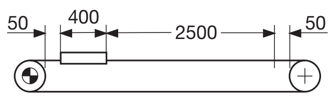
$$f_0 = \frac{n}{60} \text{ [}s^{-1}\text{]}$$

Linear drive for moving assembly carriers

Travel	S_V = 2500 mm
Speed	v = 3 m/s = const.; i = 1
Acceleration	a = 15 m/s^2
Mass of slide	m_L = 25 kg
	incl. assembly carrier + goods being carried
Frictional force of guide rails	F_R = 80 N
Slide length	l_L = 400 mm
d_0	approx. 100 mm

Required: Belt type and width b_0, RPM, timing belt pulley data, pretensioning force and take-up range, effective pull, positioning accuracy

Diagram



Effective pull F_U [N] 1

$F_U = F_A + F_R$ [N]
F_A = 25 kg · 15 m/s^2 = 375 N
F_U = 375 N + 80 N = 455 N
Mass of timing belt pulley and belt neglected.

Effective pull F_U [N] to be transmitted – approximate.

Operational and acceleration c_2 and c_3 2

c_2 = 1.4 because of high acceleration
c_3 = 0 as i = 1
455 N · 1.4 = $F_{U\,max}$ = 637 N

$F_{U\,max}$ – approximate.

Teeth in mesh factor c_1 3

Selected: c_1 = 12 for open material
Where $d_0 \approx$ 100 mm and c_1 = 12 Z_{min} = 24;
i.e. 14 und 20 mm pitches ruled out due to d_0!

$F'_{U\,req}$ 4

$$F'_{U\,req} = \frac{F_{U\,max}}{c_1} = 53.08\ \text{N}$$

$$n = \frac{v \cdot 19.1 \cdot 10^3}{d_0} = 573\ \text{min}^{-1}$$

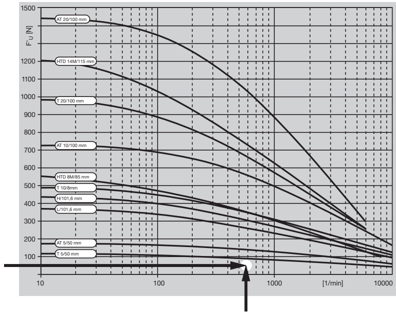
n from given values d_0 and v

Calculation example 1

Linear drive for moving assembly carriers

Belt selection

For linear drives preferably use AT and HTD! Possible types: AT 5, AT 10, HTD 8M.

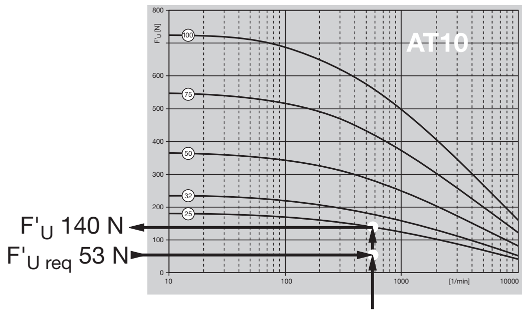


Overview graph

F'_U of selected belt type

Selected: AT 10 because of high spring resistance; t = 10 mm.

$F'_U = 140$ N



AT 10 graph

5 Selecting timing belt pulley

$d_0 = 100$ mm

=> $100 \cdot \pi = 314 / t = 31.4$ teeth

Selected: Z = 32; standard pulley

Material aluminium; $\rho = 2.7$ kg/dm^3

$d_0 = 32 \cdot t/\pi = 101.86$ mm

therefore:

$$n = \frac{v \cdot 19.1 \cdot 10^3}{101.86} = 562 \text{ min}^{-1}$$

Mass of timing belt pulley

$d_K = 100$ mm; d = 24 mm; b = 32 mm

$$\Rightarrow m_Z = \frac{(100^2 - 24^2) \cdot \pi \cdot 32 \cdot 2.7}{4 \cdot 10^6} = 0.64 \text{ kg}$$

Reduced mass of timing belt pulley

$$m_{Z\ red} = \frac{0.64}{2} \cdot \left[1 + \frac{24^2}{100^2}\right] = 0.34 \text{ kg}$$

Calculate belt length

$l = 2 \cdot (2500 + 400 + 100 + d_0) - (400 - 2 \cdot 80) + z \cdot t$

$l = 6283.7$ mm => $l = 6290$ mm

from diagram and d_0; clamping length l_K per belt end = 80 mm.

Determining belt mass

$m'_R = 0.064$ kg/m $\cdot$ 2,5 cm = 0.16 kg/m

$m_R = 1.00$ kg

$F_A = (25\ kg + 1\ kg + 2 \cdot 0.34\ kg) \cdot a$
$F_A = 400.2\ N$
$F_U = 400.2 + 80 = 480\ N$
$F_{U\,max} = 480 \cdot 1.4 = 675\ N$
$F'_{U\,req} = 56.02\ N$

$F_{U\,max}$ exact including m_R and $m_{Z\,red}$ 6

$$S_{tooth} = \frac{F'_U}{F'_{Ureq}} = \frac{140}{56.02} = 2.5 \quad >1$$

Demand fulfilled

Tooth base service factor S_{tooth} 7

$F_V \geq F_{U\,max}$ for linear drives!
F_V selected $= 1.5\ F_{U\,max} = 1000\ N$

$F_B = F_V + F_{U\,max} = 1675\ N$

$$S_{tm} = \frac{F_{per}}{F_B} = \frac{3750}{1675} = 2.24 \quad >1$$

Demand fulfilled

Force determining belt selection F_B 8

Pretensioning force F_V

Tension member service factor S_{tm}

F_{per} from calculation sheet for AT 10

$$\Delta e = \frac{F_V \cdot l}{2 \cdot c_{spec}} = \frac{1000\ N \cdot 6290\ mm}{2 \cdot 10^6\ N} = 3.14\ mm$$

Take-up range Δe [mm]
c_{spec} from calculation sheet for AT 10 9

$$c_{min} = \frac{l}{l_1 \cdot l_2} \cdot c_{spec} = \frac{6290 - 2 \cdot 80}{2684 \cdot 3446} \cdot c_{spec} = 662.77\ N/mm$$

$$c_{max} = \frac{l}{l_1 \cdot l_2} \cdot c_{spec} = \frac{6290 - 2 \cdot 80}{184 \cdot 5946} \cdot c_{spec} = 5602.96\ N/mm$$

Spring rate of system c_{min}; c_{max} 10

l_1 and l_2 from diagram!

External force here: $F_R = 80\ N$

$$\Delta s_{min} = \frac{F_R}{c_{max}} = 0.014\ mm$$

$$\Delta s_{max} = \frac{F_R}{c_{min}} = 0.122\ mm$$

Positioning accuracy due to external force 11

$$f_e = \frac{1}{2\pi} \cdot \sqrt{\frac{c_{min} \cdot 1000}{m_L}} = 25.7\ s^{-1}$$

$$f_0 = \frac{n}{60} = \frac{562}{60} = 9{,}4\ s^{-1}$$

i.e. no danger of resonance

Natural frequency of system 12

Exciter frequency

Timing belt 25 AT 10, 6290 mm long
Timing belt pulley with Z = 32 für 25 mm belt
Take-up range to generate F_V $\Delta e = 3.14\ mm$
$n = 562\ min^{-1}$
$\Delta s_{max} = 0.122\ mm$

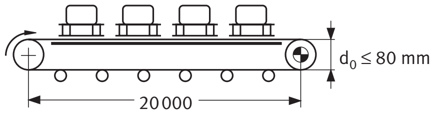
Result

If Δs_{max} has to be smaller,
$b_0 = 32\ mm$ would be selected.
No danger of resonance.

Calculation example 2

Drag band conveyor for workpiece tray

Diagram



Speed	$v = 0.5$ m/s
Mass of tray incl. load	$m = 1.8$ kg
Maximum loading	20 trays
Belt support tight side	Plastic rails
Belt support slack side	Rollers
Centre distance	$e = 20000$ mm
Start	Without load
Operation	continuous operation, purely conveying
Pulley diameter	$d_0 \leq 80$ mm

Required: Belt type, length, take-up range, timing belt pulley data

1 Effective pull F_U [N]

Effective pull F_U [N] to be transmitted without belt mass.

F_U here = F_R, as acceleration negligible.

$F_U = F_R = m \cdot \mu \cdot g$

μ selected approx. 0.25 from table 4

$m = 20 \cdot 1.8 \text{ kg} = 36 \text{ kg}$

$F_U = F_R = 36 \cdot 9.81 \cdot 0.25 = 88.3 \text{ N}$

2 Operational and acceleration factor

$c_3 = 0$, as $i = 1$

$c_2 = 1.2$ selected (20 % reserve)

$F_{U\,max} = 1.2 \cdot 8.3 \text{ N} = 106 \text{ N}$ for 2 belts

$F_{U\,max} = 53$ N per belt

3 Teeth in mesh factor

c_1 selected $= c_{1\,max} = 6$ for AdV 09

Belt rotates and has been welded endless.

