



Standard Specification for Turnbuckles, Swaged, Welded, Forged¹

This standard is issued under the fixed designation F 1145; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This specification covers swaged welded, cast, or forged turnbuckles with and without jam nuts.

1.2 A turnbuckle is an internally threaded loop or sleeve intended for assembly with a threaded stud, eye, hook, or jaw at each end, used for applying tension to rods, wire rope, etc.

1.3 The values stated in inch-pound units are to be regarded as standard. The SI units given in parentheses are for information purposes only and may be approximate.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

A 29 Specification for Steel Bars, Carbon and Alloy, Hot-Wrought and Cold-Finished, General Requirements for²

A 153/A 153M Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware³

B 633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel⁴

D 3951 Practice for Commercial Packaging⁵

2.2 AWS Standards:⁶

A5.1 Covered Carbon Steel Arc Welding Electrodes

A5.2 Iron and Steel Oxyfuel Gas Welding Rods

A5.5 Low Alloy Steel Covered Arc Welding Electrodes

2.3 ANSI Standards:⁷

B1.1 Unified Inch Screw Threads (UN and UNR Thread Form)

B18.2.2 Square and Hex Nuts

2.4 Military Standards:⁸

MIL-STD-1186 Cushioning, Anchoring, Bracing, Blocking, and Waterproofing; with Appropriate Test Methods
MIL-STD-2073-1 DoD Material Procedures for Development and Application of Packaging Requirements

2.5 Military Specification:⁸

MIL-P-116 Preservation, Methods of

MIL-L-19140 Lumber and Plywood, Fire-Retardant Treated

2.6 Federal Specifications:⁷

PPP-B-636 Boxes, Shipping, Fiberboard

PPP-F-320 Fiberboard: Corrugated and Solid Sheet Stock (Container Grade) and Cut Shapes

2.7 Federal Standard:⁸

FED-STD-123 Marking for Shipment (Civil Agencies)

3. Classification

3.1 Turnbuckles covered under this specification shall be of the following types and grades, as specified (see 4.1.3 and 4.1.7):

3.1.1 *Type I*—Open turnbuckle bodies (see 5.2.4–5.2.7)
Grade

1 Forged

2 Spread

3 Resistance welded

4 Arc or gas welded

3.1.2 *Type II*—Pipe turnbuckle bodies (see 5.2.8).

3.1.3 *Type III*—Rigging turnbuckle bodies (see 5.2.9).

3.2 Turnbuckles covered under this specification shall be of the following classes and sizes, as specified (see 4.1.3):

3.2.1 Classes:

A—turnbuckle, body only without end pulls, heads not drilled.

B—turnbuckle, body only without end pulls, heads threaded right and left hand.

C—turnbuckle with stub and stub end pulls, complete.

D—turnbuckle with eye and eye end pulls, complete.

E—turnbuckle with hook and hook end pulls, complete.

F—turnbuckle with hook and eye end pulls, complete.

G—turnbuckle with jaw and jaw end pulls, complete.

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² *Annual Book of ASTM Standards*, Vol 01.05.

³ *Annual Book of ASTM Standards*, Vol 01.06.

⁴ *Annual Book of ASTM Standards*, Vol 02.05.

⁵ *Annual Book of ASTM Standards*, Vol 15.09.

⁶ Available from American Welding Society, 550 NW LeJeune Road, Miami, FL 33126.

⁷ Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

⁸ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

H—turnbuckle with jaw and eye end pulls, complete.

3.2.1.1 The arrangement of turnbuckle bodies and end pulls for Classes C, D, E, F, G, and H shall be similar to Fig. 1.

3.2.2 *Sizes*—Shall be as listed in Table 1 and Table 2.

4. Ordering Information

4.1 Orders for material under this specification shall include the following information:

- 4.1.1 ASTM designation and year of issue,
- 4.1.2 Quantity required,
- 4.1.3 Type, class, and size (see 3.1, 3.2, and 8.1),
- 4.1.4 Material, if different (see 5.1.1),
- 4.1.5 Type thread required (see 7.3),
- 4.1.6 Type finish required (see 9.3),
- 4.1.7 Grade required, if Type I is specified (see 3.1.1),
- 4.1.8 Optional requirements, if any (see S1 and S2).

5. Materials and Manufacture

5.1 *Materials:*

5.1.1 Unless otherwise specified (see 4.1.4), turnbuckle and end pulls shall be made from steel of a grade which will meet the requirements of Table 3.

5.1.2 For materials used for welded turnbuckle bodies, eye and jaw end pulls, the carbon shall be 0.25 % maximum, sulfur 0.05 % maximum, and phosphorus 0.05 % maximum.

TABLE 1 Turnbuckle Bodies, Classes A and B, and Turnbuckles, Class C

NOTE 1—1 in. = 25.4 mm.

