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Specification for

Higher tensile steel shackles

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Foreword

This standard makes reference to the following British Standards:

BS 84, *Parallel screw threads of Whitworth form.*

BS 240, *Brinell hardness testing — Part 1: Method and tables for Brinell hardness testing.*

BS 350, *Conversion factors and tables.*

BS 860, *Tables of approximate comparison of hardness scales.*

BS 919, *Screw gauge limits and tolerances.*

BS 970, *Wrought steels.*

BS 1580, *Unified screw threads.*

BS 2772, *Iron and steel for Colliery Haulage and winding equipment — Part 2: wrought steels.*

This British Standard specifies steel shackles with a higher minimum tensile strength than the shackles specified in BS 825¹⁾.

The shackles specified are similar in design to those of BS 825, but the bodies and pins are stressed to higher values than those adopted for the mild steel shackles of BS 825, an increase of one-third being allowed for the dee and bow shackles and of one-sixth for the grab shackles.

The lower design stresses for the grab shackles have been adopted on account of the severity of the working conditions when operating grabs. These shackles are suitable for use with Bordeaux connections, BS 461²⁾.

The head of the grab shackle pin is required to be recessed by drilling a countersunk hole in it, in order to protect the outer end of the square recess from damage by repeated contact with a jib-head pulley, or with the bell-mouth of a grab. The screw thread is required not to project beyond the outer face of the shackle eye.

Steel to BS 970³⁾, Specification En. 14A has been specified for higher tensile steel shackles, on account of its high yield stress when in the normalized condition, in view of the importance of the shackle (and in particular of the shackle pin), being free from visible permanent deformation after the removal of the proof load. This ensures the satisfactory removal and replacement of the pin when in service. Steels to BS 970, En 5A and En 5B may not always be satisfactory when in the normalized condition, and for this reason these steels should be used in the hardened and tempered condition when specified as an alternative to En 14A. The heat treatment must result in a minimum tensile strength of 35 tons/sq. in. and a minimum yield stress of 21 tons/sq. in., as the design of the shackles is based on these values.

Attention is drawn to the fact that, owing to the higher safe working loads permitted for higher tensile steel shackles, as compared with those for mild steel shackles, the internal clearances in the shackle bodies will be smaller in terms of safe working load, W, than those in mild steel shackles to BS 825.

This is not necessarily a serious factor, since many other components of lifting gear are now being manufactured in higher tensile steel, and will similarly be of smaller proportions for a given safe working load.

It is emphasized that the term “British Standard Shackle” applies only to shackles of the dimensions, and within the range of sizes, laid down in the tables and figures of this standard.

¹⁾ BS 825, “Mild steel shackles.”

²⁾ BS 461, “Bordeaux connections.”

³⁾ BS 970, “Wrought steels.”

This standard does not include galvanized shackles such as those used for guys and standing rigging. Where shackles which conform to this standard are required to be galvanized, this should be arranged between the purchaser and the manufacturer at the time of the enquiry and order. The prescribed tolerances will apply *after* galvanizing, and it should be noted that the thread of the pin will be less resistant to corrosion than that on the remainder of the shackle because the coating will wear off in course of use.

Specimen shackles representative of the dee and bow types specified have been subjected to static proof loads (twice the safe working load) with satisfactory results.

The safe working loads given in the tables are for normal conditions of service: for specially hazardous conditions it is desirable that the safe working loads should be reduced.

The committee entrusted with the preparation of this standard desires to record its indebtedness to the Engineering Division of the National Physical Laboratory⁴⁾ for the theoretical investigations and experimental work involved in determining the proportions and appropriate safe working loads of the shackles specified.

Throughout this standard British weights and measures only are used; ton = 2 240 lb, cwt = 112 lb, dimensions in inches. (For corresponding metric equivalents, BS 350⁵⁾ should be consulted).

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 24 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.

⁴⁾ This Division was closed down in August 1951, and its functions transferred to the National Engineering Laboratory, East Kilbride, Glasgow.