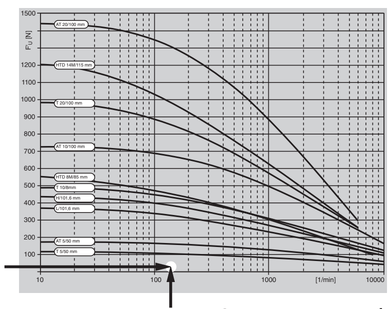
4 Specific effective pull required $F'_{U\,req}$

$$F'_{U\,req} = \frac{F_{U\,max}}{c_1} = 8.8 \text{ N}$$

Speed

where $d_0 = 75$ mm

$$n = \frac{v \cdot 19.1 \cdot 10^3}{75} = 127 \text{ min}^{-1}$$



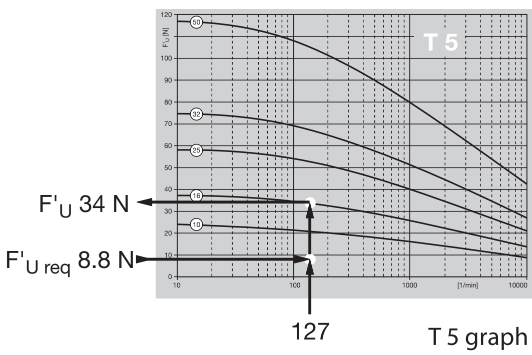
Overview graph

Belt selection

The narrowest belt is already sufficient.
Selected: 2 pieces 16 T 5.
16 mm width to provide greater support for tray.

F'_U [N] of selected belt type

$F'_U = 34$ N



T 5 graph

Selecting timing belt pulley **5**

$\frac{d_0 \cdot \pi}{t} = Z = 47.1$ teeth

Selected: Z = 48 teeth; standard pulley

Belt length

$l = Z \cdot t + 2 \cdot e = 40240$ mm

Belt mass

$m_R = l \cdot m'_R = 0.038$ kg/m $\cdot$ 40.24 m = 1.53 kg

$F_{U\,max}$ including m_R of tight side **6**

$F_{U\,max} = F_R \cdot 1.2$
$F_R = (20 \cdot 1.8$ kg $+ 2 \cdot 1.53$ kg$) \cdot 9.81 \cdot 0.25 = 95.8$ N
$F_{U\,max} = 115$ N = 57.5 N/belt
If increase is negligible, further calculation unnecessary

Tooth base service factor **7**

$S_{tooth} = \frac{F'_U \cdot c_1}{F'_{U\,max}} = \frac{34 \cdot 6}{57.5} = 3.69 \quad >1$ Demand fulfilled

Pretensioning force F_V **8**

$F_V \geq 0.5 \cdot F_{U\,max}$
Selected: $F_V = 40$ N

Force determining belt selection F_B

$F_B = F_V + F_{U\,max} = 40 + 57.5 = 97.5$ N

Tension member service factor S_{tm}

$S_{tm} = \frac{F_{per}}{F_B} = \frac{270\ \text{N}}{97.5\ \text{N}} = 2.8 \quad >1$ Demand fulfilled

F_{per} from calculation sheet for 16 T5 Adv 09

Take-up range Δe **9**

$\Delta e = \frac{F_V \cdot l}{2 \cdot c_{spec}}$ with $c_{spec} = 0.12 \cdot 10^6$ from calculation sheet

$\Delta e = \frac{40 \cdot 40240}{2 \cdot 0.12 \cdot 10^6} = 6.7$ mm

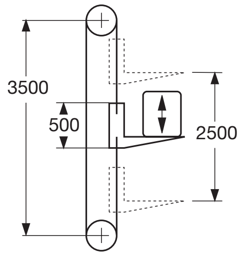
Result

2 pieces timing belt type 16 T 5, 40240 mm long, AdV 09
Timing belt pulley with Z = 48 teeth for 16 mm belt
Take-up range to generate F_V $\Delta e = 6.7$ mm

Calculation example 3

Lifting device

Diagram



Travel	2500 mm
Speed	2 m/s
Medium acceleration/deceleration	4 m/s^2
Max. deceleration (emergency shutdown)	10 m/s^2
Slide mass with load	75 kg
No. of belts	2 pieces
Frictional force of guide rails	$F_R = 120$ N
d_0	maximum 150 mm

Required: Belt type and length, pretensioning force, take-up range, speed.
Rough operating conditions!

1 Effective pull F_U [N]

Effective pull F_U [N] to be transmitted.

$F_U = F_A + F_H + F_R + \ldots$
$F_R = 120$ N
$F_A = 75\ \text{kg} \cdot 4\ \text{m/s}^2 = 300$ N
$F_{A\,max} = 75\ \text{kg} \cdot 10\ \text{m/s}^2 = 750$ N (emergency shutdown)
$F_H = 75\ \text{kg} \cdot 9.81\ \text{m/s}^2 = 736$ N
$F_U = 120\ \text{N} + 736\ \text{N} + 750$ N (emergency braking during descent)
$F_U = 1606$ N

2 Operational factor c_2 Acceleration factor c_3

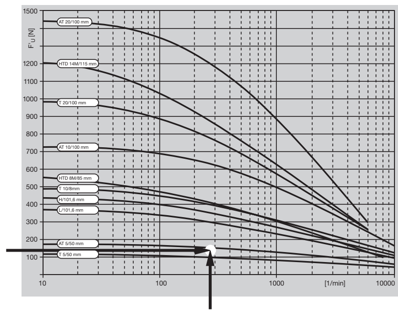
$c_3 = 0$ as $i = 1$
$c_2 = 2.0$ because of rough operating conditions
$F_{U\,max} = 1606 \cdot 2 = 3212$ N distributed between 2 belts
$F_{U\,max} = 1606$ N pro belt

3 Teeth in mesh factor c_1

Open material: $c_1 = 12 = c_{1\,max}$ for AdV 07 selected
=> $Z_{min} = 24$; $t = 20$ ruled out because of $d_{0\,max}$

4 Specific effective pull required $F'_{U\,req}$

$$F'_{U\,req} = \frac{F_{U\,max}}{12} = 133\ \text{N} \quad \text{per belt!}$$



Overview graph

Speed

Where $d_0 = 140$ mm

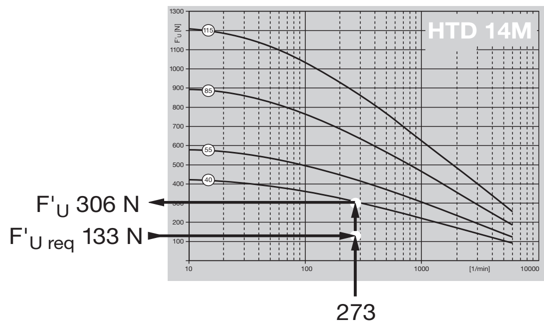
$$n = \frac{v \cdot 19.1 \cdot 10^3}{d_0} = 273\ \text{min}^{-1}$$

Belt selection

All types between L and HTD 14M are possible.
Selected: HTD 14M because of large reserves.
Designation: 40 HTD 14M

F'_U [N] of selected belt type

$F'_U = 306$ N



HTD 14M graph

$$Z = \frac{d_0 \cdot \pi}{t} = \frac{140 \cdot \pi}{14} = 31.4$$

Selected: Z = 32; standard pulley => $n = 268\ min^{-1}$

$l = 3500 \cdot 2 + Z \cdot t - 500 + 2 \cdot 114$

$l = 7176\ mm \mathrel{\hat{=}} 512{,}6$ teeth

l selected: 512 teeth $\mathrel{\hat{=}}$ 7168 mm

$m'_R \cdot l = 0.44\ kg/m \cdot 7.168\ m = 3.155\ kg/belt$

$m_Z = 6.17\ kg$	(catalogue values)
$d_K = 139.9\ mm$	(catalogue values)
$d = 24.0\ mm$	(catalogue values)

$$m_{Z\ red} = \frac{m_Z}{2} \cdot \left[1 + \frac{d^2}{d_K^2}\right] = 3.18\ kg$$