Thread, Nominal Outside Diameter, in.	Size								
	Clear Opening Between Head, in.								
	4	4½	6	9	12	18	24	36	48
¼	X	...	...	...	...	...	...	...	...
5/16	...	X	...	...	...	...	...	...	...
3/8	X	...	...	...	...	...	...
½	X	X	X	...	...	...	...
5/8	X	X	X	X	...	...	...
¾	X	X	X	X	X	...	...
7/8	X	...	X	X	X	...	...
1	X	...	X	X	X	X	...
1¼	X	...	X	X	X	X	...
1½	X	...	...	...	...	...	...
1¾	X	...	...	X	X	X	X
2	X	...	...	...	X	X	X
2¼	X	...	...	...	X	X	X
2½	X	...	...	...	X	X	X
2¾	X	...	...	...	...	...	X
3	X	...	...	...	...	...	X
3½	X	...	...	...	...	...	X
4	X	...	...	...	...	...	X

TABLE 2 Turnbuckles, Classes D, E, F, G, and H.

NOTE 1—1 in. = 25.4 mm

Thread, Nominal Outside Diameter, in.	Size								
	Clear Opening Between Heads, in.								
	4	4½	6	9	12	18	24	36	48
¼	X	...	...	...	...	...	...	...	...
5/16	...	X	...	...	...	...	...	...	...
3/8	X	...	...	...	...	...	...
½	X	X	X	...	...	...	...
5/8	X	X	X	X	...	...	...
¾	X	X	X	X	X	...	...
7/8	X	X	X	...	...
1	X	X	X	X	...
1¼	X	X	X	X	...
1½	X	X	X	X	X
1¾	X	X	X	X
2	X	X	X
2¼	X	X	X
2½	X	X	X

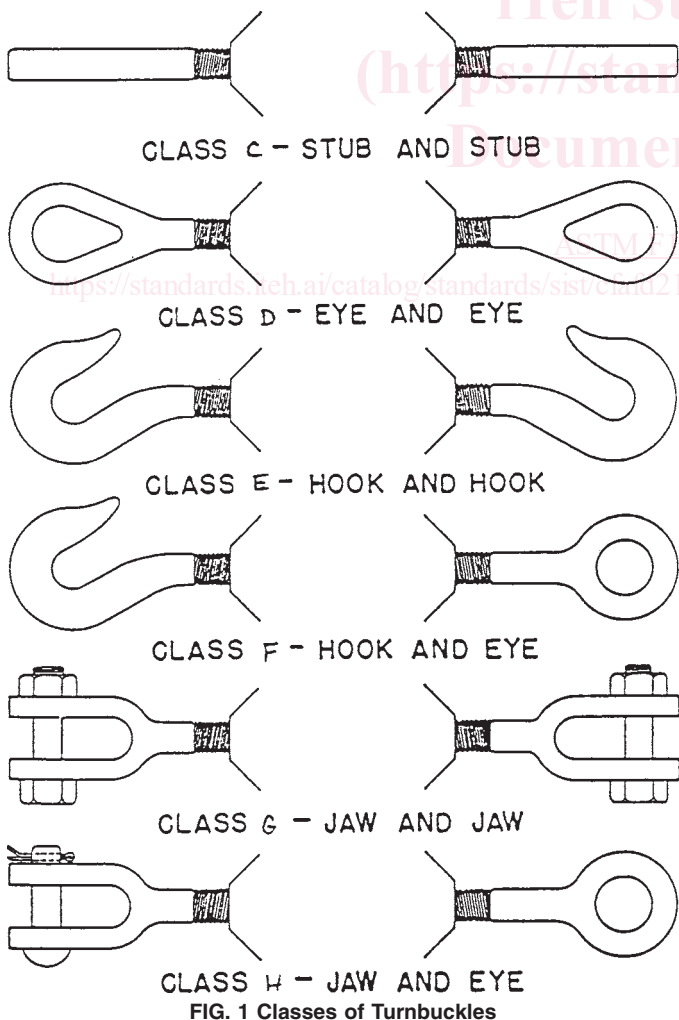


FIG. 1 Classes of Turnbuckles

5.1.3 Heavy jam nuts shall be right-hand or left-hand threaded, as required, and made of carbon steel of a type selected from Groups 1016 to 1020, inclusive in accordance with Specification A 29.

5.1.4 Jaw end pulls 5/8 in. (16 mm) and smaller shall be provided with a steel hexagon head bolt and nut of commercial quality. Jaw end pulls 3/4 in. (19 mm) and larger shall be provided with a round head steel pin and cotter of commercial value.

5.2 *Manufacture:*

5.2.1 *Eye End Pulls*—Eye end pulls shall be forged, resistance welded, or arc or gas welded, at the option of the

TABLE 3 Breaking Strength of Turnbuckles (Complete With End Pulls)

NOTE 1—1 in. = 25.4 mm.
NOTE 2—1 lb = 0.45 kg.

