BRITISH STANDARD

BS 4878:1973

Specification for

Large (vee-throated) haulage rope pulleys for mines and quarries

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Co-operating organizations

The Mining and Quarrying Requisites Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government department and scientific and industrial organizations:

Association of Mining Electrical and Mechanical Engineers
British Electrical and Allied Manufacturers' Association
British Steel Industry
Council of Underground Machinery Manufacturers
Department of Trade and Industry*
Engineering Equipment Users' Association
Federation of Manufacturers of Construction Equipment and Cranes
Institute of Quarrying
Institution of Mechanical Engineers
Institution of Mining Engineers
National Coal Board*

The Government department and industrial organization marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Council of Ironfoundry Associations
Federation of Wire Rope Manufacturers of Great Britain

This British Standard having been approved by the Mining and Quarrying Requisites Industry Standards Committee, was published under the authority of the Executive Board on 5 October 1973

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Contents

Foreword

This British Standard has been prepared under the authority of the Mining and Quarrying Requisites Industry Standards Committee to cover a range of large diameter pulleys designed primarily for haulage purposes at mines and quarries, and intended for use with steel wire ropes complying with the requirements of BS 330.

The pulleys covered by this British Standard have been specifically designed for return wheel duty, i.e. where the lap of the rope on the pulley is 180°. However, the pulleys are suitable for other conditions, where the rope lap is less than 180°. Pulleys and shafts embodying rolling bearings are regarded as a composite unit. However, in the case of pulleys having bronze bushed bearings, all components are intended to be interchangeable for a given pulley diameter. It is also intended that, for a given pulley diameter, a rolling bearing pulley assembly and a bronze bushed bearing pulley assembly will be interchangeable.

Rolling bearings in the pulley boss are specified throughout a full range of pulley diameters and it is recommended that, wherever possible, rolling bearings should be used to reduce to a minimum the necessity for service and maintenance.

Phosphor bronze bearing bushes in pedestals are specified up to a maximum pulley diameter of 1 350 mm and are not intended to be used with the shaft in a vertical position.

The pulleys covered by this standard are not designed to be hoisted in the horizontal position by means of attachments to the rim or spokes, nor for multiple stacking, storage or lifting one on top of the other.

It is not intended to cover U-shaped groove pulleys, or multiple pulley arrangements, although certain parts of the specification are pertinent to such designs and should be used where possible.

A method of determining minimum pulley diameters is given in Appendix A, taking into account the normal haulage loads in a straight rope and the induced loads when it is bent around a pulley.

NOTE While this is a metric standard, certain principal dimensions are stated in (approximate) imperial units for convenience at this stage; reference may be made to BS 350, "*Conversion factors and tables*".

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 28, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 General

1.1 Scope

This British Standard specifies requirements for a range of haulage pulleys (with shafts) and pedestals designed to incorporate, appropriately, either rolling bearings or plain bearings.

NOTE The titles of the British Standards referred to in this standard are listed on the inside back cover.

1.2 Definitions

For the purposes of this British Standard, the following definitions apply:

1.2.1
rope diameter

the value by which the nominal diameter of the wire rope is designated

1.2.2
pedestal

a device designed to support the ends of a shaft upon which a pulley rotates on rolling bearings

1.2.3
bearing housing

a device, embodying bronze bushes, designed to support the ends of a rotating shaft

1.2.4
bearing (rolling)

a bearing of the ball, roller, or the taper roller type

1.2.5
tread diameter

the nominal diameter of the pulley, measured at the root of the rope groove

NOTE The following terminology phrases are provided for information and guidance:

One-piece solid casting. A pulley without spokes.
Pulley assembly. The designed combination of pulley, shaft, bearings and shaft pedestals.

2 Pulleys

2.1 General

The following principal pulley arrangements are covered by this standard:

1) Pulleys of 600 mm to 2 100 mm diameter, incorporating rolling bearings in the boss (see Figure 4, Figure 5, Figure 6 and Figure 7); and

2) Pulleys of 600 mm and 1 350 mm diameter, incorporating phosphor bronze bushes in the associated pedestals (see Figure 8, Figure 9, Figure 10 and Figure 11).

2.1.1 Design criteria. A pulley complying with the requirements of this British Standard shall be capable of withstanding a load equal to twice the minimum breaking load of the largest diameter of rope nominated for use with that pulley (see Figure 1, Figure 2 and Figure 3), assuming a rope lap of 180° (i.e. return pulley conditions), without permanent deformation of any part of the pulley assembly.

2.1.2 Classification. Pulleys shall be in accordance with the classification shown in Table 1.

Table 1 — Pulley classification

Description		Pulley size			
Group	Construction	Diameter at rope tread			Type reference
		mm	ft	in	
C	One-piece solid casting	600	2	0	C.60
		750	2	6	C.75
		900	3	0	C.90
S	Cast rim and hub, with spokes (one-piece)	900	3	0	S.90
		1 050	3	6	S.105
		1 200	4	0	S.120
		1 350	4	6	S.135
		1 500	5	0	S.150
SH	Cast rim and hub, with spokes (two-piece)	1 350	4	6	SH.135
		1 500	5	0	SH.150
		1 800	6	0	SH.180
		2 100	7	0	SH.210

2.2 Materials

2.2.1 Pulley rims and hubs. The materials of pulley rims and hubs shall comply with the requirements of one or other of the following British Standards, subject to agreement between the purchaser and the manufacturer:

BS 1452, Grade 14 grey cast iron (as minima)

BS 2789, Grade SNG37/2 nodular graphite cast iron

BS 3100, (BS 592, Grade B carbon steel)

BS 3100, (BS 1456 Grade A 1½ % manganese steel)

2.2.2 Spokes. The material of pulley spokes shall be either mild steel complying with the requirements of Grade 43A of BS 4360, or wrought iron complying with the requirements of BS 2772, subject to agreement between the purchaser and the manufacturer.

2.3 Rim section

The rim section shall conform appropriately to the principal dimensions of Figure 1, Figure 2 or Figure 3.

The rope groove radius of the pulley shall be approximately 10 % greater than the nominal radius of the rope to be used with the pulley.

NOTE The rim sections illustrated in Figure 1, Figure 2 and Figure 3 provide a progressive range of nine pulleys for rope diameters complying with the requirements of BS 330. Users are advised to consult Appendix A, which gives a method of determining minimum pulley diameters and takes account of necessary factors in order to limit to an acceptable maximum the loading of a rope bent around a pulley.

2.4 Hubs

2.4.1 For solid type pulleys. The hubs for one-piece solid cast pulleys shall conform to the general arrangement of Figure 4, Figure 5, Figure 8 and Figure 9, as appropriate.

2.4.2 For spoked pulleys

2.4.2.2 The hubs for one-piece spoked type pulleys shall conform to the general arrangement of Figure 6 and Figure 10, as appropriate.

2.4.2.2 The hubs of spoked type split pulleys shall conform to the general arrangement of Figure 7 and Figure 11, as appropriate.

2.5 Machining

2.5.1 Rims. Unless otherwise agreed between the purchaser and the manufacturer, rope grooves shall be "as cast". Where high spots, or areas of undue roughness occur, these shall be dressed smooth and flush with the general contour of the groove. The tolerance on diameter for "as cast" pulleys shall be $\pm \begin{smallmatrix}3\\0\end{smallmatrix}$ mm. The total variation from true running for "as cast" rope grooves shall not exceed 3 mm in any direction.

Where machined rims are required by the purchaser the rope groove radius shall comply with the requirements of **2.3**. The machined radius shall blend smoothly into the flanks of the "vee" without step or undercut.

The tolerance on diameter for machined rope grooves shall be $\pm \begin{smallmatrix}1.5\\0\end{smallmatrix}$ mm. The total variation from true running of the machined rope groove radius shall not exceed 0.5 mm in any direction.

2.5.2 Hubs

2.5.2.1 Hubs for keyed shafts shall be faced on both sides subject to a tolerance on width of $\pm \begin{smallmatrix}0.5\\0\end{smallmatrix}$ mm. The bores shall comply with H8[1)] limits for holes.

2.5.2.2 Hubs to accommodate rolling bearings shall be concentric within the tolerance grade IT 4[1)] and be subject to a tolerance on width of $\pm \begin{smallmatrix}0.5\\0\end{smallmatrix}$ mm. The tolerances on bores shall comply with the N6[1)] limits for holes.

2.5.3 Split pulleys. The mating faces of split pulleys shall be machined flat and square with the plane of the rope tread.

The bolt holes in the mating faces of split pulleys shall be accurately drilled, and then countersunk 1.5 mm at 45° on the face. The nut seatings shall be spotfaced to provide square seating for the nuts.

Means, additional to fixing bolts, shall be provided to ensure accurate assembly of the components.

2.6 Keyways

Any pulley having a keyed shaft shall have a rectangular keyway, complying appropriately with the requirements of BS 4235, cut in the hub bore (see also Section **7**).

[1)] See BS 4500.

2.7 Spokes

The number of spokes per pulley and their respective diameters shall be as given in Table 2.

All spokes shall be set (cranked) at both ends, to enter the rim bosses and the hub at right angles to the axis of the shaft. The set of a spoke shall be as near as possible to the point where the spoke enters the hub and the rim boss; the set shall in no case be inside the boss or hub.

The spoke ends shall be knuckled (as shown in Figure 2 and Figure 3) by swaging or rolling. Spoke ends shall be cleaned and evenly tinned after knuckling, such tinning to extend clear of the finished casting.

The root diameter of each knuckle shall be not less than the nominal diameter of the spoke. The contour of the knuckle shall be fully radiused and have no sharp lines. There shall be 1) a 20 mm minimum parallel portion of the spoke end immediately inside the rim boss and hub, 2) a 58 mm minimum length of spoke inside the rim boss and hub and 3) a 20 mm minimum of material covering the end of each spoke in the rim and hub after any machining.

Table 2 — Details of spokes

Pulley diameter			Number of spokes	Diameter of spokes (minimum)	
mm	ft	in		mm	in
900	3	0	12	25	1
1 050	3	6	12	25	1
1 200	4	0	16	29	$1^1/_8$
1 350	4	6	16	29	$1^1/_8$
1 500	5	0	16	29	$1^1/_8$
1 800	6	0	16	32	$1^1/_4$
2 100	7	0	20	38	$1^3/_8$

3 Shafts

3.1 Material

The material for keyed (rotating) shafts shall comply with the requirements of BS 970-1, grade 070M20 (hot rolled, forged, or normalized).

The material for fixed shafts shall comply with the requirements of BS 970-1, grade 070M26 (cold drawn from hot rolled condition).

In either instance the material shall be free from seams, laps and other such defects.