gives in total: $4 \cdot 3.18 = 12.7\ kg$

Pulley selected 5

Belt length

Belt mass

Timing belt pulley data

Reduced mass of timing belt pulley

$F_U = F_A + F_H + F_R$

$F_H = 736\ N$

$F_R = 120\ N$

$F_A = (75\ kg + 12.7\ kg + 2 \cdot 3.155\ kg) \cdot 10\ m/s^2 = 940\ N$

$F_U = 940 + 120 + 736 = 1800\ N$

$F_{U\ max} = c_2 \cdot F_U = 3600\ N$; distributed between 2 belts

=> $F_{U\ max} = 1800\ N/belt$

$$F'_{U\ req} = \frac{1800}{12} = 150\ N$$

F_U with belt and pulley mass considered 6

$$S_{tooth} = \frac{F'_U}{F'_{U\ req}} = \frac{310}{150} = 2.07 \quad >1$$

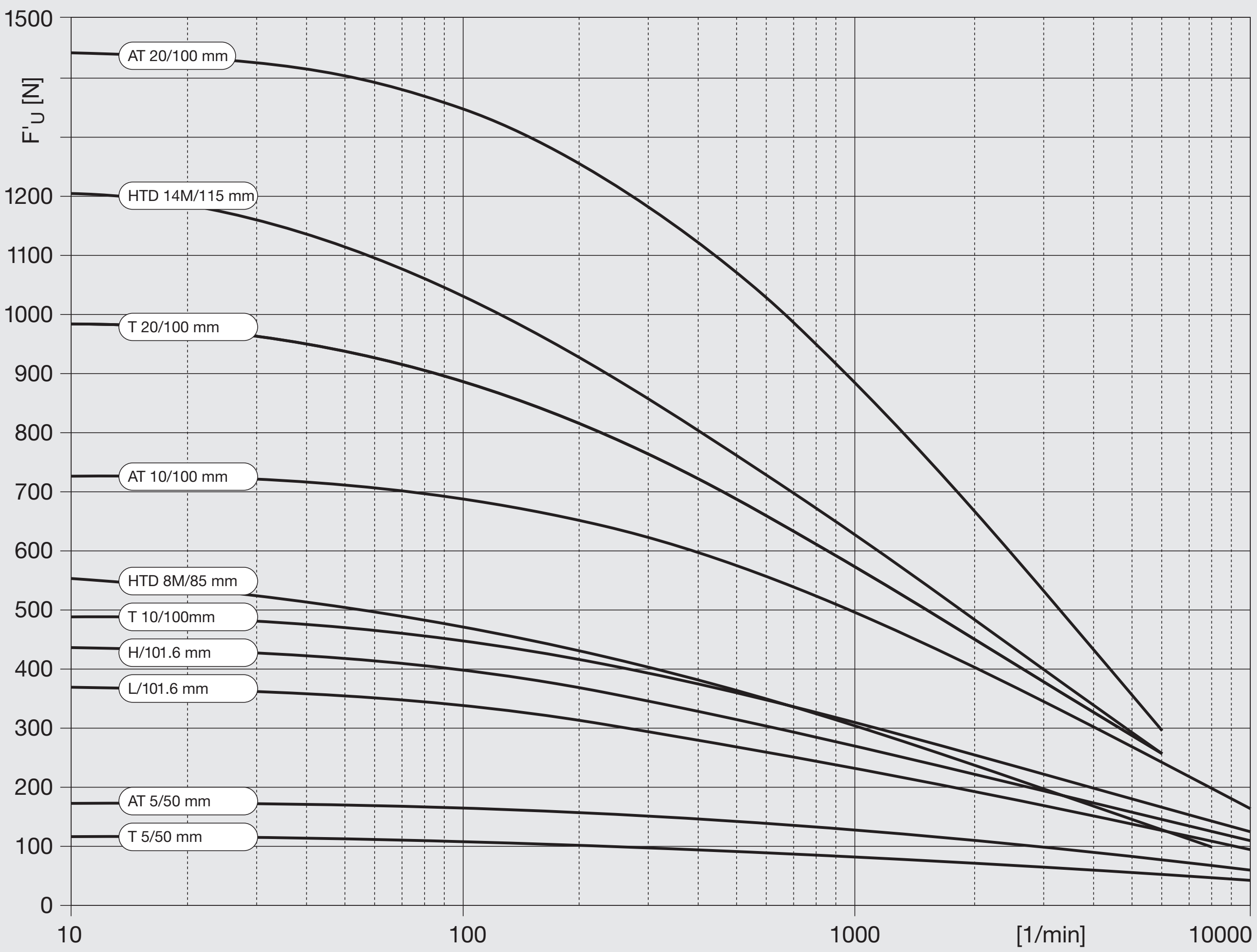
Demand fulfilled

Tooth base service factor S_{tooth} 7

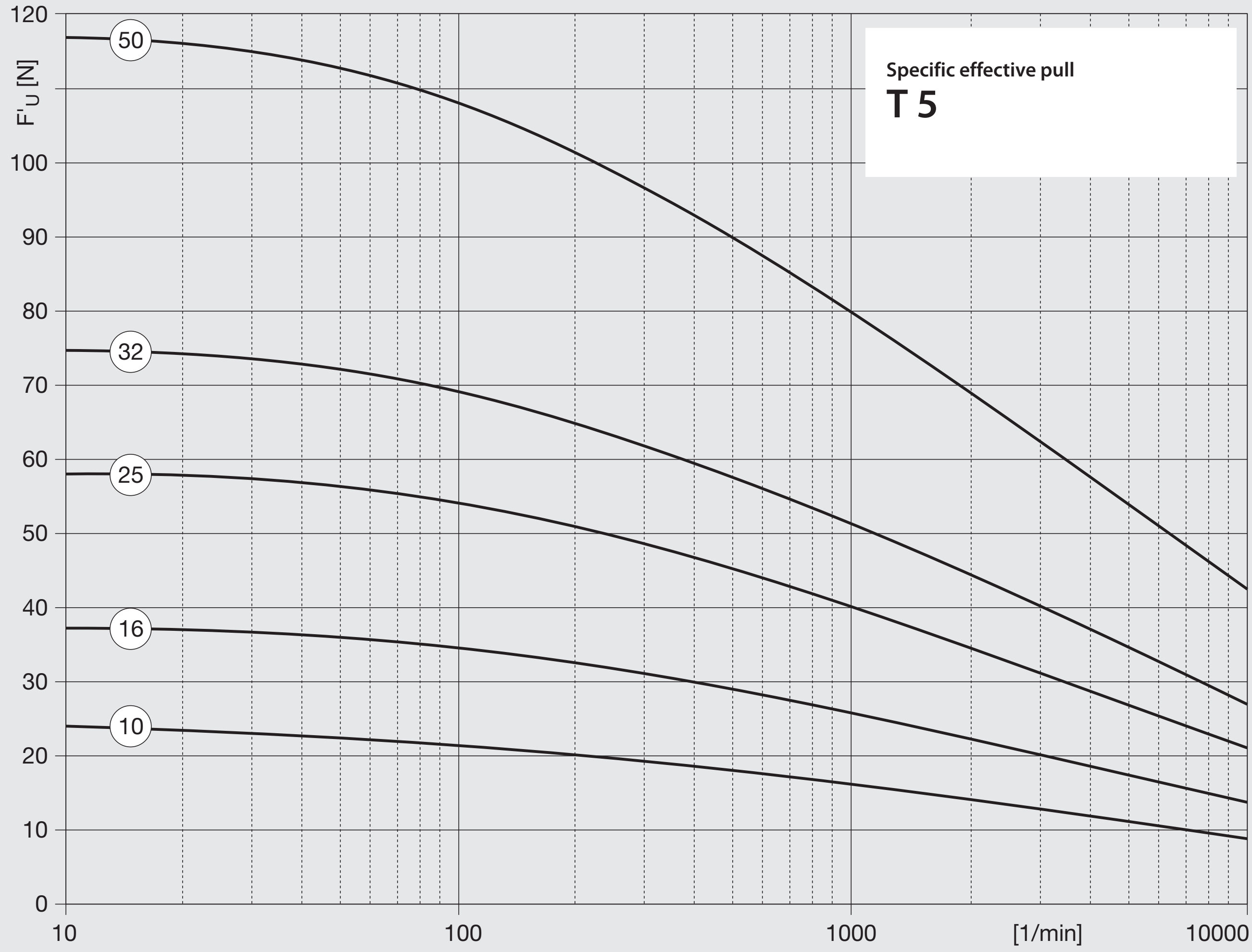
Lifting device

8 Selecting pretensioning force	$F_V \geq F_{U\,max} = 1800$ Selected: 2000 N = F_V
Force determining belt selection F_B	$F_B = F_{U\,max} + F_V = 3800$ N
Permissible force on each strand	$F_{per} = 8500$ N
Tension member service factor S_{tm}	$S_{tm} = \frac{F_{per}}{F_B} = \frac{8500}{3800} = 2.24 \quad >1$ Demand fulfilled
9 Take-up range Δe	$c_{spec} = 2.12 \cdot 10^6$ N $\Delta e = \frac{F_V \cdot l}{2 \cdot c_{spec}} = \frac{7168 \cdot 2000}{2 \cdot 2.12 \cdot 10^6} = 3.38$ mm
Result	Timing belt type 40 HTD 14M 7168 mm long = 512 teeth Timing belt pulleys à 32 teeth for 40 mm wide belt Take-up range to generate force F_V $\Delta e = 3.38$ mm
Safety note	In the case of lifting devices the regulations of professional/trade associations should be observed. If necessary, safety from breakage must be proven from the breaking load of the belt. With open material AdV 07 this is approximately 4 times the permissible force on each strand F_{per}. Exact values on request.

