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МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ

Forged shackles for general lifting purposes — Dee shackles and bow shackles

Manilles forgées pour levage — Manilles droites et manilles lyres

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 2415 was prepared by Technical Committee ISO/TC 111, *Round steel link chains, lifting hooks and accessories*.

This second edition cancels and replaces the first edition (ISO 2415 : 1973), ISO 2731 : 1973 and ISO 2791 : 1973, of which it constitutes a technical revision.

<https://standards.iteh.ai/catalog/standards/sist/d190b6c6-70ec-4788-b659-17902280610/ISO-2415-1987>

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Forged shackles for general lifting purposes — Dee shackles and bow shackles

1 Scope and field of application

This International Standard specifies the general characteristics, performance and critical dimensions necessary for interchangeability and compatibility with other components, of forged dee and bow shackles in a range of sizes having working load limits from 0,63 to 100 t, and in grades M(4), S(6) and T(8).

In the case of dee shackles for use with forged steel lifting hooks (see ISO 4779 and 7597), it may be necessary to use an intermediate component to make the connection.

2 References

ISO 261, *ISO general purpose metric screw threads — General plan*.

ISO 263, *ISO inch screw threads — General plan and selection for screws, bolts and nuts — Diameter range 0.06 to 6 in.*

ISO 643, *Steels — Micrographic determination of the ferritic or austenitic grain size*.

ISO 4779, *Forged steel lifting hooks with point and eye for use with steel chains of grade M(4)*.

ISO 4948-1, *Steel — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*.

ISO 6506, *Metallic materials — Hardness test — Brinell test*.

ISO 6508, *Metallic materials — Hardness test — Rockwell test (scales A — B — C — D — E — F — G — H — K)*.

ISO 7597, *Forged steel lifting hooks with point and eye for use with steel chains of grade T(8)*.

3 Definitions

For the purposes of this International Standard, the following definitions apply. See also figures 1 and 2.

3.1 shackle: A component consisting of two readily separable parts, the body and the pin.

3.2 body: One of the two parts of the shackle, consisting of a bar of suitable section formed through an appropriate angle (see 3.6 and 3.7) and terminating in coaxial eyes.

3.3 crown: The part of the shackle body opposite the pin.

3.4 eyes: Bosses on the ends of the body with coaxial holes through which the pin passes.

3.5 pin: A straight bar of circular section which passes through the eyes, arranged so as to be secure when in position and which can be readily disassembled. (See figures 1, 2 and 3.)

3.6 dee shackle: A shackle the crown of which forms a semicircle of internal radius half the width, W , between the eyes. (See figure 1.)

3.7 bow shackle: A shackle the crown of which forms more than a semicircle of internal radius more than half the width, W , between the eyes. (See figure 2.)

3.8 ultimate strength: The maximum force reached during tensile testing of a shackle at the end of which the shackle fails to retain the load.

3.9 proof force, F_e : The force applied as a test to a finished shackle as specified in clause 13.

3.10 working load limit (WLL): The maximum mass which a shackle is designed to sustain in general service.

3.11 working load (WL): The maximum mass which a shackle may sustain in a particular stated service.

4 Forms and dimensions

4.1 Dee shackles

The dimensions of dee shackles shall comply with the requirements laid down in table 1 and figure 1.

4.2 Bow shackles

The dimensions of bow shackles shall comply with the requirements laid down in table 2 and figure 2.

4.3 Hole diameter

The diameter of the unthreaded hole or holes in the body of the shackle shall not exceed the following values:

- a) Hole diameter for pins having a diameter up to and including 20 mm: $D + 1$ mm
- b) Hole diameter for pins having a diameter over 20 mm and up to and including 45 mm: $D + 1,5$ mm
- c) Hole diameter for pins having a diameter over 45 mm: $D + 2$ mm

where D is the actual pin diameter.

