
Specification for

Endless wedge belt drives and endless V-belt drives

Spécification des transmissions par courroies trapézoïdales sans fin

Spezifikation für endlose Keilriemenantriebe

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Foreword

This revised British Standard has been prepared under the direction of the Mechanical Engineering Standards Committee.

BS 3790 was first published in 1964 and dealt with wedge belts only; it was revised in 1973. BS 1440 was first published in 1948 and dealt with V-belts only; it was revised in 1962, 1968 and 1971. In the present revision, the opportunity has been taken to amalgamate BS 1440 and BS 3790 and to ensure technical compatibility with the following standards prepared by the International Organization for Standardization (ISO):

ISO 155	Transmission pulleys — Limiting values for adjustment of centres
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ISO 254	Quality, finish and balance of transmission pulleys
ISO 1813	Antistatic endless V-belts — Electrical conductivity — Characteristic and method of test
ISO 4183	Grooved pulleys for classical and narrow V-belts
ISO 4184	Classical and narrow V-belts — lengths
ISO 5292	Power ratings

'E' section V-belts, which form part of ISO 4183, are excluded from this standard because of the lack of demand in the United Kingdom.

This revision supersedes BS 1440 and the 1973 edition of BS 3790, which are hereby withdrawn.

British Standard Specification for

Endless wedge belt drives and endless V-belt drives

1. Scope

This British Standard specifies the dimensions and certain other properties of endless wedge belts and V-belts and their corresponding grooved pulleys, when used for power transmission.

Recommended power ratings for belts and information on the design, selection and installation of drive assemblies are given in appendices A and B. Recommendations on the storage of belts are given in appendix C.

This standard does not apply to industrial variable speed drives employing pulleys with movable flanges, or to drives covered in BS 3733 or BS AU 150.

2. References

The titles of the standards publications referred to in this standard are listed on the inside back cover.

3. Definitions

For the purposes of this British Standard the following definitions apply.

3.1 wedge or V-belt drive. A drive that consists of one or more trapezoidal belts mounted on grooved pulleys. The profiles of the belts and of the pulley grooves are such that the belts come into contact with only the sides of the pulley grooves and not with the base of the grooves.

3.2 wedge belt (also known as narrow V-belt). A belt in which the outline formed by the base, sides and top of the belt approximates to a trapezium (see figure 1(a)). These belts are characterized by a relative height of approximately 0.95 W_p (see table 1).

3.3 V-belt (also known as classical V-belt). A belt in which the outline formed by the base, sides and top of the belt approximates to a trapezium (see figure 1(b)). These belts are characterized by a relative height of approximately 0.73 W_p (see table 1).

3.4 pitch width of a belt (W_p). (See also 3.5 and 3.7). The basic dimension of standardization for the belt and for the corresponding pulley groove, considered as a whole.

3.5 pulley groove pitch width (W_p). That width of the pulley groove which is dimensionally the same as the pitch width of the belt associated with the pulley.

3.6 relative height. The ratio of the nominal height (T) of the belt to its pitch width (W_p).

3.7 pitch length of a belt (L_p). The circumferential length of the belt at the pitch width, determined by the method specified in 4.3.

3.8 nominal height of a belt (T). The height of the trapezium outlined on a cross section of the belt (see figure 1).

3.9 nominal top width of a belt (W). The larger width of the trapezium outlined on a cross section of the belt (see figure 1).

3.10 angle of a belt (A). The included angle obtained by extending the sides of the belt (see figure 1).

3.11 pulley pitch diameter (d_p). The diameter of the pulley measured at the groove pitch width.

3.12 anti-static belt. A belt that has a specified maximum electrical resistance in accordance with 4.6.

