International Standard 4778

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Chain slings of welded construction — Grades M (4), S (6) and T (8)

Élingues à chaînes assemblées par soudure — Classes M (4), S (6) et T (8)

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ISO 4778-1981 (E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4778 was developed by Technical Committee ISO/TC 111, *Round steel link chains, chain wheels, lifting hooks and accessories*, and was circulated to the member bodies in July 1978.

It has been approved by the member bodies of the following countries :

Australia	Italy	United Kingdom
Belgium	Japan	USA
Canada	Korea, Rep. of	USSR
India	Sweden	Yugoslavia

The member bodies of the following countries expressed disapproval of the document on technical grounds :

France
Germany, F. R.
Netherlands
South Africa, Rep. of

Chain slings of welded construction — Grades M (4), S (6) and T (8)

1 Scope and field of application

This International Standard specifies the requirements, methods of rating and testing of single, two, three and four branch[1] welded chain slings of grades M (4), S (6) and T (8) using chain conforming to ISO 1834, ISO 1835, ISO 3075 and ISO 3076 together with the appropriate range of components.

This International Standard does not apply to mechanically joined slings or welded slings having branches of unequal nominal reach.

2 References

ISO 1834, *Short link chain for lifting purposes — General conditions of acceptance.*

ISO 1835, *Short link chain for lifting purposes — Grade M (4) non-calibrated, for chain slings, etc.*

ISO 2766, *Single lifting hooks with shank — Capacity up to 25 tonnes — Grades M, P, S (T, V) — Hammer and drop forged hooks.*

ISO 3075, *Short link chain for lifting purposes — Grade S (6), non-calibrated, for chain slings, etc.*

ISO 3076, *Short link chain for lifting purposes — Grade T (8), non-calibrated, for chain slings, etc.*

3 Definitions

3.1 chain sling : An assembly consisting of chain or chains joined to upper and lower terminal fittings suitable according to the requirements of this International Standard for attaching loads to be lifted to the hook of a crane or other lifting machine (see figures 2 to 5).

3.2 master link : A parallel-sided link forming the upper terminal fitting of a chain sling by means of which it is attached to the hook of a crane or other lifting machine (see figures 2 to 5).

3.3 intermediate master link : A link used to connect two or more branches to a master link (see figures 2 to 5).

3.4 joining link : A link fitted to the end of a chain to connect it either directly or through an intermediate link to an upper or lower terminal fitting (see figures 2 to 5).

3.5 intermediate link : A link used to form a connection between the terminal fitting and the joining link fitted to the chain (see figures 2 to 5).

3.6 lower terminal : A link, hook or other device fitted at the end of a branch remote from the master link or upper terminal.

3.7 proof force : A force applied as a test to the whole sling, or a force applied as a test to a section of a sling (see clause 10).

3.8 working load limit : The maximum mass which a sling is designed to support in general service.

3.9 working load : The maximum mass which a sling should be used to support in a particular stated service.

4 Designations

The following designations should be used in specifying slings to this International Standard.

4.1 Nominal size

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

The nominal size of each individual master link, joining or intermediate link where it is of round section is the nominal diameter of the material from which it is made.

1) The term "branch" or "leg" may be used.

4.2 Nominal reach of sling

The nominal reach of the finished sling is the effective length from the inside of the lower terminal fitting to the inside of the upper terminal fitting. (See figures 2 to 5.)

4.3 Grade of a sling

The nominal grade of a sling, for the purpose of its designation under this International Standard, shall be the same as the grade of the chain used, i.e. M (4), S (6) or T (8) (see clause 1).

4.4 Rating

The rating of the chain sling shall be as specified in clause 9.

5 Construction

Some examples of chain slings conforming to this International Standard are shown in figures 2 to 5.

Joining links and intermediate links may be

a) parallel sided links or

b) egg-shaped links, these being links with differing radii at either end, i.e. pear-shaped.

Egg- or pear-shaped links shall not be used as master links or as lower terminals in any situation where the link could be inverted, leading to a wedging action and subsequent distortion of the link.

6 Dimensions and tolerances

The dimensions and tolerances of the chain, master links, joining links and intermediate links used in the construction of chain slings conforming to this International Standard shall be as follows :

6.1 Chain

The dimensions and tolerances of the chain shall be in accordance with the appropriate International Standards listed in clause 1.

6.2 Master links and intermediate master links

6.2.1 The inside dimension and the section of the material shall be such that :

a) the master link fits on an ISO grade M hook two sizes larger than the rating of the sling (see tables 1 and 2);

b) the inside width of the master link is not less than 1,2 times the maximum width (L_h) of the hook section defined in a);

c) for slings with hooks as lower terminals, unless another means of securing the hooks when not loaded is provided, the inside dimensions and section are such as to allow the lower terminals to be hooked into the master link while it is on a hook as defined in a).

6.2.2 Master links and intermediate master links may be of round or other suitable section but the section of the material shall be chosen so that :

a) after proof loading (see clause 10) the master link and intermediate master links do not show any significant permanent deformation (see also 8.1);

b) the minimum elongation at breaking is at least that of the corresponding grade of chain.

6.3 Lower terminal links, joining links and intermediate links

6.3.1 The number and internal dimensions of lower terminal, joining and intermediate links shall be such as to ensure free articulation of the links.

6.3.2 The section of the material shall be such that :

a) after proof loading (see clause 10) the lower terminal, joining and intermediate links do not show any significant permanent deformation (see also 8.1);

b) the minimum elongation at breaking is at least that of the corresponding grade of chain.

NOTE — A method of calculating the sections of master links and intermediate links is given in the annex.

6.4 Eyehooks

Eyehooks shall be compatible with the chain (see 6.1). (An International Standard covering eyehooks is in preparation.)

6.5 Tolerances

When constructing the sling, a tolerance of $^{+2}_{0}$ links is permissible on the nominal reach ordered by the purchaser. After proof loading, the difference between the longest and shortest branches of a multi-branch sling, when measured under a tension of 1/5 of the working load limit, shall not exceed 6 mm for branches up to 2 m in length. For slings in excess of 2 m, the difference between the longest and shortest branches may be increased by 3 mm/m.

7 Materials

The materials used in the manufacture of components shall meet the conditions laid down in the International Standard for the appropriate grade of chain.