Size, Nominal Outside Diameter of Thread, in.	Strength Breaking, min, lbf (N)				Recommended Working Loads, lbf (N)			
	Type I, Grade 1		All Others		Type I, Grade 1		All Others	
	Jaw, Eye, or Stub End Pulls	Hook End Pulls	Jaw, Eye, or Stub End Pulls	Hook End Pulls	Jaw, Eye, or Stub End Pulls	Hook End Pulls	Jaw, Eye, or Stub End Pulls	Hook End Pulls
1/4	2 500 (11)	1 500 (7)	1 550 (7)	1 050 (5)	500 (2)	300 (1.3)	310 (1.4)	210 (0.9)
5/16	3 500 (16)	2 500 (11)	2 700 (12)	1 650 (7.3)	700 (3)	500 (2.2)	540 (2.4)	330 (1.5)
3/8	5 200 (23)	3 500 (16)	4 100 (18)	2 300 (10)	1 040 (4.6)	700 (3.1)	820 (3.6)	460 (2)
1/2	9 000 (40)	5 200 (23)	7 550 (34)	3 700 (16.4)	1 800 (8)	1 040 (8)	1 500 (7)	740 (3.3)
5/8	13 500 (60)	8 000 (36)	12 100 (54)	5 400 (24)	2 700 (12)	1 600 (7.1)	2 400 (11)	1 080 (4.8)
3/4	20 000 (89)	10 000 (44)	18 100 (81)	7 500 (33)	4 000 (18)	2 000 (9)	3 600 (16)	1 500 (7)
7/8	29 000 (129)	12 000 (53)	25 100 (112)	10 000 (44)	5 800 (26)	2 400 (11)	5 000 (22)	2 000 (9)
1	38 000 (169)	14 500 (64)	33 100 (147)	12 800 (57)	7 600 (34)	2 900 (13)	6 600 (29)	2 560 (11.4)
1 1/4	60 000 (267)	23 000 (102)	53 600 (238)	20 600 (92)	12 000 (53)	4 600 (20)	10 700 (48)	4 120 (18.3)
1 3/8	72 000 (320)	29 000 (129)	63 400 (282)	24 300 (108)	14 400 (64)	5 800 (26)	12 600 (56)	4 860 (22)
1 1/2	85 000 (378)	36 000 (160)	77 700 (345)	29 300 (130)	17 000 (76)	7 200 (32)	15 500 (69)	5 860 (26.1)
1 3/4	115 000 (511)	...	105 000 (467)	...	23 000 (102)	...	21 000 (93)	...
2	150 000 (667)	...	138 000 (614)	...	30 000 (133)	...	27 600 (122)	...
2 1/4	197 000 (876)	...	181 000 (805)	...	39 400 (175)	...	36 200 (161)	...
2 1/2	242 000 (1076)	...	223 000 (992)	...	48 400 (215)	...	44 600 (198)	...
2 3/4	304 000 (1352)	...	277 000 (1232)	...	60 800 (270)	...	55 400 (246)	...
3	350 000 (1556)	...	337 000 (1499)	...	70 000 (311)	...	67 400 (300)	...
3 1/4	400 000 (1779)	...	400 000 (1779)	...	80 000 (356)	...	80 000 (356)	...
3 1/2	475 000 (2112)	...	475 000 (2113)	...	95 000 (423)	...	95 000 (423)	...
3 3/4	550 000 (2446)	...	550 000 (2446)	...	110 000 (489)	...	110 000 (489)	...
4	635 000 (2824)	...	635 000 (2824)	...	127 000 (565)	...	127 000 (565)	...

producer, except that when forged bodies are specified, forged-eye end pulls shall be required.

5.2.1.1 Each forged-eye end pull shall be forged at elevated temperature to final shape and size and shall be similar to Fig. 2. The shape of the eye may be either oval or round.

5.2.1.2 Resistance-welded eye end pulls shall be similar to Fig. 3. They shall be fabricated from one piece of material by bending the material to form the eye and joined by resistance welding process.

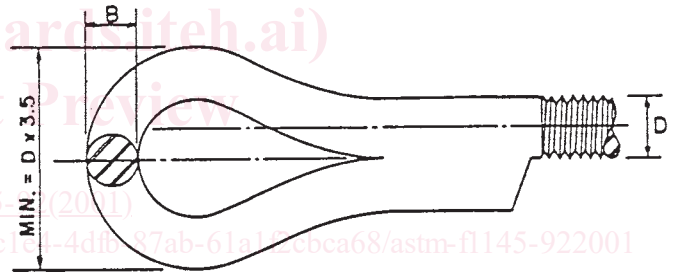


FIG. 3 Resistance-Welded-Eye End Pull

5.2.1.3 Arc- or gas-welded eye end pulls shall be similar to Fig. 4. They shall be fabricated from one piece of material by bending the material to form the eye and joined by welding. The cross-sectional area through the weld shall be not less than the cross-sectional area of the bar.