⁵⁾ BS 350, "Conversion factors and tables."

Descriptive notes

Each of the five types specified in this standard is composed of a series of geometrically similar shackles, all the dimensions (with the exception of the pins in the smaller sizes, see Notes on Design) in each type being proportional to the square root of the safe working load.

Table A — Purposes for which the shackles are intended

Type of shackle	Purpose
Small Dee Table 1	A dee shackle which has moderate internal clearances in the body and jaw, but a safe working load higher than that of the Large Dee, Table 2, and which is suitable for use with hook eyes, eyebolts, egg links, wire rope thimbles, etc., and for the head fittings of ships' blocks (BS 408).
Large Dee Table 2	A dee shackle which has ample internal clearances in the body and jaw, and which is appropriate for general engineering purposes.
Large Bow Table 3	A bow shackle which has ample internal clearances in the body and jaw and which is appropriate for general engineering purposes.
Small Bow Table 4	A bow shackle which has moderate internal clearances in the body and jaw but a safe working load higher than that of the Large Bow, Table 3 and which is suitable for use with the eyes and bodies of hooks, eyebolts, egg links, wire rope thimbles, etc., and for the head fittings of ships' blocks (BS 408).
Grab Table 5	A dee shackle having a screwed countersunk pin with sunk square socket, designed for use with grabs, where the shackle must pass through a circular aperture of minimum diameter.

The proportions of the shackle in terms of the square root of the safe working load, W , in tons, are given in Table B, the dimensions being in inches.

The safe working load, W , in Table B applies to shackles conforming in all respects to this standard.

Table B — Proportions of shackles in terms of $\sqrt{W}$ square root of safe working load in tons

Particulars of dimensions		Type of shackle				
		Small dee Table 1	Large dee Table 2	Large bow Table 3	Small bow Table 4	Grab Table 5
Diameter of pin	D	0.51	0.56	0.56	0.55	0.52
Diameter of material in body	d	0.45	0.49	0.52	0.49	0.47
Inside width of jaw	w	0.69	0.95	0.95	0.89	0.56
Inside width of body	2r	0.69	0.95	1.39	1.18	0.56
Inside length	s	1.62	1.81	2.34	1.97	1.24
Measurement across eye	e	1.02	1.12	1.12	1.10	1.04

The proportions of the shackles in terms of the diameter (d) of the material in the body are given in Table C.

Table C — Proportions of shackles in terms of (d) body diameter

Particulars of dimensions		Type of shackle				
		Small dee Table 1	Large dee Table 2	Large bow Table 3	Small bow Table 4	Grab Table 5
Diameter of pin	D	1.14	1.13	1.08	1.11	1.12
Inside width of jaw	w	1.54	1.93	1.83	1.80	1.20
Inside width of body	2r	1.54	1.93	2.67	2.40	1.20
Inside length	s	3.60	3.68	4.50	4.00	2.67
^a Measurement across eye	e	2.28	2.26	2.16	2.22	2.24

^a Not less than 2D.

The proportions in Table B are also given at the head of each column in Table 1 to Table 5. The actual dimensions in Table 1 to Table 5 are to the nearest one-eighth or one-sixteenth of an inch, except in some of the smaller sizes (see Diagram 3), where practical considerations (e.g. imperfections, corrosion and abuse) necessitate a greater departure.

All the rated safe working loads are based upon the actual dimensions specified in Table 1 to Table 5.

Shackles of the proportions given in Table B and Table C will have safe working loads as given in Table D, in which the dimensions of (d) and (D) are in inches, and the safe working loads are in tons. (Table D does not take into account the pin corrections called for in Diagram 3).