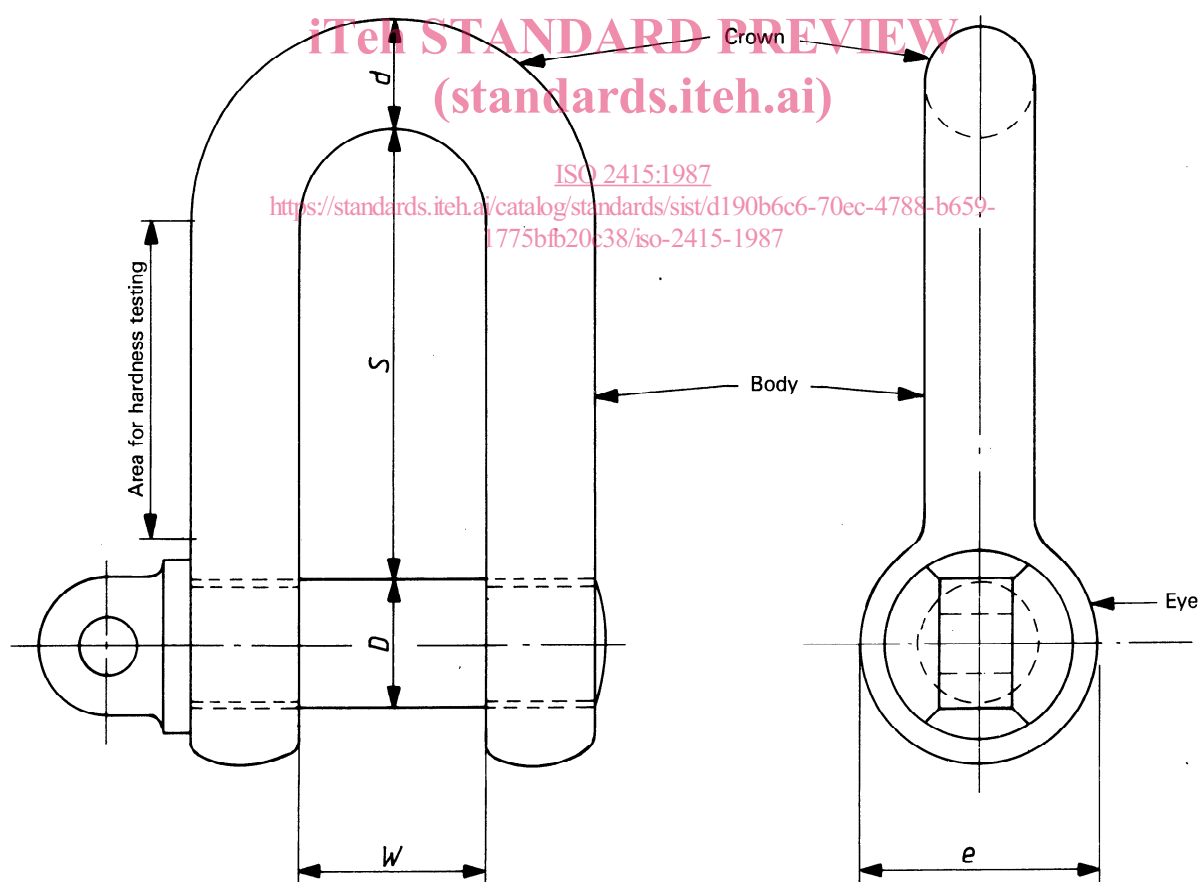


Figure 1 — Dimensions of dee shackles

Table 1 — Dimensions of dee shackles

Working load limit for grades			$d^{(1)}$ max.	$D^{(2)}$ max.	e max.	$S^{(3)}$ min.	$W^{(2)}$ min.
M(4)	S(6)	T(8)					
t			mm	mm		mm	mm
—	—	0,63	8	9	2,2 D max.	18	9
—	0,63	0,8	9	10		20	10
—	0,8	1	10	11,2		22,4	11,2
0,63	1	1,25	11,2	12,5		25	12,5
0,8	1,25	1,6	12,5	14		28	14
1	1,6	2	14	16		31,5	16
1,25	2	2,5	16	18		35,5	18
1,6	2,5	3,2	18	20		40	20
2	3,2	4	20	22,4		45	22,4
2,5	4	5	22,4	25		50	25
3,2	5	6,3	25	28		56	28
4	6,3	8	28	31,5		63	31,5
5	8	10	31,5	35,5		71	35,5
6,3	10	12,5	35,5	40		80	40
8	12,5	16	40	45		90	45
10	16	20	45	50		100	50
12,5	20	25	50	56		112	56
16	25	32	56	63		125	63
20	32	40	63	71		140	71
25	40	50	71	80		160	80
32	50	63	80	90		180	90
40	63	—	90	100		200	100
50	80	—	100	112		224	112
63	100	—	112	125		250	125
80	—	—	125	140		280	140
100	—	—	140	160		315	160