Overview graph



Timing belt type T 5



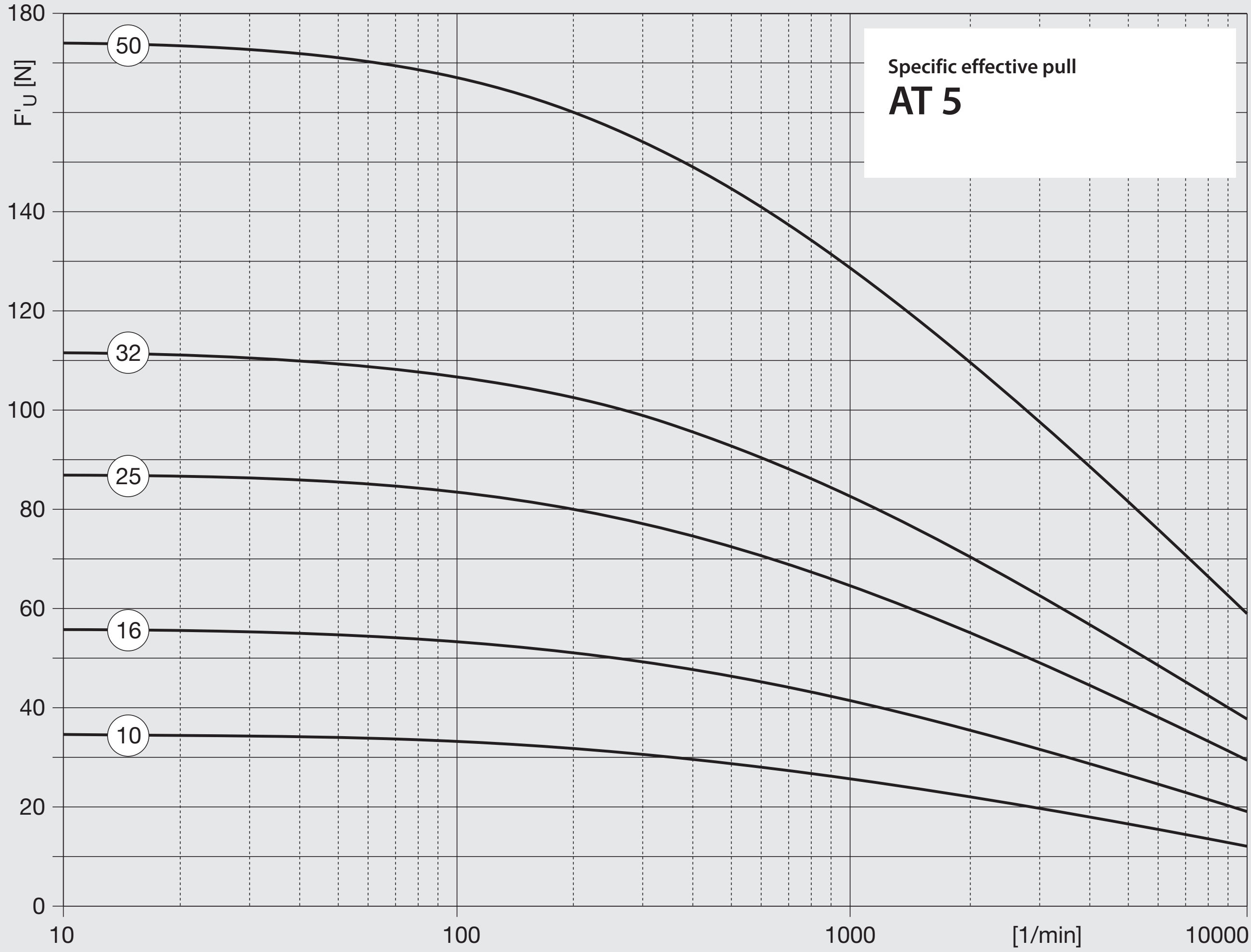
Minimum no. of teeth Z_{min} 14
Take-up pulley on back of belt $d_{S\ min}$ [mm] 30
Take-up pulley on toothing $d_{S\ min}$ [mm] 30

Clamping length
for linear drives
for belt AdV 07 [mm] 40.7

Characteristic values: Type T 5

Value	b_0 [mm]	10	16	25	32	50
F_{per} [N] AdV 09		190	270	450	550	840
F_{per} [N] AdV 07		390	550	910	1100	1690
C_{spec} [N] · 10^6		0.08	0.12	0,19	0.24	0.38
m'_R [kg/m]		0.024	0.038	0.060	0.077	0.12

Timing belt type AT 5



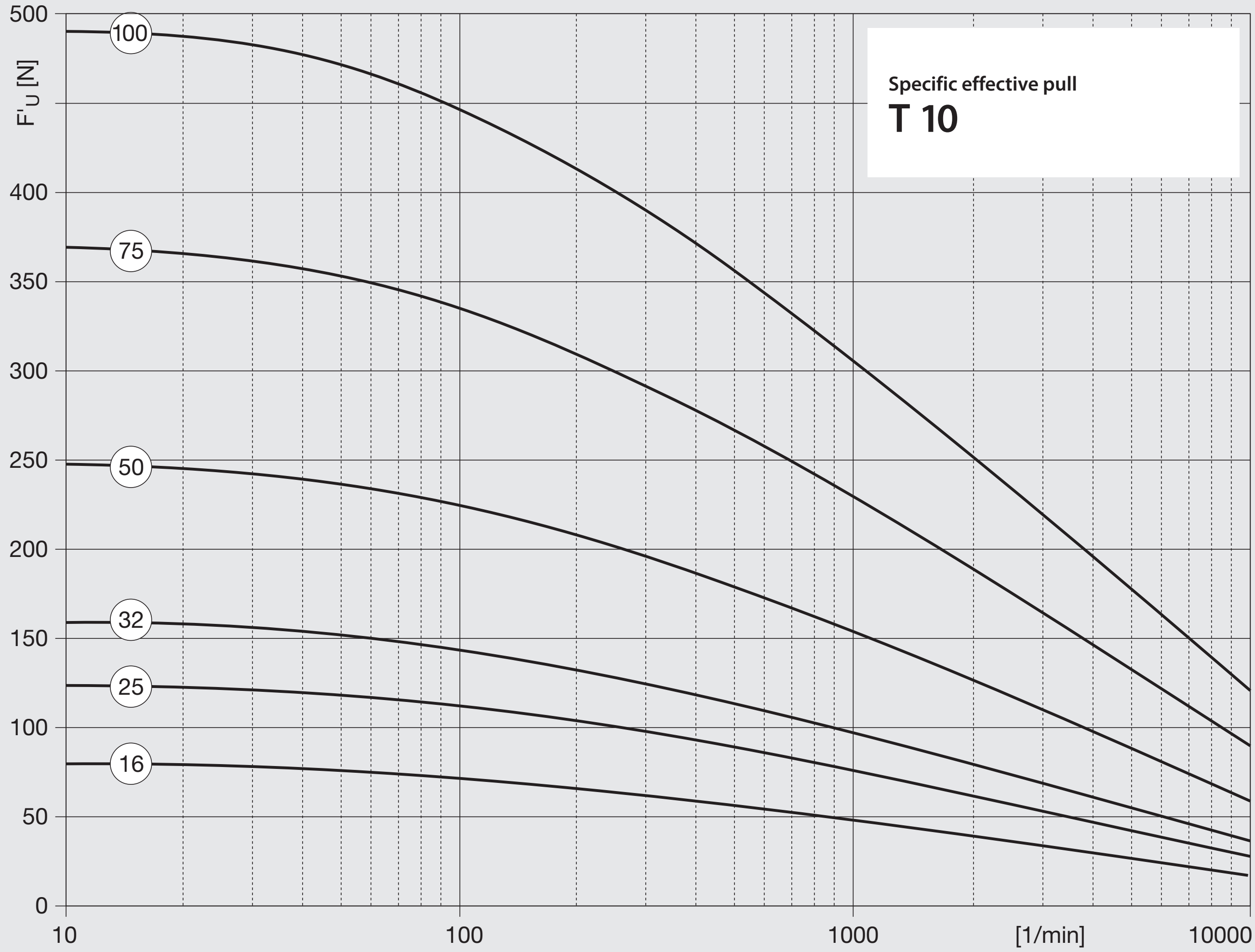
Minimum no. of teeth Z_{min} 14
Take-up pulley on back of belt $d_{S\,min}$ [mm] 45
Take-up pulley on toothing $d_{S\,min}$ [mm] 25

Clamping length for linear drives for belt AdV 07 [mm] 40.7

Characteristic values: Type AT 5

Value	b_0 [mm]	10	16	25	32	50
F_{per} [N]	AdV 09	280	630	840	1100	1750
F_{per} [N]	AdV 07	560	1260	1680	2240	3500
C_{spec} [N] · 10^6		0.17	0.27	0.42	0.54	0.84
m'_R [kg/m]		0.030	0.048	0.075	0.096	0.150

