

CONFIRMED
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Specification for

Alloy steel chain slings

Co-operating organizations

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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Air Ministry	High Commission of India
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Association of Consulting Engineers (Incorporated)	Institute of Petroleum
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Electricity Council, The Generating Board and the Area Boards in England and Wales	Ministry of Transport
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	National Physical Laboratory (D.S.I.R.)*
	Radio Industry Council
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The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the Committee entrusted with the preparation of this standard:

Association of Crane Makers	Institute of Welding
Association of Lifting Tackle Makers	Lloyd's Register of Shipping
British Constructional Steelwork Association	Machine-made Chain Manufacturers' Association
Chain & Anchor Manufacturers' Association	Ministry of Aviation
Chain Testers Association of Great Britain	National Association of Drop Forgers and Stampers
Dock & Harbour Authorities Association	Individual Manufacturers
Federation of Civil Engineering Contractors	
Federation of Wire Rope Manufacturers of Great Britain	

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Foreword

This standard makes reference to the following British Standards:

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

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

BS 970, *Wrought steels. En series*.

BS 1610, *Verification of testing machines*.

BS 1718, *Tolerances for steel drop forgings and upset forgings*.

BS 3113, *Alloy steel chain grade 60. Short link for lifting purposes*.

This British Standard provides for alloy steel chain slings made from alloy steel chain to BS 3113¹⁾, having safe working loads 50 per cent higher than those specified for higher tensile steel chain slings to BS 2902.²⁾ The same range of sizes has been included.

Single, two-leg, three-leg and four-leg slings are specified, and are assembled with hooks and rings, or with hooks and links alternative to rings. The substitution of a link for a ring is justified in the larger sizes by the proportionate reduction in weight. Reeveable and non-reeveable collar slings are also specified.

In terms of safe working load, the internal diameters of the rings, or the internal lengths of the links alternative to rings, are closely related to those of the preferred rings for higher tensile steel chain slings (see Appendix D of that standard). This is to permit the use of slings with the normal range of crane hooks. The dimensions of these terminal components, diameter D , or length L , have been based on the curve in Figure 1.

The bed diameter C of the trapezoidal section eye hooks (Table 7) has been made equal to $1.30\sqrt{W}$, inches, where W is the safe working load of the hook in tons. This ratio of C to $\sqrt{W}$ is the same as that adopted for the trapezoidal section crane hooks in Table 1 of BS 2903³⁾.

The sling components are proportioned to the size d_c of the corresponding chain, and these proportions are given to two places of decimals at the head of each column in the tables.

Terminal rings and links alternative to rings have been designed for use with more than one size or type of sling. This departs from the system of geometrical similarity which has hitherto formed the basis of nearly all British Standards for lifting components. It results in some of the rings and links being stronger than actually required, but it does reduce considerably the number of different ring or link sizes required for the sling assemblies, and it will effect an appreciable economy in the cost of dies when rings or links are drop forged. It will also reduce the number of different sizes which has to be stocked by the manufacturer or supplier.

Components outside the range of sizes in this standard may be designed from the information given in "Notes on Design" and used in special British Standard sling assemblies. These components must, however, comply in all respects except dimensions with the requirements of the standard, and with the formulae and limiting design stresses.

The Committee entrusted with the preparation of the standard desires to record its indebtedness to the Department of Scientific and Industrial Research for help in the theoretical and experimental investigations on which this standard is based.

¹⁾ BS 3113, "Alloy steel chain, grade 60. Short link for lifting purposes".

²⁾ BS 2902, "Higher tensile steel chain slings and rings, links alternative to rings, egg links and intermediate links".

³⁾ BS 2903, "Higher tensile steel hooks for chains, slings, blocks and general engineering purposes".

Throughout this standard British weights and measures only are used: ton, 2 240 lb; hundredweight, 112 lb; dimensions in inches. (For corresponding metric equivalents, see BS 350, "Conversion factors and tables").