Table 1. Belt cross section dimensions

Cross section symbol	Pitch width W_p	Nominal top width W	Nominal height T	Nominal included angle A
	mm	mm	mm	degrees
Wedge belts				
SPZ	8.5	10.0	8.0	40
SPA	11.0	13.0	10.0	40
SPB	14.0	17.0	14.0	40
SPC	19.0	22.0	18.0	40
V-belts				
Y	5.3	6.0	4.0	40
Z	8.5	10.0	6.0	40
A	11.0	13.0	8.0	40
B	14.0	17.0	11.0	40
C	19.0	22.0	14.0	40
D	27.0	32.0	19.0	40

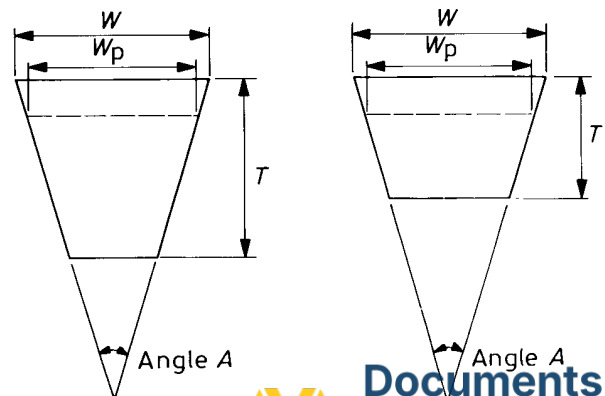


Figure 1. Belt cross sections

4. Wedge belts and V-belts

4.1 Materials and workmanship. Belts shall consist of a suitable combination of fabric, cord and elastomeric compound(s), the whole being bonded together in a uniform manner and shape in accordance with the best manufacturing practice. Belts shall be suitable for operating at ambient temperatures between -18°C and 60°C and shall not be adversely affected by the temperature under normal operating conditions within this range.

4.2 Cross section dimensions. The nominal cross section dimensions and the nominal included angle of belts shall be as given in table 1. The dimensions of belts made by individual manufacturers may vary slightly from the nominal values given in table 1, but the belts shall fit pulley grooves within the limits given in table 2(a) when mounted on two measuring pulleys made in accordance with table 2(b).

4.3 Determination of belt pitch length. The belt pitch length and pitch length variation shall be as given in table 3. The pitch length of a belt shall be determined when the belt is mounted on a pair of measuring pulleys (see figure 2) having groove dimensions as given in table 2(b), with total forces applied and with the belt positioned in the grooves in accordance with table 2(a). The total forces shown shall be equally divided between the two strands of the belt and the pulleys shall be rotated at least two revolutions to seat the belt properly. The pitch length shall be calculated by adding the pitch circumference of one of the two equal pulleys to twice the measured centre distance (E).

4.4 Matched belts. In order to avoid uneven distribution of load, belts running on a multi-belt drive shall be matched belts and their lengths shall be within the tolerances given for matched sets in table 3.

NOTE 1. Age and storage conditions may alter a belt length (see appendix C).

NOTE 2. It is recommended that belts from different manufacturers should not be mixed on the same drive.

4.5 Belt fitting. Wedge belts and V-belts shall not be mixed on the same drive. If a drive is designed to be fitted with wedge belts, replacement belts shall always be wedge belts.

NOTE 1. If a drive is designed to be fitted with V-belts with pulley groove profiles as given in table 6, replacement belts may be either V-belts or wedge belts. If wedge belts are used, consideration should be given to minimum pulley diameters.

NOTE 2. Further information on drive design, including a worked example, is given in appendix A.

4.6 Electrical resistance. Where belts are required by the purchaser to be anti-static, the electrical resistance, in ohms, when measured by the method given in appendix D, shall be not greater than

$$\frac{5 \times 10^6 \times L}{8l}$$

where

L is the distance between electrodes (mm), and

l is the sum of the lengths of the two sloping sides of the belt (mm)

$$= 2T \sec\left(\frac{A}{2}\right) \text{ (see figure 1)}$$

NOTE. This maximum resistance refers to new complete endless belts. General information on electrical resistance of conductive and anti-static products made from flexible polymeric material is given in BS 2050.

The electrical resistance shall be measured for at least five

different portions of the wedge belt or V-belt, spaced so as to be representative of the whole belt. No individual result shall exceed the maximum specified in this clause.