Timing belt type T 10



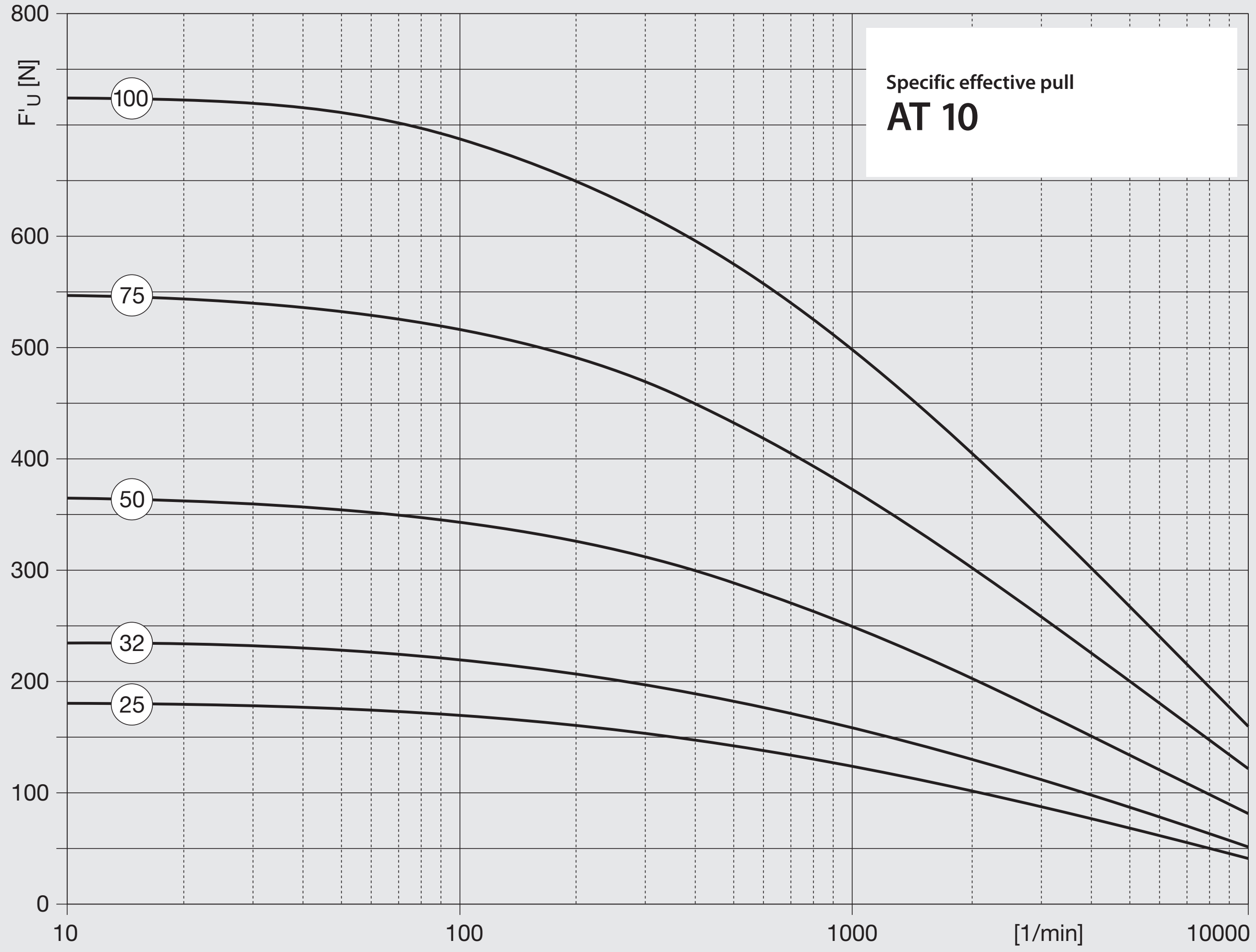
Minimum no. of teeth Z_{min} 16
Take-up pulley on back of belt $d_{S\ min}$ [mm] 60
Take-up pulley on toothing $d_{S\ min}$ [mm] 60

Clamping length
for linear drives
for belt AdV 07 [mm] 80

Characteristic values: Type T 10

Value	b_0 [mm]	16	25	32	50	75	100
F_{per} [N] AdV 09		650	1100	1300	2100	2550	3550
F_{per} [N] AdV 07		1310	2200	2620	4200	5100	7100
C_{spec} [N] · 10^6		0.32	0.50	0.64	1.00	1.50	2.00
m'_R [kg/m]		0.077	0.120	0.154	0.240	0.360	0.480

Timing belt type AT 10



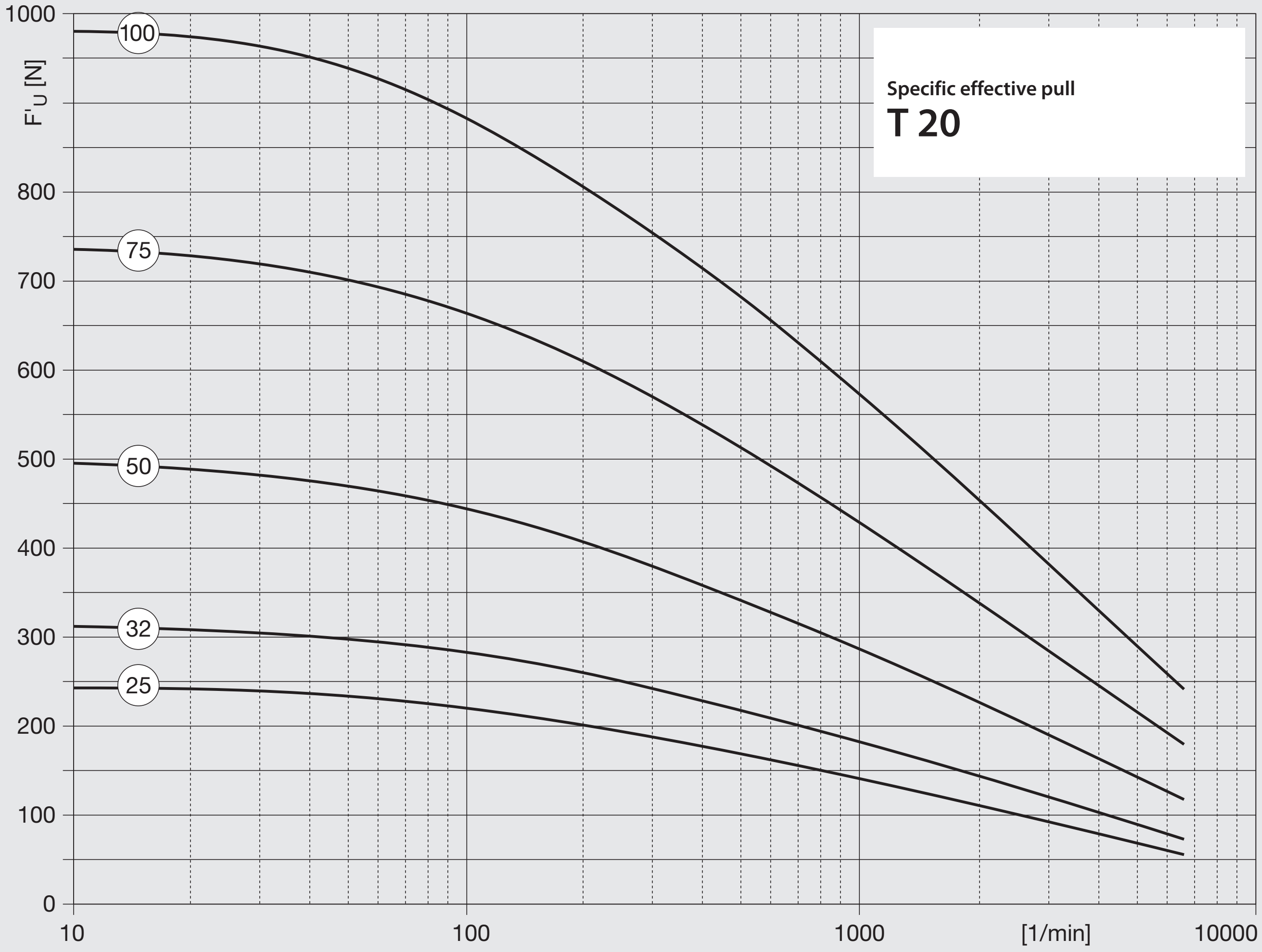
Minimum no. of teeth Z_{min} 16
Take-up pulley on back of belt $d_{S\ min}$ [mm] 120
Take-up pulley on toothing $d_{S\ min}$ [mm] 50

Clamping length
for linear drives
for belt AdV 07 [mm] 80

Characteristic values: Type AT 10

Value	b_0 [mm]	25	32	50	75	100
F_{per} [N] AdV 09		1850	2500	3700	6000	8000
F_{per} [N] AdV 07		3750	5000	7500	12000	16000
C_{spec} [N] · 10^6		1.00	1.28	2.00	3.00	4.00
m'_R [kg/m]		0.160	0.205	0.320	0.480	0.640

