DRIVE DESIGN

TIMING BELTS IN optibelt OMEGA PROFILE

EXPLANATION OF SYMBOLS

a	=	Drive centre	[mm]
a_{nom}	=	Drive centre distance with standard belt length	[mm]
c_0	=	Basic load factor	
c_1	=	Teeth in mesh factor	
c_2	=	Overall load factor	
c_3	=	Speed ratio correction factor	
c_6	=	Fatigue correction factor	
c_7	=	Belt length correction factor	
d_a	=	Outside diameter of pulley	[mm]
d_w	=	Pitch diameter of pulley	[mm]
d_{wg}	=	Pitch diameter of large pulley	[mm]
d_{wk}	=	Pitch diameter of small pulley	[mm]
d_{w1}	=	Pitch diameter of driving pulley	[mm]
d_{w2}	=	Pitch diameter of driven pulley	[mm]
E_a	=	Belt deflection for given span length	[mm]
F	=	Force to create deflection	[N]
f	=	Frequency	[Hz]
i	=	Speed ratio	
L	=	Drive span length	[mm]
L_{wSt}	=	Standard pitch length of timing belt	[mm]
L_{wth}	=	Calculated pitch length of timing belt	[mm]
n_1	=	Speed of driving pulley	[min^{-1}]
n_2	=	Speed of driven pulley	[min^{-1}]
P	=	Power to be transmitted by timing belt drive	[kW]
P_B	=	Design power	[kW]
P_N	=	Rated power	[kW]
$P_Ü$	=	Transmissible power for standard belt width $[P_N \cdot c_1 \cdot c_7]$	[kW]
S_a	=	Minimum static shaft force when stationary	[N]
$S_{n\ zul}$	=	Maximum allowed circumferential force	[N]
S_{n3}	=	Circumferential force to be effectively transmitted	[N]
S_n	=	Effective circumferential force to be transmitted incl. actual centrifugal force	[N]
t	=	Tooth pitch	[mm]
v	=	Belt speed	[m/s]
x	=	Minimum adjustment of drive centre distance a_{nom} for tensioning timing belt	[mm]
y	=	Minimum adjustment of drive centre distance a_{nom} for installation	[mm]
z_e	=	Number of teeth in mesh of small pulley	
z_g	=	Number of teeth on large pulley	
z_k	=	Number of teeth on small pulley	
z_r	=	Number of teeth on timing belt	
z_1	=	Number of teeth on driving pulley	
z_2	=	Number of teeth on driven pulley	

