EDITION 1 · 2026 · ISO · EN · DIN · ASTM · SAE ·

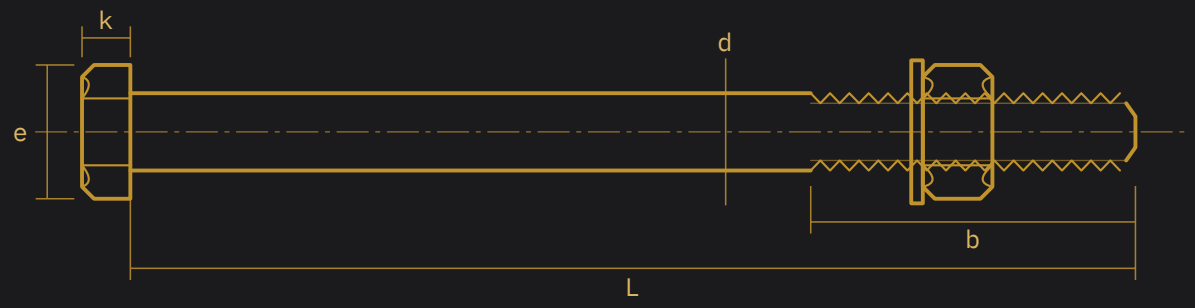
MF Fastener Industries LLC

MANUFACTURER · ANCHOR BOLTS · STUDS · PLATE WASHERS

REFERENCE FOR ENGINEERS, QA / QC AND LABORATORIES

FASTENER TECHNICAL DATA BOOK

Mechanical properties, dimensions, materials, coatings, torque and marking for every grade and product we manufacture or stock — compiled from the current editions of the international standards, for reference.



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ISO 9001:2015
ADNOC APPROVED VENDOR

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Read this before using any page

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4. Guide values. Figures marked * (clamp load, torque) are derived, not published; the method is printed beside them and they depend on lubrication, finish and joint condition. Verify on the joint.

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Reading a bolt — anatomy and terms

The vocabulary used throughout this book

A fastener is described by four things: its **form** (the product standard — what shape it is), its **size and thread**, its **property class or grade** (the material standard — how strong it is), and its **finish**. A complete callout carries all four: "M20 × 80 hex bolt, ISO 4014, class 8.8, hot-dip galvanized to ISO 10684".

The parts of a bolt

Head	the driving feature — hex, socket, countersunk, flange
Bearing face	the underside of the head; carries the clamp load into the joint
Shank	the plain, unthreaded portion (absent on a full-thread screw)
Thread run-out	the transition from plain shank to full thread
Thread length b	from the end of the bolt back along the thread
Chamfer / point	the lead-in that starts the nut
Grip length	the thickness of the parts being clamped
Nominal length L	under the head to the end, except countersunk heads where L is overall

A bolt is a tension spring. Tightening stretches it; the stretch is the clamp load. Anything that lets the stretch relax — embedment, gasket creep, an under-strength washer — loses preload without loosening the nut.

The three diameters

Nominal d	the size on the drawing — M20 is 20 mm
Pitch diameter d2	where thread flanks make contact; governs fit
Minor diameter d3	the root; the smallest metal section
Stress area As	the area used for every load calculation

As is not the area of any real circle. It is the mean of the pitch and minor diameters, squared: $As = (\pi/4)\cdot((d2+d3)/2)^2$. It sits between d2 and d3 because a threaded bar breaks somewhere between the two.

Every proof load and breaking load in this book is As × a stress from the standard. Use As, never $d^2\cdot\pi/4$.

Where bolts carry load

Tension	the intended case — preload plus external load
Shear	across the shank or across the thread; different areas
Bearing	the plate against the shank
Friction	a properly preloaded joint transfers shear by friction, not by the bolt

- A preloaded joint should not see the external load as bolt tension at all — the joint absorbs it until the preload is exceeded.
- Threads in the shear plane reduce the shear area to roughly As.

Sources ISO 898-1:2013 · ISO 724 · ISO 965-1 · ISO 4014 · ISO 4017

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Head-marking identification chart

ISO · SAE · ASTM — what is struck on the part and what it means

Identify the grade before measuring anything else. The marking tells you which system the part belongs to, and therefore which table in this book applies.