3.2 Machining

3.2.1 Shafts for use with phosphor bronze bearings. The surface finish on journals, pulley seatings and radii on shafts in accordance with Figure 8, Figure 9, Figure 10 or Figure 11 shall be of a quality grade complying, both diametrically and longitudinally, with $63R_a$ [2)].

Fillet radii shall blend smoothly, without step or undercut, into the journal. All burrs and sharp edges shall be removed.

3.2.2 Shafts for rolling bearings. The surface finish on all parts of the shaft which come into contact with rolling bearings shall be of a quality grade complying, both diametrically and longitudinally, with $63R_a$ [2)].

Fillet radii shall blend smoothly. All burrs and sharp edges shall be removed.

Thread holes for lubricators shall be countersunk at 45° to the depth of the first thread.

3.3 Dimensions and tolerances

3.3.1 Shafts for phosphor bronze bearings. Shafts for phosphor bronze bearings shall conform appropriately to the dimensions given in Figure 8, Figure 9, Figure 10 or Figure 11, subject to the following machining tolerances:

Dimension	Tolerance
Journal diameter	f6[a] limits for shafts
Shaft body diameter	g6[a] limits for shafts
Shaft body length	± 0.4 mm
Journal length	± 0.8 mm
Journal fillet radius	$^{+0.25}_{-0}$ mm
Depth of key seat	$^{+0.15}_{-0}$ mm

[a] See BS 4500.

3.3.2 Shafts for rolling bearings. Shafts for use with rolling bearings shall be concentric within the tolerance grade IT 4 [3)] and shall conform appropriately to the dimensions given in Figure 4, Figure 5, Figure 6 or Figure 7, subject to the following machining tolerances:

Dimension	Tolerance
Journal diameter	e8[a] limits for shafts
Bearing seating	g6[a] limits for shafts
Shaft body length	± 1.5 mm

[a] See BS 4500.

[2)] See BS 1134.

[3)] See BS 4500.

3.4 Bearing pedestal centres

The bearing pedestal centres for all shafts shall be as follows:

Pulley diameter	Bearing/pedestal centres
mm	mm
600 and 750	335
900 and 1 050	370
1 200	440
1 350	455
1 500	470
1 800	495
2 100	500

NOTE The bearing centres given for shafts in Figure 8, Figure 9, Figure 10 and Figure 11 allow 2 mm end float for the pulley.

4 Bearing pedestals

4.1 General

4.1.1 Where pedestals are required to accommodate shafts normally operating in the vertical position, for pulleys embodying rolling bearings, an end cap in accordance with Figure 12 shall be provided for the lower pedestal.

4.1.2 Pedestals embodying phosphor bronze bushes shall be provided with means of lubrication (see **5.2**).

4.1.3 Each pedestal for use with a pulley containing rolling bearings shall be fitted with an M16, 8.8 grade, half-dog pointed set screw of sufficient length to engage and bottom in a suitable blind hole drilled in the shaft.

4.1.4 Where an end cap is provided for a pedestal, such pedestal shall be drilled and tapped concentrically with the bore, the holes being equally spaced within a tolerance of ± 0.08 mm on the pitch circle. (See Figure 12.)

4.2 Material

4.2.1 Bearing housings (see Figure 13) and pedestals (see Figure 12) shall be cast in material not inferior to Grade 14, grey cast iron, complying with the requirements of BS 1452.

4.2.2 End caps (see Figure 12) shall be made of mild steel complying with the requirements of Grade 43A 6f BS 4360.

4.3 Machining

4.3.1 The surface finish of the bores shall be of a quality complying with $125R_a$ [4)]

The bottom face of pedestals shall be machined flat and parallel with the bore.

All burrs and sharp edges shall be removed.

4.3.2 Where required by the purchaser, bases shall be left undrilled.

4.3.3 Threads for lubricators shall be countersunk at 45° to the depth of the first thread.

4.4 Dimensions and tolerances

4.4.1 Bearing housings for phosphor bronze bushes. These bearing housings shall conform to the dimensions given in Figure 13, subject to the following tolerances:

Dimension	Tolerance
C(Diameter)	H8[a] limit for holes
F(Width)	$^{+0}_{-0.4}$ mm
G(Hole centres)	± 0.8 mm
H(Base length)	± 2 mm
h(Centre height)	± 0.13 mm

[a] See BS 4500.

4.4.2 Pedestals for shafts with rolling bearings. Pedestals for these shafts shall conform to the dimensions given in Figure 12, subject to the following tolerances:

Dimension	Tolerance
A(Diameter)	H8[a] limit for holes
F(Width)	$^{+0}_{-0.4}$ mm
G(Hole centres)	± 0.8 mm
H(Base length)	± 2 mm
h(Centre height)	± 0.13 mm

[a] See BS 4500.

4.4.2.1 Bearing end caps shall conform to the dimensions given in Figure 12, subject to the following tolerances:

Dimension	Tolerance
d(Diameter)	$^{+0}_{-1.0}$ mm
P.C.D(Pitch circle diameter)	± 0.13

The holes in the end cap shall be drilled to accord with those in the pedestal (see **4.1.4**).

4.4.2.2 Fixing screws in accordance with Figure 12 shall be provided with each bearing end cap.

[4)] See BS 1134.

5 Bearing bushes

5.1 Material

The material for bearing bushes (and thrust washers) shall be phosphor bronze complying with the requirements of Grade PB4 of BS 1400. Other suitable bearing materials may be used, subject to agreement between the purchaser and the manufacturer; in such an event, the recommendations of the relevant material manufacturer shall apply in respect of the machining finishes, tolerances and lubrication.

5.2 Machining

The surface finish of bush bores and working faces of thrust washers shall be of a quality grade complying with $32R_a$[5)].

The radius "*R*" at the inner end of bearing bushes (see Figure 14) shall blend smoothly, without step or undercut, into the bore and shall be concentric with the bore. Bushes and thrust washers shall be machined to permit adequate lubrication.

All burrs and sharp edges shall be removed.

5.3 Dimensions and tolerances

5.3.1 Bearing bushes shall conform to the dimensions of Figure 14, subject to the following tolerances:

Dimension	Tolerance
A(Diameter)	H8[a] limit for holes (after fitting)
C(Diameter)	s6[a] limit for shafts
M(Length)	$^{+0}_{-0.4}$ mm
R(Radius)	$^{+0.25}_{-0}$ mm

[a] See BS 4500.

5.3.2 Thrust washers shall conform to the dimensions of Figure 14, subject to the following tolerances:

Dimension	Tolerance
P(Diameter)	± 0.8 mm
Q(Diameter)	± 0.8 mm
Thickness	± 0.13 mm

The thrust faces shall be parallel within the specified thickness tolerance.

6 Rolling bearings

6.1 Bearings

Where rolling bearings are required they shall be fitted in the pulley boss. Rolling bearings shall have a minimum life rating of 25 000 hours (see Note 1).

The assembled bearings shall be capable of withstanding without undue deterioration a static load of twice the breaking load[6)] of the appropriate rope shown in Figure 1, Figure 2 or Figure 3.

NOTE 1 The life rating of the rolling bearing assembly is calculated on an assumed radial working load of 25 % of twice the breaking load of the appropriate maximum diameter haulage rope indicated in Figure 1, Figure 2 or Figure 3 with an axial load on the bearings of one tenth of the above stated working load. The rope is assumed to be travelling at a speed of 10 km/h. Calculations on bearing life and load ratings should be in accordance with the recommendations contained in Appendix B of BS 292.

NOTE 2 Where agreed between the purchaser and the manufacturer, cartridge assembled rolling bearings may be used.

6.2 Seals

Adequate seals shall be provided, where appropriate, with each rolling bearing. These seals shall be effective against the normal ingress of dust and water. Provision shall be made for the ease of seal replacement.

6.3 Bearing lubrication

A lubrication point shall be provided.

7 Keys

7.1 Details

The material for keys shall be steel complying with the requirements of grade 070M26 of BS 970-1, unless decided otherwise between the purchaser and the manufacturer.

Keys shall be of rectangular close fit, gib head, taper type complying with the requirements of BS 4235.

The finished fitted key shall not protrude outside the width of the pulley boss.

The gib head shall be removed when the key has been worked down to size and fitted.

8 Bolts for split pulleys (with nuts and washers)

8.1 Bolts

The material for the clamping bolts for split sheaves shall comply with the requirements of grade 220M07 of BS 970-1.

[5)] See BS 1134.

[6)] To cater for return pulley condition, i.e. 180° lap of rope on the pulley.

Bolts shall be machined and fitted, the surface finish complying with $63R_a$[7)].

The size and strength of these bolts shall be determined by the manufacturer to suit the design requirements (see **2.1.1**).

Threads shall be ISO metric coarse series complying with the requirements of BS 3643, with "close fit" tolerance.

Fillet radii shall blend smoothly with the shank, without step or undercut.

The length of the bolt shall be such that when fitted with nuts complying with the requirements of **8.2**, one thread protrudes beyond the locknut when assembled.

8.2 Nuts

Two full nuts and two locknuts, with ISO metric coarse series threads complying with the requirements of BS 3643, with "close fit" tolerance, shall be fitted to each bolt (see also **8.3**).

Nuts shall have a strength grade designation of 8 in accordance with BS 3692.

8.3 Washers

Two steel plain washers, complying with the requirements of BS 4320, shall be provided with each bolt.

9 Workmanship

9.1 Details

Castings shall be fettled, dressed and cleaned for inspection purposes as required by the appropriate British Standard listed in **2.2.1**.

Castings shall be free from cracks and other injurious defects and shall comply in all respects with the requirements of the appropriate British Standard listed in **2.2.1**.

Castings which after machining show defects not previously evident and which would be likely to affect the strength or efficient running of the pulley shall be rejected.

Machined parts shall be finished to the limits and tolerances of size, and the surface finish as detailed in the respective clauses of this standard.

10 Inspection

10.1 Purchaser's rights

The purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on the orders; he shall be at liberty to inspect the manufacture at any stage, to witness the required tests and to reject any material that does not comply with the requirements of the relevant specification.

11 Protective coating

11.1 Details

Each pulley assembly shall be painted on all non-bearing surfaces. Other surfaces (e.g. journals, rope groove) shall be suitably protected to resist corrosion.

12 Marking

12.1 Details

All principal components of each assembly shall be marked with the following information:

1) manufacturer's registered trade name or trade mark.

2) The number of this British Standard, i.e. BS 4878.

NOTE 1 The presence of this mark is a unilateral claim that the product so marked or described does conform in all respects to the British Standard number quoted.

NOTE 2 Attention is drawn to the certification facilities offered by BSI; see the inside back cover of this standard.