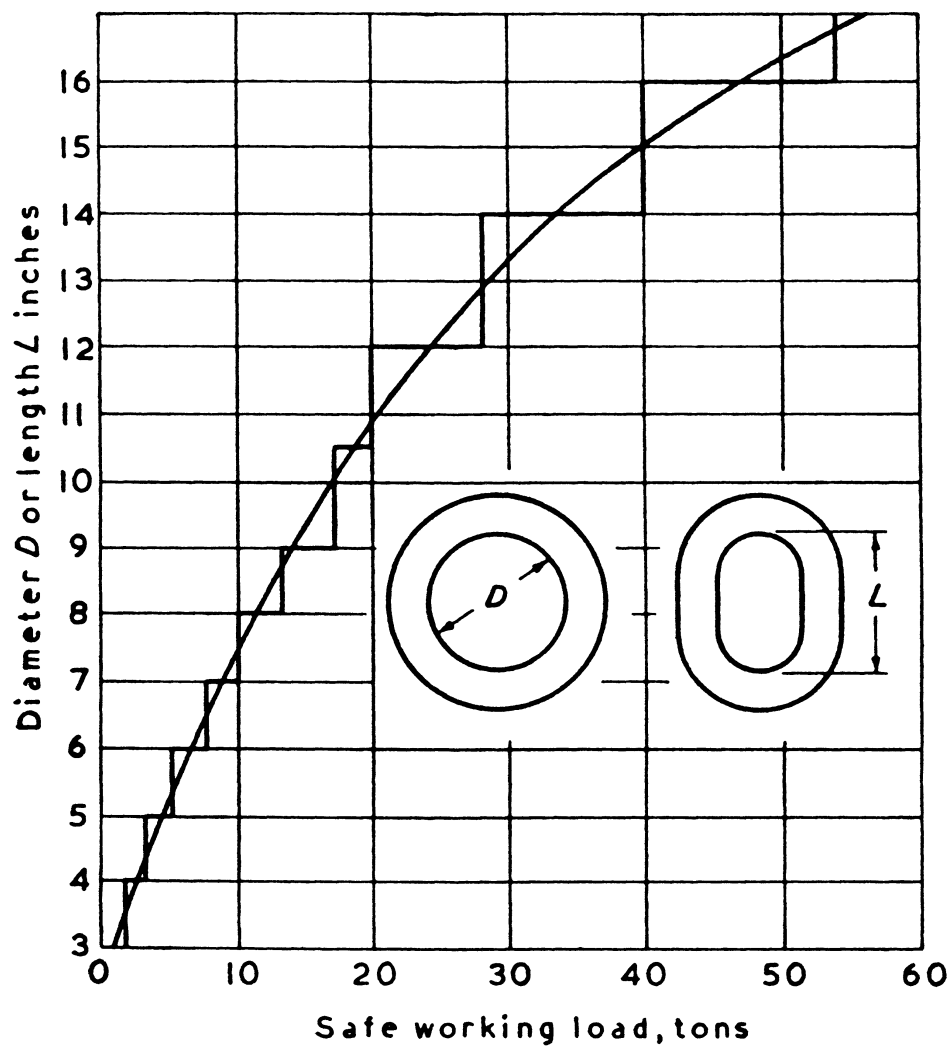


Figure 1

Notes on design

The design of all standard components is based on the extreme fibre (tensile) stress under proof load. The limiting stress value is the same throughout the whole range of any one type of component. The limiting stress value, however, differs from component to component, being greatest for the chain, least for rings and links alternative to rings, and of intermediate values for the various joining links.

This system has been adopted not from any consideration of allowable working stresses, but because the deformations of the terminal components under proof load might otherwise have been too great. The system does, however, ensure that when the sling is overloaded, the extension of the common links of the chain should afford ample warning before there is any risk of failure of the other components.