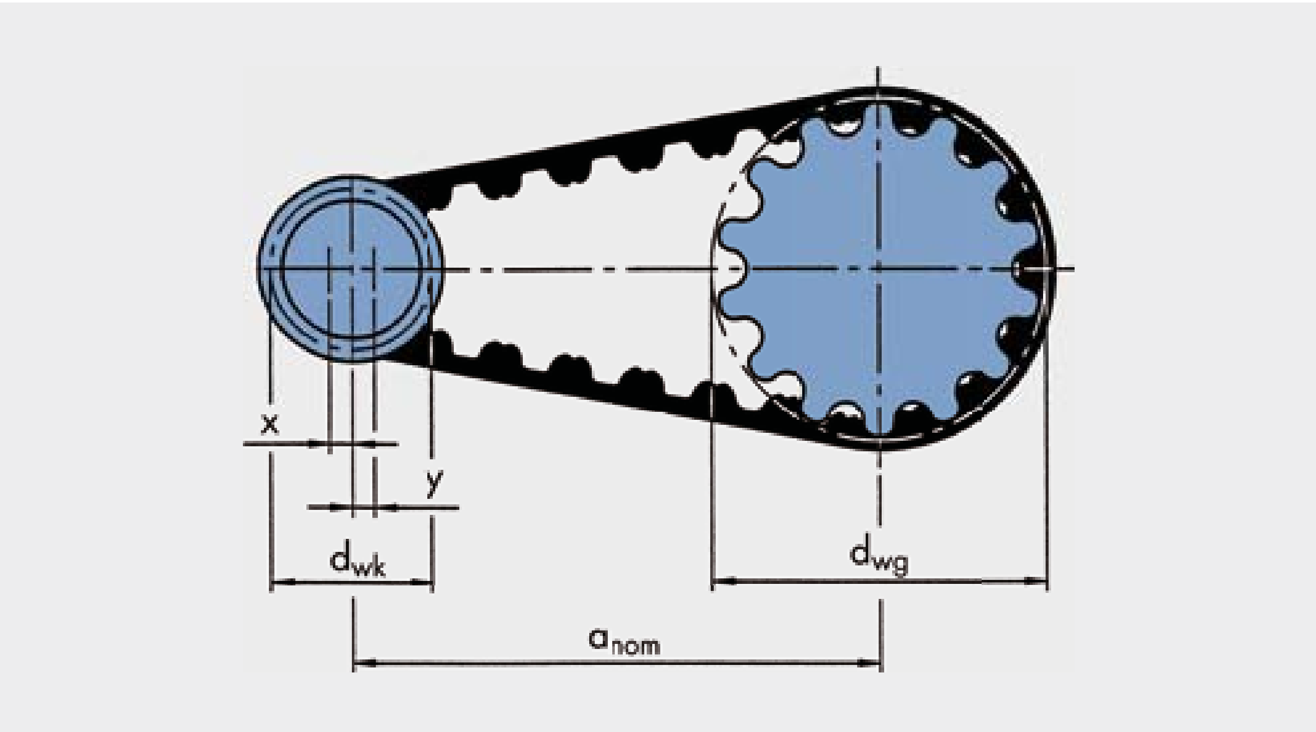
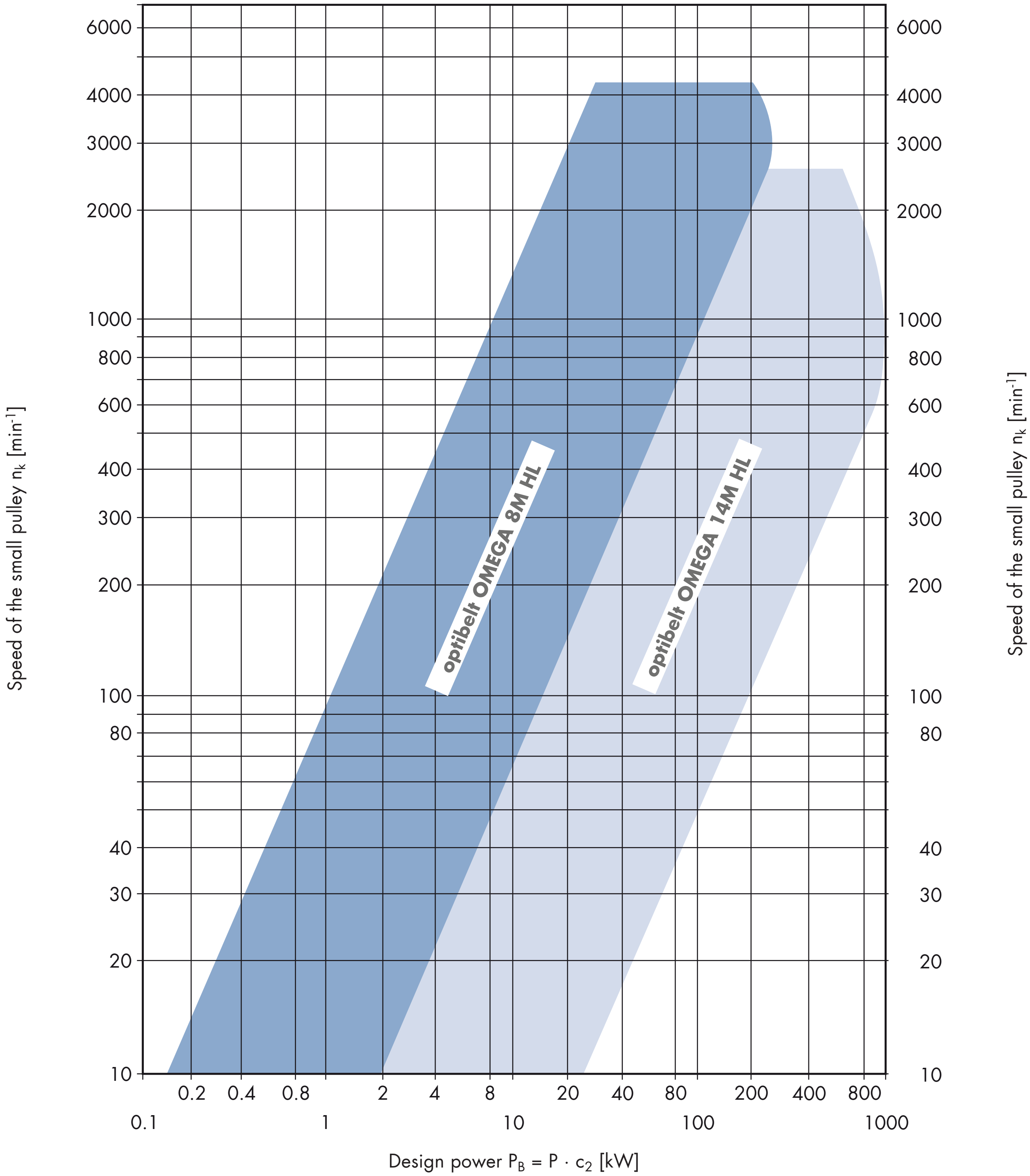