13 Information to be provided with order

13.1 Details

When requiting pulleys complying with the requirements of this British Standard, purchasers should give at least the following information.

1) The number of this British Standard, i.e. BS 4878.

2) Type reference of the pulleys required (see Table 1).

3) Type of bearing.

7) See BS 1134.

4) Type of materials for rim, hub and spokes.

5) Whether bearing pedestal is required and, if so, whether the bases are to be left undrilled.

6) Whether machined rope groove is required.

7) Diameter of rope.

8) Details of non-destructive testing and certification required.

9) Whether any bearing pedestal(s) to be provided with end cap(s) (see **4.1.1**).

Appendix A Notes on the determination of minimum pulley diameters

The user, by taking into account the gravity loads owing to vehicles and their contents and the rope; also friction in the vehicles and the rope; acceleration and retardation forces; and any other forces, such as tensioning gear in endless rope haulage systems, may estimate the straight rope load in normal usage. Then, with a factor of safety on the straight rope load chosen in regard to the conditions of use, the minimum breaking load of the selected rope construction can be established. Provided the pulleys used are of a diameter not less than that determined by the method given in this appendix, the factor of safety on the straight rope load decided upon will be sufficient to allow for the loads set up in the wire rope due to bending. Users are advised to check the effect of bending on the total stresses in a rope. Preferably, the total load (including bending load) should be less than 30 % of the actual breaking load of the rope; it is recommended that this should not exceed 35 %. The limit of proportionality of individual wires in the rope will be exceeded if the total load, including bending load, is greater than 45 % of the actual breaking load of the rope.

It would be more correct to relate the tensile, bending and total loads to the ultimate tensile strength or actual breaking load of the rope. The actual breaking load can only be obtained from practical tests, and for a new rope it will exceed the minimum breaking load by a small amount. Therefore, the figures under the percentage minimum breaking load given in the following examples would, in practice, be slightly smaller.

A maximum rope diameter has been specified for use with each size of pulley in this standard (see **2.3**; also Figure 1, Figure 2 and Figure 3); however, all other factors being equal, longer rope life would be expected from the use of a pulley of larger diameter than one for which the rope would be the maximum permitted size.

There may be many instances where the minimum ratio between the pulley diameter and the wire diameter, as now recommended, are not met; in such instances, the fatigue life of the rope will be adversely affected.

Where the angle of lap of rope on a pulley is less than 10°, a pulley of smaller diameter than the minimum recommended for the conditions of the installation may be used.

Where, for particular applications, the pulley/rope diameter combinations shown in Figure 1, Figure 2 or Figure 3 are not suitable, then the tread diameter of the pulley should be decided by the outer wire size of the construction of rope selected for the installation, and by the rope factor of safety required for that installation. The graphs show that the minimum pulley/wire diameter ratio should be 450 : 1 for a factor of safety of 8 to the direct pull on a straight rope, and be progressively increased through a range to a minimum of 700 : 1 for decreasing factors of safety on the direct pull on a straight rope down to 3.0.

BS 330 nominates five constructions of steel wire rope for haulage purposes:

Construction		Size range
Round strand	6 × 7 (6/1)	8–35 mm
	6 × 19 (9/9/1)	13–38 mm
Triangular strand	6 × 8 (7/Δ)	13–35 mm
	6 × 22 (9/12/Δ)	13–35 mm
	6 × 25 (12/12/Δ)	13–38 mm

Given the rope diameter and construction, also the factor of safety on the load in a straight rope in the installation, the recommended minimum pulley diameter can be read from the graphs, Figure 15, Figure 16, Figure 17 and Figure 18.

(As, for all practical purposes, 6 × 7 round strand and 6 × 8 triangular strand ropes use the same outer wire size for any given diameter, their graphs have been combined in Figure 15.) Where a value is obtained between two pulley sizes, the larger should be regarded as the minimum to be used.

Examples:

1) Assuming the total load on the straight rope is 41.71 kN, with a factor of safety of 6, a breaking load on the rope of 6 × 41.71 kN = 250.26 kN is required and this can be satisfied by the 22 mm diameter 6 × 7 round strand fibre core rope in a tensile grade of 1 570 N/mm^2 having a minimum breaking load of 252 kN. From the graph (see Figure 15) for the 6 × 7 construction chosen it can be seen that the recommended minimum pulley diameter is 1 350 mm.

The additional load due to bending the rope around this pulley can be calculated from the accepted formula:

$$B_L = \frac{E \times d \times A}{D}$$

where E = modulus of elasticity for the rope construction selected

d = outer wire diameter

A = cross sectional area of rope

D = tread diameter of pulley.

By substituting $d \times R$ for D

where R = pulley diameter/wire diameter ratio

$$B_L = \frac{E \times d \times A}{d \times R}$$

$$= \frac{E \times A}{R}$$

In this case B_L is calculated to be 38.76 kN, where E = 11 729 N/mm^2 (6 × 7 construction rope in the pre-loaded state, i.e. after all constructional stretch has been removed), A = 185.9 mm^2 (assuming a rope manufactured to 2 % over the nominal size)

and $R = \frac{1350 \text{ (tread diameter of pulley)}}{2.4 \text{ (outer wire size)}} = 562.5.$

Therefore, when being bent around the pulley, the rope is subjected to a total load as follows:

		kN	Percentage of minimum breaking load %
Straight rope load		41.71	16.55
Load due to bending		38.76	15.38
Total load	=	80.47	31.93

Should a rope user wish to make his own calculations, data concerning E, d and A should be obtained from the wire rope manufacturers.

2) If it be decided to increase the straight rope load to, say 54.67 kN without altering the rope size or its tensile grade, the factor of safety on the straight rope load is reduced to **4.6**. It will, therefore, be necessary to increase the minimum pulley size and, from the graph (see Figure 15), it can be seen that the recommended minimum pulley diameter is 1 500 mm. This gives a pulley diameter/wire diameter ratio of 625 and produces the following total load:

		kN	Percentage of minimum breaking load %
Straight rope load		54.67	21.69
Load due to bending		34.87	13.84
Total load	=	89.54	35.53

This is a significant but marginally acceptable increase in the total load.

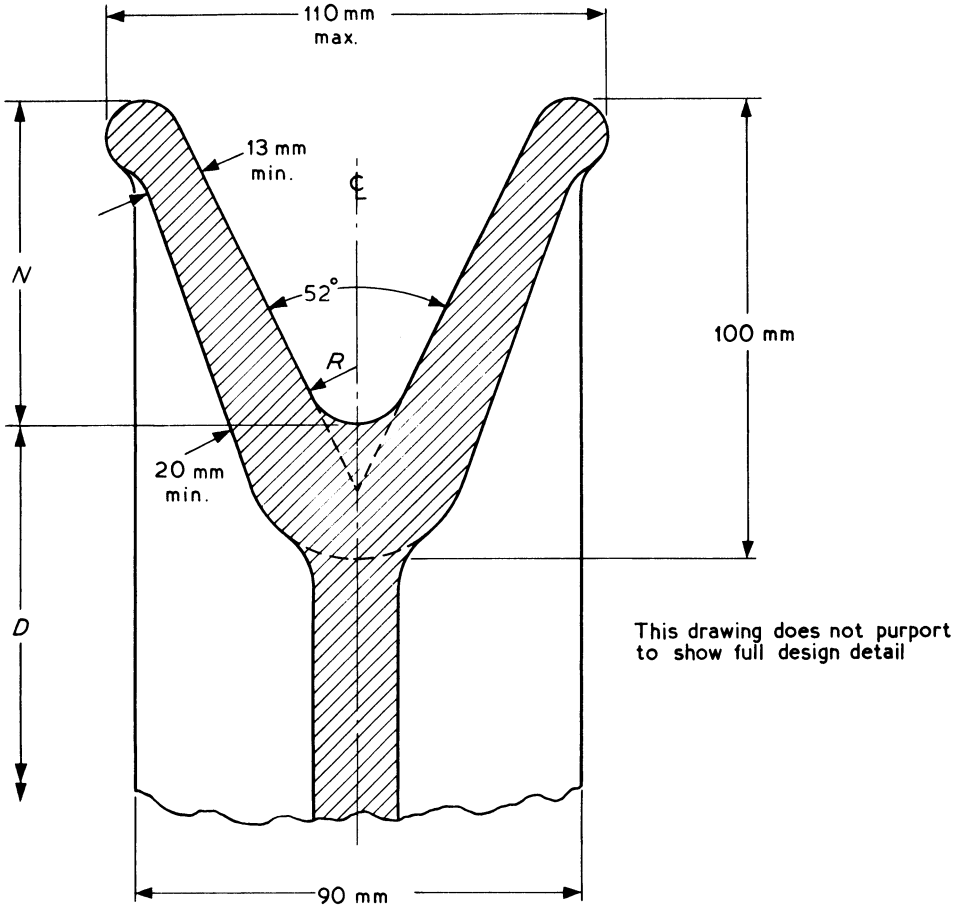
3) This example demonstrates the effects of bending a rope around a pulley when low factors of safety are used and it indicates the importance of using as large a pulley as possible. Using the same rope as in the previous example, but increasing the straight rope load to 83.47 kN, a factor of safety of 3 is obtained. From the graph (see Figure 15) the recommended minimum pulley diameter is 1 800 mm. The total load produced is as follows:

		kN	Percentage of minimum breaking load %
Straight rope load		83.47	33.12
Load due to bending		29.06	11.53
Total load	=	112.53	44.65

If the next smaller size of pulley (i.e. 1 500 mm) had been incorrectly chosen, then the loads would be:

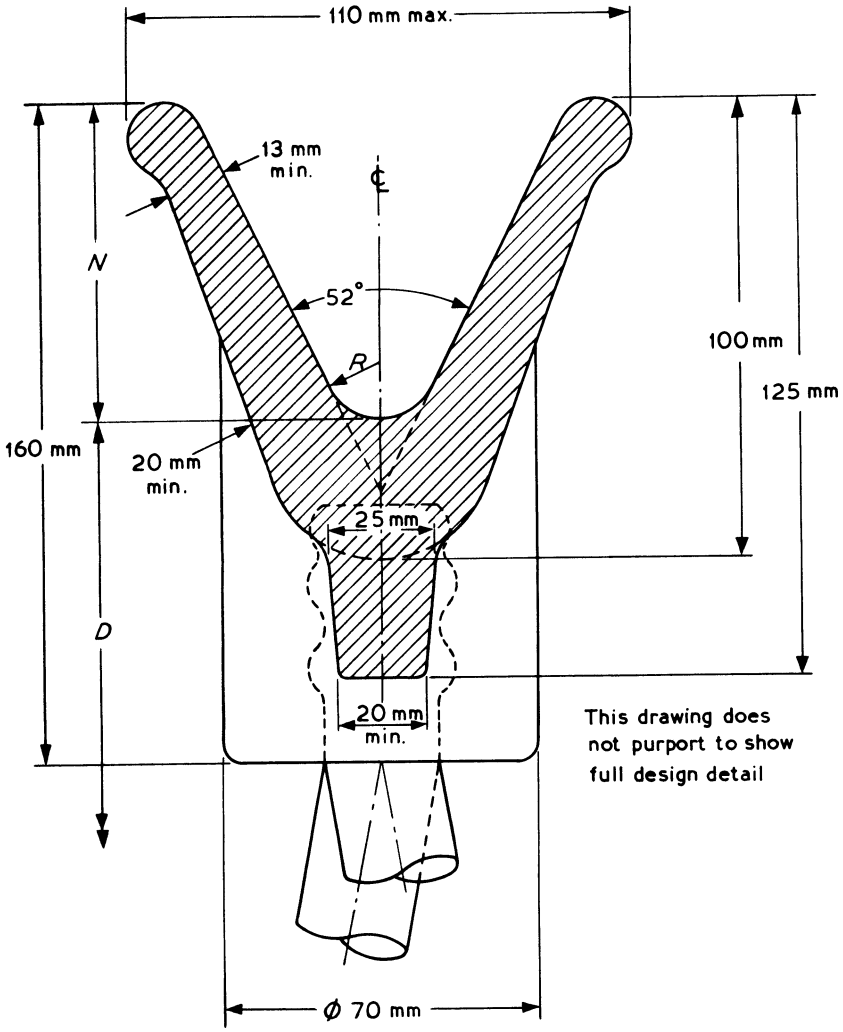
		kN	Percentage of minimum breaking load %
Straight rope load		83.47	33.12
Load due to bending		34.87	13.84
Total load	=	118.34	46.96

These total loads will adversely affect the bending fatigue component in the overall deterioration of the haulage rope to be expected during normal use.



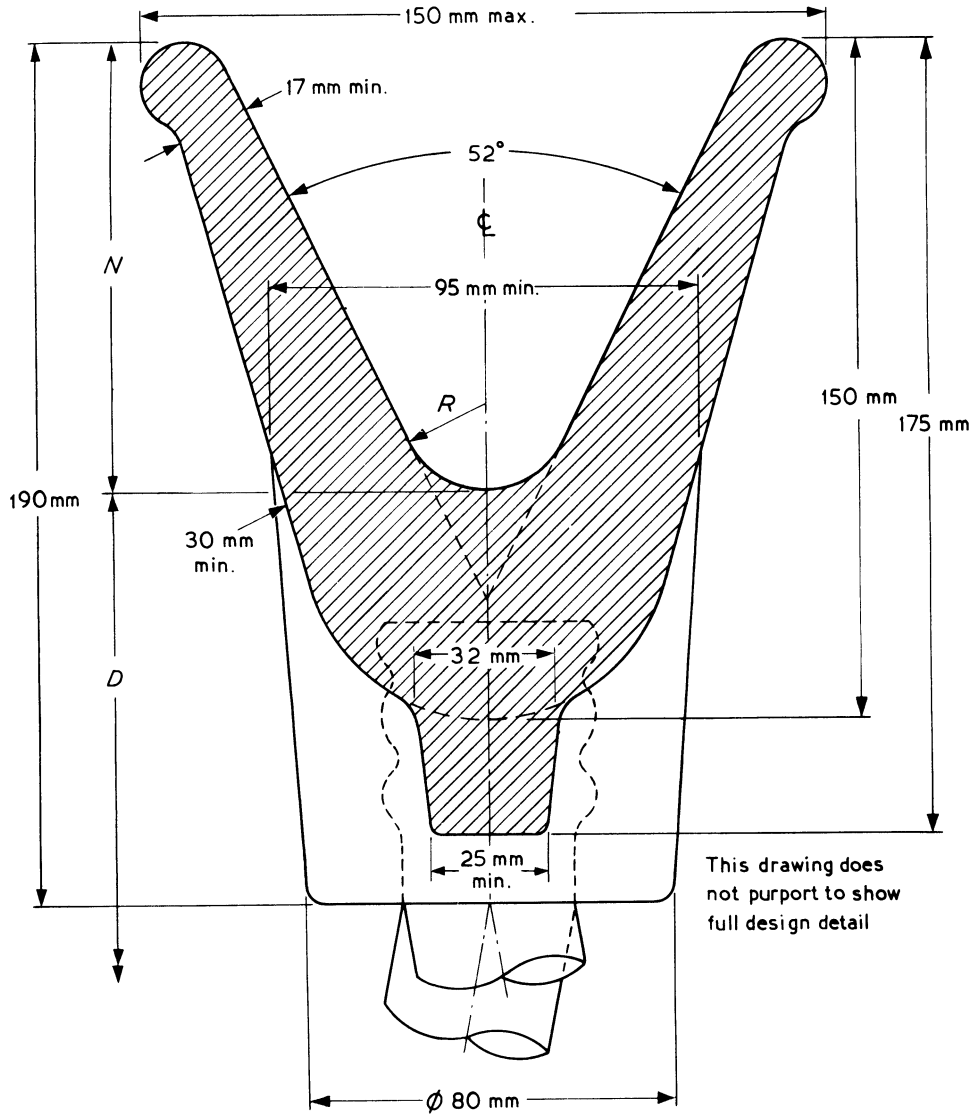
Dimensions		1 mm	2 mm	3 mm
Pulley diameter *D*		600 (2 ft)	750 (2 ft 6 in)	900 (3 ft)
Rope diameter	max.	13	16	19
	min.	8	9	11
Groove radius *R*	For maximum diameter of rope	7.15	8.80	10.45
Nominal groove depth *N*		77	75	73

Figure 1 — Rim section (one-piece solid type pulley) for ropes of 19 mm diameter and under



Dimensions		1 mm	2 mm
Pulley diameter *D*		900 (3 ft)	1 050 (3 ft 6 in)
Rope diameter	max.	19	22
	min.	11	13
Groove radius *R*	For maximum diameter of rope	10.45	12.10
Nominal groove depth *N*		73	71

Figure 2 — Rim section (spoked type pulley) for ropes of 22 mm and under



Dimensions		1 mm	2 mm	3 mm	4 mm	5 mm
Pulley diameter *D*		1 200 (4 ft)	1 350 (4 ft 6 in)	1 500 (5 ft)	1 800 (6 ft)	2 100 (7 ft)
Rope diameter	max.	26	29	32	35	38
	min.	14	16	18	22	22
Groove radius *R*	For maximum diameter of rope	14.30	15.95	17.60	19.25	20.90
Nominal groove depth *N*		104	102	100	98	96

Figure 3 — Rim section for ropes of 14 mm to 38 mm diameter (inc.)