1) Formulae used to calculate values of d max. :

- M(4) : $14\sqrt{WLL}$
- S(6) : $11,2\sqrt{WLL}$
- T(8) : $10\sqrt{WLL}$

2) Formulae used to calculate values of D max. and W min. :

- M(4) : $16\sqrt{WLL}$
- S(6) : $12,5\sqrt{WLL}$
- T(8) : $11,2\sqrt{WLL}$

3) Formulae used to calculate values of S min. :

- M(4) : $31,5\sqrt{WLL}$
- S(6) : $25\sqrt{WLL}$
- T(8) : $22,4\sqrt{WLL}$

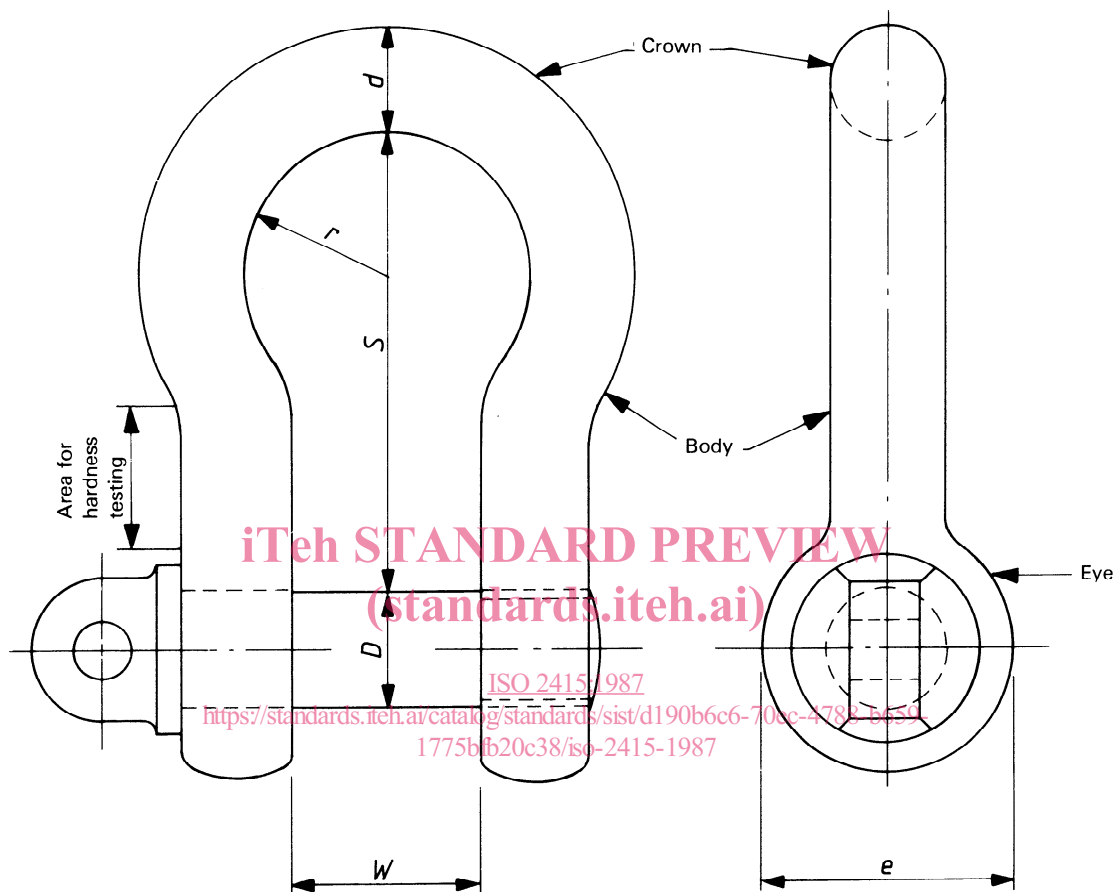


Figure 2 — Dimensions of bow shackles

Table 2 — Dimensions of bow shackles

Working load limit for grades			$d^{1)}$ max.	$D^{2)}$ max.	e max.	$2r^{3)}$ min.	$S^{4)}$ min.	$W^{2)}$ min.
M(4)	S(6)	T(8)						
t			mm	mm		mm	mm	mm
—	—	0,63	9	10	2,2 D max.	16	22,4	10
—	0,63	0,8	10	11,2		18	25	11,2
—	0,8	1	11,2	12,5		20	28	12,5
0,63	1	1,25	12,5	14		22,4	31,5	14
0,8	1,25	1,6	14	16		25	35,5	16
1	1,6	2	16	18		28	40	18
1,25	2	2,5	18	20		31,5	45	20
1,6	2,5	3,2	20	22,4		35,5	50	22,4
2	3,2	4	22,4	25		40	56	25
2,5	4	5	25	28		45	63	28
3,2	5	6,3	28	31,5		50	71	31,5
4	6,3	8	31,5	35,5		56	80	35,5
5	8	10	35,5	40		63	90	40
6,3	10	12,5	40	45		71	100	45
8	12,5	16	45	50		80	112	50
10	16	20	50	56		90	125	56
12,5	20	25	56	63		100	140	63
16	25	32	63	71		112	160	71
20	32	40	71	80		125	180	80
25	40	50	80	90		140	200	90
32	50	63	90	100		160	224	100
40	63	—	100	112		180	250	112
50	80	—	112	125		200	280	125
63	100	—	125	140		224	315	140
80	—	—	140	160		250	355	160
100	—	—	160	180		280	400	180

1) Formulae used to calculate values of d max. : <https://standards.iteh.ai/catalog/standards/sist/d190b6c6-70ec-4788-b659-1775bfb20c38/iso-2415-1987>

- M(4) : $16\sqrt{WLL}$
- S(6) : $12,5\sqrt{WLL}$
- T(8) : $11,2\sqrt{WLL}$

2) Formulae used to calculate values of D max. and W min. :

- M(4) : $18\sqrt{WLL}$
- S(6) : $14\sqrt{WLL}$
- T(8) : $12,5\sqrt{WLL}$

3) Formulae used to calculate values of $2r$ min. :

- M(4) : $28\sqrt{WLL}$
- S(6) : $22,4\sqrt{WLL}$
- T(8) : $20\sqrt{WLL}$

4) Formulae used to calculate values of S min. :

- M(4) : $40\sqrt{WLL}$
- S(6) : $31,5\sqrt{WLL}$
- T(8) : $28\sqrt{WLL}$

5 Mechanical properties

5.1 General