5.2.2 *Jaw End Pulls*—Jaw end pulls shall be forged, arc or gas welded, or upset, at the option of the producer, except that if forged bodies are specified, forged-jaw end pulls shall be provided.

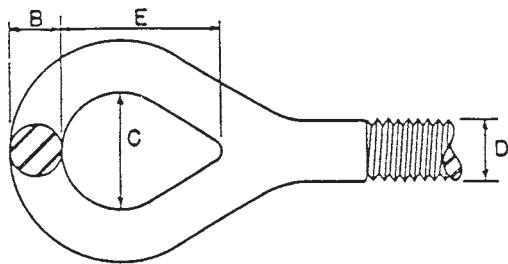


FIG. 2 Forged-Eye End Pull

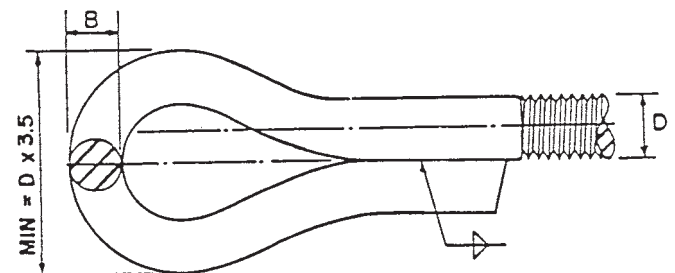


FIG. 4 Arc or Gas Welded-Eye End Pull

5.2.2.1 Forged-jaw end pulls shall be similar to Fig. 5.

5.2.2.2 Arc- or gas-welded end pulls shall be similar to Fig.

6.

5.2.2.3 Upset jaw end pulls shall be similar to Fig. 7.

5.2.3 Hook End Pulls—Hook end pulls shall be forged and be similar to Fig. 8.

5.2.4 Type I, Grade 1 Turnbuckles—Each forged turnbuckle body shall be forged at elevated temperature to final shape and size and shall be similar to Fig. 9. The shape of the head of the turnbuckle shall be either round or hexagonal.

5.2.5 Type I, Grade 2 Turnbuckles—For each spread turnbuckle body, one piece of material shall be cut lengthwise from near one end to the other end by any suitable means, such as an oxyacetylene cutting torch; the resulting reins shall then be spread apart at elevated temperatures to final shape and size. The bodies shall be similar to Fig. 10. The shape of the cross section of the material shall be at the option of the producer.

5.2.6 Type I, Grade 3 Turnbuckles—Each resistance-welded turnbuckle body shall be fabricated by joining two formed pieces of material by either the flash or upset welding process. The welds shall be parallel to the long axis of the piece. The surfaces to be joined shall be held in intimate contact by external forces, an electric current passed through the surfaces, and the weld consolidated by the forces. The bodies shall be similar to Fig. 11. The shape of the cross section of the pieces shall be at the option of the producer.

5.2.7 Type I, Grade 4 Turnbuckles—The welds shall be either electric arc or oxyacetylene (gas) at the option of the producer. Arc- or gas-welded turnbuckle bodies shall be fabricated by joining four pieces of material by welds similar to Fig. 12. The faces of the welds shall not be concave but may be somewhat convex.

5.2.8 Type II, Pipe—Pipe turnbuckle bodies shall be forged, swaged, spun, drawn, or upset in way of the threaded ends, and shall be similar to Fig. 13.