The application to curved beams of the theory of elasticity leads to expressions for the strength of rings and links which are too complicated for normal use⁴, the following simple formula, developed by the National Physical Laboratory gives sufficiently close approximations to the exact values.

$$W = \left(\frac{0.224 f d^3}{B + 0.4d} \right) \left(1.75 + \frac{B + d}{L + d} \right)$$

for values of L greater than $2.55d$

where:

- W = proof load, tons.
- d = nominal diameter of material from which the component is made, inches.
- L = internal length of link, inches.
- B = internal breadth of link, inches. (For egg links, use the value at the large end).
- f = nominal extreme fibre (tensile) stress at proof load, ton/sq in.
 - = 48 ton/sq in for rings or straight sided terminal links alternative to rings, or alternative to egg links.
 - = 60 ton/sq in for egg links, or straight sided links when used as intermediate components.
 - = 72 ton/sq in for intermediate links.
 - = 85.7 ton/sq in for short link chain.

The tensile stress f to which this formula relates is that set up in the extreme fibres at the extrados in the line of the load. When L is less than $2.55d$, the tensile stress in the extreme fibres at the intrados at the ends of the straight sides of a link is greater than that in the extreme fibres at the extrados in the line of the load, and the proof load must be correspondingly reduced. This is effected by multiplying the formula for W by the reduction factor $0.22 (2 + L/d)$.

⁴ See *Design of crane hooks and other components of lifting gear* by H. J. Gough, H. L. Cox and D. G. Sopwith. Proc. Inst. Mech. Engrs., 1934, **128**, page 253.

For rings, $L = B = D$, where D is the internal diameter, and the basic formula reduces to:

$$W = \frac{0.616 f d^3}{D + 0.4d} = \frac{29.6d^3}{D + 0.4d}$$

This formula again is restricted to values of D/d greater than 2.55. If D/d is less than 2.55, the maximum tensile stress occurs in the extreme fibres at the intrados at the section of the ring midway between the two loading points, and the value of W must be multiplied by the reduction factor $0.22 (2 + D/d)$. (For all the rings in this standard the ratio of D/d is greater than 2.55).

The errors involved by the use of the formulae are negligible in practice (less than 4 per cent in the worst case and in general less than 2 per cent). The formulae are to be used for the design of special components complying with this standard but not with the tables of dimensions (see foreword).

The proof load values given in the tables do not agree exactly with those given by the above formulae. In the case of Table 1 and Table 2, this is due to the fact that a given ring (or link alternative to ring) is utilized for more than one size and type of sling, and similarly, in Table 5, some of the egg links serve more than one type of sling. In the case of the remaining links, there will be small discrepancies owing to rounding-up to the nearest fraction of an inch.

The specified hooks comprise a geometrically similar series, designed to induce an equal stress at the intrados of the principal section (i.e. at the inside of the mid-section at the back of the hook) under the rated working load. The internal diameter C (inches.) and the safe working load W (tons) are related by the formula $C = 1.30 \sqrt{W}$.

The trapezoidal cross section specified is the closest practical approximation to the theoretical optimum triangular section. The principal cross section (at the back of the hook) and the vertical cross section (at the bottom of the hook) are equal and similar in form, with the exception of the crown radius at the vertical cross section, which is somewhat smaller to accommodate links or other similar components used for coupling up to the hook. The maximum cross section is situated midway between the principal and vertical cross sections and is 8 per cent to 10 per cent greater in depth. This increased depth at the maximum cross section adds greatly to the stability of the hook after appreciable deformation has taken place.

Cases may arise where a hook is required with an internal diameter C , differing from $C = 1.30 \sqrt{W}$; for this standard hook $C/H = 1.29$. Other hooks can be designed within the range $C/H = 0.7$ to $C/H = 2.2$, to give a stress rating similar to that of the standard hooks, provided that the following rules and approximate formula are observed:

The section must be geometrically similar to the specified hook section.

The depth of the principal cross-section (at the back of the hook) and of the vertical cross-section (at the bottom of the hook) shall be equal. The depth of the section mid-way between the principal and vertical sections must exceed that of the principal and vertical sections by not less than 8 per cent.

$$H \text{ must equal } 0.883 \sqrt{W + 0.10 C}$$

where:

H = depth at principal cross-section (in).