The mechanical properties of the shackles in terms of proof force and ultimate strength shall be as specified in table 3.

5.2 Proof force

Each shackle, tested in accordance with 12.2, shall be capable of sustaining the proof force specified in table 3 without permanent deformation of the pin, which, after loosening, shall turn freely, and without an increase in the actual dimension, S , of the shackle body or in a similar dimension measured between punch marks on the pins and the crown, exceeding 0,25 % or 0,5 mm, whichever is the greater.

5.3 Ultimate strength

Each shackle, tested in accordance with 12.3, shall have an ultimate strength at least equal to that specified in table 3 without fracture or distortion to the extent that the shackle becomes incapable of retaining the load.

On completion of the test, each shackle shall show evidence of ductility.

5.4 Fatigue resistance [grades S(6) and T(8)]

Shackles with a working load limit up to and including 10 t, when tested in accordance with 12.4, shall, after at least 10 000 cycles, be capable of retaining the load.

Table 3 — Mechanical properties

Working load limit (WLL)	Proof force F_e	Minimum ultimate strength
t	kN	kN
0,63	12,5	25
0,8	16	32
1	20	40
1,25	25	50
1,6	32	63
2	40	80
2,5	50	100
3,2	63	125
4	80	160
5	100	200
6,3	125	250
8	160	320
10	200	400
12,5	250	500
16	320	630
20	400	800
25	500	1 000
32	630	1 250
40	800	1 600
50	1 000	2 000
63	1 250	2 500
80	1 600	3 200
100	2 000	4 000

6 Material

6.1 Grade M(4)

6.1.1 General

The steel shall be produced by the open-hearth, the electric or an oxygen-blown process.

In its finished state, as supplied to the shackle manufacturer, the steel shall comply with the requirements specified in 6.1.2, as determined by a cast or check analysis on the bar or on the finished shackle. The manufacturer should supply a cast analysis of the steel if required by the purchaser.

6.1.2 Specific requirements

The steel shall be fully killed, shall be suitable for forging and shall be capable of being heat treated to obtain the mechanical properties required by this International Standard.