4.7 Fire resistance. Where belts are required by the purchaser to be fire resistant, they shall comply with the requirements of table 4 when tested by the method given in appendix E.

Six samples shall be tested. The belt shall be deemed not to be fire resistant if either the average extinguishing time for six test pieces or the extinguishing time for any one test piece exceeds the appropriate value given in table 4.

4.8 Marking

4.8.1 All belts shall be marked legibly and durably on the outer non-working face with symbols indicating the belt cross section, the nominal pitch length as given in table 3, and, where appropriate, the marking specified in **4.8.2** and **4.8.3**.

NOTE. It is recommended that where manufacturers mark their belts to indicate the tolerance on pitch length for the purpose of matching belts for use on multi-belt drives, they should adopt the following system of marking.

When the measured pitch length is less than 1 mm longer than and not more than 1 mm shorter than the nominal pitch length, stamp the length code 50 on the belt.

Each 2 mm deviation from the nominal pitch length is by definition represented by one unit (see table 3) and the length code is adjusted accordingly, e.g.:

an SPZ 630 marked 50 may have a pitch length of 629 mm up to but not including 631 mm;

if it is marked 48, it may have a pitch length of 625 mm up to but not including 627 mm;

if it is marked 52, it may have a pitch length of 633 mm up to but not including 635 mm.

This length code should appear adjacent to the marking specified in **4.8.1**.

4.8.2 Belts with anti-static properties complying with the requirements of **4.6** shall be marked either with the word 'anti-static' or with the letters 'AS'.

4.8.3 Belts with fire resistant properties complying with the requirements of **4.7** shall be marked either with the words 'fire resistant' or with the letters 'FR'.

Table 2(a). Tolerances and force requirements when measuring new belts

Cross section symbol	Total force (F) applied to belt	Position of top face of belt with respect to top of groove	
		max.	min.
	N	mm	mm
Wedge belts			
SPZ	360	+1.1	-0.4
SPA	560	+1.3	-0.6
SPB	900	+1.4	-0.7
SPC	1500	+1.5	-1.0
V-belts			
Y	40	+0.8	-0.8
Z	110	+1.6	-1.6
A	200	+1.6	-1.6
B	300	+1.6	-1.6
C	750	+1.5	-1.5
D	1400	+1.5	-1.5

Table 2(b). Dimensions of pulleys for measuring new wedge and V-belts (see figure 2)

Cross section symbol	Pitch width, W_p	Nominal pitch diameter, d_p	Nominal pulley circumference at pitch diameter	Outside diameter	Top width of groove, g	Minimum groove depth, d	Groove angle, A
Wedge belts	mm	mm	mm	mm	mm	mm	degrees
SPZ	8.5	95.5	300	99.76 +0.00 -0.06	9.91 -0.00 +0.03	11.0	3.8 ± 0.25
SPA	11.0	143.2	450	149.13 +0.00 -0.06	12.96 -0.00 +0.03	14.0	38 ± 0.25
SPB	14.0	191.0	600	198.29 +0.00 -0.06	16.45 -0.00 +0.03	17.5	38 ± 0.25
SPC	19.0	318.3	1000	328.26 +0.00 -0.06	22.35 -0.00 +0.03	23.8	38 ± 0.25
V-belts							
Y	5.3	28.7	90	32.13 +0.00 -0.06	6.24 -0.00 +0.03	6.3	32 ± 0.25
Z	8.5	57.3	180	62.60 +0.00 -0.06	10.06 -0.00 +0.03	9.5	34 ± 0.25
A	11.0	95.5	300	102.42 +0.00 -0.06	13.05 -0.00 +0.03	12.0	34 ± 0.25
B	14.0	127.3	400	136.08 +0.00 -0.06	16.61 -0.00 +0.03	15.0	34 ± 0.25
C	19.0	222.8	700	234.62 +0.00 -0.06	22.53 -0.00 +0.03	20.0	34 ± 0.25
D	27.0	318.3	1000	334.97 +0.00 -0.06	32.32 -0.00 +0.03	28.0	36 ± 0.25