C = internal diameter of hook (in).

W = safe working load (tons).

All other proportions of the hooks, and the requirements of the standard (other than dimensions) must be met.

ERRATUM

Single, Two-leg, Three-leg and Four-leg slings.

In the figures, the egg links should be omitted from the hook end.

Three-leg and Four-leg slings.

In the figures, the hooks should face outwards.

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 vi, pages 1 to 32 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.

1 Scope

This British Standard specifies materials and tests for alloy steel chain slings, rings, links alternative to rings, egg links, intermediate links and trapezoidal section eye-hooks.

It also specifies dimensions for a series of slings ranging in size from $\frac{1}{4}$ in to $1\frac{1}{2}$ in.

2 Definitions

For the purposes of this standard the following definitions apply.

British Standard sling

a sling complying with this standard and with one of the sets of dimensions in the tables

special sling to British Standard 3458

a sling designed according to the principles described in “Notes on design”, and complying with the standard except in the matter of tabulated dimensions

The above definitions also apply if “sling assembly” or “sling component” is substituted for “sling”.

3 Designation of size and length

The size of a sling is the size of the chain in the sling, as designated in BS 3113⁵⁾.

The length of a sling is the effective length from the inside of the ring or link at one end to the inside of the hook or link at the other end.

4 Material

The rings, links alternative to rings, egg links, intermediate links and hooks shall be manufactured from steel produced by the electric or open hearth process, complying with the following composition:

Element	min.	max.
	per cent	per cent
Carbon	0.18	0.23
Silicon	0.15	0.35
Manganese	0.70	1.00
Nickel	0.40	0.70
Chromium	0.40	0.70
Molybdenum	0.15	0.25
Sulphur	—	0.05
Phosphorus	—	0.05

For comments on the material, see Appendix A.

The steel used for the chain shall be as specified in BS 3113⁶⁾.

If the purchaser requires chemical analysis of the material or tests of the finished rings, links or hooks, these requirements shall be clearly stipulated in the enquiry and order, and if so desired, the samples shall be selected by a person representing or approved by the purchaser.

5 Form and dimensions

Special slings and components shall be designed in accordance with the formulae and stress values in the section entitled “Notes on design”.

⁵⁾ BS 3113, “Alloy steel chain, grade 60, short link for lifting purposes”.

⁶⁾ BS 3113, “Alloy steel chain, Grade 60”.

Slings and components of tabulated dimensions shall comply with the following tables as appropriate:

Component	Table
Ring	Table 1
Link alternative to ring	Table 2
Reevable egg link	Table 3
Non-reevable egg link	Table 4
Egg link	Table 5
Intermediate link	Table 6
Hook	Table 7
Single sling	Table 8
Two-leg sling	Table 9
Three-leg sling	Table 10
Four-leg sling	Table 11
Reevable collar sling	Table 12
Non-reevable collar sling	Table 13

6 Permissible variations in dimensions

The actual diameter of the material in a finished ring, link alternative to ring, egg link or intermediate link shall be not less than the nominal diameter and shall not exceed the nominal diameter by more than the following amounts:

Diameter of material	Permissible oversize
in	in
Up to and including 1	$\frac{1}{32}$
Over 1, up to and including $1\frac{1}{2}$	$\frac{1}{16}$
Over $1\frac{1}{2}$, up to and including 2	$\frac{1}{8}$
Over 2	$\frac{3}{16}$

The above tolerances are subject to free articulation between the components.

The internal length and breadth of egg links, Table 3, Table 4 and Table 5 (dimensions L , B , and B_1 ; links alternative to rings, Table 2; and intermediate links, Table 6 (dimensions L and B), shall not vary from the dimensions given by more than plus or minus 5 per cent.

The internal diameter of rings, Table 1 (dimension D) shall not vary from the nominal diameter by more than plus $2\frac{1}{2}$ per cent or minus 5 per cent.