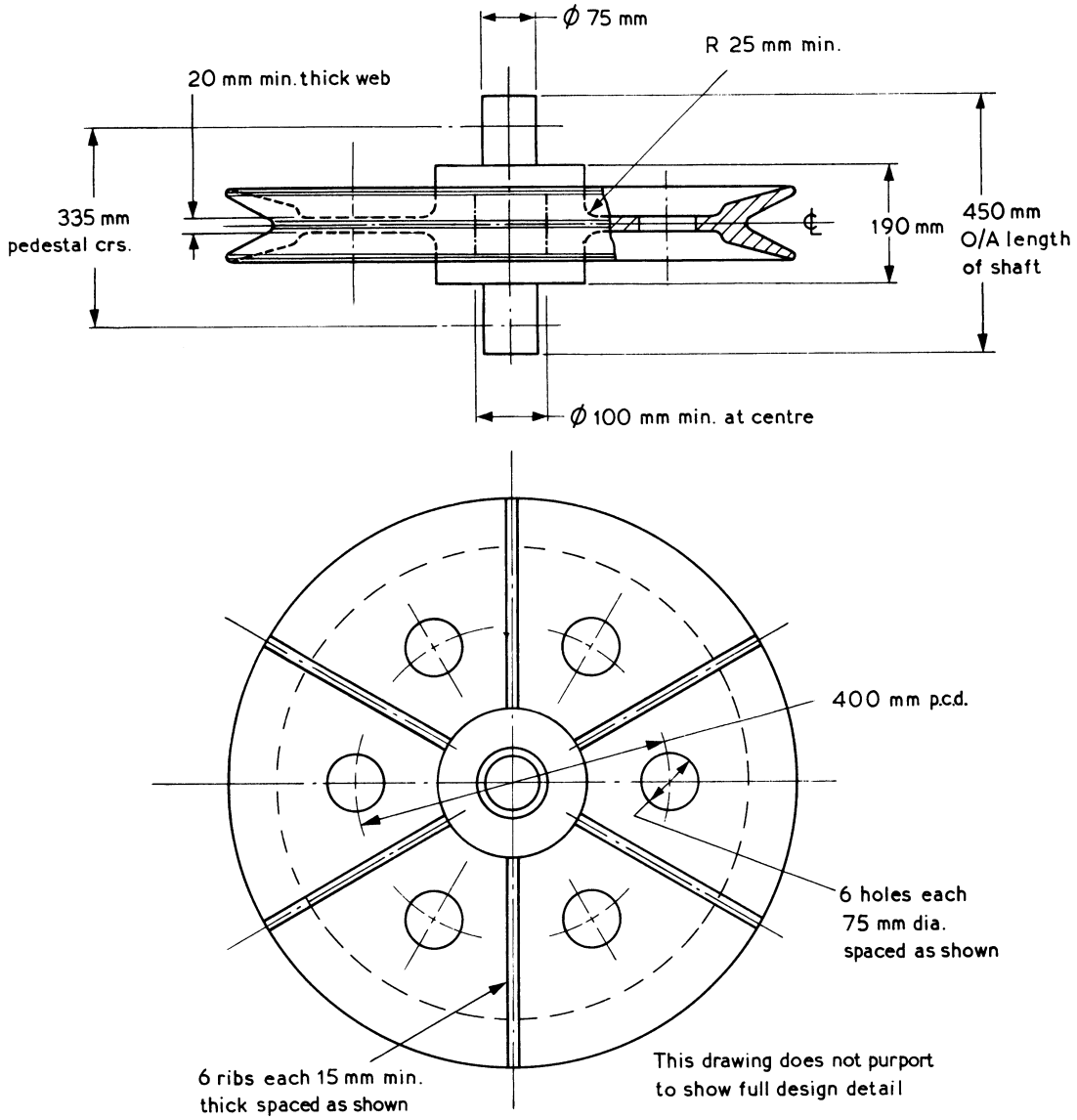


Figure 4 — Pulleys 600 mm (2 ft) and 750 mm (2 ft 6 in) diameter

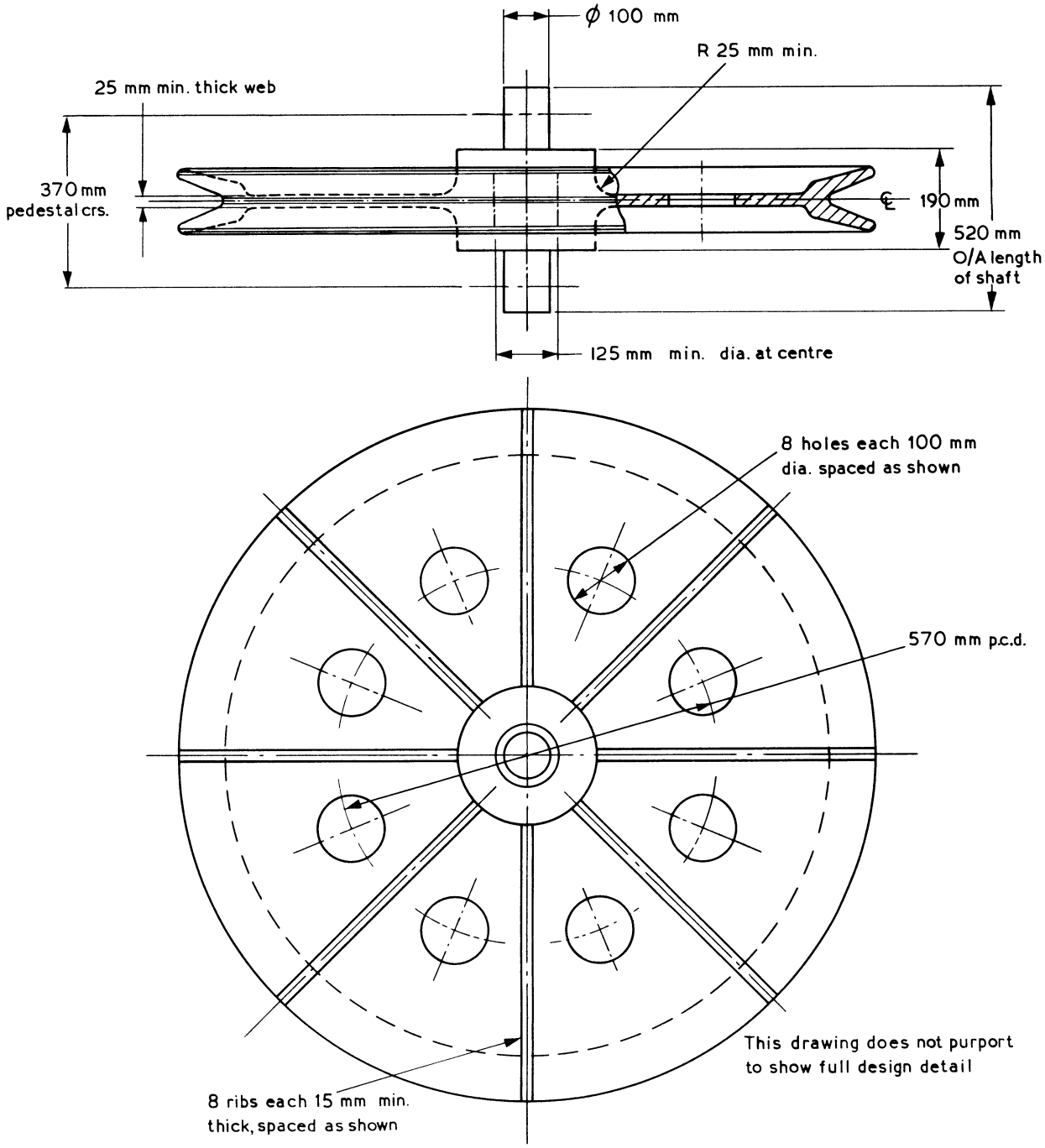
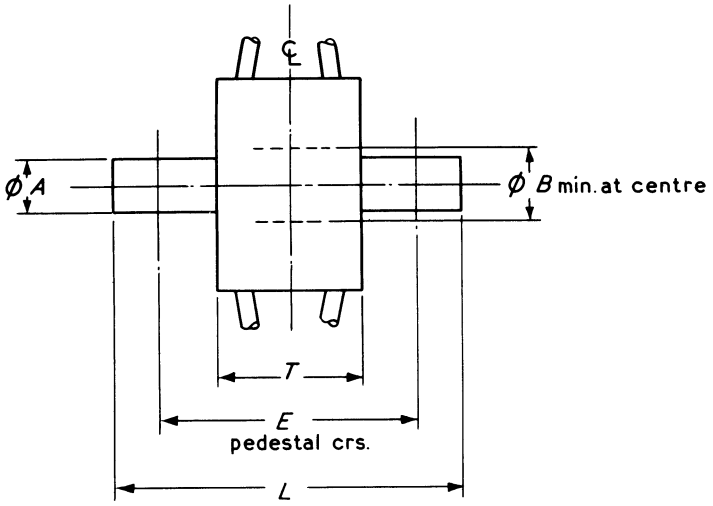
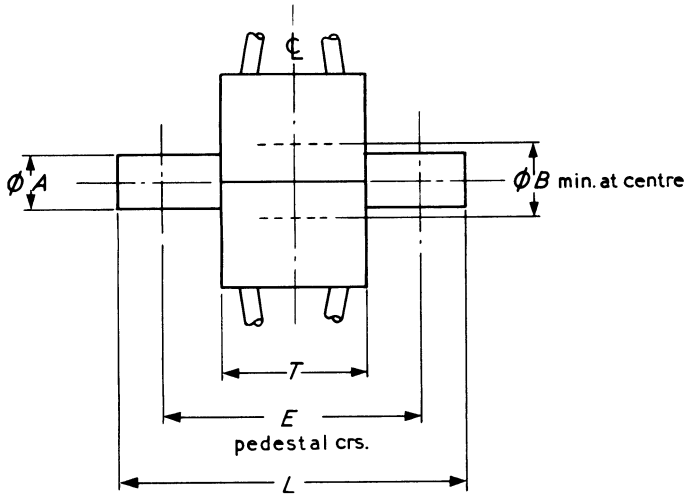


Figure 5 — Pulley 900 mm (3 ft) diameter (internal rolling bearings)



Dimensions	1		2	3	4	5	6
	Pulley diameter (mm)						
	900 (3 ft)	1 050 (3 ft 6 in)	1 200 (4 ft)	1 350 (4 ft 6in)	1 500 (5 ft)	1 800 (6 ft)	2 100 (7 ft)
A Diameter	100		120	130	135	150	155
B Minimum diameter	125		150	160	170	180	190
T	190		230	230	230	230	230
E	370		440	455	470	495	500
L	520		620	650	680	730	740

Figure 6 — Solid hub and shaft arrangement (internal rolling bearings)



Dimensions	1	2	3	4
	Pulley diameter (mm)			
	1 350 (4 ft 6in)	1 500 (5 ft)	1 800 (6 ft)	2 100 (7 ft)
A Diameter	130	135	150	155
B Minimum diameter	160	170	180	190
T	230	230	230	230
E	455	470	495	500
L	650	680	730	740

Figure 7 — Split hub and shaft arrangement (internal rolling bearings)

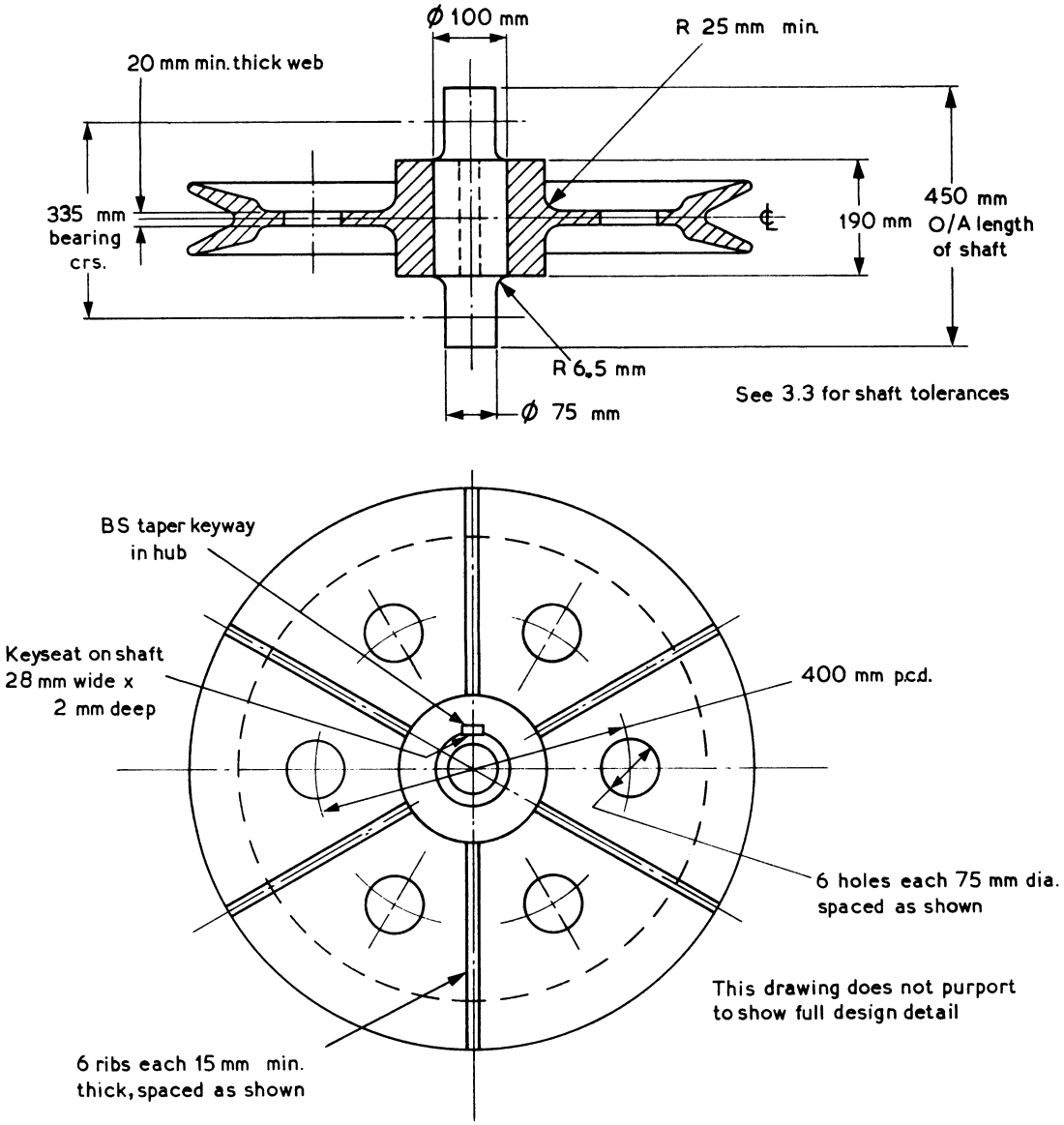


Figure 8 — Pulleys 600 mm (2 ft) diameter and 750 mm (2 ft 6 in) diameter (external plain bearings)

