

Higher tensile steel chain slings and rings, links alternative to rings egg links and intermediate links

UDC 621.86.061:669.14.018.29

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This British Standard, having been approved by the Mechanical Engineering Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 30 September, 1957

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The following BSI references relate to the work on this standard:
Committee references
MEE/12, MEE/12/2
Draft for comment CV(MEE)531

Amendments issued since publication

Amd. No.	Date	Comments
5225	December 1958	
5061	October 1963	Indicated by a sideline in the margin

ISBN 0 580 32617 9

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Foreword

This standard makes reference to the following British Standards:

BS 970, *Wrought steels*.

BS 1610, *Verification of testing machines, Part 1*.

BS 1663, *Higher tensile steel chain*.

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

BS 2903, *Higher tensile steel hooks*.

This British Standard provides for chain slings having a higher minimum tensile strength than those covered by BS 781, "*Wrought iron chain slings*".

By comparison with BS 781, the range of sizes in this standard has been extended to include chain of $\frac{1}{4}$ in. and $\frac{9}{32}$ in.: the $\frac{1}{16}$ in. sizes above 1 in. have been omitted. The range of safe working loads has been extended up to 18 tons for the $1\frac{1}{2}$ in. chain leg. The same range of components as in BS 781 has been included.

The sling assemblies are similar to those in BS 781 with the exception that at the hook ends the joining egg links have been omitted, and for collar slings they have been made optional. In the case of wrought iron chain slings, the purpose of these links was to allow room for the smith to "tool" the joint, but this necessity did not arise with electrically welded links.

The internal dimensions of the upper terminal fittings, in terms of $\sqrt{W}$ (where W is the proof load of the sling) have been kept the same as in BS 781, to permit the use of these slings with the normal range of crane hooks. In view of the smaller size of chain for a given safe working load, however, these dimensions in terms of d_c (the nominal size of the corresponding short link chain) have been increased.

The proportions of the enlarged egg links and joining egg links in terms of d_c are the same as those in BS 781, and the proportions of the intermediate links are based on those in BS 781, but allowing a slightly increased internal clearance. In the case of the trapezoidal eye hooks, the proportions in terms of d_c are the same.

The components included have been designed for use with higher tensile steel chain and the specified proof loads conform to those laid down in BS 1663 "*Higher tensile steel chain*".

As the components included will most generally be used for assembly into slings, their proportions have been so arranged that the most widely used types of slings can be made up from the minimum number and types of components.

Chain slings of the more usual types assembled from the specified components are included in the standard. These represent sufficient variety for the majority of normal purposes.

The dimensions of the components included are proportioned to the nominal size of the chain, d_c , for which they are designed. The proportions are given to two places of decimals at the head of each column in the tables.

In the smaller sizes the dimensions of the material used are specified in increments of $\frac{1}{16}$ in. and in the larger sizes in increments of $\frac{1}{8}$ in.

Instances may arise for which similar components outside the range specified may be required. Such components, (i.e. rings and links) can be designed from the information given in "Notes on Design", and used in British Standard sling assemblies as laid down in Figure 8 to Figure 13 of this standard. These components must, however, comply in all respects with the formulae and nominal design stresses given in "Notes on Design".

In the case of terminal rings, direct selections, having regard to working load and internal diameter, can be made from Table 14, Appendix C, the rings in which have been calculated from an adaptation of the ring formula in "Notes on Design". When terminal rings are selected from Table 14, or when rings, links or joining components are designed by the use of the design formulae, care must be taken to ensure that they are so dimensioned that they work freely together.

A short list of rings prepared from Table 1, to reduce the number of ring sizes required, is given in Appendix D.

In view of the purpose for which the components and slings are required, and the great importance of reliability, it is recommended that supplies should be obtained only from manufacturers possessing adequate testing equipment and maintaining a qualified staff for detailed examination.

It is to be noted that heat treatment of higher tensile steel slings is a mandatory part of the specification and the indiscriminate use of uncontrolled thermal treatments can result in dangerous loss of properties (see Appendix E, paragraph 11).

It is obvious that joinings and fittings must be made from steel similar to that of the chain, but care is necessary in the choice of welding method. Fire welding is quite unsuitable. Certain fusion welding methods are permissible. Atomic hydrogen welding is a widely used and very suitable method. For sizes above 2 in. in diameter, submerged-arc or covered electrode methods are suitable. Electric resistance butt or flash-butt methods as used for chains are also suitable. It is necessary to ensure that true union and sound metal are obtained in all parts of the cross-section.