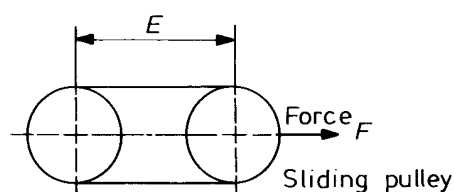
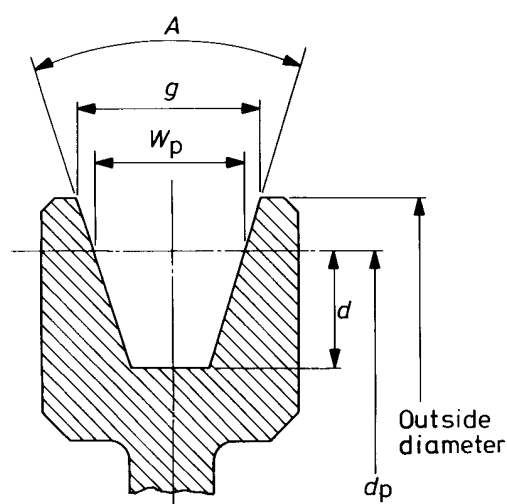


Figure 2. Measuring pulley

Table 3. Standard pitch lengths of wedge belts and V-belts and permitted tolerances

Pitch length range	Standard pitch lengths										Maximum pitch length variation		
	Wedge belts				V-belts						Non-matched sets	Matched sets	
	SPZ	SPA	SPB	SPC	Y	Z	A	B	C	D		Allowable consecutive code numbers*	Maximum pitch length variation*
mm 200 to 399	mm	mm	mm	mm	200 224 250 280 315 355	mm	mm	mm	mm	mm	mm +8 -6	One length code number	mm 2
400 to 529					400 450 500	405 475					+10 -6		
530 to 709	630					530 625 700	630 700				+12 -6		
710 to 899	710 800	800				780	790 890				+12 -8		
900 to 1 249	900 1 000 1 120	900 1 000 1 120				920 1 080	990 1 100	930 1 000 1 100 1 210			+14 -10		
1 250 to 1 599	1 250 1 400	1 250 1 400	1 250 1 400 1 600				1 250 1 430 1 550	1 370 1 560	1 560		+16 -10		
1 600 to 1 899	1 600 1 800	1 600 1 800	1 800				1 750	1 690 1 760	1 760		+18 -12		
1 900 to 2 249	2 000	2 000 2 240	2 000	2 000 2 240			1 940 2 050 2 200	1 950 2 180	1 950 2 190		+30 -16	Two length code numbers	4
2 250 to 2 799	2 240 2 500	2 500	2 240 2 500	2 500			2 300 2 480 2 570 2 700	2 300 2 500 2 700	2 340 2 490 2 720	2 740	+34 -18		
2 800 to 3 149	2 800	2 800	2 800	2 800			2 910 3 080	2 870	2 880 3 080	3 130	+36 -18		
3 150 to 3 699	3 150 3 550	3 150 3 550	3 150 3 550	3 150 3 550			3 290 3 540	3 200 3 600	3 310 3 520	3 330	+38 -20	Three length code numbers	6
3 700 to 4 999		4 000 4 500	4 000 4 500	4 000 4 500				4 060 4 430 4 820	4 060 4 600	3 730 4 080 4 620	+46 -24		
5 000 to 5 999			5 000 5 600	5 000 5 600				5 370	5 380	5 400	+50 -28	Four length code numbers	8
6 000 to 6 999			6 300	6 300				6 070	6 100 6 860	6 100 6 840	+56 -32		
7 000 to 8 999			7 100 8 000	7 100 8 000					7 600	7 620 8 410	+66 -38		
9 000 to 9 999				9 000					9 100	9 140	+66 -38	Six length code numbers	12
10 000 to 12 499				10 000 11 200					10 700	10 700 12 200	+74 -44		
12 500 to 16 000				12 500						13 700 15 200	+90 -50	Seven length code numbers	14