8 Manufacturing methods and workmanship

8.1 Master links and intermediate master links

Welding methods (where applicable), workmanship, materials, form and heat treatment of master links shall be such as to ensure that the ratio between the breaking force and the appropriate proof force is not less than 2 : 1 up to working load limits of 25 t (see figure 1).

8.2 Lower terminal links, joining links and intermediate links

Welding methods (where applicable), workmanship, materials, form and heat treatment of links shall be such as to ensure that the breaking force is not less than the minimum breaking force of the chain.

8.3 Heat treatment

All master links, intermediate master links, joining links, intermediate links, lower terminals and chain shall, before application of the proof force, be heat treated in such a way as to ensure that they have the required mechanical and metallurgical properties.

NOTE — No one but the chain manufacturer, his licensee or an organization authorized by an appropriate authority should be allowed to weld or heat treat slings covered by this International Standard.

Where chain assemblies need to be altered or repaired, this should be undertaken only by the manufacturer, his licensee, or a manufacturer authorized by an appropriate authority.

8.4 Test data

Upon request to prove design, the sling manufacturer shall supply test data representing an actual test of a master link intermediate master link or joining link or lower terminal link or intermediate link of equivalent size, shape, material and heat treatment to the link supplied.

9 Rating

9.1 Single branch sling

Single branch slings shall have a working load limit equal to that of the chain used in their construction.

9.2 Multi-branch slings

There are two alternative methods of rating multi-branch slings, i.e.

a) Uniform load method :

The slings are rated at a uniform working load limit for any angle between branches of 0 to 90° (0 to 45° to the vertical) or additionally at a uniform working load limit for any angle between branches of 90 to 120° (45 to 60° to the vertical).

b) Trigonometric method :

The slings are rated at a working load limit according to the particular angle between branches at which the sling is to be employed; for this purpose reference is usually made to trigonometric tables.

9.2.1 Uniform load method

a) Double branch slings :

For all angles between branches from 0 to 90° (0 to 45° to the vertical)

WLL = 1,4 × WLL of a single branch made from similar chain

When additionally marked for angles between branches of 90 to 120° (45 to 60° to the vertical)

WLL = 1 × WLL of a single branch made from similar chain

b) Three and four branch slings :

For all angles between branches from 0 to 90° (0 to 45° to the vertical).

WLL = 2,1 × WLL of a single branch made from similar chain

When additionally marked for angles between branches of 90 to 120° (45 to 60° to the vertical)

WLL = 1,5 × WLL of a single branch made from similar chain.

NOTE — In the case of a three branch sling the angle between branches shall be taken as twice the angle to the vertical, i.e. $2 \times \beta$ (see figure 6).

In the case of a four branch sling the angle between branches shall be that between diagonally opposite branches (see figure 6).

9.2.2 Trigonometric method

a) Double branch slings :

WLL = 2 × WLL of a single branch × cos β

b) Three and four branch slings :

WLL = 3 × WLL of a single branch × cos β

9.3 Nominal rating

The nominal rating of any multi-branch sling whether rated by the uniform load or trigonometric method shall be the WLL for that sling when used at an angle of 90° between the branches (45° to the vertical).

10 Proof force

After final heat treatment, slings with accessories shall be tested as an assembly; multi-branch chain slings shall be tested in sections.

Individual sections of the chain slings shall be subjected to twice the force to which that section will be subjected, when the assembly is subjected to its working load limit in accordance with the following plan.