Marking as struck	Standard	Where and what	Material and condition	Nearest other system
4.6	ISO 898-1	Head: **4.6**	Carbon steel, not heat-treated	A307 Gr A
5.8	ISO 898-1	Head: **5.8**	Carbon steel, cold worked	–
8.8	ISO 898-1	Head: **8.8**	Carbon/alloy steel, Q&T	A449 · F3125 A325
10.9	ISO 898-1	Head: **10.9**	Alloy steel, Q&T	F3125 A490 · A354 BD
12.9	ISO 898-1	Head: **12.9**	Alloy steel, Q&T	A574
Grade 2	SAE J429	Head: **no radial lines**	Low/medium carbon	–
Grade 5	SAE J429	Head: **3 radial lines**	Medium carbon, Q&T	8.8 (nearest)
Grade 8	SAE J429	Head: **6 radial lines**	Medium carbon alloy, Q&T	10.9 (nearest)
A325	ASTM F3125	Head: **A325** + maker	Structural, 120 ksi	8.8 (nearest)
A490	ASTM F3125	Head: **A490** + maker	Structural, 150–173 ksi	10.9 (nearest)
B7	ASTM A193	End: **B7** + maker	42CrMo4 Q&T, pressure service	–
B7M	ASTM A193	End: **B7M** + maker	B7, hardness capped, sour service	–
B16	ASTM A193	End: **B16** + maker	21CrMoV5-7, high temperature	–
B8 / B8M	ASTM A193	End: **B8** / **B8M** + class	304 / 316 stainless	A2 / A4
L7 / L7M	ASTM A320	End: **L7** / **L7M** + maker	Low temperature, impact tested	–
2H	ASTM A194	Nut face: **2H** + maker	Q&T carbon nut	Class 10 (nearest)
A2-70 / A4-70	ISO 3506	Head: **A2-70** / **A4-70**	304 / 316 stainless, cold worked	B8 / B8M Cl.2
Class 8 nut	ISO 898-2	Face or side: **8**	Nut for 8.8 bolts	A563 DH (nearest)

Rules that apply to all systems

Maker's mark	required alongside the class from M5 (ISO) / ¼" (ASTM)
Raised or indented	either is permitted; both are original
Studs and rod	marked on the end, not the side
Small sizes	below M5 the class mark may be omitted — check the certificate
Left-hand thread	arrow, or notches on the head corners

What a marking does not tell you

- **Finish.** A galvanized 8.8 and a plain 8.8 carry the same head mark and behave very differently under torque.
- **Batch.** Only the certificate ties a part to a heat number.
- **Whether it is genuine.** Marks are cheap to counterfeit; hardness testing is not.
- **Class 1 or Class 2** on stainless studs — the strength differs by about 70 % and the mark may not distinguish them.

Quick identification

Number with a dot	ISO metric — 8.8, 10.9, 12.9
Radial lines	SAE inch — count them: 3 = Gr 5, 6 = Gr 8
Letters + digits	ASTM — A325, A490, B7, 2H
A2 / A4	ISO stainless
No mark at all	unclassified — treat as scrap for structural use

▲ **Note:** Confirm the ISO 898-1 rule for the smallest size requiring a class mark, and the ASTM F3125 rule on maker's mark placement, against the current editions.

Sources ISO 898-1:2013 · ISO 898-2:2012 · ISO 3506-1 · SAE J429 · ASTM F3125 · A193 · A194 · A320

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Metric thread chart — coarse and fine