The limit on ovality of any ring shall be such that the maximum internal diameter shall not exceed the minimum internal diameter by more than $2\frac{1}{2}$ % per cent.

The tolerances on drop forged rings or links shall be the relevant DF tolerances specified in BS 1718.⁷⁾ The “close” thickness tolerances included in Table DF1 of that standard shall not apply.

The tolerances on drop forged hooks shall be the same as those specified above for drop forged rings and links.

The tolerances on hand forged hooks shall be:

- on the radius Z , plus $33\frac{1}{3}$ per cent, minus 0 per cent.
- on dimension C , plus $2\frac{1}{2}$ per cent, minus 5 per cent.
- on all other dimensions, plus $7\frac{1}{2}$ per cent, minus 0 per cent.

⁷⁾ BS 1718, “Tolerances for steel drop forgings and upset forgings”.

7 Workmanship

The rings, links alternative to rings, egg links and intermediate links shall be produced by one of the following manufacturing processes:

Drop forging.

Rolling.

Welding.

Welded rings and links shall be made by one of the following methods:

Electric pressure butt welding.

Electric flash butt welding.

Atomic hydrogen welding.

Inert gas shielded arc welding.

Submerged arc welding.

Metallic arc covered electrode welding.

It shall be the responsibility of the manufacturer to select from the list above a method suitable to the size of material to be joined. It shall also be the responsibility of the manufacturer to ensure that the method of welding is suitable to the material, and that the technique is kept under adequate control. The weld shall be smoothly finished all round and care shall be taken to avoid unsoundness and to ensure adequate penetration and fusion throughout the section.

The weld in any ring, link alternative to ring, egg link or intermediate link may be subjected to radiographic examination. If the radiograph should reveal any sign of porosity, blow holes, lack of fusion and penetration or any other defect, the manufacturer shall satisfy the purchaser that the strength of the component is not significantly impaired (see Appendix B).

The hooks shall be free from patent defects and shall be cleanly forged in such a manner that the macroscopic flow lines follow the body outline of the hook.

8 Heat treatment

With the exception mentioned below, all chain sling components shall, before proof loading, be heat treated by quenching from 850/890 °C in cold water, followed by tempering at a temperature between 500 and 600 °C, followed by cooling in air, oil or water.

This requirement does not preclude an alternative heat treatment for inserted links which will ensure that they are in a uniform condition with the other links of the slings.

9 Quality marking

Each upper terminal component of a sling assembly shall be legibly marked on a non-vital part with the mark "06" enclosed in a circle.

Care shall be taken that the indentation is neither too sharp nor too deep, and that in the case of a circular cross-section, the stamps used have a concave surface. (For recommended sizes of figures, see clause 15).

10 Testing machine

The testing machine shall be of an approved type complying with the requirements specified in Appendix C. A signed certificate of the latest examination shall be prominently displayed adjacent to the machine.

The testing machine shall be balanced in the presence of the inspector before the tests are made.

11 Proof loading

Each complete sling shall be tested in such a manner that the chain, rings, links and hooks are subjected to the specified proof loads, (see notes on design, or Table 8 to Table 13).

Each complete leg and each end fitting may be subjected separately to its appropriate proof load, or the whole sling may be subjected to proof load in one test. If the latter method is used, care must be exercised to ensure that the legs of the sling share the load equally.

Care shall be taken that all chain shall be placed in the testing machine without twist.

Prior to the application of the proof load, each ring or link alternative to ring shall bear centre punch marks defining the mean diameter or breadth.

In the case of a ring, if welded, the centre punch marks shall be at sections at right angles to the weld, and when proof loading, the weld shall be at the point of application of the load. The distance between the centre punch mark shall be measured before application of the proof load and after its removal. The difference between the two measurements shall not exceed one per cent of the original distance.

Similarly, each hook shall bear a centre punch mark at position b from which a scribed line shall be trammelled to position a (see Figure 2). After removal of the proof load, a second line a_1 shall be scribed with the trammel unaltered, and the distance (if any) between the two scribed lines shall not exceed $\frac{1}{4}$ of 1 per cent of the trammelled distance $a b$.