Diagram 1

Also see
optibelt CAP drive calculation
software at www.optibelt.com

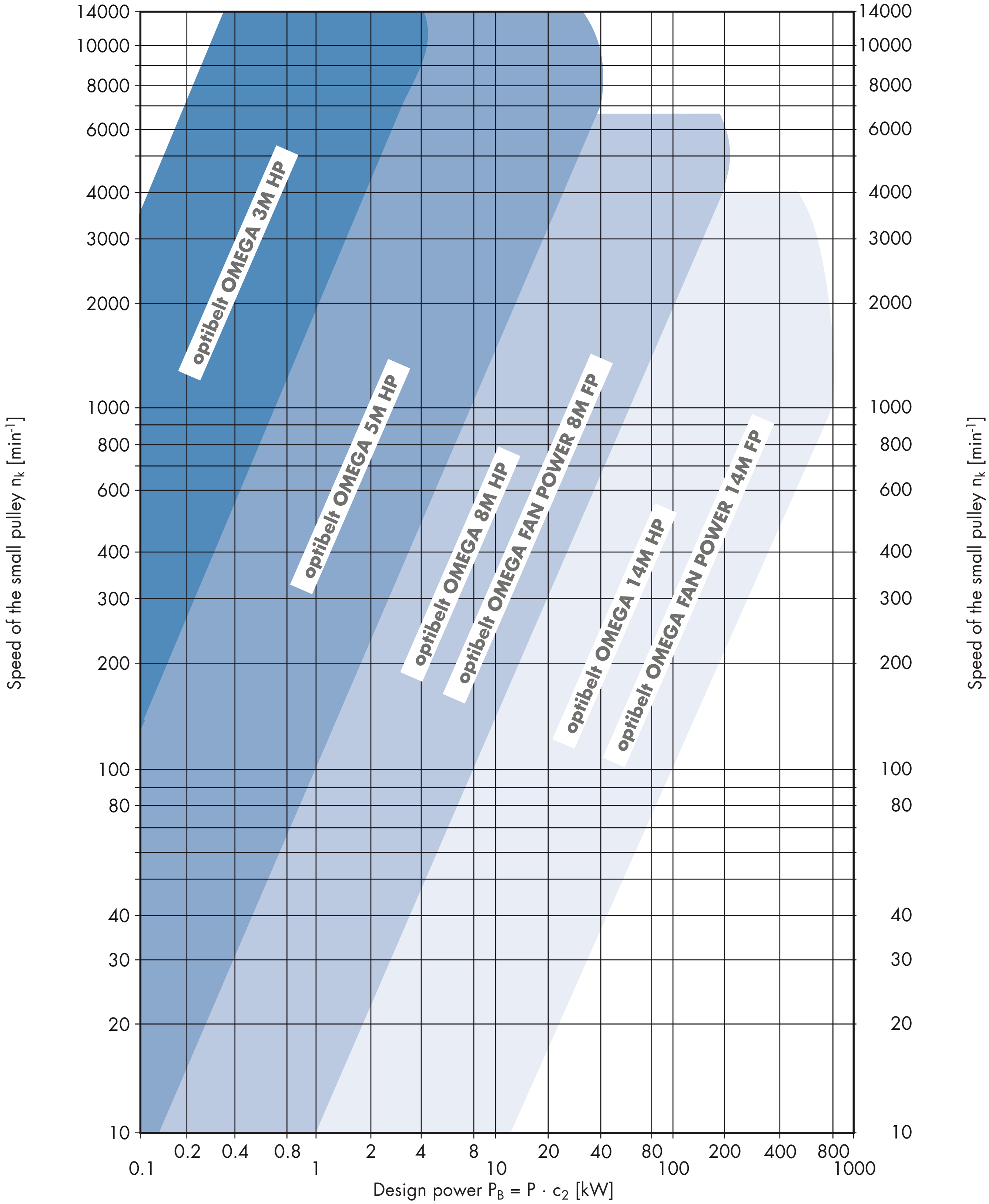


DRIVE DESIGN

optibelt OMEGA HP, optibelt OMEGA FAN POWER TIMING BELTS
GUIDELINES FOR SELECTING THE TIMING BELT PROFILE

Diagram 2

Also see
optibelt CAP drive calculation