Timing belt type T 20



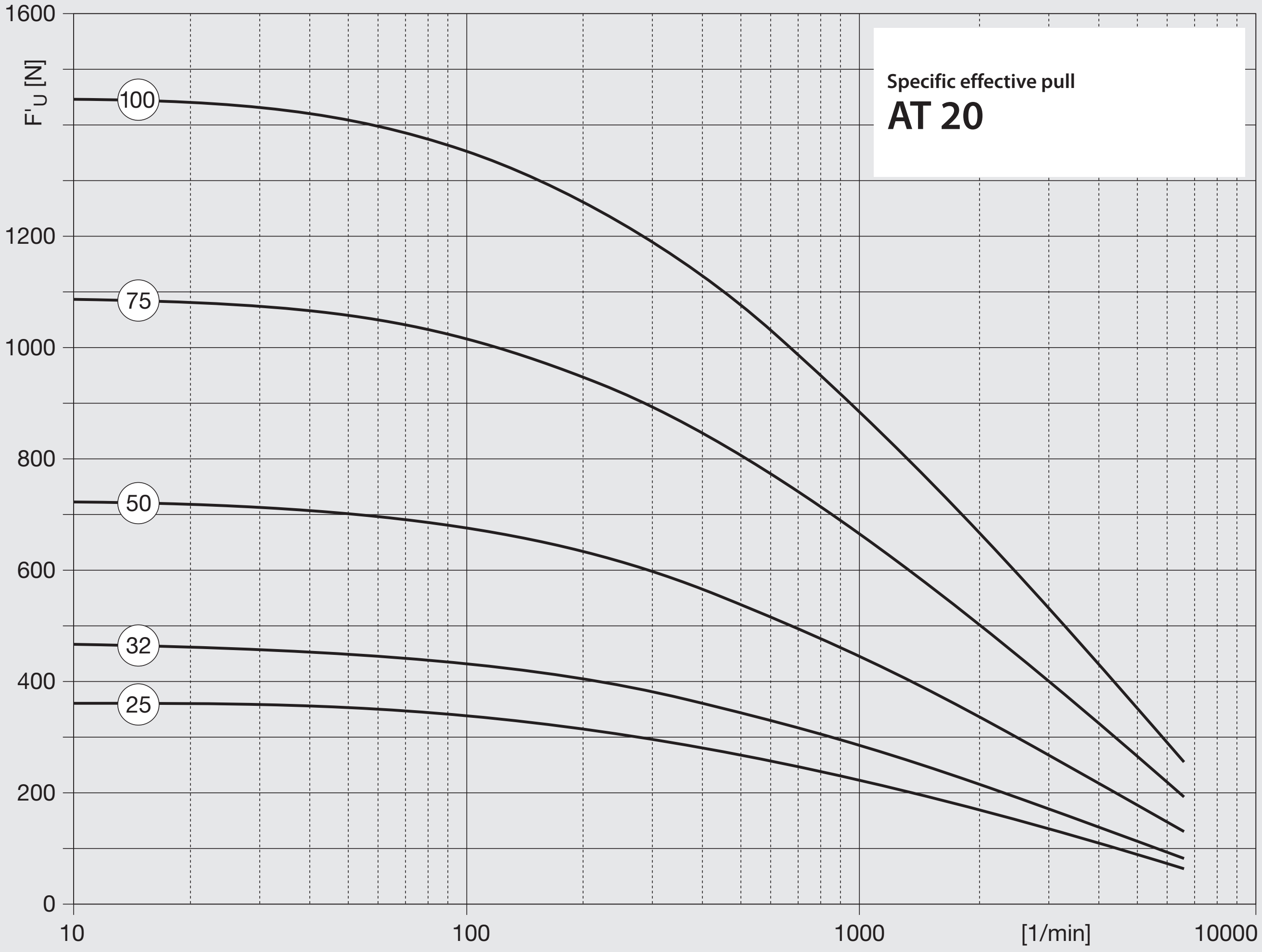
Minimum no. of teeth Z_{min} 16
Take-up pulley on back of belt $d_{S\,min}$ [mm] 120
Take-up pulley on toothing $d_{S\,min}$ [mm] 120

Clamping length for linear drives for belt AdV 07 [mm] 160

Characteristic values: Type T 20

Value	b_0 [mm]	25	32	50	75	100
F_{per} [N] AdV 09		1600	2050	3250	4900	6700
F_{per} [N] AdV 07		3200	4100	6500	9800	13500
C_{spec} [N] · 10^6		0.88	1.32	1.75	2.63	3.50
m'_R [kg/m]		0.193	0.246	0.385	0.577	0.770

Timing belt type AT 20



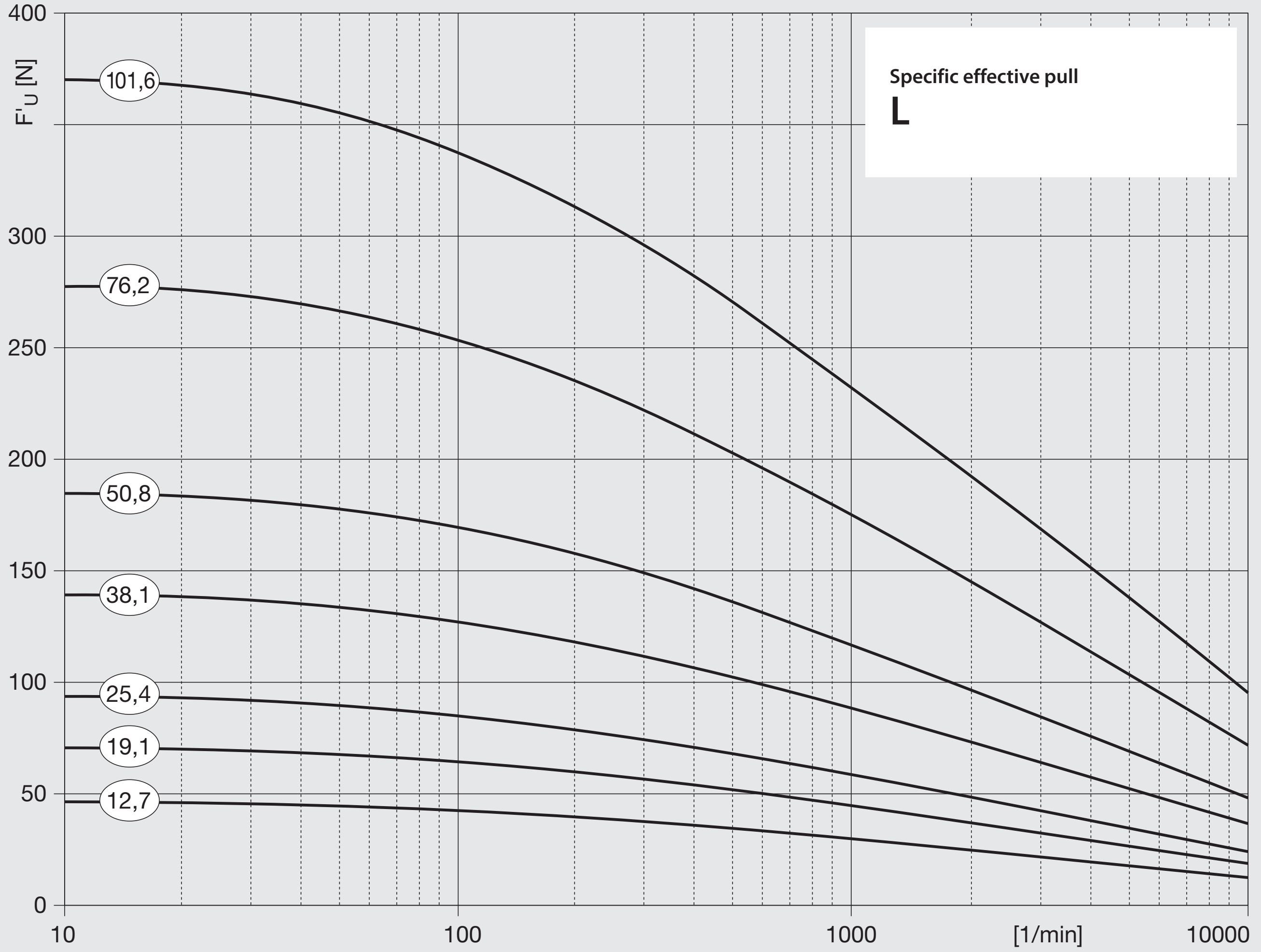
Minimum no. of teeth Z_{min} 18
Take-up pulley on back of belt $d_{S\ min}$ [mm] 180
Take-up pulley on toothing $d_{S\ min}$ [mm] 120

Clamping length
for linear drives
for belt AdV 07 [mm] 160

Characteristic values: Type AT 20

Value	b_0 [mm]	25	32	50	75	100
F_{per} [N] AdV 09		2900	3600	5800	9000	12000
F_{per} [N] AdV 07		5800	7200	11700	18000	25200
C_{spec} [N] · 10^6		1.56	2.00	3.13	4.69	6.25
m'_R [kg/m]		0.250	0.320	0.500	0.750	1.000