Table 4. Fire resistance requirements

Cross section symbol		Requirements			
V-belts	Wedge belts	Average extinguishing time for six test pieces		Maximum extinguishing time for any one test piece	
		Flame	Glow	Flame	Glow
—	SPZ	s	s	s	s
A	SPA	5	5	10	12
C	SPB	5	5	10	12
C	SPC	5	7	10	15
D	—	5	7	10	15

5. Grooved pulleys

5.1 Materials

5.1.1 Pulleys shall be made of cast iron, steel, suitable alloys, or any material that can be shaped to the standardized dimensions and tolerances and is capable of withstanding without damage the conditions of service (heating, mechanical stresses, abrasion, environment, etc.). The pulley material shall dissipate any significant heat which might be generated by the belts.

5.1.2 Cast or sintered pulleys shall consist of an appropriate material and be free of significant porosities or flaws and of shrinkage holes or voids in the arms, the web and the hub.

5.1.3 In the case of cast pulleys, superficial defects of the rim, boss and centre plate or web (excluding those in the spokes or arms) may be filled with a material homogenous with the original material in such a way as not to give rise to internal stresses. Materials having only the appearance of metal shall not be used.

5.2 Finish

5.2.1 The surface finish of the working surfaces shall be measured in a plane parallel to the action of the belt and shall be not coarser than the value given in table 5.

5.2.2 The edge of V-pulley grooves shall be chamfered or radiused to remove the sharp corners.

Table 5. Surface finish

Working surface	Surface finish
	$\mu\text{m } R_a^*$
V-pulley grooves	3.2
All pulley bores and rim edges	6.3

*As defined in BS 1134 : Part 1.

5.3 Tolerances. The tolerances for side wobble and for run-out (eccentricity), in mm per millimetre of pulley diameter, shall be as follows:

pulley diameter ≤ 500 mm:	± 0.001
$500 \text{ mm} < \text{pulley diameter} \leq 1500$ mm:	± 0.0015
pulley diameter > 1500 mm:	± 0.002

5.4 Balancing

5.4.1 General. The purpose of balancing a pulley is to improve its mass distribution so as to diminish the

out-of-balance forces exerted as it revolves; such forces cannot be completely eliminated, but the remaining imbalance shall not be greater than the allowable limit.

As balancing is an expensive operation, the specified limit of the residual imbalance is given a value as large as the envisaged applications might allow.

Two classes of balancing are considered:

- (a) balancing in one plane, called static balancing;
- (b) balancing in two planes, called dynamic balancing.

Static balancing is usually sufficient; dynamic balancing may be necessary for pulleys with large face widths or for pulleys revolving relatively quickly.

5.4.2 Static balancing. Pulleys manufactured for stock shall be statically balanced, their future conditions of use not being known at the time of manufacture.

Static balancing shall be done so as to leave on the working diameter (pitch or effective, according to the type of pulley) an eccentric residual mass not exceeding the larger of the following two values:

- (a) 0.2 % of the pulley and companion bush mass;
- (b) 0.005 kg.

Limit (a) applies only to cast-iron pulleys: for pulleys made of another material, it shall be multiplied by the ratio of the density of cast iron (7.2 g/cm^3) to the density of the respective pulley material.

5.4.3 Dynamic balancing

5.4.3.1 When the rotational speed n (r/min) of a pulley is known, the necessity for dynamic balancing shall be ascertained as follows.

Determine the limiting speed n_1 , in r/min, by reference to figure 3 or by calculation using the formula

$$n_1 = \sqrt{\frac{1.58 \times 10^{11}}{ld}}$$

where

l is the pulley face width (mm), and

d is the diameter (pitch or effective) of the pulley (mm).

If $n \leq n_1$, static balancing is normally sufficient.

If $n > n_1$, dynamic balancing is normally necessary.

5.4.3.2 When required, dynamic balancing shall be carried out by the method specified in BS 5265 : Part 1 and, unless the user has specified a particular requirement, the G quality level shall be determined by the larger of the following two values:

- (a) $G_1 = 6.3$;
- (b) $G_2 = 5 \nu/M$

where

ν is the circumferential pulley speed (m/s), and

M is its equivalent mass (kg) taken as the mass of a geometrically similar pulley made of cast iron.