software at www.optibelt.com



DRIVE DESIGN

optibelt OMEGA TIMING BELTS

GUIDELINES FOR SELECTING THE TIMING BELT PROFILE

Diagram 3

Also see
optibelt CAP drive calculation
software at www.optibelt.com

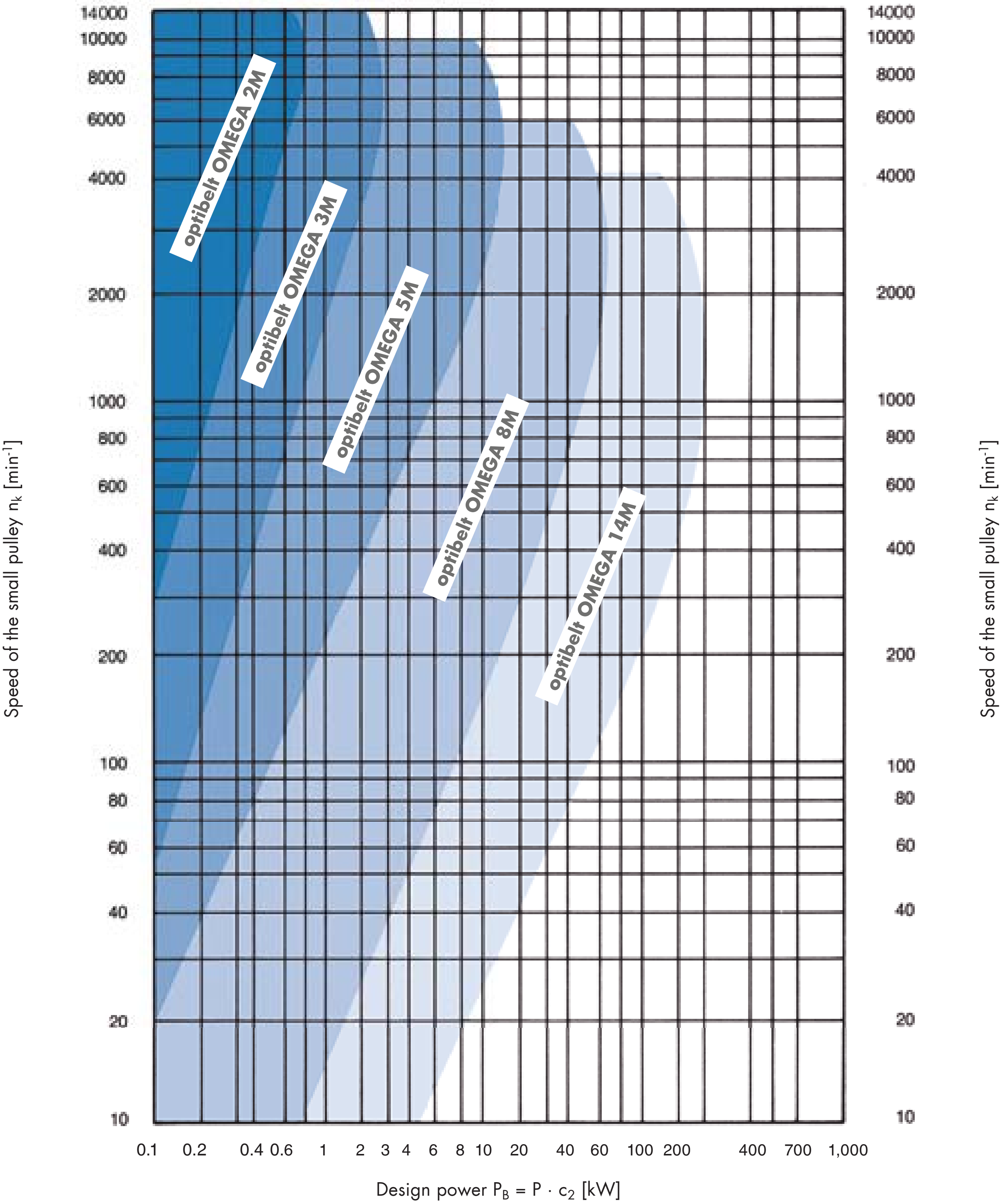
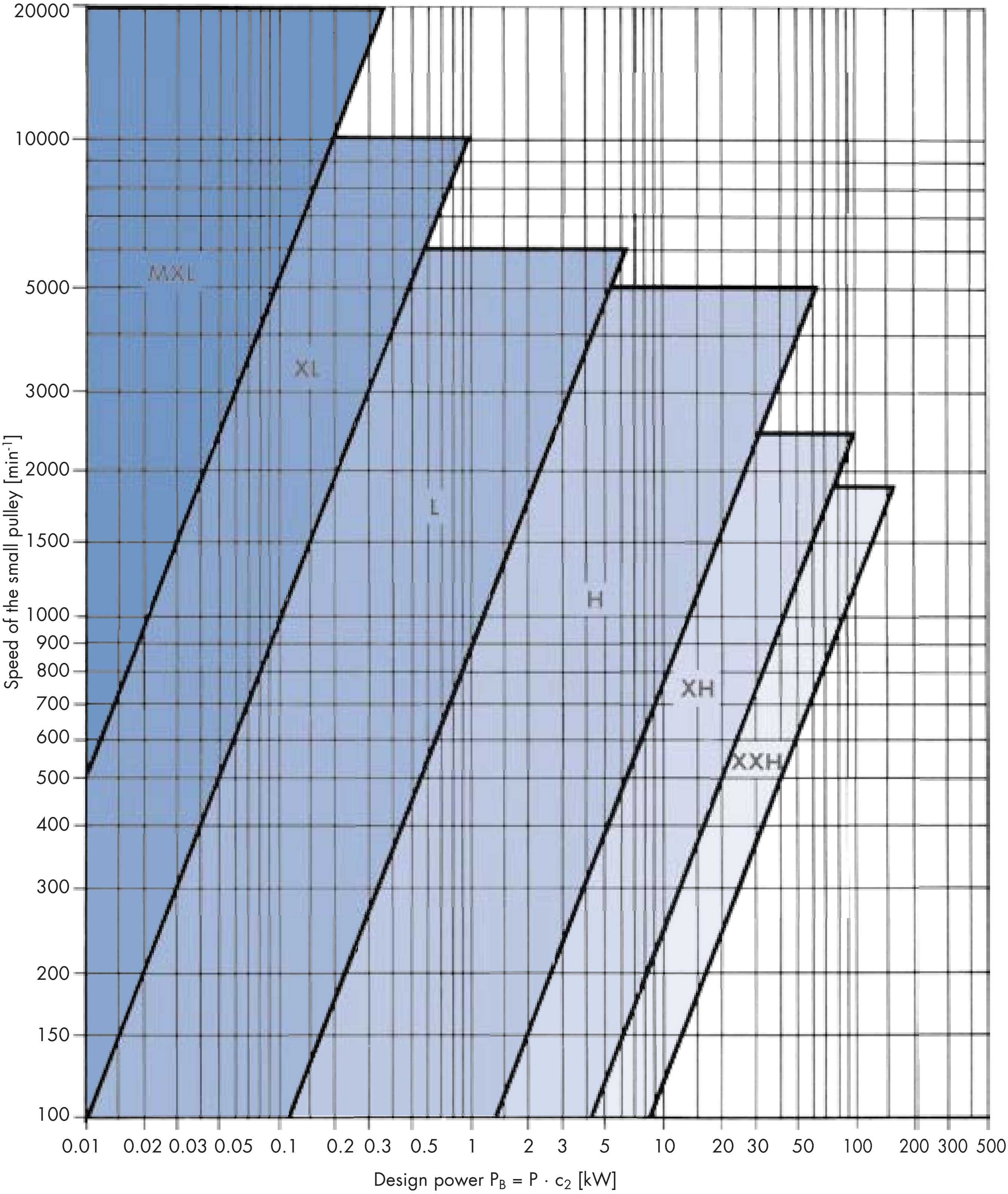