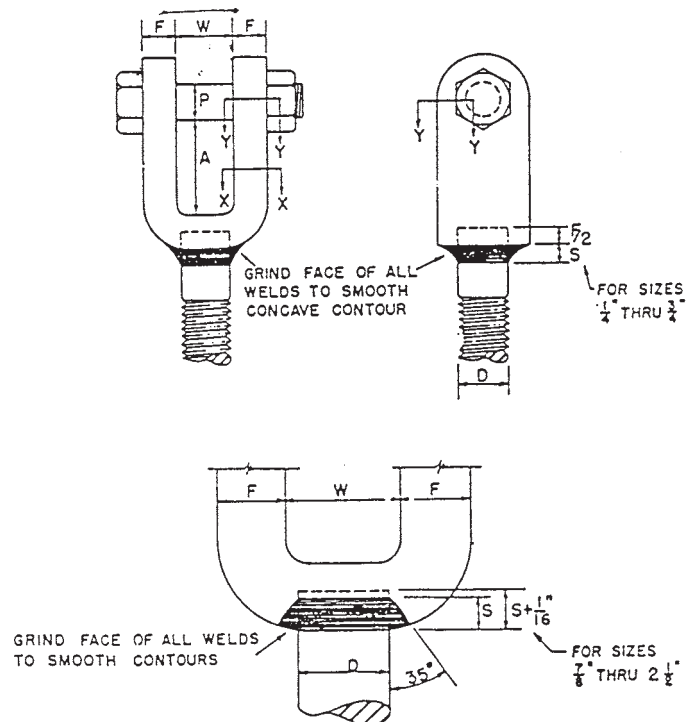


FIG. 6 Arc or Gas Welded-Jaw End Pull

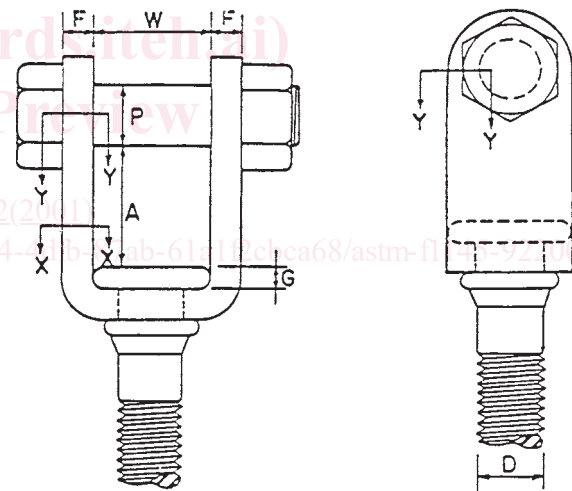


FIG. 7 Upset Jaw End Pull

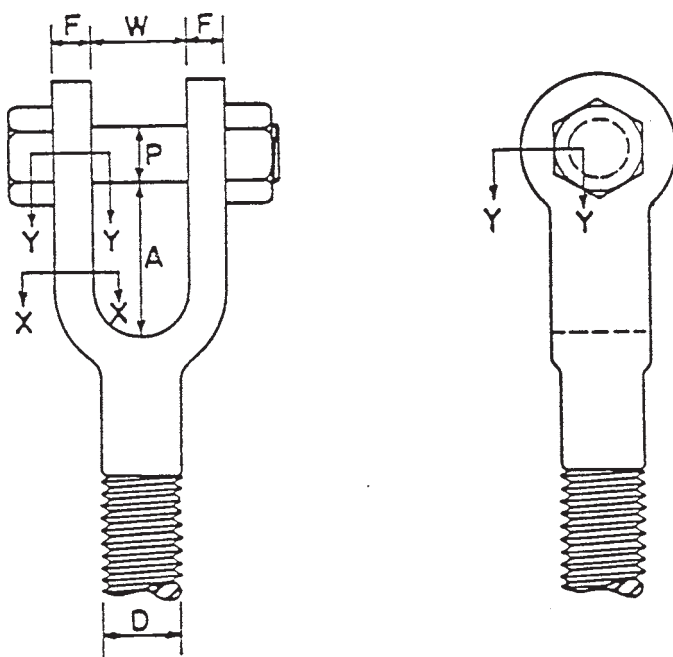


FIG. 5 Forged-Jaw End Pull

5.2.9 Type III, Rigging—Rigging turnbuckle bodies shall be forged, similar to Fig. 14, and shall be provided with a heavy jam nut (see 5.1.3) of a type which does not depend upon deformation of the threads for security.

6. Mechanical Properties

6.1 The breaking strength of turnbuckles, equipped with end pulls, shall be not less than the value given in Table 3 for the required size, type, and grade of end pull specified.

6.2 End pulls shall be capable of bending through an angle of 90° around a pin twice the nominal major diameter of the end pull without either crack or rupture.