10.1 Method of proof loading where uniform load method of rating is used. (See figure 1.)

10.2 Method of proof loading where trigonometric method of rating is used.

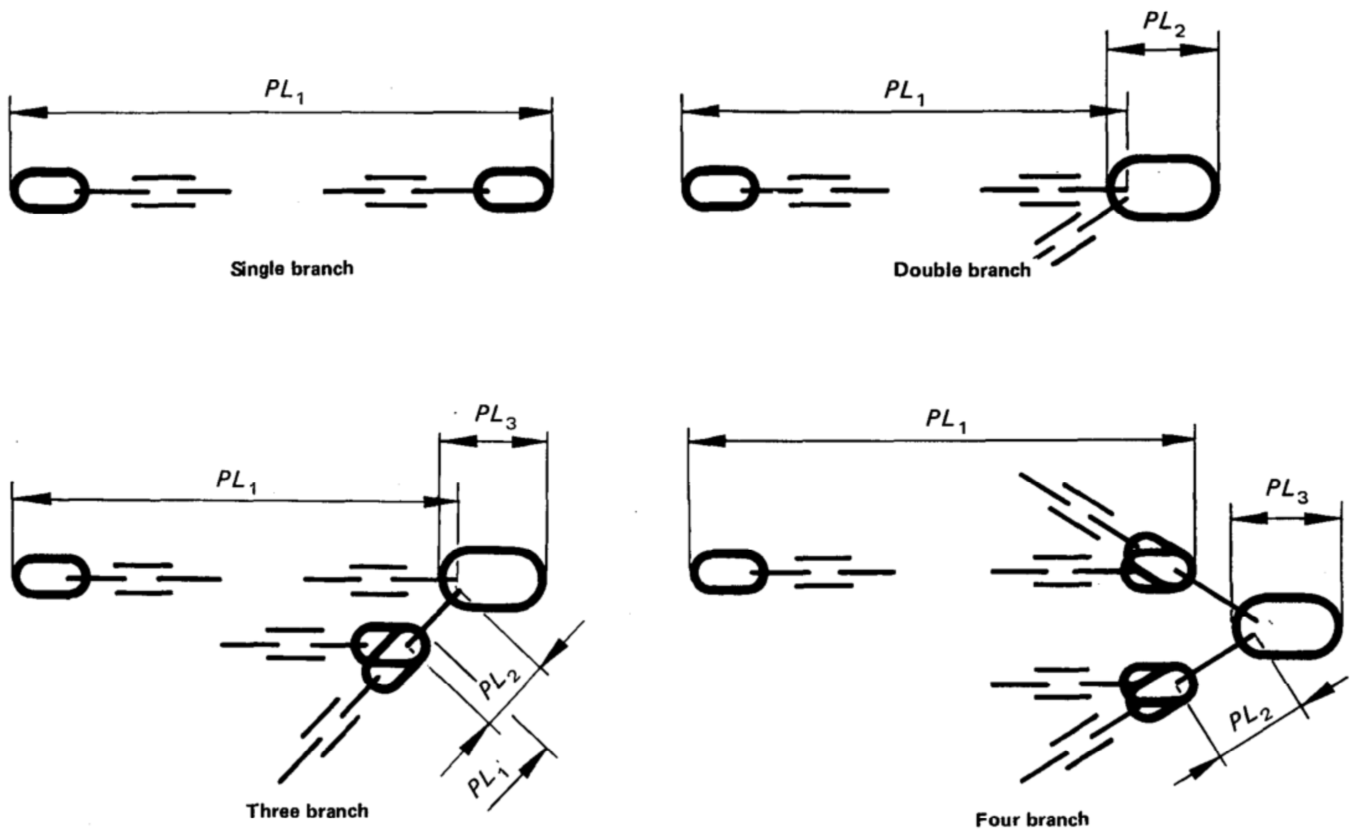
10.2.1 Double branch slings

The proof force on each branch of a double branch sling shall be twice the working load limit of the chain. The proof force on the master link shall be four times the working load limit on the chain.

10.2.2 Three and four branch slings

The proof force on each branch of a three or four branch sling shall be twice the working load limit of the chain. The proof force for the master link shall be six times the working load limit of the chain. For intermediate master links, the proof force shall be four times the working load limit of the chain.

10.3 After completion of the proof loading and removal of the force, the sling shall be carefully examined by a competent person and any faulty components replaced.



	Factors for		
	PL_1	PL_2	PL_3
Working load limit	1,0	1,4	2,1
Proof force (2 × WLL)	2,0	2,8	4,2

NOTE — For WLL over 25 t it is permissible to apply proof forces to the links PL_2 and PL_3 reduced in accordance with ILO Recommendations.

Figure 1 — Factors for proof loading

11 Marking

The following information shall be shown on a metal tag or label permanently attached to the master link or to a link immediately adjacent to it. Alternatively, all or part of the information may be marked on the master link provided the mechanical properties of the link are not significantly impaired.

11.1 For single branch slings :

a) working load limit (kg or t);

b) individual identification number or symbol;

c) grade [M (4), S (6) or T (8)];

d) manufacturer's name or symbol;

e) size of chain (optional);

f) other information as agreed between the user and manufacturer.

11.2 For slings rated uniformly for use with angles 0 to 90° (0 to 45° to the vertical) :

a) the working load limit in kilograms or tonnes, thus

WLL (kg or t) 0 to 90° (0 to 45° to the vertical);

b) individual identification number or symbol;

c) grade [M (4), S (6) or T (8)];

d) manufacturer's name or symbol;

e) size of chain (optional);

f) number of branches;

g) other information as agreed between the user and manufacturer;

h) additionally there may be marked on the tag or label or on a separate tag or label attached in a similar manner, the working load limit applicable for use between 90 to 120° (45 to 60° to the vertical), thus

WLL (kg or t) 90 to 120° (45 to 60° to the vertical).

11.3 For slings rated for use with trigonometrical tables :

a) working load limit at 90° between the branches (45° to the vertical), thus

WLL (kg or t) 90° (45° to the vertical);

b) individual identification number or symbol;

c) grade [M (4), S (6) or T (8)];

d) manufacturer's name or symbol;

e) size of chain (optional);

f) number of branches;

g) other information as agreed between the user and manufacturer.

11.4 If a tag or label described in 11.1, 11.2 or 11.3 becomes detached, the chain sling may be used only in accordance with the rating shown on a remaining tag or label. If no tag or label remains, the chain sling should be taken out of service if the necessary information is not marked on the master link itself.

12 Certification

Every sling shall be provided with a dated test certificate giving the following information :

a) name of manufacturer or supplier;

b) establishment where the sling was proof tested;

c) identification mark or symbol (see clause 11);

d) type of sling (see clause 5);

e) size and grade of chain;

f) nominal reach;

g) proof force or proof forces applied;

h) working load limit;

j) working load where stated service demands;

k) certification that the sling was proof tested and then examined by a competent person.

13 Working load limits

Table 1 — Working load limits for chain slings rated 0 to 90° between branches; hooks on which master links are required to fit

NOTE — These values are based on the uniform load method of rating (see 9.2.1).

1	2	3	4	5	6	7
Size of chain in grade			Working load limit			To fit grade M crane hook
M (4) mm	S (6) mm	T (8) mm	Single branch t	Double branch t	Three and four branch t	t
						1
						1,25
						1,6
6,3			0,63	0,8	1,3	2,0
7,1		5,0	0,8	1,1	1,6	2,5
8,0	6,3		1,0	1,4	2,1	3,2
9,0	7,1	6,3	1,25	1,7	2,6	4,0
10,0	8,0	7,1	1,6	2,2	3,3	5,0
11,2	9,0	8,0	2,0	2,8	4,2	6,3
12,5	10,0	9,0	2,5	3,5	5,2	8,0
14,0	11,2	10,0	3,2	4,4	6,7	10,0
16,0	12,5	11,2	4,0	5,6	8,4	12,5
18,0	14,0	12,5	5,0	7,0	10,5	16,0
20,0	16,0	14,0	6,3	8,8	13,2	20,0
22,4	18,0	16,0	8,0	11,2	16,8	25,0
25,0	20,0	18,0	10,0	14,0	21,0	32,0
28,0	22,4	20,0	12,5	17,5	26,2	40,0
32,0	25,0	22,4	16,0	22,4	33,6	50,0
36,0	28,0	25,0	20,0	28,0	42,0	63,0

EXPLANATORY NOTE — Columns 1, 2 and 3 give the sizes of chain in each grade necessary to produce, single, double and three and four branch slings of the ratings 0 to 90° (0 to 45° to the vertical) shown in columns 4, 5 and 6. The single branch slings are in the R 10 Renard series. The rating of the double, and three and four branch slings are derived from the single by multiplying by 1,4 and 2,1 respectively. These factors are not in the R 10 series and therefore the double, three and four branch are only approximately in the series.

The dotted lines connect the ratings of slings for which the master link is required to fit on the same grade M hook (see 6.2.1).

For example, a 5,6 t double branch sling (column 5) reading to the left, on the same line, will be made in 11,2 mm size grade T (8) chain, 12,5 mm size grade S (6) chain, 16 mm size grade M (4) chain, and following the dotted line to the right, the master link is required to fit on an 8 t grade M crane hook.