The expression for G_2 derives from the definitions given in BS 5265 : Part 1 in relation to the smallest practical residual eccentric mass given in 5.4.2(b).

5.5 Standard dimensions of pulleys. Pulley faces and grooves shall conform to the dimensions and tolerances shown in figure 4 and table 6.

NOTE. Recommended pulley diameters are given in table 6.

5.6 Installation and take-up allowances. The limiting values for the adjustment of centres for the two transmission pulleys shall be as follows:

lower limiting value: nominal centre distance minus 1.5 % L_p ;

higher limiting value: nominal centre distance plus 3 % L_p , where L_p is the pitch length of the belt.

NOTE 1. The above limiting values should be regarded by the belt manufacturers as maxima and by the designers and makers of the machinery as minima.

NOTE 2. Recommended practice for installation tension in drives and for calculation of the resultant force imposed on shafts is given in appendix B.

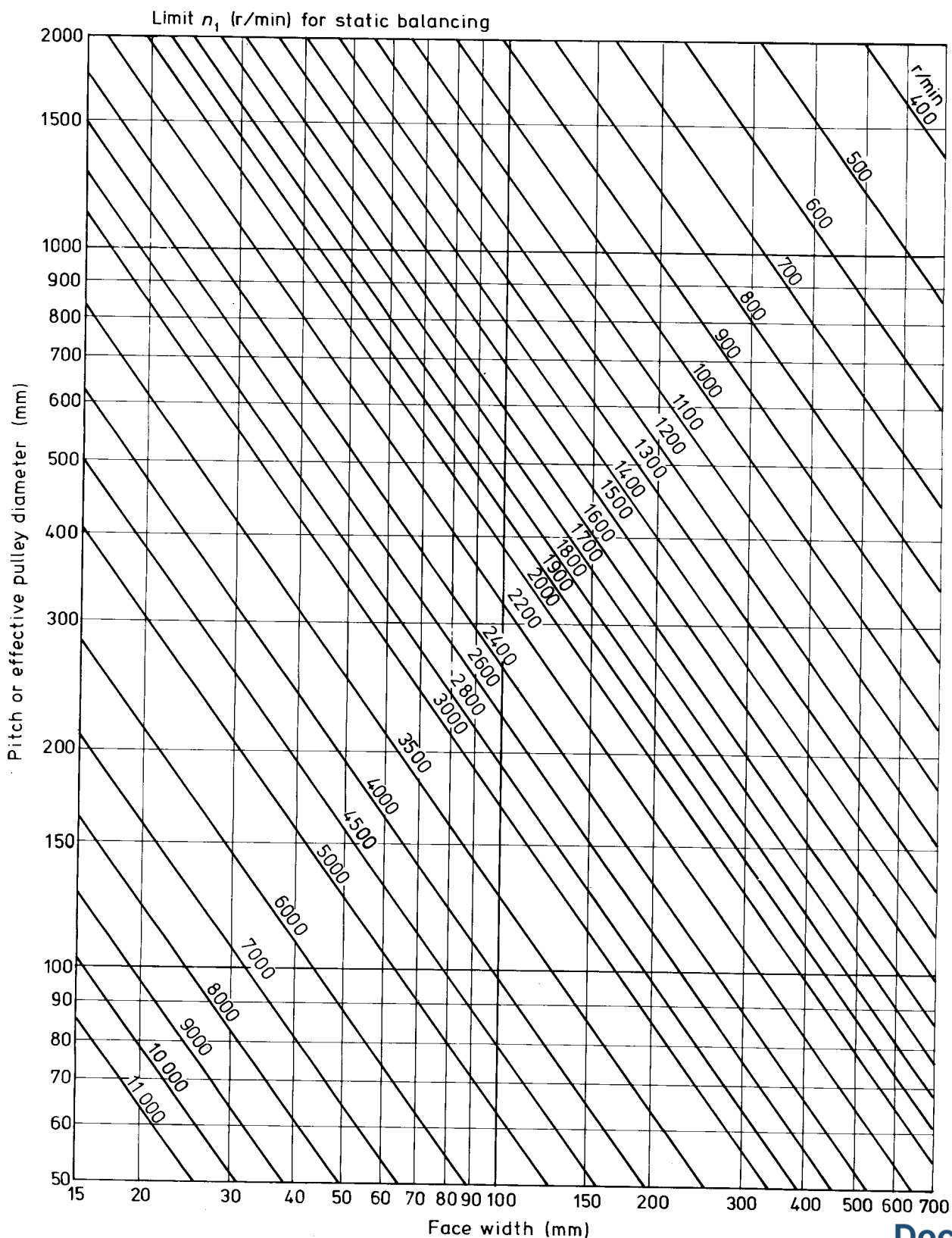
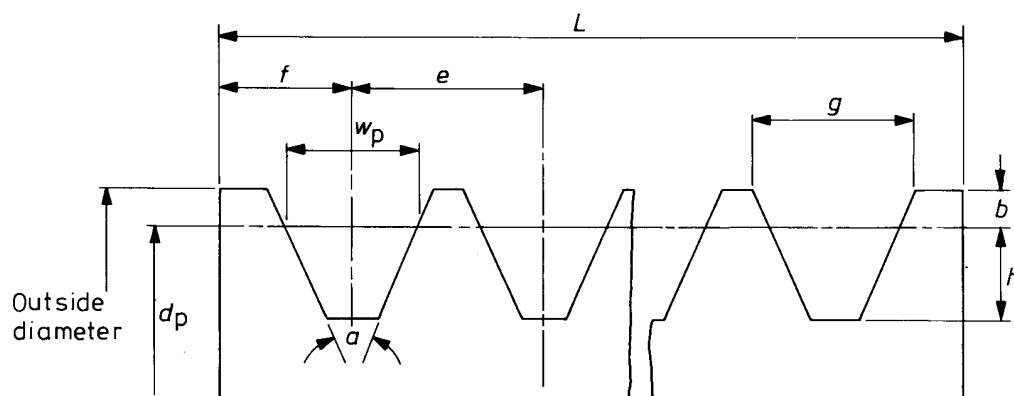