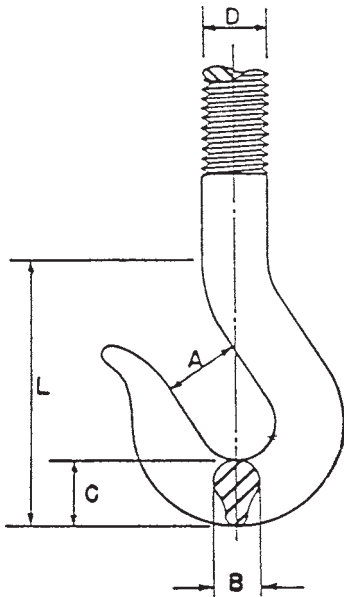


FIG. 8 Hook End Pull

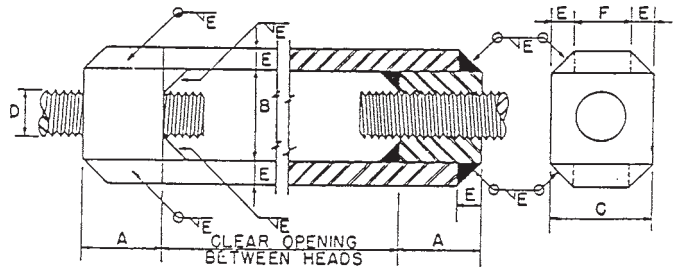


FIG. 12 Type I, Grade 4, Open Turnbuckle Body, Arc or Gas Welded

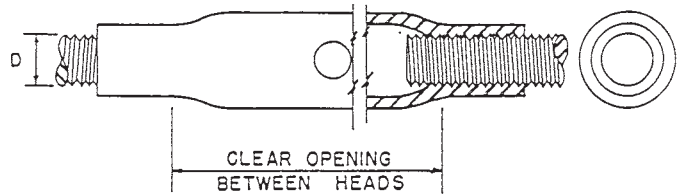


FIG. 13 Type II, Pipe Turnbuckle Body

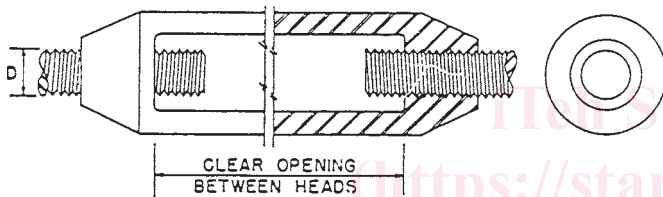


FIG. 9 Type I, Grade 1, Open Turnbuckle Body, Forged

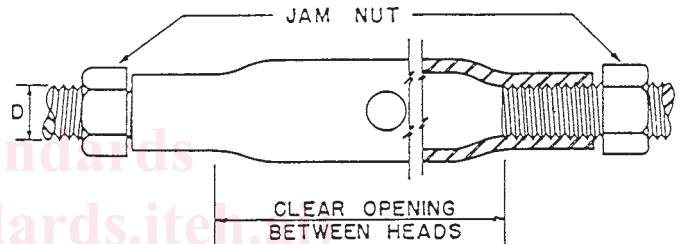


FIG. 14 Type III, Rigging Turnbuckle Body

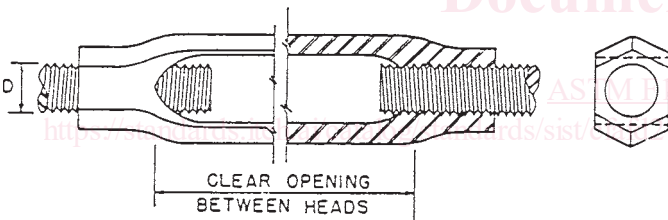


FIG. 10 Type I, Grade 2, Open Turnbuckle Body, Spread

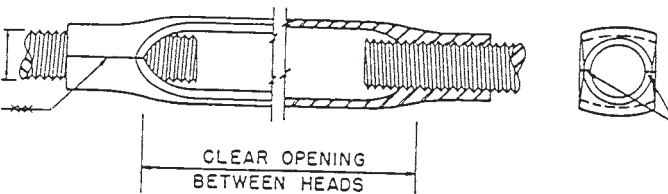


FIG. 11 Type I, Grade 3, Open Turnbuckle Body, Resistance Welded

6.3 End pulls for Classes D, E, F, G, and H shall be capable of supporting a load equal to one half of the specified breaking strength without permanent deformation.

7. Other Requirements

7.1 All arc-welded bodies, eyes, and jaws shall be welded with Type 7015, 7016, 8015, or 8016 electrodes of AWS A 5.1 or AWS A 5.5, as applicable.

7.2 All gas-welded bodies, eyes, and jaws shall be welded with welding rods in accordance with AWS A 5.2.

7.3 Turnbuckle bodies and end pulls shall be threaded after fabrication to final size and shape. The threads in the heads of the turnbuckle bodies and on the end pulls shall comply with ANSI B 1.1 (see 4.1.5). Unified threads in the coarse (UNC) and fine (UNF) standard series should be used. If neither is specified, the threads will be in the UNC series. If the standard diameter-pitch combinations are not suitable, the UNS threads with dimensions in accordance with ANSI B 1.1 should be used.

7.3.1 Threads on the finished turnbuckle shall not be looser than class 1A/1B fit. If coated turnbuckles are specified, the male threads on the end pulls may be undercut, as necessary, so that after coating they will properly mate (not looser than 1A/1B fit) with the standard size female threads of the turnbuckle bodies.

7.3.2 The thread in one head of each turnbuckle body shall be right-hand and in the other head, left-hand.

7.3.3 The threads on the end pulls shall be right-hand on one end pull and left-hand on the other. The length of the thread on the two end pulls shall be great enough so that the ends of the end pull can be brought into contact with each other at the middle of the body length when jam nuts are not used.