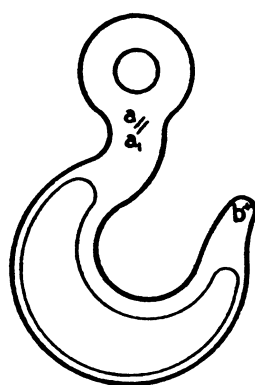


Figure 2

Diagram showing points a and b between which the hook shall be measured before proof loading, and points a and a_1 for ascertaining the amount of permanent set (if any), see Clause 11.

After the determination of the permanent set (if any), each sling, ring, link or hook, shall be carefully examined by a competent person and shall be deemed to comply with the standard if no flaw or defect is found.

12 Additional tests on hooks

a) *Hardness*: The hooks shall have a Brinell Hardness number between 223 and 277.⁸⁾

Where practicable, the hardness testing shall be carried out in accordance with BS 240-1⁹⁾, using a 10 mm 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 860.¹⁰⁾

b) *Destruction Test*: If required by the purchaser in the enquiry and order, a sample hook shall be selected by the representative of the purchaser and opened out by the application of a test load.

The hook shall, at any load less than five times the rated safe working load, neither fracture nor so distort as to be incapable of retaining the load.

13 Testing facilities

The manufacturer shall at his own cost supply the necessary labour and appliances required by this standard. In the absence of facilities at his own works for proof loading, the manufacturer shall bear the cost of proof loading at a public test house.

⁸⁾ This corresponds to BS 970, "Wrought Steels", condition "S".

⁹⁾ BS 240, "Brinell Hardness Testing", Part 1, "Method and tables for Brinell Hardness testing."

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

14 Inspection

The representative of the purchaser shall have access to the works of the manufacturer at all reasonable times for the purpose of witnessing the specified tests and inspecting the testing machine and methods of examination.

15 Identification marking

Each sling shall, after testing, be permanently and legibly stamped on the upper terminal fitting of the sling, or on an included solid link, or on a separate idle link with the safe working load and such marks or symbols as will allow identification with the manufacturer's certificate (clause 16). The solid link, when fitted, shall be suitable in all respects. Such stamping of any component shall not be on or near the weld.

For stamping links or rings, stamps having a suitable concave surface shall be used, and care shall be taken that the indentation is neither too sharp nor too deep.

Recommended maximum sizes of stamps are as follows:

Diameter of material of ring or link in	Size of mark in
Up to and including $\frac{1}{2}$	$\frac{1}{8}$
Over $\frac{1}{2}$, up to and including 1	$\frac{3}{16}$
Over 1	$\frac{1}{4}$

In the case of a two-leg sling, the safe working load marked on the sling shall be that appropriate for an included angle of 90° (see column 6 in the Table of safe working loads for two-leg slings, Appendix D).

In the case of a three-leg sling, the safe working load marked on the sling shall be 50 per cent greater than that marked on a two-leg sling of the same size.

In the case of a four-leg sling, the safe working load marked on the sling shall be twice that marked on a two-leg sling of the same size.

The upper terminal components of these multiple-leg slings shall also be marked "S.W.L. at 90° " (see Figure 3).

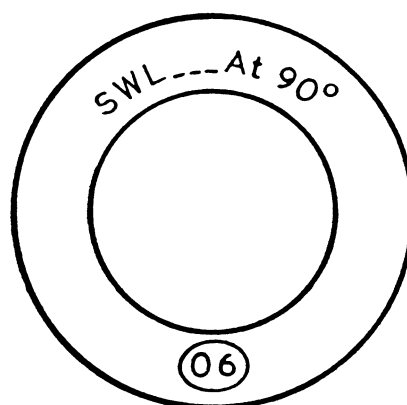


Figure 3 — Marking on upper terminal components of multi-leg slings (It is recommended that maker's identification mark be stamped on the opposite side).