Timing belt type L = 3/8" ≙ t = 9.525 mm



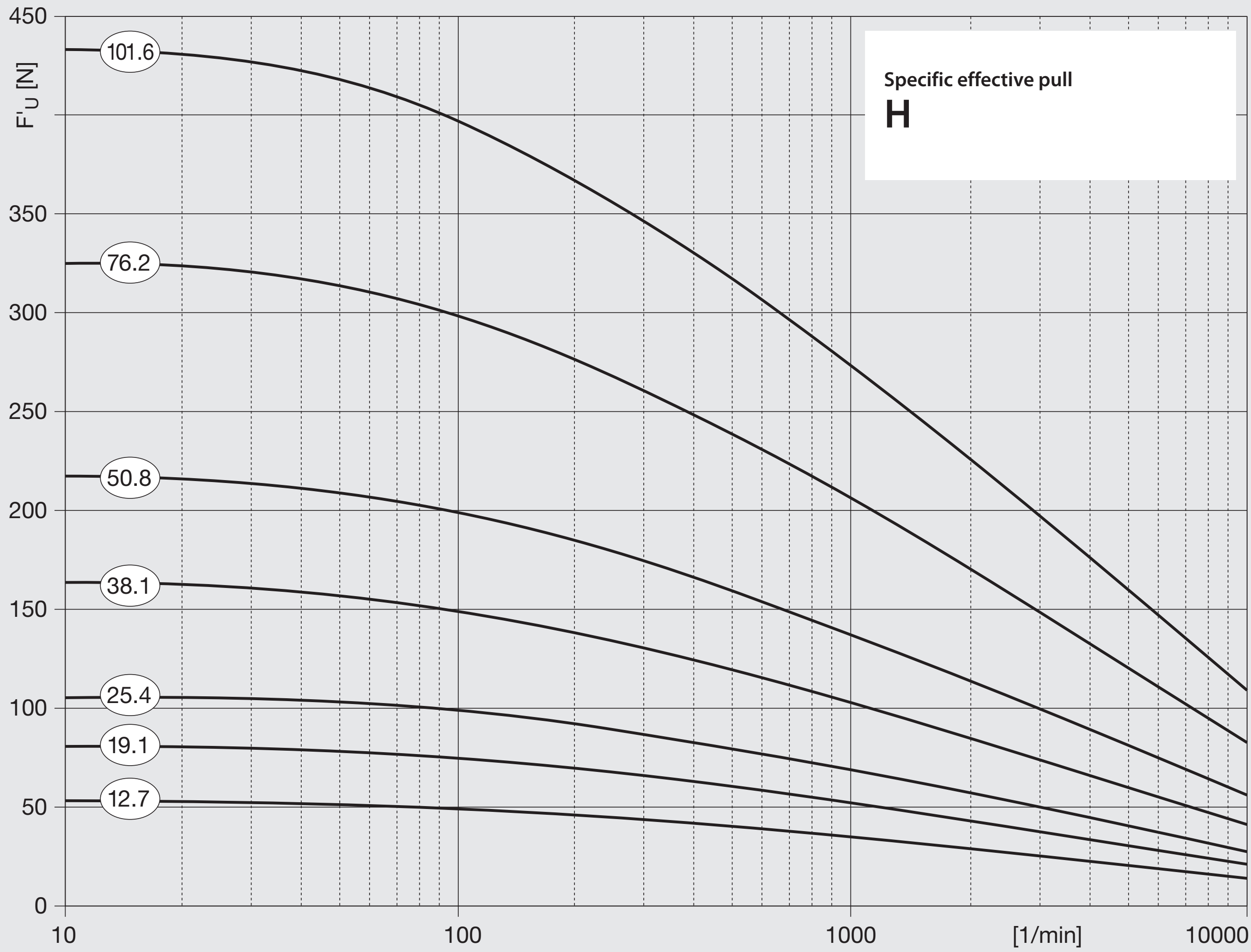
Minimum no. of teeth Z_{min}	16
Take-up pulley on back of belt $d_{S\,min}$ [mm]	50
Take-up pulley on toothing $d_{S\,min}$ [mm]	50

Clamping length
for linear drives
for belt AdV 07 [mm] 76,5

Characteristic values: Type L = 3/8''

Value	b_0 [mm]	12.7	19.1	25.4	38.1	50.8	76.2	101.6
F_{per} [N] AdV 09		440	650	870	1310	1760	2550	3300
F_{per} [N] AdV 07		890	1340	1780	2670	3560	5100	6600
C_{spec} [N] · 10^6		0.25	0.38	0.50	0.75	1.00	1.50	2.00
m'_R [kg/m]		0.050	0.074	0.099	0.149	0.198	0.297	0.396

Timing belt type H = 1/2" ≙ t = 12.7 mm



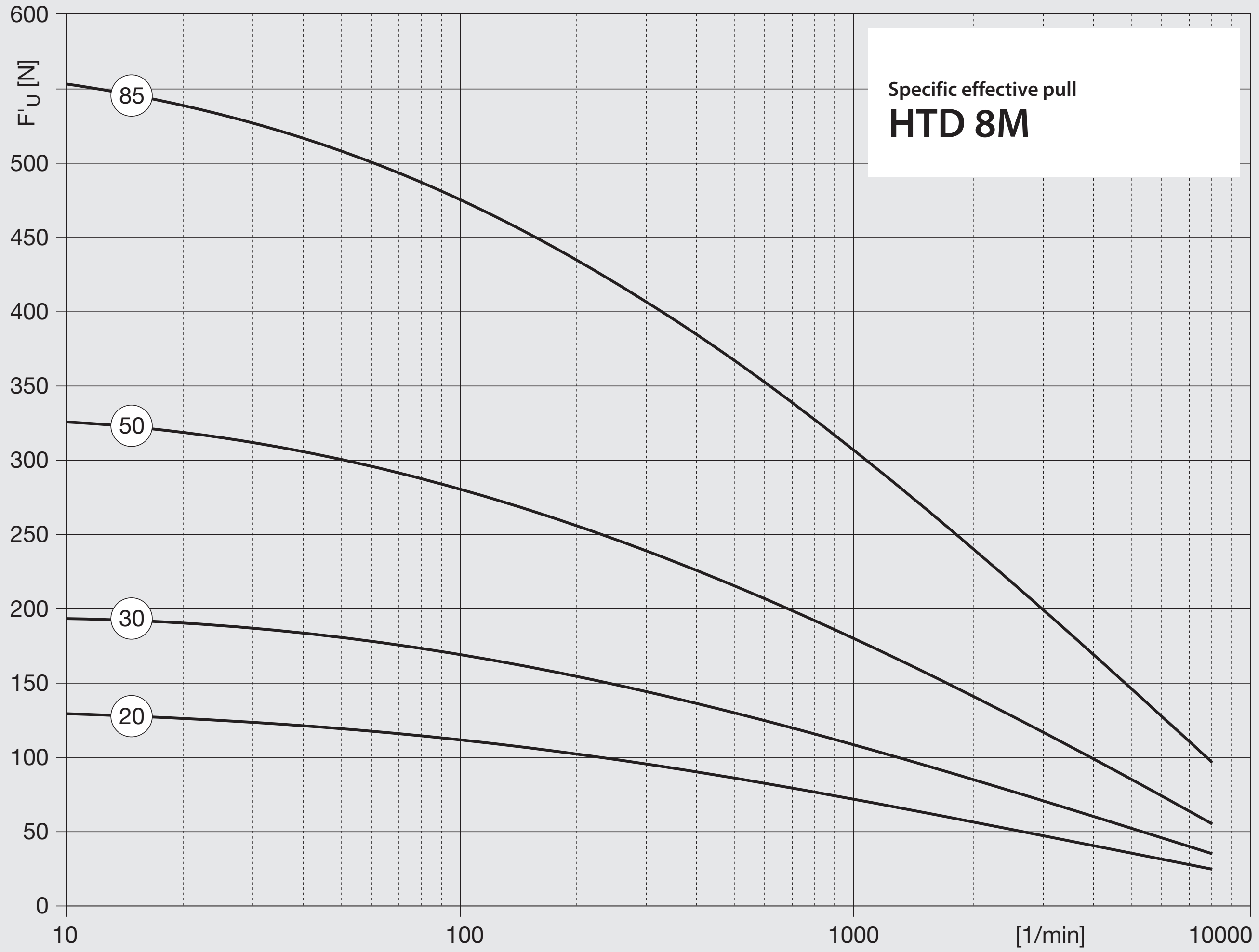
Minimum no. of teeth Z_{min} 14
Take-up pulley on back of belt $d_{S\,min}$ [mm] 80
Take-up pulley on toothing $d_{S\,min}$ [mm] 80

Clamping length
for linear drives
for belt AdV 07 [mm] 104,3

Characteristic values: Type H = 1/2"

Value	b_0 [mm]	12.7	19.1	25.4	38.1	50.8	76.2	101.6
F_{per} [N] AdV 09		440	650	870	1310	1760	2550	3300
F_{per} [N] AdV 07		890	1340	1780	2670	3560	5100	6600
C_{spec} [N] · 10^6		0.25	0.38	0.50	0.75	1.00	1.50	2.00
m'_R [kg/m]		0.057	0.086	0.114	0.171	0.229	0.343	0.457