The Committee entrusted with the preparation of this standard desires to record its indebtedness to the Engineering Division¹⁾ of the National Physical Laboratory for the theoretical investigations and the large amount of experimental work carried out, which forms the basis of this standard.

Throughout this standard British weights and measures only are used: ton, 2240 lb, hundredweight, 112 lb, dimensions in inches. (For corresponding metric equivalents see 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.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to x, 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⁾ This Division was closed down in August, 1951, and its functions transferred to the Mechanical Engineering Research Laboratory, East Kilbride, Glasgow.

Descriptive notes

a) *Rings for slings* (Table 1, Figure 1). The rings specified are of four types, A, B, C and D, the internal diameters of which are respectively 7.51, 9.24, 10.39 and 12.70 times the nominal size of the corresponding short link chain for use with single, two-leg, three-leg and four-leg slings respectively. The four types make provision for the normal range of crane hooks.²⁾

The proportions of the rings are as follows:

Particulars of dimensions	Type of ring			
	Single sling Type A	Two-leg sling Type B	Three-leg sling Type C	Four-leg sling Type D
^a Internal diameter D	$7.51d_c$	$9.24d_c$	$10.39d_c$	$12.70d_c$
Nominal diameter of material d	$1.88d_c$	$2.54d_c$	$3.03d_c$	$3.56d_c$
^a These internal diameters correspond to values of $1.88 \sqrt{W}$, $1.63 \sqrt{W}$, $1.50 \sqrt{W}$ and $1.59 \sqrt{W}$, for the single, two-leg, three-leg and four-leg slings, respectively. The same coefficients of $\sqrt{W}$ apply in the case of rings to BS 781:1950 (see paragraph 4 of Foreword).				

where d_c is the nominal size of the corresponding short link chain.

b) *Links alternative to rings* (Table 2, Figure 2). The substitution of a link for the ring is permissible and is justified by the proportionate reduction in weight.

Four types of links alternative to rings have been specified which correspond to rings types A, B, C and D.

The proportion of the links alternative to rings are as follows:

Particulars of dimensions	Type of link			
	Single sling Type A	Two-leg sling Type B	Three-leg sling Type C	Four-leg sling Type D
Internal length L	$7.51d_c$	$9.24d_c$	$10.39d_c$	$12.70d_c$
Internal breadth B	$4.50d_c$	$5.54d_c$	$6.24d_c$	$8.08d_c$
Nominal diameter of material d	$1.69d_c$	$2.28d_c$	$2.73d_c$	$3.24d_c$

where d_c is the nominal size of the corresponding short link chain.

c) *Terminal reeveable and non-reeveable egg links* (Table 3 and Table 4, Figure 3 and Figure 4). The egg links specified are of two types, reeveable and non-reeveable. Reeveable egg links, as their name implies, are proportioned so that one can be threaded through another of equal size. In certain cases (e.g. three-leg slings) the non-reeveable egg link has also been used as an intermediate component.

d) *Enlarged and joining egg links* (Table 5 and Table 6, Figure 5 and Figure 6). The enlarged egg links are used to connect a ring or link alternative to ring (single, two-leg and four-leg slings) to an intermediate link; and the joining egg links (which are optional) to connect a reeveable or non-reeveable egg link (collar slings) to an intermediate link.

The proportions of the four types of egg links are as follows:

Particulars of dimensions	Type of egg link			
	^a Reeveable Table 3	^a Non-reeveable Table 4	Enlarged Table 5	Joining Table 6 (Optional)
Smaller internal breadth B_1	$2.31d_c$	$1.73d_c$	$1.50d_c$	$1.50d_c$
Larger internal breadth B	$5.20d_c$	^b $4.27d_c$	$3.00d_c$	$3.00d_c$
Internal length L	$10.68d_c$	$6.35d_c$	$5.00d_c$	$4.50d_c$
Nominal diameter of material d	$1.66d_c$	$1.52d_c$	$1.37d_c$	$1.36d_c$
^a The internal dimensions of the reeveable and non-reeveable egg links, when expressed in terms of $\sqrt{W}$ are the same as those in BS 781:1950 (see paragraph 4 of Foreword).				
^b When used as joining links for three-leg slings, dimension B should be slightly reduced (see foot-note to Table 4).				