Table 2 — Working load limits at 90° between branches (45° to the vertical) and hooks on which master links are required to fit, for slings made from chain in temporary additional sizes (ISO 1835,3075, 3076)

NOTE — These values are based on the trigonometric method of rating (see 9.2.2).

Limit values in tonnes

1	2		3		4		5		6		7		8		9		10	
	Grade M (4) (ISO 1835)						Grade S (6) (ISO 3075)						Grade T (8) (ISO 3076)					
	Single branch		Double branch		Three and four branch		Single branch		Double branch		Three and four branch		Single branch		Double branch		Three and four branch	
Size of chain mm	Working load limit	To accept hook grade M	Working load limit at 90°	To accept hook grade M	Working load limit at 90°	To accept hook grade M	Working load limit	To accept hook grade M	Working load limit at 90°	To accept hook grade M	Working load limit at 90°	To accept hook grade M	Working load limit	To accept hook grade M	Working load limit at 90°	To accept hook grade M	Working load limit at 90°	To accept hook grade M
6,0	0,57	1,0	0,8	1,25	1,2	2,0	0,9	1,6	1,2	2,0	1,9	3,2	1,1	2,0	1,5	2,5	2,3	4,0
7,0	0,78	1,25	1,1	2,0	1,6	2,5	1,2	2,0	1,6	2,5	2,5	4,0	1,5	2,5	2,1	4,0	3,1	5,0
8,7	1,2	2,0	1,6	2,5	2,5	4,0	1,9	3,2	2,6	5,0	4,0	6,3	2,4	4,0	3,3	6,3	5,0	8,0
9,5	1,4	2,5	1,9	3,2	2,9	5,0	2,2	4,0	3,1	5,0	4,6	8,0	2,8	5,0	3,9	6,3	5,9	10,0
10,3	1,7	3,2	2,4	4,0	3,6	6,3	2,6	5,0	3,6	6,3	5,5	10,0	3,3	6,3	4,6	8,0	7,0	12,5
11,0	1,9	3,2	2,6	5,0	4,0	6,3	3,0	5,0	4,2	8,0	6,3	10,0	3,8	6,3	5,3	10,0	8,0	12,5
12,0	2,3	4,0	3,2	5,0	4,8	8,0	3,6	6,3	5,0	8,0	7,6	12,5	4,6	8,0	6,5	12,5	9,7	16,0
13,0	2,7	5,0	3,8	6,3	5,7	10,0	4,2	8,0	5,9	10,0	8,9	16,0	5,4	10,0	7,6	12,5	11,4	20,0
13,5	2,9	5,0	4,1	8,0	6,1	10,0	4,5	8,0	6,3	10,0	9,5	16,0	5,8	10,0	8,2	16,0	12,3	20,0
16,7	4,4	8,0	6,2	10,0	9,3	16,0	7,0	12,5	9,8	16,0	14,8	25,0	8,9	16,0	12,5	20,0	18,8	32,0
19,0	5,7	10,0	8,0	12,5	12,0	20,0	9,1	16,0	12,8	25,0	19,3	32,0	11,5	20,0	16,2	32,0	24,3	40,0
20,6	6,8	12,5	9,6	16,0	14,4	25,0	10,7	20,0	15,1	25,0	22,6	40,0	13,5	25,0	19,0	32,0	28,6	50,0
25,4	10,3	20,0	14,5	25,0	21,8	40,0	16,2	32,0	22,9	40,0	34,3	63,0	* 15,5	* 25,0	* 21,9	* 40,0	* 32,8	* 63,0
30,0	14,4	25,0	20,2	40,0	30,5	50,0												

* 22,0 mm size chain in grade T (8).

14 Examples of chain slings

Figures 2 to 5 are intended to show examples of typical forms of sling and to illustrate the terms used; they are not intended to limit the design of slings.