8. Dimensions and Tolerances

8.1 Turnbuckles covered by this specification shall be furnished in the sizes shown in Table 1 and Table 2, as specified (see 4.1.3).

8.1.1 The size of turnbuckle bodies and turnbuckles shall be the nominal major diameter of the threads in the heads and the clear opening between heads (which is approximately equal to the take up); thus, for a 3/4 by 6-in. (19 by 152-mm) turnbuckle body, the heads shall be threaded for a 3/4-in. (19-mm) nominal major diameter end pull, and the clear opening between heads shall be 6 in. (152 mm). The difference between the actual clear opening in the turnbuckle body and the nominal value given in Table 1 or 2 for the size specified shall not exceed 5 % of the nominal value.

8.1.2 The lengths of the heads of the turnbuckle bodies shall not be less than 1 1/2 times the nominal outside diameter of the end pull for sizes up to 1 1/4 in. (32 mm), and 1 1/4 times for sizes 1 1/4 in. (32 mm) and above.

8.2 Type I, Grade 4 turnbuckle bodies shall comply with the dimensional requirements given in Table 4 for the size specified.

8.3 For Types II and III turnbuckle bodies, holes in body shall be 1/4 in. (6 mm) in diameter for sizes up to and including 5/8 in. (16 mm); holes in body for sizes larger than 5/8 in. (16 mm) shall be 1/2 in. (13 mm) in diameter (see Fig. 13 and Fig. 14, respectively).

8.4 Minimum dimensions for forged-eye end pulls are as shown in Table 5.

8.5 For arc- or gas-welded and resistance-welded eye end pulls, the outside diameter of the eye shall be not less than 3 1/2 times the nominal diameter of the end pull. Nominal dimensions "D" and "B" (see Fig. 3 and Fig. 4) shall be in accordance with Table 5.

8.6 Forged-jaw end pulls shall comply with the dimensional requirements of Table 6.

8.6.1 In Fig. 5, the area of the cross section X-X shall be not less than 0.75 of the area corresponding to the nominal diameter. The area of the cross section Y-Y shall be not less than 0.40 of the area corresponding to the nominal diameter.

8.7 Arc- or gas-welded jaw end pulls shall comply with the dimensional requirements of Table 7.

TABLE 5 Dimensions of Eye End Pulls, in. (mm)

D, Nominal, in.	A, min	B, min	C, min	E, min
1/4	1/2 (12.7)	7/32 (5.56)	11/32 (8.73)	11/16 (17.4)
5/16	5/8 (7.93)	9/32 (7.14)	7/16 (11.11)	13/16 (20.6)
3/8	3/4 (19)	11/32 (8.73)	17/32 (13.4)	15/16 (23.8)
1/2	1 (25.4)	7/16 (11.11)	23/32 (18.2)	13/16 (30.1)
5/8	1 1/4 (31.7)	1/2 (12.7)	7/8 (22.2)	13/8 (34.9)
3/4	1 1/2 (38.1)	5/8 (15.8)	1 (25.4)	15/8 (41.2)
7/8	1 3/4 (44.4)	3/4 (19)	1 1/4 (31.7)	1 7/8 (47.6)
1	2 (50.8)	7/8 (22.2)	1 7/16 (36.5)	2 1/4 (57.1)
1 1/4	2 3/8 (53.9)	1 1/16 (26.9)	1 11/16 (42.8)	2 3/16 (65)
1 1/2	2 1/4 (57.1)	1 1/4 (31.7)	2 1/8 (53.9)	3 1/4 (82.5)
1 3/4	2 1/2 (63.5)	1 7/16 (36.5)	2 3/8 (60.3)	3 3/4 (95.2)
2	3 (76.2)	1 5/8 (41.2)	2 11/16 (68.2)	4 3/8 (111.1)
2 1/4	3 1/4 (82.5)	1 13/16 (46)	2 15/16 (74.6)	5 3/16 (131.7)
2 1/2	3 1/2 (88.9)	2 (50.8)	3 1/8 (79.3)	6 (152.4)

TABLE 6 Dimensions of Forged-Jaw End Pulls, in. (mm)