²⁾ See also Appendix D.

where d_c is the nominal size of the corresponding short link chain.

e) *Intermediate links* (Table 7 and Figure 7). These links are used at the ends of the short link chain, to connect the chain to an egg link or to a trapezoidal eye-hook.

f) *Chain slings* (Table 8 to Table 13, Figure 8 to Figure 13). The slings are made up from standardized components connected to higher tensile steel short link chain to BS 1663. The hooks are trapezoidal section eye-hooks, BS 2903, Table 3.

The assembly of the slings is shown in Figure 8 to Figure 13 and the components in each case are detailed in Table 8 to Table 13.

i) *Single sling* (Table 8, Figure 8). The egg link at the ring end is either the enlarged egg link or the joining egg link. The ring is type A, Table 1, having an internal diameter equal to 7.51 times the nominal size of the chain. The link alternative to ring is type A, Table 2, having an internal length equal to 7.51 times the nominal size of the chain.

ii) *Two-leg sling* (Table 9, Figure 9). The egg link at the ring end is either the enlarged egg link or the joining egg link. The ring is type B, Table 1, having an internal diameter equal to 9.24 times the nominal size of the chain. The link alternative to ring is type B, Table 2, having an internal length equal to 9.24 times the nominal size of the chain.

iii) *Three-leg sling* (Table 10, Figure 10). The egg link at the ring end is the non-reevable egg link. The ring is type C, Table 1, having an internal diameter equal to 10.39 times the nominal size of the chain. The link alternative to ring is type C, Table 2, having an internal length equal to 10.39 times the nominal size of the chain.

iv) *Four-leg sling* (Table 11, Figure 11). The four-leg sling comprises a pair of two-leg slings, complete with rings or links alternative to rings, connected together by a terminal main ring or link alternative to ring. The main ring is type D, Table 1, having an internal diameter equal to 12.70 times the nominal size of the chain. The link alternative to ring is type D, Table 2, having an internal length equal to 12.70 times the nominal size of the chain.

v) *Collar slings* (Table 12 and Table 13, Figure 12 and Figure 13). The terminal links, whether reeable or non-reeable, are connected to the chain by means of a joining link, or links.

g) As a result of the method of design described above, the leg of a single sling can be utilized as one of the legs of a two-leg sling, and a complete two-leg sling as one of the double legs of a four-leg sling. (See "Working loads" and Appendix D).

h) With the exception of the four-leg sling, the terminal components of all slings lie in the same plane. In the four-leg sling the terminal components are at right angles.

j) The effective length (see Figure 8 to Figure 13) of any sling depends upon the number of chain links included, and only in exceptional cases will the effective length work out at an even dimension. The incremental difference in effective length, with the terminal components in the same relative position, will in all cases be twice the internal length of one chain link.

Consequent upon the foregoing it is virtually impossible to work exactly to ordered length, and it is normal practice to work to the nearest length in excess of the ordered length. The difference between the ordered length and the actual length may be negligible in small sizes up to $\frac{1}{2}$ in., but may be appreciable in sizes 1 in. or over. As it is impracticable to specify tolerances on the effective length of chain slings, the ordered length should be the minimum acceptable length.

Where it is essential that the ordered length shall not be exceeded, this should be stipulated in the enquiry and order.

Notes on design

Standard components of any one kind, for example reeveable egg links, Figure 3 and Table 3, differ only in size and proof load. They are all identical in shape, and under its proof load each component in any one table is subjected to the same stress.

On the other hand the maximum stress set up under the proof load differs from component to component. It is greatest for the chain, least for rings and links alternative to rings, and for the various joining links intermediate values are used.

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 use³⁾. The following simple formula, developed by the National Physical Laboratory give sufficiently close approximations to the exact values.

$$W = \left(\frac{0.224fd^3}{B + 0.4d} \right) \left(1.75 + \frac{B + d}{L + d} \right) \begin{array}{l} \text{for values of } L \\ \text{greater than } 2.55d \end{array}$$

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, tons/sq.in.
= 32 tons/sq.in. for rings; or straight sided terminal links alternative.
= 40 tons/sq.in. for egg links; or straight sided links when used as intermediate components.
= 48 tons/sq.in. for intermediate links.
= 57 tons/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 $0.22(2 + L/d)$.