Diagram 4

Please also use software:
optibelt CAP drive calculation
and data optibelt CAD 2D / 3D
online at: www.optibelt.com



Total load factor c_2

The total load factor c_2 is comprised of the basic load factor c_0 plus two further loads c_3 and c_6.

$c_2 = c_0 + c_3 + c_6$

$c_2 \geq M_A/M_N$ recommended for frequent starts and stops

Basic load factor c_0

The basic load factor c_0 takes into account the daily operating time, the type of drive and the prime mover. As it is almost impossible to put all the possible combinations of prime mover / driven unit / environmental conditions in a shortened form which conforms to standards, the service factors shown here are given only as a guideline. The classification of the work machine is dependent on the respective present load type.

Table 5
Basic load factor c_0

Load type and examples for work machines	Load type and examples for drive machines			
	Continuous running Electric motor Turbine running at high speed Reciprocating engine with higher quantity of cylinders		**Non-continuous running** Hydraulic motor Turbine running at low speed Reciprocating engine with lower quantity of cylinders	
	Basic load factor c_0 with daily operation times			
	up to 16 h	up to 16 h	up to 16 h	over 16 h
Light drives. shock-free with smooth running characteristics Measurement devices Film cameras Office machines Conveyor systems (light goods)	1.3	1.4	1.4	1.5
Medium drives. operation with smaller to medium intermittent shock strain Mixing machines Kitchen machines Printing shop machines Textile machines Packaging machines Conveyor systems (heavy goods)	1.6	1.7	1.8	1.9
Heavy drives. operation with medium to high intermittent shock strain Tool machines Wood processing machines Eccentric drives Conveyor systems (heavy goods)	1.8	1.9	2.0	2.1
Extremely heavy drives. operation with high constant shock strain Mills Calendars Extruders Piston pumps/compressors Lifting appliances	2.0	2.1	2.2	2.3

Speed correction factor c_3

For speed increasing drives, a factor corresponding to the speed ratio is added to the basic load factor c_0.