Timing belt type HTD 8M



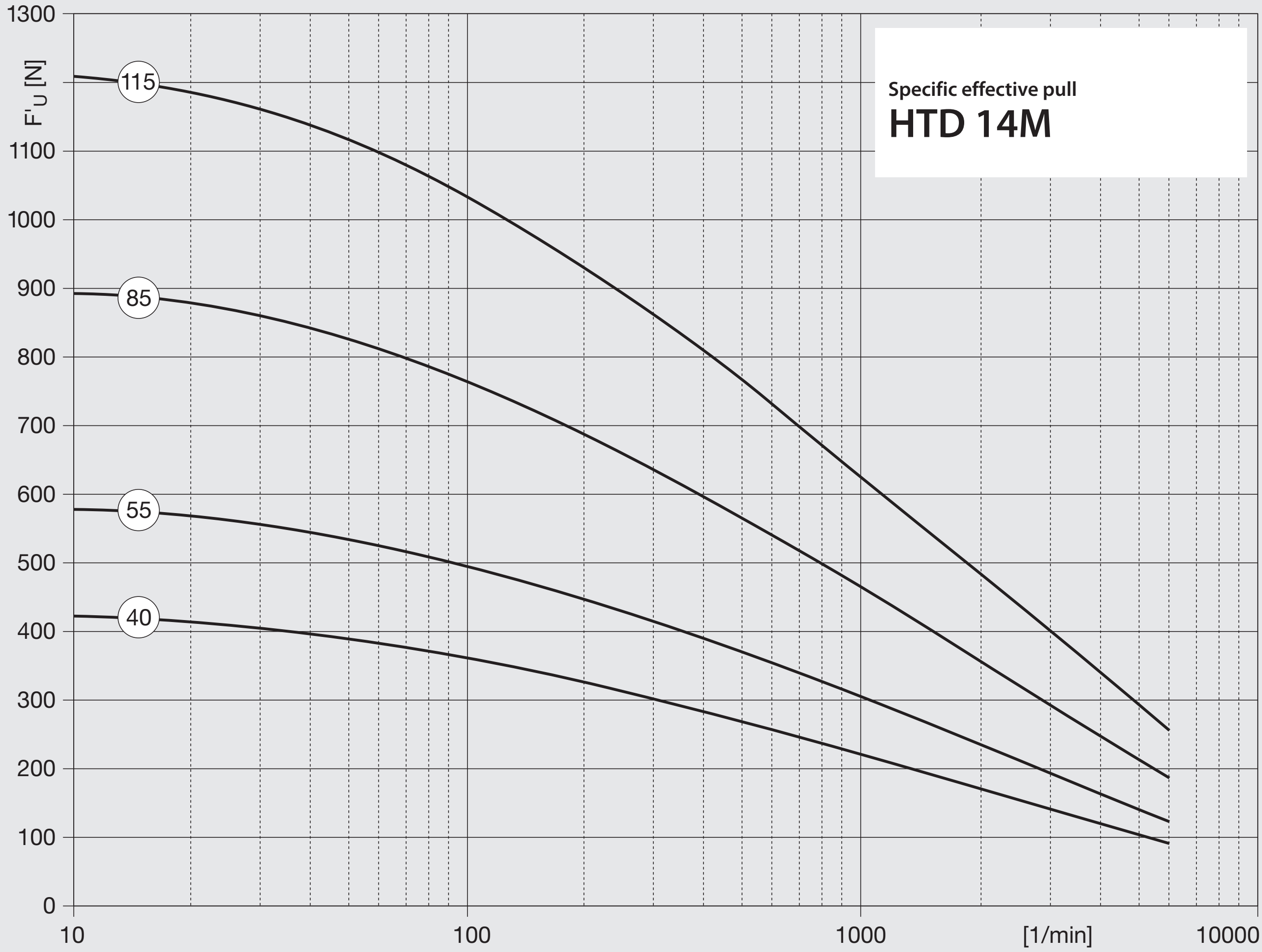
Minimum no. of teeth Z_{min}	20
Take-up pulley on back of belt $d_{S\ min}$ [mm]	120
Take-up pulley on toothing $d_{S\ min}$ [mm]	50

Clamping length for linear drives for belt AdV 07 [mm] 65

Characteristic values: Type HTD 8M

Value	b_0 [mm]	20	30	50	85
F_{per} [N] AdV 09		1400	2100	3500	5700
F_{per} [N] AdV 07		2800	4200	7000	11500
C_{spec} [N] · 10^6		0.70	1.05	1.75	2.98
m'_R [kg/m]		0.132	0.198	0.330	0.561

Timing belt type HTD 14M



Minimum no. of teeth Z_{min} 25
Take-up pulley on back of belt $d_{S\ min}$ [mm] 180
Take-up pulley on toothing $d_{S\ min}$ [mm] 120

Clamping length for linear drives for belt AdV 07 [mm] 114

Characteristic values: Type HTD 14M

Value	b_0 [mm]	40	55	85	115
F_{per} [N] AdV 09		4200	5800	9600	11600
F_{per} [N] AdV 07		8500	11800	19500	23600
C_{spec} [N] · 10^6		2.12	2.92	4.51	5.83
m'_R [kg/m]		0.440	0.605	0.935	1.265

Tables

Table 1
Teeth in mesh factor c_1

Application	c_1 max
Welded belts AdV 09	6
Open belts AdV 07	12
Linear drives with higher positioning accuracy	4

c_1 = Number of teeth involved in power flux

Table 2
Operational factor c_2

Smooth operating conditions	$c_2 = 1.0$
Short-term overload < 35 %	$c_2 = 1.10 - 1.35$
Short-term overload < 70 %	$c_2 = 1.40 - 1.70$
Short-term overload < 100 %	$c_2 = 1.75 - 2.00$

Table 3
Acceleration factor c_3

Transmission ratio i	c_3
i > 1 to 1.5	0.1
i > 1.5 to 2.5	0.2
i > 2.5 to 3.5	0.3
i > 3.5	0.4

Table 4
Friction coefficients of timing belts

µ	PU	PAZ	PAR
Bed/rail	0.5	0.2 – 0.3	0.2 – 0.3
Plastic support rail	0.2 – 0.3	0.2 – 0.25	0.2 – 0.25
Accumulation	0.5	0.2 – 0.3	0.2 – 0.3

All values are guidelines
PU = polyurethane
PAZ = polyamide fabric on toothed side
PAR = polyamide fabric on back of belt

Resistances

Chemical	Resistance
Acetic acid 20 %	❍
Acetone	❍
Aluminium chloride, aqueous 5 %	●
Ammonia 10 %	●
Aniline	–
ASTM oil 1	●
ASTM oil 2	●
ASTM oil 3	❍
Benzol	❍
Butyl acetate	–
Butyl alcohol	❍
Carbon tetrachloride	–
Common salt solution, conc.	●
Cyclohexanol	❍
Diesel oil	●
Dimethyl formamide	–
Ethyl acetate	–
Ethyl alcohol	❍
Ethyl ether	●
Hydrochloric acid 20 %	❍
Iron chloride, aqueous 5 %	❍
Isopropyl alcohol	❍
Kerosine	●

Chemical	Resistance
Lubricating grease (sodium soap fat)	●
Methyl alcohol	❍
Methyl alcohol/Benzine 15-85	●
Methyl ethyl ketone	❍
Methylene chloride	–
Mineral oil	●
n-Heptane	●
n-Methyl-2-pyrrolidone	–
Nitric acid 20 %	–
Petrol, regular	●
Petrol, super	●
Potash lye 1 N	❍
Sea water	●
Soda lye 1 N	❍
Sodium chloride solution, conc.	●
Sodium soap fat	●
Sodium soap fat + 20 % water	❍
Sulphuric acid 20%	❍
Tetrahydrofurane	–
Toluene	–
Trichloroethylene	–
Water	●

Table 5
Chemical resistance at room temperature

Symbols

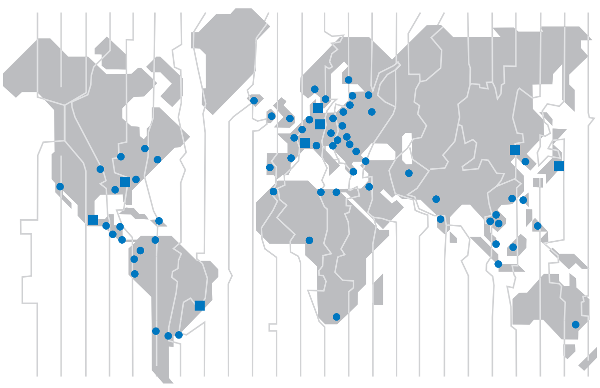
● = good resistance

❍ = limited resistance; slight weight and dimensional changes after a certain period of time

– = no resistance

Siegling – total belting solutions

Because our products are used in so many applications and because of the individual factors involved, our operating instructions, details and information on the suitability and use of the products are only general guidelines and do not absolve the ordering party from carrying out checks and tests themselves. When we provide technical support on the application, the ordering party bears the risk of the machinery functioning properly.



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