D, Nominal, in.	A, min	F, min	P, min	W, min
1/4	5/8 (15.8)	1/8 (3.17)	1/4 (6.35)	3/8 (9.52)
5/16	23/32 (18.2)	1/8 (3.17)	1/4 (6.35)	15/32 (11.9)
3/8	13/16 (20.6)	3/16 (4.76)	5/16 (7.93)	1/2 (12.7)
1/2	1 1/32 (26.1)	1/4 (6.35)	3/8 (9.52)	5/8 (15.8)
5/8	1 1/4 (31.7)	5/16 (7.93)	1/2 (12.7)	3/4 (19)
3/4	1 1/2 (38.1)	3/8 (9.52)	5/8 (15.8)	15/16 (23.8)
7/8	1 3/4 (44.4)	7/16 (11.11)	3/4 (19)	1 1/8 (28.5)
1	2 (50.8)	1/2 (12.7)	7/8 (22.2)	1 3/16 (30.1)
1 1/4	2 3/8 (60.3)	5/8 (15.8)	1 1/8 (28.5)	1 3/4 (44.4)
1 1/2	2 3/4 (69.8)	1 1/16 (17.4)	1 3/8 (34.9)	2 1/16 (52.3)
1 3/4	3 (76.2)	3/4 (19)	1 5/8 (41.2)	2 3/8 (60.3)
2	3 3/4 (95.2)	13/16 (20.6)	1 7/8 (47.6)	2 1/2 (63.5)
2 1/4	4 (101.6)	7/8 (22.2)	2 1/16 (52.3)	2 5/8 (66.6)
2 1/2	4 1/4 (107.9)	1 (25.4)	2 1/4 (57.1)	2 7/8 (73)

8.7.1 In Fig. 6, the area of the cross section X-X shall be not less than 0.75 of the area corresponding to the nominal diameter. The area of the cross section Y-Y shall be not less than 0.40 of the area corresponding to the nominal diameter.

TABLE 4 Type I, Grade 4 Dimensions of Open Turnbuckle Bodies Fabricated by Arc or Gas Welding, in. (mm)

Size, D, Nominal, in.	Head			Rein		Size of All Fillet Welds, min
	Length, A, min	Thickness, B, min	Width, C, min	Thickness, E, min	Width, F, min	
1/4	7/16 (11.11)	1/2 (12.7)	9/16 (14.3)	1/8 (3.1)	5/16 (7.9)	1/8 (3.17)
5/16	5/8 (15.8)	1 1/16 (17.5)	1 3/16 (20.6)	3/16 (4.7)	7/16 (11.11)	3/16 (4.76)
3/8	1 1/16 (17.5)	3/4 (19)	7/8 (22.2)	3/16 (4.7)	1/2 (12.7)	3/16 (4.76)
1/2	7/8 (22.2)	1 (25.4)	1 1/8 (28.6)	1/4 (6.35)	5/8 (15.8)	1/4 (6.35)
5/8	1 1/8 (28.6)	1 1/4 (31.7)	1 7/16 (36.5)	5/16 (7.9)	13/16 (20.6)	5/16 (7.93)
3/4	1 3/8 (34.9)	1 1/2 (38.1)	1 3/4 (44.4)	3/8 (9.5)	1 (25.4)	3/8 (9.52)
7/8	1 9/16 (39.7)	1 3/4 (44.4)	2 (50.8)	7/16 (11.11)	1 1/8 (28.5)	7/16 (11.11)
1	1 3/4 (44.4)	2 (51)	2 1/4 (57.1)	1/2 (12.7)	1 1/4 (31.7)	1/2 (12.7)
1 1/4	2 1/8 (54)	2 1/2 (63.5)	2 3/4 (70)	5/8 (15.8)	1 1/2 (38.1)	5/8 (15.8)
1 3/8	2 3/8 (60.3)	2 3/4 (70)	3 1/16 (77.7)	1 1/16 (17.4)	1 11/16 (42.8)	1 1/16 (17.4)
1 1/2	2 9/16 (65.1)	3 (76.2)	3 3/16 (84.1)	3/4 (19.05)	1 13/16 (46)	3/4 (19.05)
1 3/4	2 13/16 (71.4)	3 3/8 (85.7)	3 5/8 (92.1)	13/16 (20.6)	2 (50.8)	13/16 (20.6)
2	3 3/16 (81)	3 7/8 (98.4)	4 1/8 (104.8)	1 5/16 (23.8)	2 1/4 (57.1)	1 5/16 (23.8)
2 1/4	3 1/2 (89)	4 1/4 (108)	4 1/2 (114.3)	1 (25.4)	2 1/2 (63.5)	1 (25.4)
2 1/2	3 15/16 (100)	4 3/4 (120.6)	5 1/16 (128.6)	1 1/8 (28.5)	2 13/16 (71.4)	1 1/8 (28.5)
2 3/4	4 3/8 (111)	5 1/4 (133.4)	5 5/8 (142.9)	1 1/4 (31.7)	3 1/8 (79.3)	1 1/4 (31.7)
3	4 13/16 (122)	5 3/4 (146)	6 3/16 (157.2)	1 3/8 (34.9)	3 7/16 (87.3)	1 3/8 (34.9)
3 1/2	5 3/16 (141)	6 3/4 (171.5)	7 3/16 (182.5)	1 5/8 (41.2)	3 15/16 (100)	1 5/8 (41.2)
4	6 5/16 (160)	7 3/8 (193.7)	8 1/8 (206.3)	1 13/16 (46)	4 1/2 (114.3)	1 13/16 (46)