For rings of internal diameter D , the basic formula reduces to:

$$W = \frac{0.616fd^3}{D + 0.4d} = \frac{19.7d^3}{D + 0.4d}$$

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 D/d is greater than 2.55.)

The proof load values given in the tables do not agree exactly with those given by the above formulae owing to the rounding-up to the nearest fraction of an inch. The errors involved in 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) and they may be used for the design of components which conform in all respects (except dimensions) to the requirements of this standard.

³⁾ See "Design of Crane Hooks and Other Components of Lifting Gear" by H. J. Gough, H. L. Cox and D. G. Sopwith. Proceedings of the Institution of Mechanical Engineers, Vol. 128, page 253, 1934.

Working loads

For normal conditions of use the maximum permissible load (safe working load) should not exceed one-half the specified proof load. When the conditions of use are exceptionally hazardous or severe the permissible working load should be *substantially less* than one-half the proof load. (For further details see Appendix E).

Where there is special risk of injury a safe working load of not more than $6 d^2$ tons should be adopted. For sling assemblies where chains will be subjected to shock or heavy wear, or will be required to work over pulleys, or will be used for lifting vessels containing molten metal or heated liquids; or where links are liable to be bent or indented by severe localized pressure, as when a single sling is reeved round a load having a hard irregular surface, the safe working load should not exceed $4.5 d^2$ tons.

Two-leg slings. The load lifted by two-leg slings must be reduced as the angle between the legs increases. The loads given in the table of safe working loads for two-leg slings are the greatest which can be lifted without exceeding the specified safe working load of the chain in each leg.

Three-leg slings. Three-leg slings are often used for lifting articles which do not lend themselves to lifting by single or two-leg slings. Owing to the variety of conditions under which such slings may be used it is not possible to specify safe working loads. Users are recommended to draw up their own tables of safe working loads, with due regard to the particular conditions of service.

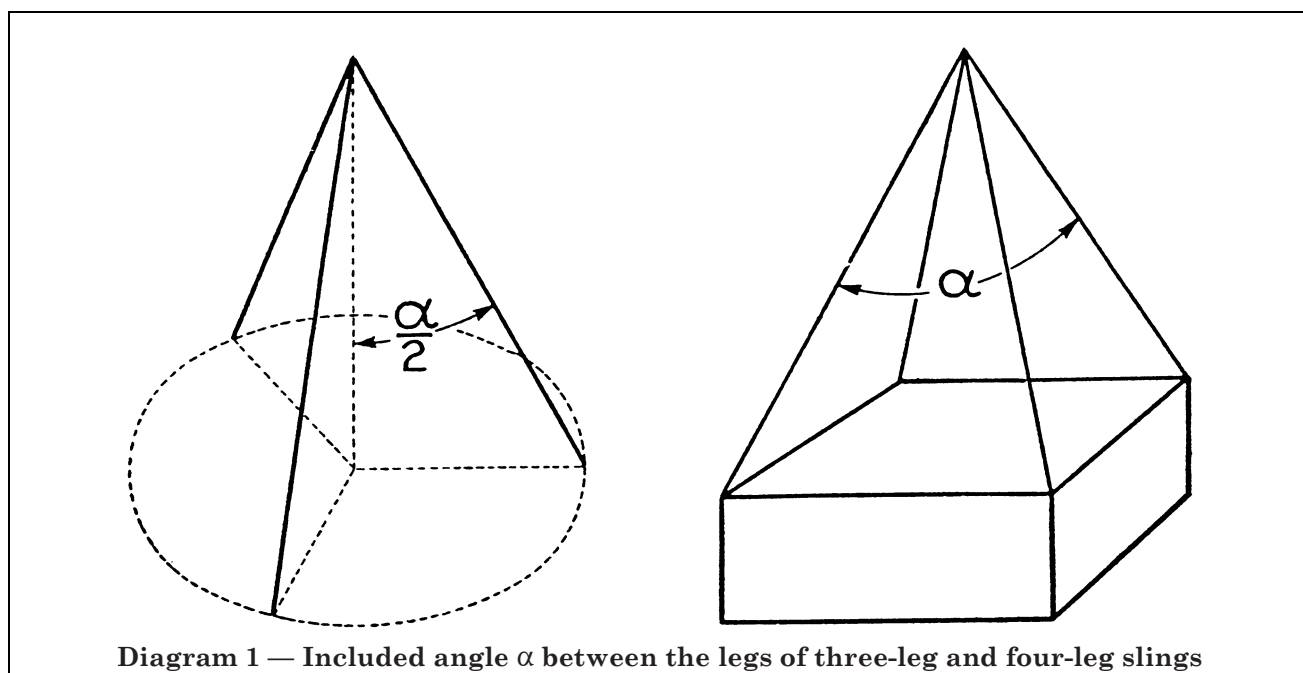
Assuming equal load distribution on each leg of a three-leg sling (a condition rarely operative), the table of safe working loads for two-leg slings can be used to deduce the load for a three-leg sling for any given angle between the legs and the vertical; e.g. for an angle of 30° between any leg and the vertical ($\alpha/2 = 30^\circ$, see Diagram 1), the load is 50 per cent greater than for a two-leg sling with an included angle of 60° .