Figure 3. Pulleys requiring dynamic balancing



The maximum distance L between the outside edges of the pulley, i.e. the face width, is equal to $(x - 1)e + 2f$ where x is the number of grooves.

Figure 4. Multi-groove pulley cross section

Table 6. Dimensions of standard V-grooved pulleys

(See table 7 for recommended pulley pitch diameters.)

Cross section symbol	Groove pitch width (w_p)	Minimum distance from outside diameter to pitch diameter (b)	Minimum groove depth below pitch diameter (see note 4) (h)	Centre to centre of grooves (see note 2) (e)	Edge of pulley to first groove centre (see note 3) (f)	Pitch diameter (d_p)	Groove angle (a)	Minimum top width of groove (g)
Y	5.3	1.6	4.7	8 ± 0.3	7.0 ± 1.0	Up to 60	32 ± 0.5	6.2
						60 and over	36 ± 0.5	6.33
Z SPZ	8.5	2.0	9.0	12 ± 0.3	8.0 ± 1.0	Up to 80	34 ± 0.5	9.7
						Over 80	38 ± 0.5	9.9
A SPA	11.0	2.75	11.0	15 ± 0.3	$10.0 + 2.0$ $- 1.0$	Up to 118	34 ± 0.5	12.7
						Over 118	38 ± 0.5	12.9
B SPB	14.0	3.5	14.0	19 ± 0.4	$12.5 + 2.0$ $- 1.0$	Up to 190	34 ± 0.5	16.1
						Over 190	38 ± 0.5	16.4
C SPC	19.0	4.8	19.0	25.5 ± 0.5	$17.0 + 2.0$ $- 1.0$	Up to 315	34 ± 0.5	21.9
						Over 315	38 ± 0.5	22.3
D	27.0	8.1	19.9	37 ± 0.6	$24.0 + 3.0$ $- 1.0$	Up to 475	36 ± 0.5	32.3
						475 and over	38 ± 0.5	32.6

NOTE 1. See figure 4 for symbols.