Table D — Safe working loads (W) in tons of the shackles in terms of (d) body diameter and (D) pin diameter

Small dee Table 1	Large dee Table 2	Large bow Table 3	Small bow Table 4	Grab Table 5
$4.95 d^2$	$4.12 d^2$	$3.69 d^2$	$4.11 d^2$	$4.61 d^2$
$3.78 D^2$	$3.24 D^2$	$3.19 D^2$	$3.33 D^2$	$3.72 D^2$

The approximate weights of shackles are given in Table E.

The coefficients are based on the proportions given in Table B and Table C, and the rounding off of these proportions to appropriate fractions of an inch, together with the allowable manufacturing tolerances, will tend to increase the weight of the shackles, these estimated weights should therefore be treated as minimum values.

Table E — Approximate weights of shackles

Type of pin	Type of shackle				
	Small dee Table 1	Large dee Table 2	Large bow Table 3	Small bow Table 4	Grab Table 5
	lb	lb	lb	lb	lb
<i>Type A.</i> Screwed pin with eye and collar	$5.08 d^3$	$5.11 d^3$	$5.34 d^3$	$5.19 d^3$	$4.33 d^3$
<i>Type B.</i> Screwed pin with eye and collar	$4.90 d^3$	$4.94 d^3$	$5.19 d^3$	$5.03 d^3$	$4.16 d^3$
<i>Type C.</i> Countersunk screwed pin with slotted head	$4.64 d^3$	$4.70 d^3$	$4.98 d^3$	$4.81 d^3$	$3.93 d^3$
<i>Type D.</i> Countersunk screwed pin with sunk square socket	$4.66 d^3$	$4.72 d^3$	$4.99 d^3$	$4.82 d^3$	$3.95 d^3$
<i>Type E.</i> Bolt with hexagon head, hexagon nut and split cotter pin	$5.85 d^3$	$5.81 d^3$	$5.97 d^3$	$5.86 d^3$	$5.03 d^3$
<i>Type F.</i> Plain cylindrical pin with circular head and forelock	$5.18 d^3$	$5.20 d^3$	$5.42 d^3$	$5.28 d^3$	$4.42 d^3$
NOTE 1 Types B, C and D are limited to pins not exceeding 2½ in. diameter.					
NOTE 2 Type E is normally limited to pins not exceeding 3½ in. diameter.					
NOTE 3 Types A and F are suitable for all sizes of pin without restriction as to diameter.					

1 Types of shackles

The shackles shall be one of the following types as specified by the purchaser.

- Small dee shackle (Table 1). Large dee shackle (Table 2).
- Large bow shackle (Table 3). Small bow shackle (Table 4).
- Grab shackle (Table 5).

The shackles shall be supplied assembled with one of the following pins.

- Type A. Screwed pin with eye and collar (Figure 6).
- Type B. Screwed pin with eye and collar (Figure 7).
- Type C. Countersunk screwed pin with slotted head (Figure 8).
- Type D. Countersunk screwed pin with sunk square socket (Figure 9).⁶⁾
- Type E. Bolt with hexagon head, hexagon nut and split cotter pin (Figure 10).
- Type F. Plain cylindrical pin with circular head and forelock (Figure 11).

2 Material

The bodies and pins of the shackles shall be made from steel conforming to the requirements of BS 970, ⁷⁾specification En 5A, En 5B or En 14A; or, at the purchaser's request, from "25/30" carbon steel or 1.5 per cent manganese steel conforming to the requirements of BS 2772-2⁸⁾.

It shall be the responsibility of the manufacturer of the shackles to ensure that suitable heat treatment is given to the shackle (see foreword and clause 8).

When analysis of the steel in the shackle is required by the purchaser, he shall state so at the time of the enquiry and order.

3 Hardness test

The bodies and pins of the shackles shall have a maximum Brinell hardness number of 217.

Where practicable, the test shall be made in accordance with BS 240-1⁹⁾, using a 10 mm diameter ball, and a load of 3 000 kg.

Suitable precautions should be taken to ensure that the surface tested is representative of the material, and that its hardness is not affected by decarburization, carburization, or by the method used for its preparation.