Table 6

Speed correction i	Speed correction factor c_3
1.00–0.80	0.0
0.79–0.57	0.1
0.56–0.40	0.2
0.39–0.28	0.3
0.27 and smaller	0.4

Table 7
Fatigue correction factor c_6

Operating conditions	Fatigue correction factor c_6
Use of tension or guide idlers	0.2
Operating time 16 to 24 hours	0.2
Only infrequent or occasional operation	– 0.2

With frequent starts and stops or continual reversing operation, the selected total load factor c_2 should be higher than the ratio between starting torque and nominal torque. If there is a brake on the prime mover the same procedure should apply for the braking torque, if the brake is used frequently. For further questions, please contact the Optibelt Application Engineering Department.

Minimum adjustment of centre distance 'x' for tensioning of timing belts

$x = 0.004 \cdot a_{nom}$

Table 8
Minimum adjustment of centre distance 'y' for installation on timing belt pulleys without flanges

Axial distance [mm]	Shifting distance for the installation of the belt [mm]
Up to 1000	1.8
From 1000 to 1780	2.8
From 1780 to 2540	3.3
From 2540 to 3300	4.1
From 3300 to 4600	5.3

Table 9
Minimum adjustment of centre distance 'y' for installation on timing belt pulleys with flanges

Pitch [mm]	Flange on one timing pulley [mm]	Flange on both timing pulleys [mm]
2	6	12
3	8	14
5	14	19
8	22	33
14	36	58

Table 10
Belt length factor c_7

Profile 2M Pitch length [mm]	c_7
≤ 190	0.8
> 190 ≤ 260	0.9
> 260 ≤ 400	1.0
> 400 ≤ 600	1.1
> 600	1.2

Profile 3M Pitch length [mm]	c_7
≤ 190	0.8
> 190 ≤ 260	0.9
> 260 ≤ 400	1.0
> 400 ≤ 600	1.1
> 600	1.2

Profile 5M Pitch length [mm]	c_7
≤ 440	0.8
> 440 ≤ 555	0.9
> 555 ≤ 800	1.0
> 800 ≤ 1100	1.1
> 1100	1.2

Profile 8M Pitch length [mm]	c_7
≤ 600	0.8
> 600 ≤ 880	0.9
> 880 ≤ 1200	1.0
> 1200 ≤ 1760	1.1
> 1760	1.2

Profile 14M Pitch length [mm]	c_7
≤ 1190	0.80
> 1190 ≤ 1610	0.90
> 1610 ≤ 1890	0.95
> 1890 ≤ 2450	1.00
> 2450 ≤ 3150	1.05
> 3150	1.10

Table 11
Teeth in mesh factor c_1

Number of meshing teeth	Teeth in mesh factor c_1
≥ 6	1.0
5	0.8
4	0.6
3	0.4
2	0.2

DRIVE DESIGN

TIMING BELTS IN optibelt OMEGA PROFILE
FORMULAS AND CALCULATION EXAMPLES

Prime mover

Electric motor 50 Hz
Star delta start
P = 18.5 kW
n_1 = 2850 min^{-1}

Operating conditions

Daily operating time: 12 hours
Number of starts/stops: 2 per day
Environmental influences:
ambient room temperature,
no influence from oil, water or dust
Centre distance: 400 mm to 450 mm
Max. pulley diameter: 200 mm

Driven machine

Textile machine
P = 15 kW
n_2 = 1830 min^{-1} ± 1%
Type of load: constant

Also see
optibelt CAP drive calculation software at www.optibelt.com

Formulae	Worked example
Total load factor $c_2 = c_0 + c_3 + c_6$ c_0 from table 5, page 40 c_3 from table 6, page 41 c_6 from table 7, page 42	c_2 = 1.6 + 0 + 0 = **1.6** c_0 = 1.6 c_3 = 0 c_6 = 0
Design power $P_B = P \cdot c_2$	P_B = 18.5 · 1.6 = **29.6 kW**
Timing belt profile from diagrams 1-4, pages 36-39	optibelt OMEGA HP Type 8M
Speed ratio $i = \frac{n_1}{n_2} = \frac{z_2}{z_1} = \frac{d_{w2}}{d_{w1}}$	$i = \frac{2850}{1830}$ = **1.557**
Number of teeth of the pulleys z_1, d_{w1} selected from standard range of timing belt pulleys page 75 $z_2 = z_1 \cdot i$ See to the minimum diameter requirement!	z_1 = **36** d_{w1} = 91.67 mm z_2 = 36 · 1.56 = 56.16 z_2 = **56** d_{w2} = 142.60 mm z_2 selected from standard range pulleys page 75 In compliance with requirement $z_1 \geq 22$ (minimum number of teeth for profile 8M)
Check the rotary frequency $i = \frac{z_2}{z_1}$ $n_2 = \frac{n_1}{i}$	$i = \frac{56}{36}$ = 1.556 $n_2 = \frac{2850}{1.556}$ = **1832 min^{-1}** **Requirement: 1830 min^{-1}** ± 1% met
Recommended centre distance Recommendation: $a > 0.5\ (d_{w1} + d_{w2}) + 15$ mm $a < 2.0\ (d_{w1} + d_{w2})$	a > 0.5 (91.67 + 142.60) + 15 mm = 132.14 mm a < 2.0 (91.67 + 142.60) = 468.54 mm a = **425 mm** provisionally selected