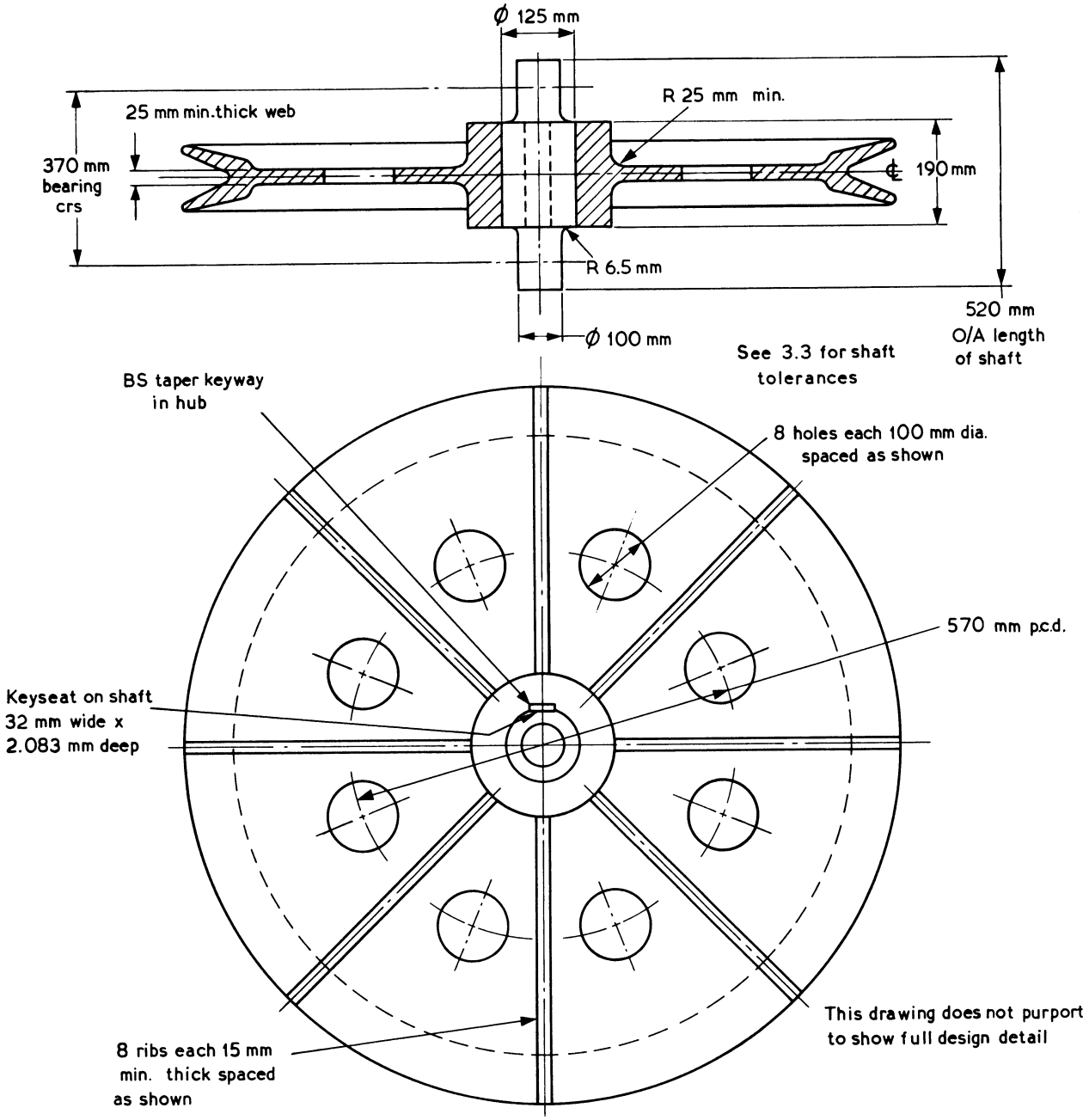
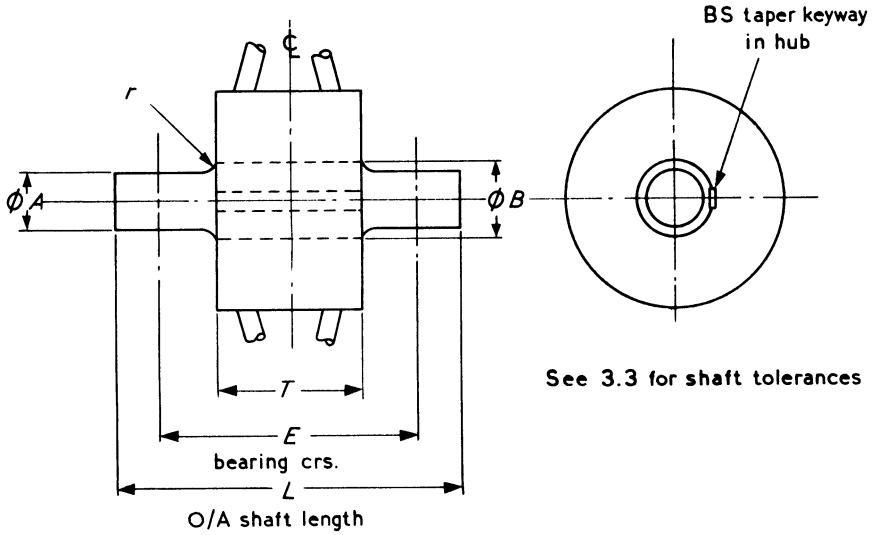
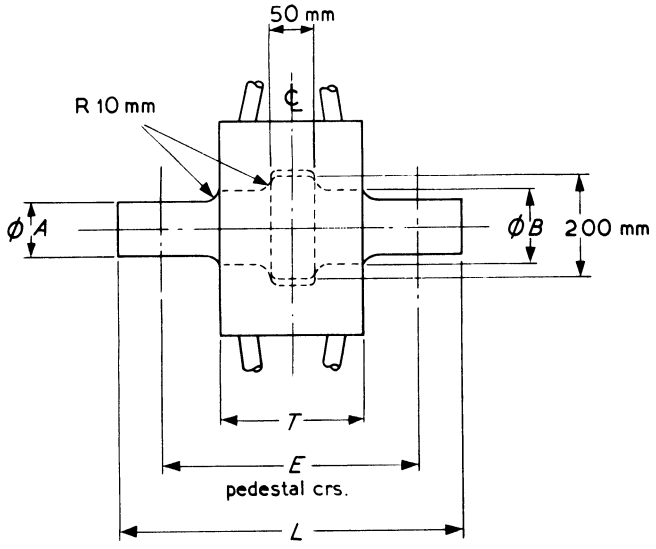


Figure 9 — Pulley 900 mm (3 ft) diameter (external plain bearings)



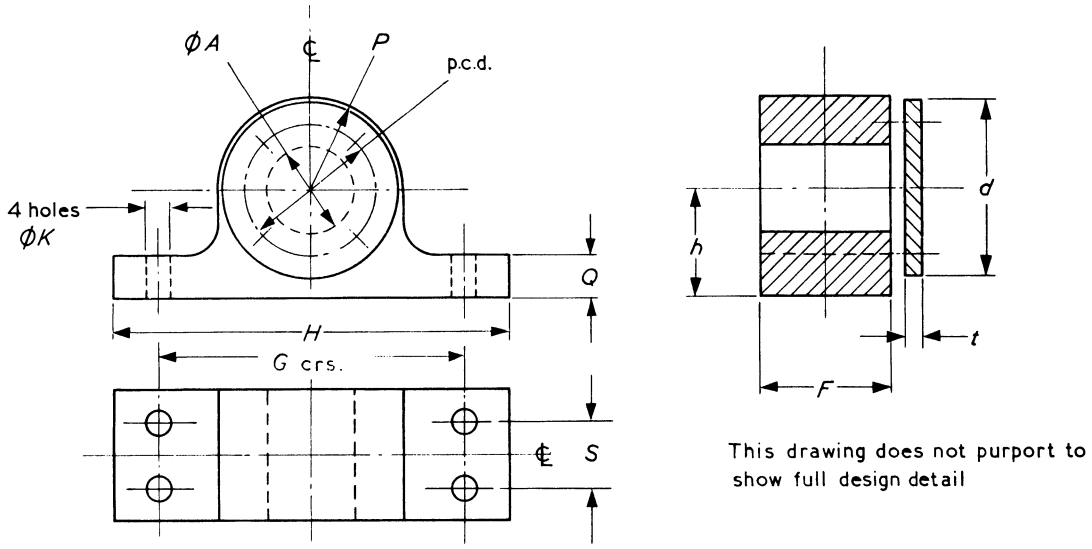
Dimensions	1	2	3
	Pulley diameter (mm)		
	900 (3 ft) 1 050 (3 ft 6 in)	1 200 (4 ft)	1 350 (4 ft 6 in)
A Diameter	100	120	130
B Diameter	125	150	160
T	190	230	230
E	370	440	455
L	520	620	650
R Radius	6.5	10	10
Width of keyseat on shaft	32	40	40
Depth of keyseat on shaft	2.083	2.716	2.540

Figure 10 — Solid hub and shaft arrangement (external plain bearings)