NOTE 2. The tolerances on dimension e apply to the distance between the centres of any two grooves whether adjacent or not.

NOTE 3. It is recommended that the tolerances on dimension f should be taken into account in the alignment of the pulleys.

NOTE 4. When the pulleys are to be used for V-belt sections Z, A, B or C only, dimension h may be reduced by 20 %.

Table 7. Recommended pulley pitch and outside diameters

Pitch diameter*	Outside diameter									
	Y	Z only	Z and SPZ	A only	A and SPA	B only	B and SPB	C only	C and SPC	D
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
20	23.2									
22.4	25.6									
25	28.2									
28	31.2									
31.5	34.7									
35.5	38.7									
40	43.2									
45	48.2									
50	53.2	54								
53		57								
56	59.2	60								
60		64								
63	66.2	67								
67			71							
71	74.2		75							
75			79	80.5						
80	83.2		84	85.5						
85			89	90.5						
90	93.2		94	95.5						
95			99	100.5						
100	103.2		104		105.5					
106					111.5					
112	115.2		116		117.5					
118					123.5					
125	128.2		129		130.5	132				
132					137.5	139				
140			144		145.5	147				
150			154		155.5	157				
160			164		165.5		167			
170							177			
180			184		185.5		187			
190							197			
200			204		205.5		207	209.6		
212							219	221.6		
224							231		233.6	
236							243		245.6	
250			254		255.5		257		259.6	
265									274.6	
280							287		289.6	
315			319		320.5		322		324.6	
355							362		364.6	371.2
375										391.2
400			404		405.5		407		409.6	416.2
425									441.2	441.2
450									459.6	466.2
475										491.2
500			504		505.5		507		509.6	516.2
530										546.2
560									569.6	572.2
630			634		635.5		637		639.6	646.2
710										726.2
800			804		805.5		807		809.6	816.2
900										916.2
1000					1005.5		1007		1009.6	1016.2
1250							1257		1259.6	1266.2
1600										1616.2
2000										2016.2

*The limits of tolerance on the pitch diameter shall be $\pm 0.8\%$.

Appendix A

Recommendations for drive design

A.1 Design power. The design power is the prime mover power in kW multiplied by the service factor given in table 8 for the appropriate type of service, taking into account the operational hours per day.

A.2 Power ratings. The recommended power ratings of single belts are given in tables 11(a) to 11(k) inclusive. These ratings have been calculated for belts with 180° arc of contact and with a certain pitch length; for belts with other arcs of contact or other pitch lengths, the correction factors given in tables 9 and 10 respectively should be applied. In the case of multi-belt drives, these ratings are applicable only to belts that are matched for length in accordance with table 3.

A.3 Pitch lengths of belts. The pitch lengths of belts corresponding to given pulley diameters and centre distances may be obtained by the following formula:

$$L = 2C + 1.57 (D + d) + \frac{(D - d)^2}{4C}$$

where

- L is the pitch length of belt;
- D is the pitch diameter of larger pulley;
- d is the pitch diameter of smaller pulley; and
- C is the centre distance of drive (using the same units in each case).

A.4 Centre distances. Centre distances may be calculated from the following formula:

$$C = A + \sqrt{A^2 - B}$$

where

$$A = \frac{L}{4} - \pi \frac{(D + d)}{8};$$

$$B = \frac{(D - d)^2}{8}$$

C is the centre distance of drive;

D is the pitch diameter of larger pulley;

d is the pitch diameter of smaller pulley; and

L is the pitch length of belt (using the same units in each case).

A.5 Selection of belt cross section. Selection of the most favourable belt section can be facilitated by use of figures 5 and 6. In borderline cases alternative design calculations may be necessary to determine the best solution of a drive problem.

A.6 Pulley diameters in relation to speed ratios. It is the normal practice to use the pulley pitch diameter in calculating the speed ratios of wedge belt and V-belt drives. Where very accurate speed ratios are required, the manufacturer should be consulted.