Its content of sulfur and phosphorus shall be restricted as specified in table 4.

Table 4 — Sulfur and phosphorus content [grade M(4)]

Element	Maximum content, % (m/m), as determined by	
	cast analysis	check analysis
Sulfur	0,045	0,05
Phosphorus	0,04	0,045

The steel shall be made in conformity with fine grain practice in order to obtain an austenitic grain size of 5 or finer when tested in accordance with ISO 643. This could be achieved, for example, by ensuring that it contains sufficient aluminium or an equivalent element to permit the manufacture of shackles stabilized against strain-age embrittlement during service; a minimum value of 0,02 % (m/m) of metallic aluminium is given for guidance.

Within the limitations specified above, it is the responsibility of the shackle manufacturer to select steel so that the finished shackle, suitably heat-treated, complies with the requirements for the mechanical properties specified in this International Standard for the appropriate grade of shackle.

6.2 Grades S(6) and T(8)

6.2.1 General

The steel shall be produced by the open-hearth, the electric or an oxygen-blown process.

In its finished state, as supplied to the shackle manufacturer, it shall comply with the requirements specified in 6.2.2, as determined by a cast or check analysis on the bar or on the finished shackle. The manufacturer should supply a cast analysis of the steel if required by the purchaser.

6.2.2 Specific requirements

The steel shall be fully killed, shall be suitable for forging and shall contain alloying elements in sufficient quantities to guarantee the mechanical properties of the shackle after appropriate heat treatment.

The steel for grade S(6) shackle bodies shall contain at least one of the following elements, in the alloying proportions specified in ISO 4948-1:

- nickel;
- chromium;
- manganese;
- molybdenum.

The steel for grade S(6) shackle pins shall contain at least one of the following elements, in the alloying proportions specified in ISO 4948-1:

- nickel;
- chromium;
- molybdenum.

The steel for grade T(8) shackles shall contain at least two of the following elements, in the alloying proportions specified in ISO 4948-1:

- nickel;
- chromium;
- molybdenum.

Its content of sulfur and phosphorus shall be restricted as specified in table 5.

**Table 5 — Sulfur and phosphorus content
[grades S(6) and T(8)]**

Element	Maximum content, % (m/m), as determined by	
	cast analysis	check analysis
Sulfur	0,035	0,04
Phosphorus	0,035	0,04

The steel shall be made in conformity with fine grain practice in order to obtain an austenitic grain size of 5 or finer when tested in accordance with ISO 643. This could be achieved, for example, by ensuring that it contains sufficient aluminium or an equivalent element to permit the manufacture of shackles stabilized against strain-age embrittlement during service; a minimum value of 0,02 % (m/m) of metallic aluminium is given for guidance.

Within the limitations specified above, it is the responsibility of the shackle manufacturer to select steel so that the finished shackle, suitably heat-treated, complies with the requirements for mechanical properties specified in this International Standard for the appropriate grade of shackle.

7 Heat treatment

7.1 Grades M(4) and S(6)

After forging, the shackle shall be subjected to a suitable heat treatment, account being taken of the material and the mechanical properties required.

7.2 Grade T(8)

After forging, the shackle shall be hardened and tempered, account being taken of the material and the mechanical properties required.

Grade T(8) shackles can be used up to a maximum temperature of 400 °C without impairment or change to their metallurgical and mechanical properties when returned to room temperature. When required, for verification, sample shackles shall be tested after they have been re-heated to 400 °C, maintained at that temperature for 1 h, and then cooled to room temperature.

NOTE — Any heat treatment should be carried out only by the manufacturer or after reference to the manufacturer.

8 Hardness

8.1 Hardness requirement

The hardness values of shackles shall not exceed the values specified in table 6.

Table 6 — Hardness values

Grade	Brinell hardness HBS	Rockwell hardness HRC
M(4)	217	17
S(6)	300	32
T(8)	380	41

8.2 Hardness testing

In order to determine Brinell hardness numbers, the tests shall be carried out in accordance with ISO 6506 using, where practicable, a 10 mm steel ball and a force of 29,42 kN (HBS 10/3 000).

In order to determine Rockwell C hardness numbers, the tests shall be carried out in accordance with ISO 6508.

Other methods of determining hardness may be used provided the values obtained, when converted to equivalent Brinell or Rockwell C values, comply with the requirements laid down in 8.1.