If another method is employed, conversion shall be made in accordance with BS 860¹⁰⁾.

4 Nominal size

The nominal size of the shackle shall be the diameter of the material from which the shackle is made (dimension d, Table 1 to Table 5).

5 Form and dimensions

The form and dimensions of the shackles and pins shall be in accordance with Figure 1 to Figure 11 and Table 1 to Table 5.

6 Tolerance on dimensions

The dimensions of the shackles (with the exception of the pins and the pin holes) shall be not less than the dimensions given in Table 1 to Table 5, and shall not exceed them by more than 5 per cent, subject to the dimensions affecting diameter, Q, Table 5, being limited to a plus tolerance of 2½ per cent.

⁶⁾ Grab shackles normally have type D pin.

⁷⁾ BS 970, "Wrought steels."

⁸⁾ BS 2772, "Iron and steel for colliery haulage and winding equipment — Part 2: wrought steels."

⁹⁾ BS 240, "Methods and tests for Brinell hardness testing."

¹⁰⁾ BS 860, "Table of approximate comparison of hardness scales."

The diameters of the pins (Table 1 to Table 5, dimension D) are subject to the following tolerances:

Up to and including 2 in. diameter	– 0.003	– 0.010 in.
Over 2 in. diameter	– 0.005	– 0.020 in.

The diameters of the pin holes in the bodies of the shackles (dimension D) are subject to the following tolerances:

Up to and including $\frac{3}{4}$ in.	+ $\frac{1}{32}$ in.	– 0 in.
$\frac{7}{8}$ in., up to and including 1 $\frac{3}{4}$ in.	+ $\frac{3}{64}$ in.	– 0 in.
Over 1 $\frac{3}{4}$ in.	+ $\frac{1}{16}$ in.	– 0 in.

When the pins are screwed home, not more than one half thread shall be visible between the jaws of the shackle.

7 Workmanship

The pins shall be forged and machined, or machined from the bar. The screwed portion of the pin shall be concentric with the plain portion of the body of the pin.

The bodies of the shackles shall be solid forgings without weld. Pin or bolt holes in the bodies shall be drilled from the solid, or hot pierced to two-thirds finished size, and in all cases drilled or bored in axial alignment at one setting central to the outside diameter of the eyes.

8 Heat treatment

All bodies and pins of shackles shall be subjected to one of the following heat treatments:

- Normalizing by heating to a temperature within 50 degC. above the upper critical point of the steel used, followed by cooling in still air.
- Heating to a temperature within 50 degC. above the upper critical point of the steel used, followed by quenching in oil or water and tempering at a temperature between 550 °C. and 660 °C.

Details of the heat treatment which has been given to the shackles by the manufacturer shall be stated on the maker's test certificate or Docks Regulations Prescribed Form 86. (Clause 18 and Appendix A).

9 Bolts and nuts

The length of the plain portion of the bolt shall be such that the nut will jam on the inner end of the thread and not on the eye of the shackle. When in this position, the nut and bolt shall be cross drilled for the split cotter pin.

10 Screw threads

The screw threads shall conform either to BS 84¹¹⁾, or, preferably, to BS 1580¹²⁾.

Screw threads to BS 84 shall be of the Free Class and Normal Class, and shall be either B.S.W., B.S.F., Whit.S. or Whit.

Screw threads to BS 1580, shall be of Classes 1A and 1B, and shall be either UNC, UNF, UNS or UN.

It is recommended that the screw threads be gauged with an appropriate gauge constructed in conformity with the specifications in BS 919¹³⁾.

11 Quality marking

Each shackle shall be legibly marked with the symbol “04” when in the hardened and tempered condition, and with the symbol “4” when normalized.

The mark shall be enclosed in a circle. (For size and position of mark, see clause 17).

¹¹⁾ BS 84, “Parallel screw threads of Whitworth form.”

¹²⁾ BS 1580, “Unified screw threads.”

¹³⁾ BS 919, “Screw gauge limits and tolerances.”