DRIVE DESIGN

TIMING BELTS IN optibelt OMEGA PROFILE
FORMULAS AND CALCULATION EXAMPLES

Formulas	Worked example
Pitch length of the timing belt $L_{wth} \approx 2a + \frac{\pi}{2}(d_{wg} + d_{wk}) + \frac{(d_{wg} - d_{wk})^2}{4\,a}$ L_{wSt} see standard lengths, see pages 10-11, 13, 16-19, 21-27, and 32-34	$L_{wth} \approx 2 \cdot 425 + \frac{\pi}{2}(142.60 + 91.67) + \frac{(142.60 - 91.67)^2}{4 \cdot 425}$ $L_{wth} \approx$ **1219.33 mm** next standard belt length selected from page 18 L_{wSt} = **1200 mm**
Centre distance from L_{wSt} $a_{nom} = K + \sqrt{K^2 - \frac{(d_{wg} - d_{wk})^2}{8}}$ $K = \frac{(L_{wSt})}{4} - \frac{\pi}{8}(d_{wg} + d_{wk})$	$a_{nom} = 208 + \sqrt{208^2 - \frac{(142.60 - 91.67)^2}{8}}$ a_{nom} = **415.22 mm** $K = \frac{1200}{4} - \frac{\pi}{8}(142.60 + 91.67) = 208$ mm
Minimum adjustment for tensioning $x = 0.004 \cdot a_{nom}$	$x \geq$ **1.66 mm**
Minimum adjustment for fitting belts y = from table 9, page 41	y = **22 mm** (with flanged pulley)
Number of teeth in mesh on the small pulley $z_e = \frac{z_k}{6}\left(3 - \frac{d_{wg} - d_{wk}}{a_{nom}}\right)$	$z_e = \frac{36}{6}\left(3 - \frac{142.60 - 91.67}{415}\right) = 17.26$ z_e = **17**
Belt length factor c_7 from table 10, page 41	c_7 = **1.0**
Teeth in mesh factor c_1 from table 11, page 41	c_1 = **1.0**
Belt width above nominal power rating Requirement: $P_Ü \geq P_B$ $P_Ü$ = transmissible nominal power of a standard belt width $P_Ü = P_N \cdot c_1 \cdot c_7$ P_N value and, if required, width correction factor (which is to be multiplied by the P_N value) see pages 46 to 58	**31.09 kW > 29.60 kW Requirement met!** $P_Ü = 31.09 \cdot 1.0 \cdot 1.0$ = **31.09 kW** P_N for width of 30 mm = $19.68 \cdot 1.58$ = **31.09 kW**

Drive to be fitted with:

1 optibelt OMEGA HP timing belt	**1200 8M HP**	**30**
1 optibelt ZRS timing belt pulley	**36 8M**	**30**
1 optibelt ZRS timing belt pulley	**56 8M**	**30**

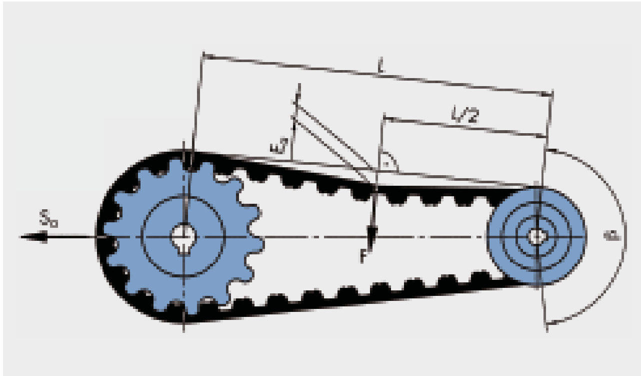
DRIVE DESIGN
TIMING BELTS IN optibelt OMEGA PROFILE
BELT TENSION

Belt tension for optibelt OMEGA HP/optibelt OMEGA HL and optibelt OMEGA timing belts
For proper power transmission and for achieving an acceptable belt service life, the correct belt tension is of the utmost importance.
Too low or too high belt tension will lead to the premature failure of the timing belts. Over tensioning often leads to bearing failure on the prime mover or the driven machine. Experience shows that unscientific belt tensioning methods, such as the "thumb pressure method", are not suitable for applying the optimum tension to the drive for maximum efficiency and drive/bearing life. It is therefore recommended that the correct static belt tension should be calculated for each drive. Due to their extremely low-stretch characteristics Optibelt timing belts do not require any further tensioning after correct installation, if properly used.