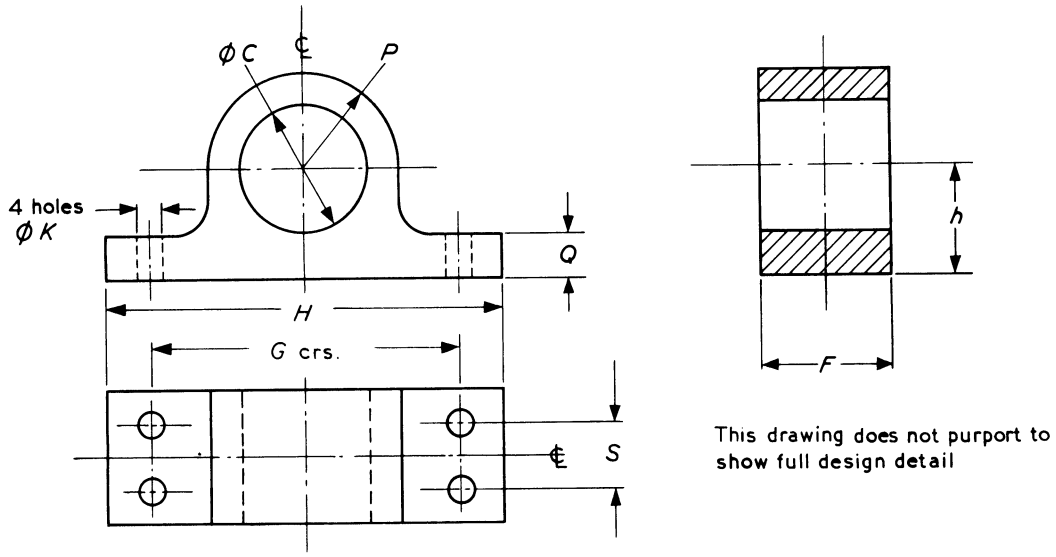
Dimensions	Pulley diameter (mm)
	1 350 (4 ft 6 in)
A Diameter	130
B Minimum diameter	160
T	230
E	455
L	650

Figure 11 — Split hub and shaft arrangement (external plain bearings)



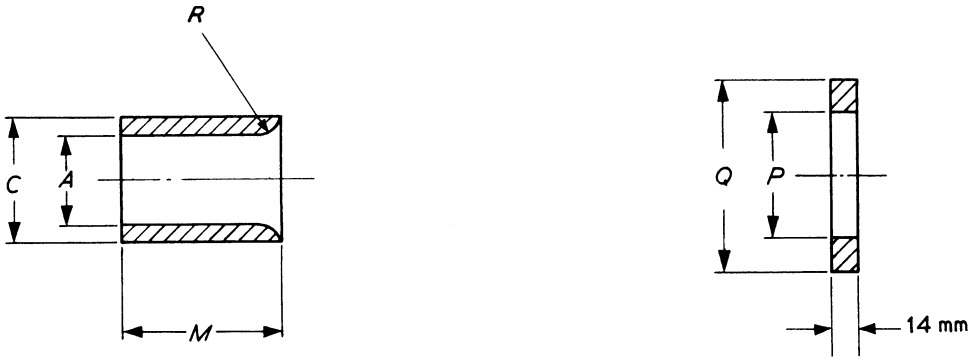
Dimensions		1		2		3	4	5	6	7
		Pulley diameter (mm)								
		600 (2 ft)	750 (2 ft 6 in)	900 (3 ft)	1 050 (3 ft 6 in)	1 200 (4 ft)	1 350 (4 ft 6 in)	1 500 (5 ft)	1 800 (6 ft)	2 100 (7 ft)
A Diameter		75		100		120	130	135	150	155
F		115		150		180	195	205	225	235
G		260		350		420	450	470	520	540
H		340		440		520	550	570	630	650
K		24		24		28	28	35	35	42
h		85		110		135	145	150	170	175
End cap	*t*	12		12		16	16	16	20	20
	d	140		190		230	250	260	290	300
	p.c.d.	125		160		190	200	210	220	230
Hexagon head setscrews to BS 3692 (guide 8.8)	Size	M12		M12		M12	M12	M12	M12	M12
	No required	4		4		4	4	6	6	6
P		75		100		120	130	135	150	155
Q		35		45		55	60	65	70	75
S		63.5		89		101.5	114	120.5	120.5	120.5

Figure 12 — Pedestal



Dimensions	1		2		3	4
	Pulley diameter (mm)					
	600 (2 ft)	750 (2 ft 6 in)	900 (3 ft)	1 050 (3 ft 6 in)	1 200 (4 ft)	1 350 (4 ft 6 in)
C Diameter	95		120		140	150
F	115		150		180	195
G	260		350		420	450
H	340		440		520	550
K	24		24		28	28
h	85		110		135	145
P	75		100		120	130
Q	35		45		55	60
S	63.5		89		101.5	114

Figure 13 — Bearing housing



Dimensions	1		2		3	4
	Pulley diameter (mm)					
	600 (2 ft)	750 (2 ft 6 in)	900 (3 ft)	1 050 (3 ft 6 in)	1 200 (4 ft)	1 350 (4 ft 6 in)
A Diameter	75		100		120	130
C Diameter	95		120		140	150
M	129		164		194	209
P Diameter	97		122		142	152
Q Diameter	140		185		215	235
R Radius	6.5		6.5		10	10

Figure 14 — Bush and thrust washer

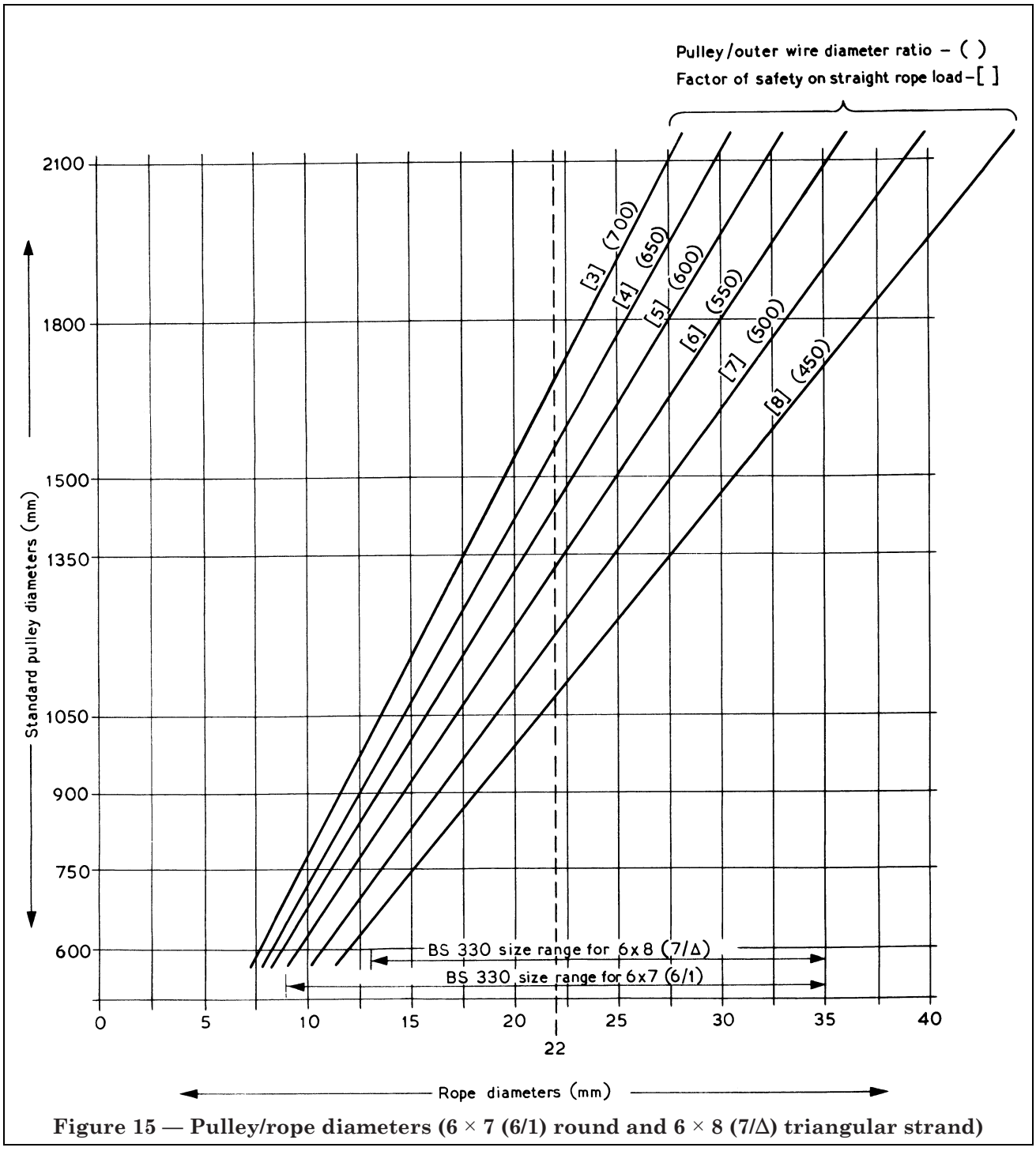


Figure 15 — Pulley/rope diameters (6 × 7 (6/1) round and 6 × 8 (7/Δ) triangular strand)