As load distribution may be unequal, caution is advisable in fixing appropriate working loads.

Four-leg slings. In making allowance for the angle of four-leg slings, assuming equal load distribution, the angle which applies is that between the diagonally opposite legs (see Diagram 1).

Four-leg slings are suitable for lifting boxes, platforms or containers which have some inherent flexibility tending to equalize the load distribution on the legs of the sling.

They are also used for lifting rigid articles such as structures, castings, etc., where the centre of gravity of the load is not central with the four points of suspension. Also the slinging points may be at different levels, resulting in unequal angles and loadings of the sling legs. In such instances users should evaluate the appropriate safe working loads to suit the particular conditions of service, care being taken that the tension in the heaviest loaded leg does not exceed the maximum permissible working load of one leg, as given in column 2 of the table of safe working loads for two-leg slings, the table being used to deduce the proportionate effect due to sling angularity. It is essential in the case of any multiple leg sling that the safe working load of any leg is not exceeded.



Safe working loads for two-leg slings

1	2			3		4		5		6		7	
Nominal diameter of chain d_c	Permissible working load of one leg			Included angle between legs									
													
				0°	30°		60°		90°		120°		
in.	tons	cwt.	lb.	tons	cwt.	tons	cwt.	tons	cwt.	tons	cwt.	tons	cwt.
$\frac{1}{4}$	0	10	1 120	1	0	0	19	0	17	0	14	0	10
$\frac{9}{32}$	0	12	1 344	1	4	1	3	1	0	0	16	0	12
$\frac{5}{16}$	0	15	1 680	1	10	1	8	1	5	1	1	0	15
$\frac{3}{8}$	1	2	2 464	2	4	2	2	1	18	1	11	1	2
$\frac{7}{16}$	1	10	3 360	3	0	2	17	2	11	2	2	1	10
$\frac{1}{2}$	2	0	4 480	4	0	3	17	3	9	2	16	2	0
$\frac{9}{16}$	2	10	5 600	5	0	4	16	4	6	3	10	2	10
$\frac{5}{8}$	3	2	6 944	6	4	5	19	5	7	4	7	3	2
$\frac{11}{16}$	3	15	8 400	7	10	7	4	6	9	5	6	3	15
$\frac{3}{4}$	4	10	10 080	9	0	8	13	7	15	6	7	4	10
$\frac{13}{16}$	5	5	11 760	10	10	10	2	9	1	7	8	5	5
$\frac{7}{8}$	6	2	13 664	12	4	11	15	10	11	8	12	6	2
$\frac{15}{16}$	7	0	15 680	14	0	13	10	12	2	9	17	7	0
1	8	0	17 920	16	0	15	9	13	17	11	6	8	0
$1\frac{1}{8}$	10	2	22 624	20	4	19	10	17	9	14	5	10	2
$1\frac{1}{4}$	12	10	28 000	25	0	24	2	21	13	17	13	12	10
$1\frac{3}{8}$	15	2	33 824	30	4	29	3	26	3	21	7	15	2
$1\frac{1}{2}$	18	0	40 320	36	0	34	15	31	3	25	9	18	0
Load reduction factor				1.000		0.966		0.866		0.707		0.500	
Approximate percentage reduction				0 percent		3½ percent		13½ percent		29½ percent		50 percent	
NOTE The above safe working loads have been rounded down to the nearest hundredweight. It is recommended that, wherever possible, the included angle between the legs should not exceed 90° (see Clause 15)													

NOTE This standard provides alternative types of components, and alternative heat treatments. The enquiry and order should state the size and type of sling or sling component by reference to the tables and figures as well as to the required working load. The enquiry and order should also state whether the chain is to be supplied in the normalized or in the quenched and tempered condition. The purchaser should verify that the terminal rings or links, Table 1 and Table 2 respectively, are of suitable internal dimensions for the purpose required. Unless otherwise agreed between the purchaser and the supplier, rings or links of the dimensions given in these tables will be supplied.