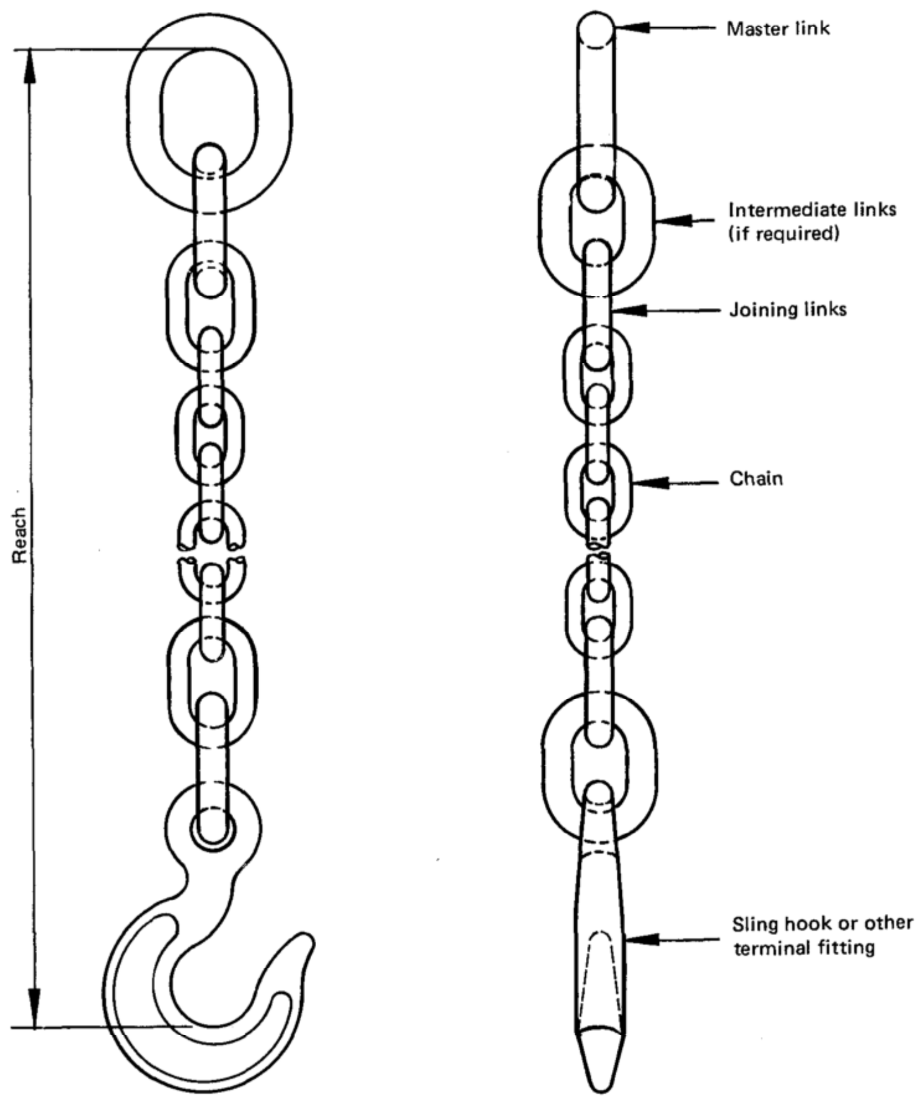


Figure 2 — Single branch sling

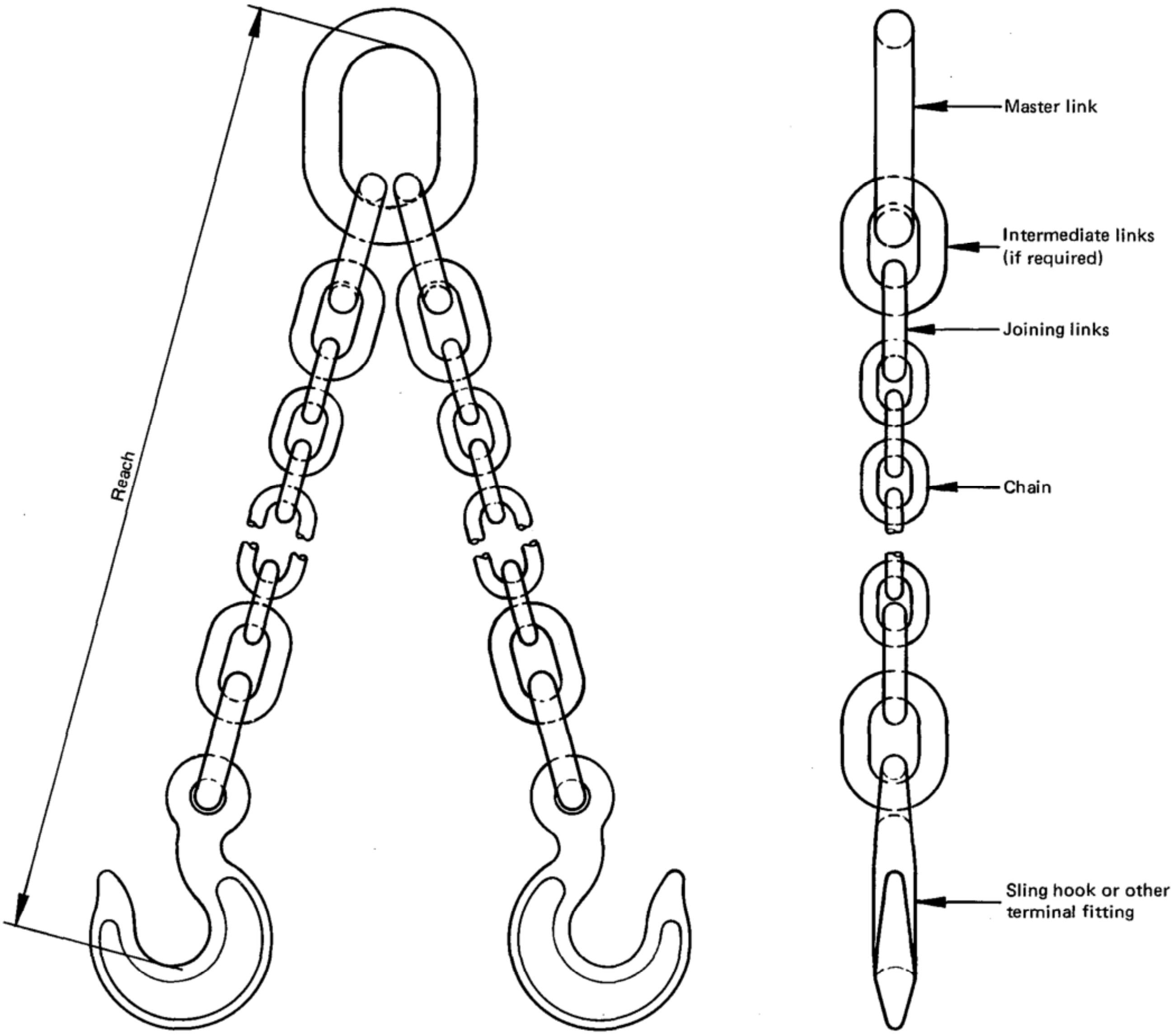


Figure 3 — Double branch sling