Symbol

F	= test force	[N]
S_a	= static shaft loading	[N]
S_{n3}	= circumferential force to be effectively transmitted	[N]
E_a	= belt deflection for given span length	[mm]
L	= span length	[mm]

Apply test force F in the centre of the span in a right angle to the belt top surface as shown in the illustration below; measure the deflection E_a, correct the tension if necessary.



1. Calculation of the test force F

$$F = \frac{S_{n3}}{20} \qquad S_{n3} = \frac{P \cdot 1000}{v} \qquad v = \frac{d_{wk} \cdot n_k}{19100}$$

$$F = \frac{1352}{20} = \mathbf{67.60\ N}$$

$$S_{n3} = \frac{18.5 \cdot 1000}{13.68} \qquad v = \frac{91.67 \cdot 2850}{19100}$$

$$S_{n3} = 1352\ \text{N} \qquad v = 13.68\ \text{m/s}$$

2. Calculation of the belt deflection E_a for the existing span length L

$$E_a = \frac{L}{50}$$

$$L = \sqrt{a_{nom}^2 - \left(\frac{d_{wg} - d_{wk}}{2}\right)^2}$$

$$E_a = \frac{414.44}{50} = \mathbf{8.3\ mm}$$

$$L = \sqrt{415.22^2 - \left(\frac{142.60 - 91.67}{2}\right)^2} = 414.44\ \text{mm}$$

3. Calculation of the minimum static shaft loading

$$S_a = S_{n3} \cdot 1.1$$

$$S_a = 1352\ \text{N} \cdot 1.1 = \mathbf{1487.2\ N}$$

4. Calculation of the frequency for measuring the belt tension using the Optibelt frequency tension tester

$$f = \sqrt{\frac{T}{4 \cdot k \cdot L^2}}$$

$T = 0.5 \cdot S_a$
k belt weight per metre from table 37, page 72
L span length per metre

$$f = \sqrt{\frac{743.6}{4 \cdot 0.174 \cdot 0.414^2}} = \mathbf{78.9\ Hz}$$

T = 0.5 · 1487.2 N = 743.6 N
k = 0.174 kg/m
L = 0.414 m

DRIVE DESIGN

TIMING BELTS IN optibelt OMEGA PROFILE
optibelt CAP DRIVE CALCULATION

Also use
the optibelt CAP drive calculation
Software available at www.optibelt.com

The drive is to be equipped with:

– optibelt OMEGA HP timing belt 1200 8M HP 30

– optibelt ZRS pulley 36-8M-30 (cylindrical bore)
– optibelt ZRS pulley 56-8M-30 (cylindrical bore)

Prime mover	**Electric motor P = 18.5 kW**				
Driven machine	**Textile machine**				
Timing belt data				Variations/Information	
Pitch	t:	8.000	mm		
Width	b:	30.00	mm		
Calculated pitch length	L_{wth}:	1200.00	mm		
Standard pitch length	L_w:	1200.00	mm		
Number of teeth	z_r:	150			
Belt speed	v:	13.68	m/s		
Timing belt pulley data		**Pulley 1 (driving)**		**Pulley 2 (driven)**	
Number of teeth	**z:**	**36**		**56**	
Pitch diameter	d_w:	91.67	mm	142.60	mm
Pulley face width	b_1:	38.00	mm	38.00	mm
Speed	**n:**	**2850.0**	**1/min**	**1832.1**	**1/min**
Number of teeth in mesh	z_e:	17		29	
Torque	M:	104	Nm	162	Nm
Standard Design		6F		6WF	
Number of flanged pulleys		2		2	
Material		St		GG	
Nominal drive data				Variations/Information	
Design power	**P_B:**	**29.60**	**kW**		
Nominal power rating	$P_{Ü}$:	31.09	kW		
Effective service factor	**c_2:**	**1.68**			
Actual drive ratio	i:	1.56		0.0	%
Actual centre distance	**a:**	**415.22**	**mm**	**-9.78**	**mm**
Minimum adjustment of centre distance for belt installation	y:	≥ 22.00	mm		
Minimum adjustment of centre distance for belt tensioning	x:	≥ 1.66	mm		
Actual circumferential load	S_{n3}:	1353	N		
Static shaft load	S_a:	1488	N		
Static span tension	T:	744	N		
Span length	L:	414.50	mm		

Methods for setting belt tension

Belt deflection per span length	E_a:	8.29 mm with a load	F 67.60 N
optibelt TT 3 frequency tension tester	f:	78.88 1/s	