1 Scope

This British Standard specifies materials, dimensions and tests for higher tensile steel chain slings from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. nominal size; rings, links alternative to rings, reeveable and non-reeveable egg links, enlarged egg links, joining egg links and intermediate links.

2 Material

The material used in the manufacture of rings, links alternative to rings, egg links and intermediate links shall comply with the requirements of BS 970, Specifications En 5A, En 5B or En 14A.

It shall be the responsibility of the manufacturer to ensure that suitable heat treatment is given in order that the steel in the components will possess mechanical properties not less than the minimum required for the short link chain.

When analysis of the steel in the rings, links alternative to rings, egg links or intermediate links is required by the purchaser, he shall state so at the time of the enquiry and order.

The short link chain shall be in accordance with the requirements laid down in BS 1663 (see Clause 8).

The hooks shall be in accordance with the requirements laid down in BS 2903, “Higher tensile steel hooks”.

3 Nominal size

The nominal size of a sling is the nominal size of the short link chain in the sling.

The nominal size of each individual ring or link is the nominal diameter of the material from which it is made.

4 Nominal length of sling

The nominal length of a finished 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. The effective lengths of the legs in any two-leg, three-leg or four-leg sling shall be as nearly as possible equal; the permissible inequality shall in no case exceed one-quarter inch.

5 Form and dimensions

The slings and their components shall be in accordance with the following tables and figures:

Component	^a Table	Figure
^b <i>a</i> Ring	Table 1	Figure 1
<i>b</i> Link alternative to ring	Table 2	Figure 2
^b <i>c</i> Reeveable egg link	Table 3	Figure 3
^b <i>d</i> Non-reeveable egg link	Table 4	Figure 4
<i>e</i> Enlarged egg link	Table 5	Figure 5
<i>f</i> Joining egg link (optional)	Table 6	Figure 6
<i>g</i> Intermediate link	Table 7	Figure 7
<i>h</i> Single sling	Table 8	Figure 8
<i>i</i> Two-leg sling	Table 9	Figure 9
<i>j</i> Three-leg sling	Table 10	Figure 10
<i>k</i> Four-leg sling	Table 11	Figure 11
<i>l</i> Reeveable collar sling	Table 12	Figure 12
<i>m</i> Non-reeveable collar sling	Table 13	Figure 13
^a As an alternative to the use of the components given in Table 1 to Table 7, it is permissible to design the rings and links in accordance with the formulae and stress values given in “Notes on design”.		
^b Unless otherwise agreed between the purchaser and the manufacturer.		

6 Permissible variation in dimensions

The size of the material in a finished ring or 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 $1\frac{1}{2}$	$\frac{1}{10}$
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 links.

The internal length and breadth of egg links, Table 3 to Table 6 (dimensions L , B and B_1), links alternative to rings, Table 2 and intermediate links Table 7 (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 and Table 14 (dimension D) shall not vary from the nominal diameter by more than plus $2\frac{1}{2}$ per cent or minus 5 per cent.

In any one ring the maximum internal diameter shall not exceed the minimum internal diameter by more than $2\frac{1}{2}$ per cent.

In the case of drop-forged components, the tolerances shall be the “plus” values of the “standard tolerances” as specified in BS 1718,⁴⁾ Table DF 1.

7 Workmanship

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

- a) Drop forging.
- b) Rolling.
- c) Welding.

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

- i) Electric Resistance butt welding
- ii) Flash-butt welding
- iii) Atomic hydrogen welding
- iv) Inert gas shielded-arc welding
- v) Submerged-arc welding
- vi) Covered Electrode,, } suitable for bars above 2 in. in diameter.

The weld shall be smoothly finished all round, and care shall be taken to avoid porosity and to ensure penetration and fusion throughout.

When inspection by radiography is required by the purchaser he shall state so at the time of the enquiry and order.

⁴⁾ BS 1718, “Tolerances for steel drop forgings and upset forgings”.