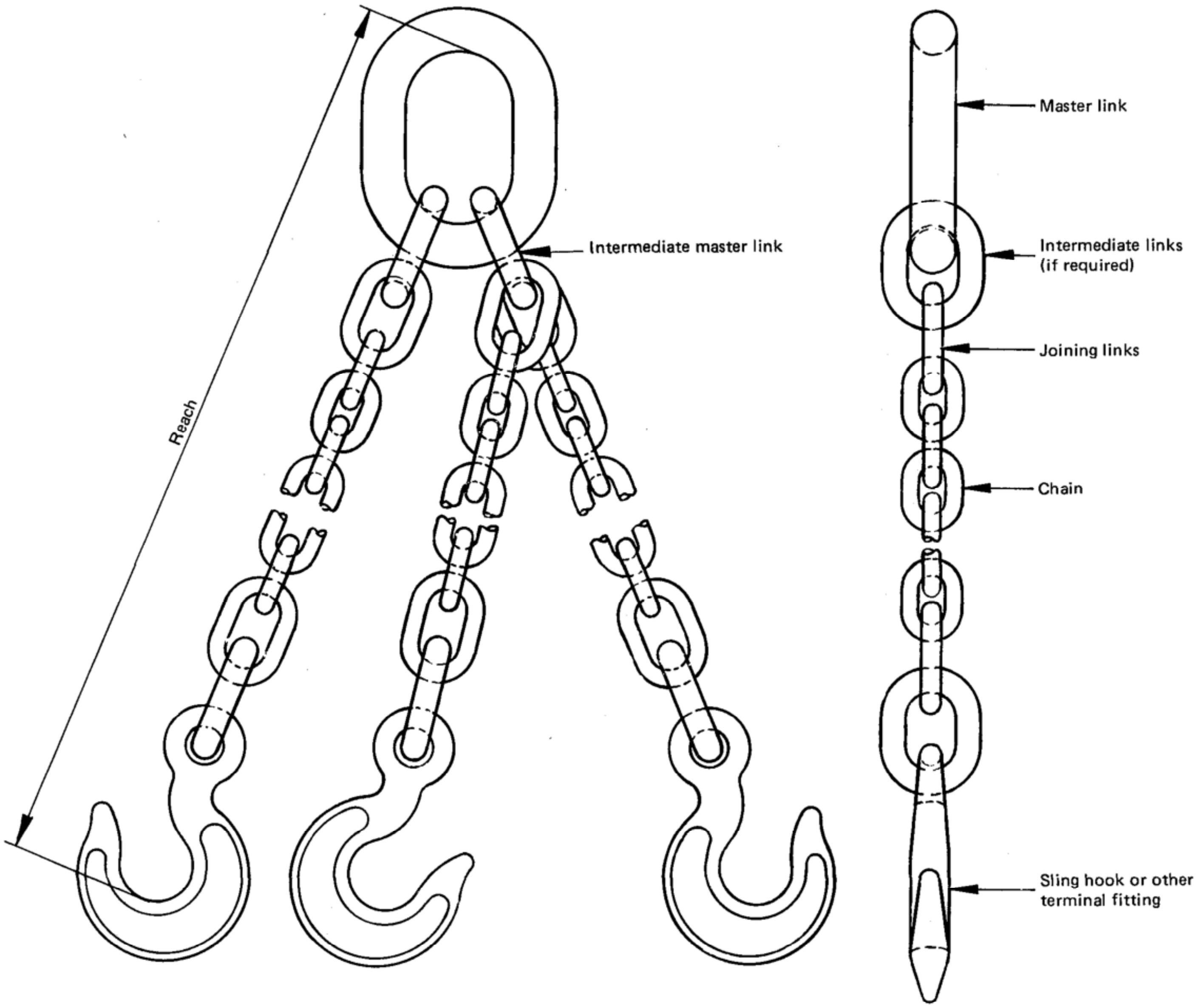


Figure 4a) — Three branch sling

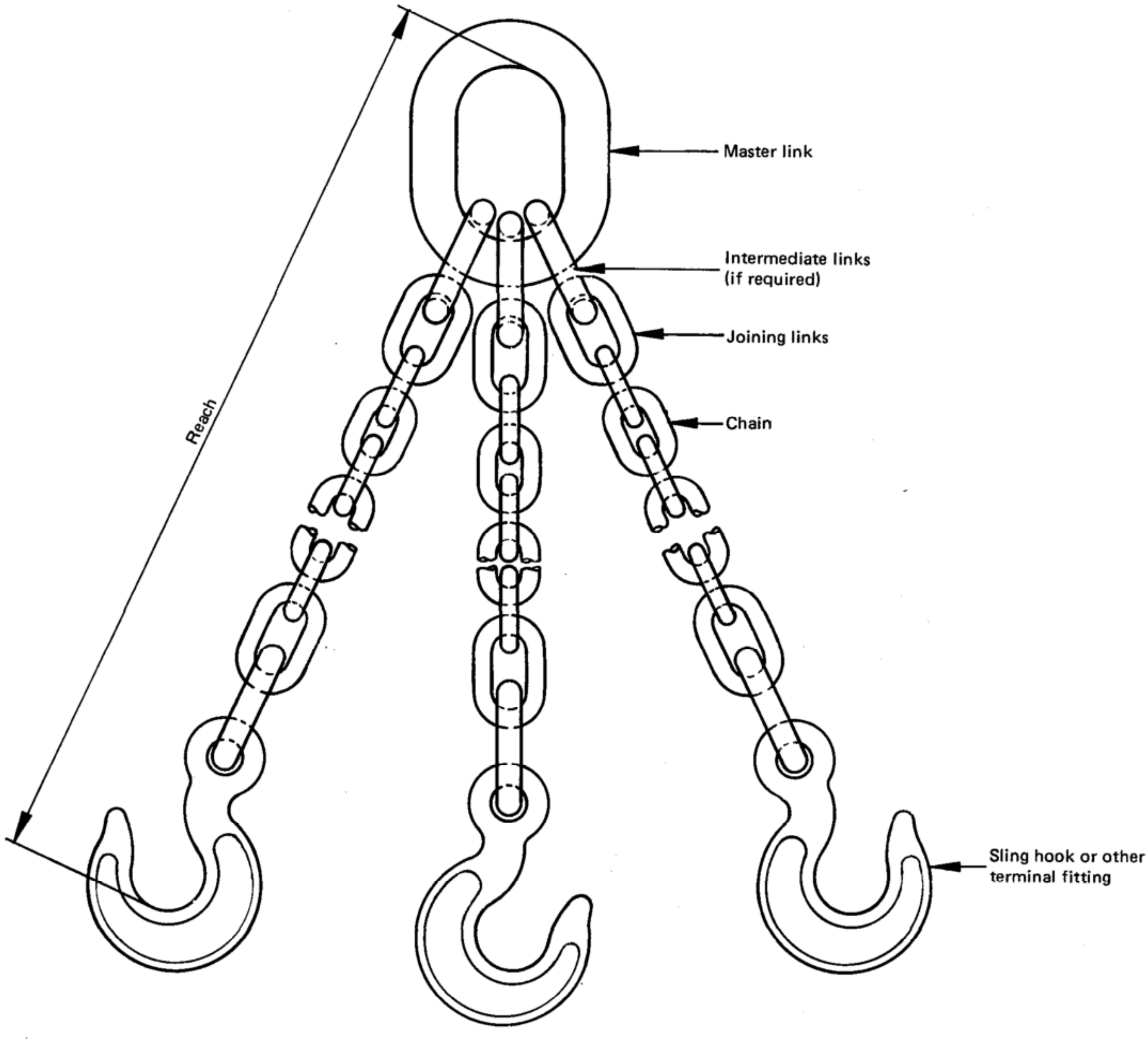


Figure 4b) — Three branch sling — Alternative construction

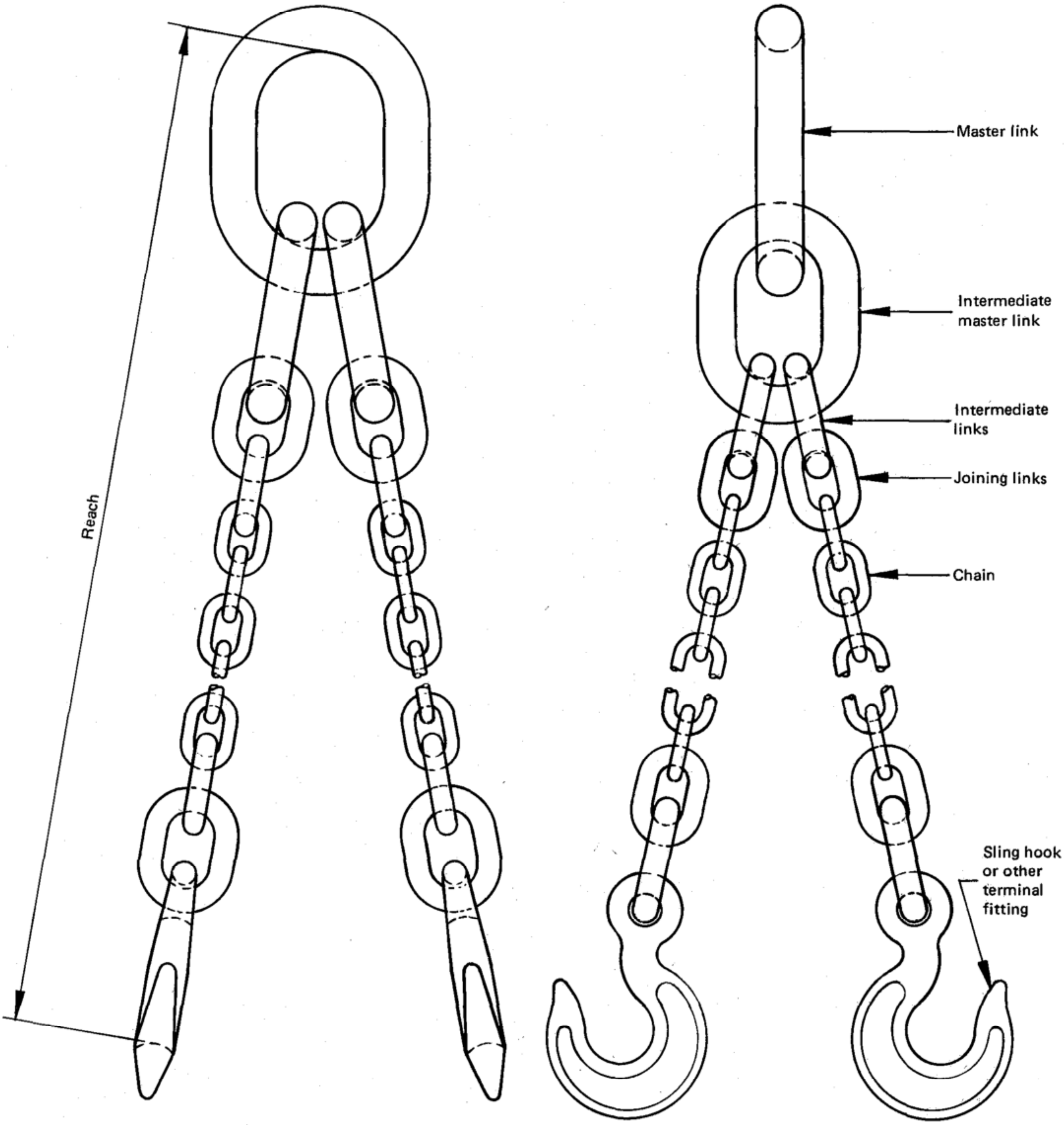
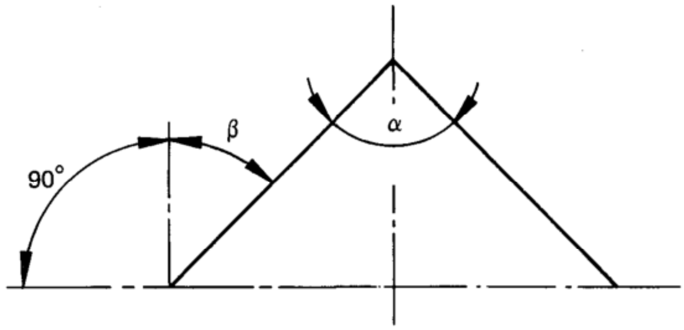
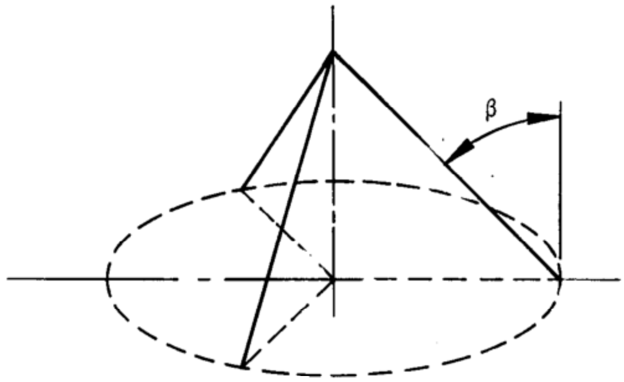