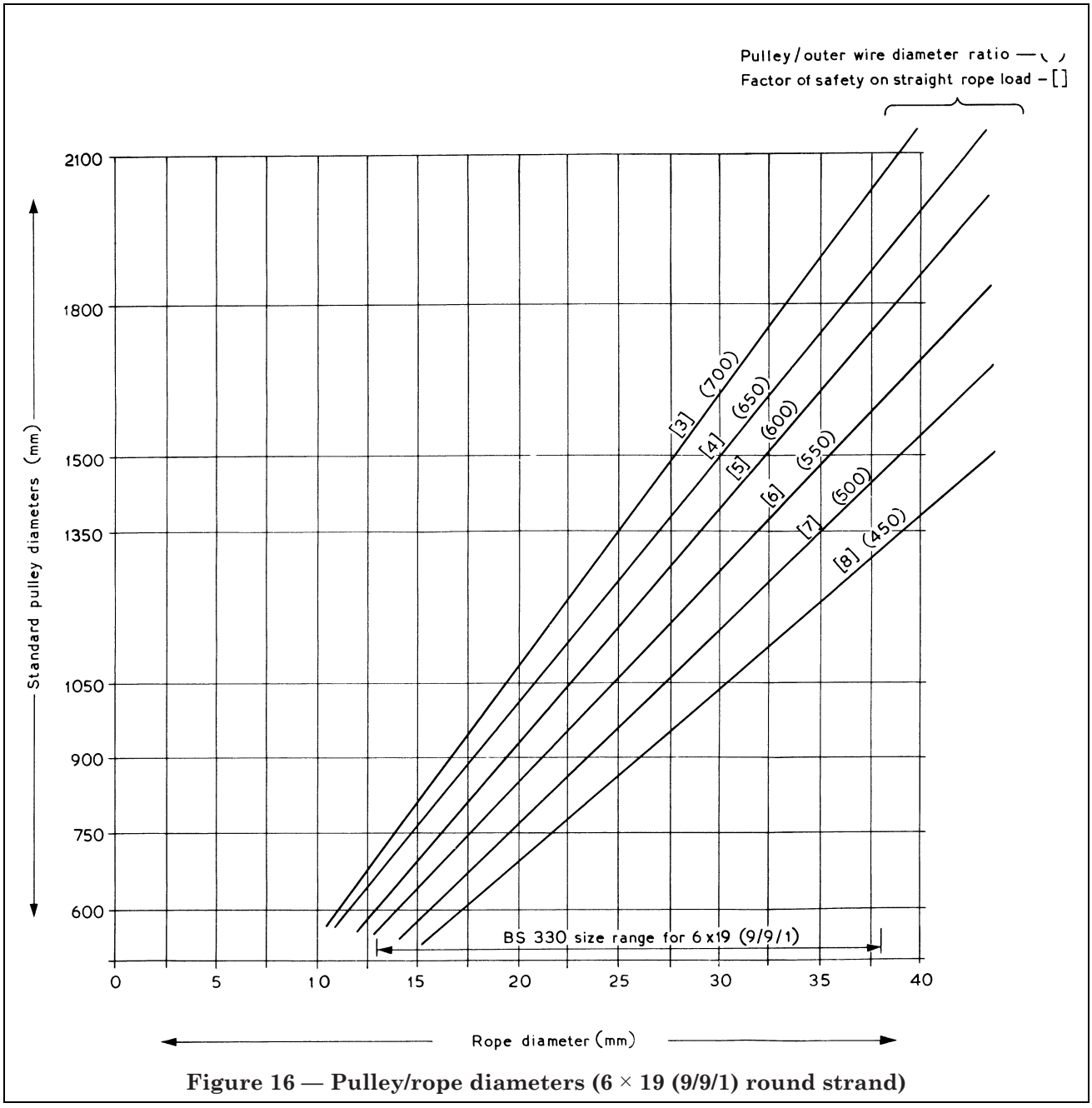


Figure 16 — Pulley/rope diameters (6 × 19 (9/9/1) round strand)

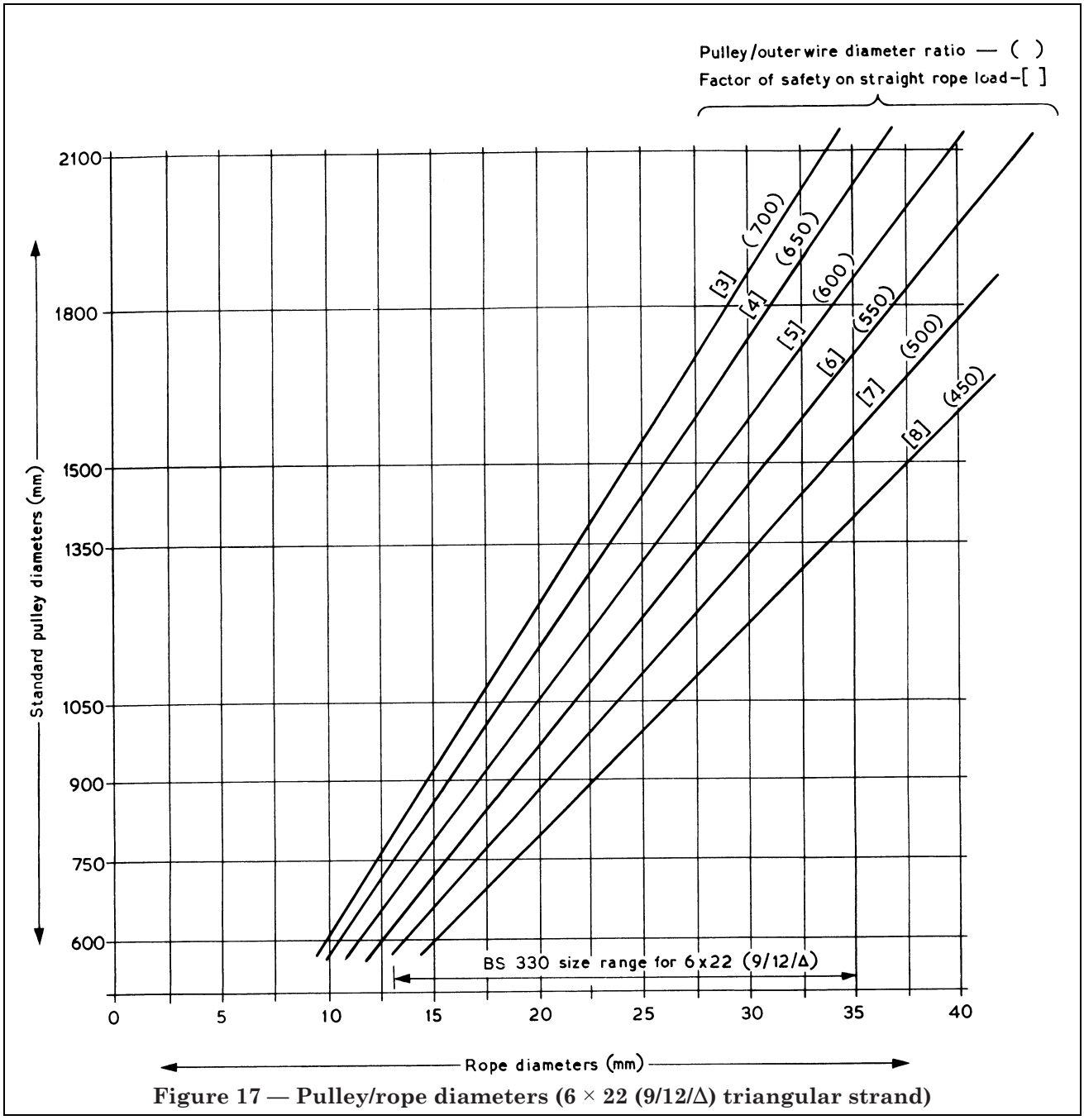


Figure 17 — Pulley/rope diameters (6 × 22 (9/12/Δ) triangular strand)

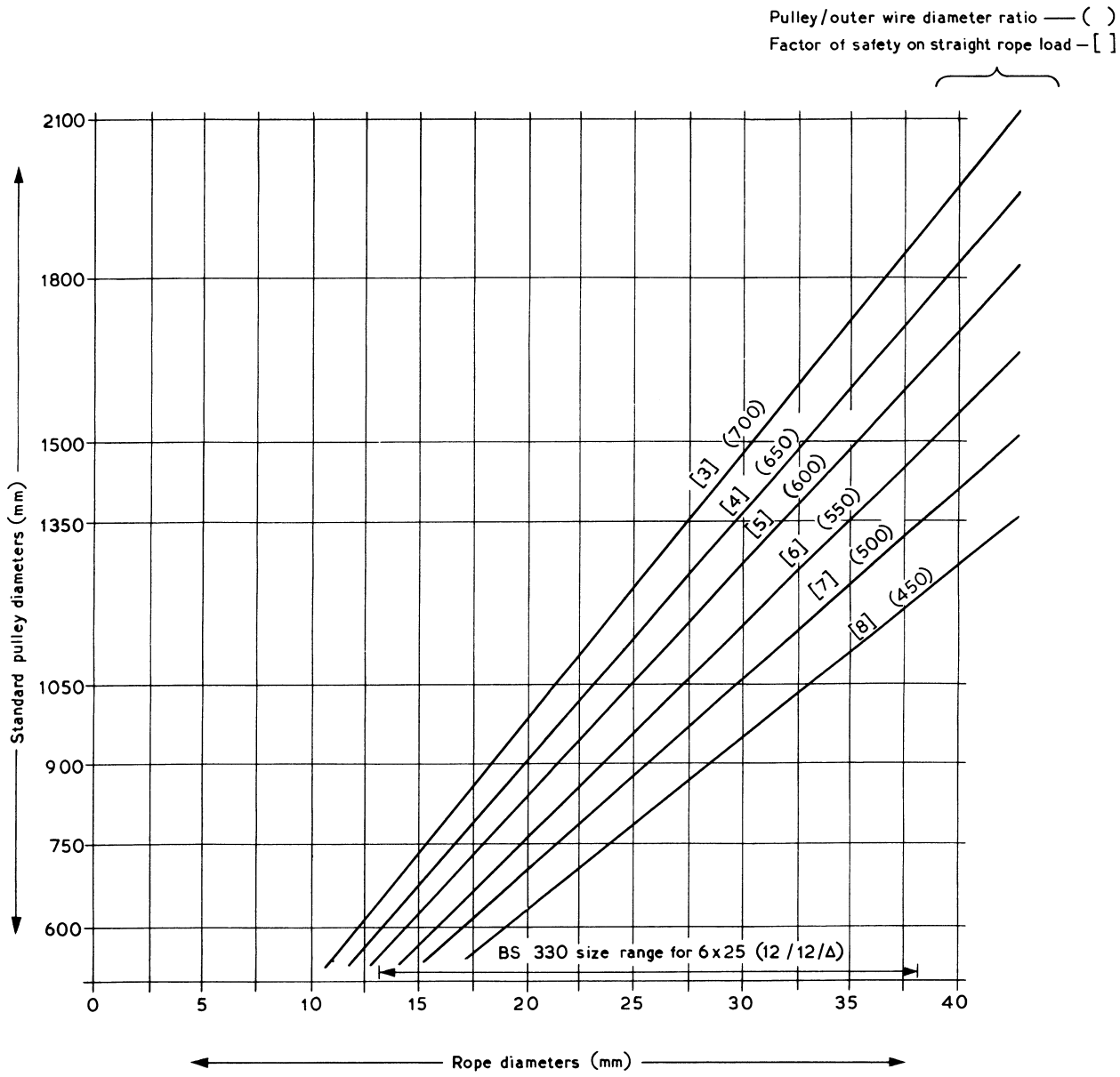


Figure 18 — Pulley/rope diameters (6 × 25 (12/12/Δ) triangular strand)

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Publications referred to

This standard makes reference to the following British Standards:
BS 292, *Dimensions of ball bearings and cylindrical roller bearings.*
BS 330, *Stranded wire ropes for haulage purposes.*
BS 592, *Carbon steel castings for general purposes (contained in BS 3100).*
BS 970, *Wrought steels in the form of blooms, billets, bars and forgings.*
BS 970-1, *Carbon and carbon manganese steels, including free cutting steels.*
BS 1134, *Method for the assessment of surface texture.*
BS 1400, *Schedule of copper alloy ingots and copper and copper alloy castings.*
BS 1452, *Grey iron castings.*
BS 1456, *1½ per cent manganese steel castings (contained in BS 3100).*
BS 2772, *Iron and steel for colliery haulage and winding equipment.*
BS 2789, *Iron castings with spheroidal or nodular graphite.*
BS 3643, *ISO metric screw threads.*
BS 3692, *ISO metric precision hexagon bolts, screws and nuts.*
BS 4235, *Metric keys and keyways.*
BS 4320, *Metal washers for general engineering purposes.*
BS 4360, *Weldable structural steels.*
BS 4500, *ISO limits and fits.*

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