Figure 5 — Four branch sling

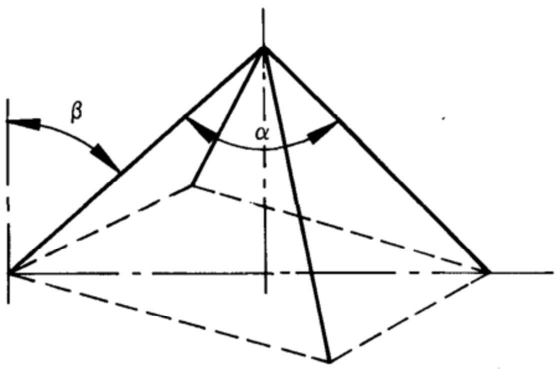
15 Inclination of sling branches



Double branch



Three branch



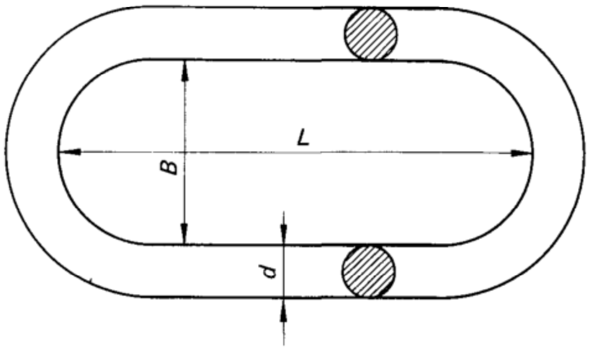
Four branch

Figure 6

Annex

Design of a master link

A.1 Links of circular cross-section



The following simple formulae[1] may be used to design master links made of a material of circular cross-section; the diameter, d, of the material of the link is the larger of the two values obtained :

$$d = 0{,}2\,AB\left[6{,}7 + A - \frac{B}{L}\right] \qquad \ldots (1)$$

$$d = B\left[0{,}1 + A\,(1 + A) - 0{,}12\frac{L}{B}\right] \qquad \ldots (2)$$

where

L is the internal length of the link;

B is the internal breadth of the link;

$$A = \left[\frac{W}{fB^2}\right]^{1/3}$$

W being the working load limit of the link;

f being the maximum nominal extreme fibre stress in the link under the working load limit.

The units of d, L, B, W and f must be self-consistent.

The recommended values of f, in metric units, for the various grades of link are :

grade M : 315 MPa (N/mm^2)

grade P : 400 MPa (N/mm^2)

grade S : 500 MPa (N/mm^2)

grade T : 630 MPa (N/mm^2)

grade V : 800 MPa (N/mm^2)

L, B and d must be in millimetres and W must be in newtons, for the above units for f.

The above method represents the exact analysis of a link to within 2,5 % in all practical cases and the difference is seldom greater than 1,5 %.

The table below is presented as a guide in obtaining the cube root in A.

x	$x^{1/3}$
0,000 343	0,07
0,001 000	0,10
0,008 000	0,20
0,027 000	0,30
0,064 000	0,40
0,125 000	0,50
0,216 000	0,60
0,343 000	0,70
0,512 000	0,80
0,729 000	0,90
1,000 000	1,00

An example of the use of the above formulae is given below, using the following values :

f : 315 MPa (N/mm^2)

W : 126 500 N

L : 203 mm

B : 130 mm

$\frac{W}{fB^2}$: 0,023 76

$\left[\frac{W}{fB^2}\right]^{1/3}$: 0,287 5

Thus

d : 47,44 mm, from formula (1)

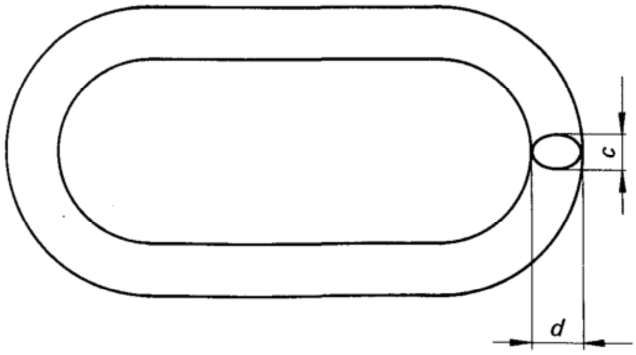
d : 36,76 mm, from formula (2)

The minimum value to use for d is the greater of the above i.e. 47,44 mm. In the majority of cases formula (1) will give a greater value for d than formula (2). However there is no simple rule whereby it is possible to predict the correct formula in any particular case. It is therefore recommended that both formulae be evaluated each time.

1) Developed at the National Physical Laboratory, United Kingdom.

A.2 Links of elliptical cross-section

The formulae described in A.1 can also be used to design links made of a material of elliptical cross-section.



The axes of the ellipse are designated c and d as shown in the figure (c can be greater than or less than d). W, f, L and B are as in A.1.

The design procedure is as follows :

a) choose a value of the ratio d/c;

b) calculate A, which for the ellipse, equals $\left[\frac{W}{fB^2} \times \frac{d}{c}\right]^{1/3}$;

c) calculate d as for the circular cross-section but using the value of A given in b) above;

d) calculate c from the chosen value of d/c;

e) should the above values of c and d not be suitable, a different value of the ratio d/c can be chosen.

Examples :

	a)	b)
f :	315 MPa (N/mm^2)	315 MPa (N/mm^2)
W :	126 500 N	126 500 N
L :	203 mm	203 mm
B :	130 mm	130 mm
$\frac{d}{c}$:	1,5	0,5
$\frac{W}{fB^2} \times \frac{d}{c}$:	0,035 64	0,011 88
$\left[\frac{W}{fB^2} \times \frac{d}{c}\right]^{1/3}$:	0,329 1	0,228 2

Thus

	a)	b)	
d =	54,67 mm	37,30 mm	from formula (1)
c =	36,44 mm	74,61 mm	from formula (1)
d =	45,50 mm	25,07 mm	from formula (2)
c =	30,34 mm	50,15 mm	from formula (2)

In both cases, the values of d and c found using the formula (1), being the higher, are the values to be used.

NOTES

1) The expressions for d were derived by fitting formulae to data obtained from the analytical stress analysis of links.

2) The maximum tensile stress in a link will occur at one of two places, the extrados at the crown or the intrados where the straight and circular parts meet. d from formula (1) represents data for the former point and d from formula (2) for the latter. It is therefore necessary to choose the higher of d from formula (1) and d from formula (2) in order to design the link for the correct maximum stress.

3) The use of the formulae for the elliptical cross-section is based on the fact that the stress at any point in a circular section is c/d times the stress at the equivalent point in an elliptical section. Axes c and d are as defined in A.2 and d must have the same value in the circular as in the elliptical cross-section for the comparison to be valid. Therefore, the stress in the fibre wz of the circular section is c/d times that in fibre xy of the elliptical section, both fibres being the same distance from the axis of bending.