ISO 261 · ISO 262 · ISO 965 · stress areas per ISO 898-1 Table 5 · M6 to M39

Size	Coarse pitch mm	Pitch dia d2 mm	Minor dia d3 mm	Stress area As mm² · coarse	Tapping drill mm · coarse	Fine pitch mm	Stress area As mm² · fine
M6	1.00	5.351	4.773	20.1	5.00	—	—
M8	1.25	7.188	6.466	36.6	6.75	1.00	39
M10	1.50	9.026	8.160	58.0	8.50	1.25	61
M12	1.75	10.863	9.853	84.3	10.25	1.25	92
M14	2.00	12.701	11.546	115.0	12.00	1.50	125
M16	2.00	14.701	13.546	157.0	14.00	1.50	167
M18	2.50	16.376	14.933	192.0	15.50	1.50	216
M20	2.50	18.376	16.933	245.0	17.50	1.50	272
M22	2.50	20.376	18.933	303.0	19.50	1.50	333
M24	3.00	22.052	20.319	353.0	21.00	2.00	384
M27	3.00	25.052	23.319	459.0	24.00	2.00	496
M30	3.50	27.727	25.706	561.0	26.50	2.00	621
M33	3.50	30.727	28.706	694.0	29.50	2.00	761
M36	4.00	33.402	31.092	817.0	32.00	3.00	865
M39	4.00	36.402	34.092	976.0	35.00	3.00	1,030

How these are derived

Pitch diameter d2	$d - 0.6495\,P$
Minor diameter d3	$d - 1.2269\,P$
Stress area As	$(\pi/4)\cdot((d2+d3)/2)^2$
Tapping drill	d − P (nominal, 100 % thread)
Thread profile	ISO 68-1, 60° flank angle

Values here are computed from the ISO formulas, not copied. ISO 898-1 Table 5 lists As to the same figures.

Tolerance classes

External, normal fit	6g
External, plated	6g before plating; 6e or 6f allows coating
Internal, normal fit	6H
Internal, hot-dip galvanized	tapped oversize to ISO 10684
Class of fit	the letter is the allowance, the number the tolerance grade

A 6H nut will not fit a hot-dip galvanized 6g bolt. Galvanized nuts must be ordered as such.

Fine thread — when

- Higher As for the same nominal size, so more load capacity.
- Finer adjustment and better resistance to vibration loosening.
- Thinner wall section at the root — more sensitive to damage and corrosion.
- Not interchangeable with coarse: an M12×1.25 nut will not run on an M12×1.75 bolt.

▲ **Note:** Fine-pitch stress areas are computed from the ISO formula; check a sample against ISO 898-1 Table 5 for fine pitch.

Sources ISO 68-1 · ISO 261 · ISO 262 · ISO 724 · ISO 965-1 · ISO 898-1:2013 Table 5 · ISO 10684

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Inch thread chart — UNC, UNF and 8UN

ASME B1.1 · stress areas as published, with millimetre equivalents

Size	UNC tpi	UNC stress area in²	UNC As mm² equivalent	UNF tpi	UNF stress area in²	UNF As mm² equivalent
1/4"	20	0.0318	21	28	0.0364	23
5/16"	18	0.0524	34	24	0.0580	37
3/8"	16	0.0775	50	24	0.0878	57
7/16"	14	0.1063	69	20	0.1187	77
1/2"	13	0.1419	92	20	0.1599	103
9/16"	12	0.182	117	18	0.203	131
5/8"	11	0.226	146	18	0.256	165
3/4"	10	0.334	215	16	0.373	241
7/8"	9	0.462	298	14	0.509	328
1"	8	0.606	391	12	0.663	428
1 1/8"	7	0.763	492	12	0.856	552
1 1/4"	7	0.969	625	12	1.073	692
1 3/8"	6	1.155	745	12	1.315	848
1 1/2"	6	1.405	906	12	1.581	1,020
1 3/4"	5	1.90	1,226	—	—	—
2"	4.5	2.50	1,613	—	—	—
2 1/4"	4.5	3.25	2,097	—	—	—
2 1/2"	4	4.00	2,581	—	—	—

8-pitch series (8UN)

Used for	1" and larger flange bolting
Thread	8 threads per inch at every size
Why	constant pitch keeps the root section large on big diameters
Standard	ASME B1.1
Typical parts	A193 B7 studs, A320 L7, large A354 rod

Above 1", flange studs are usually 8UN, not UNC. Confirm which is called for before cutting.

Reading an inch callout

½–13 UNC–2A	½" nominal, 13 tpi, coarse, external class 2A
¾–10 UNC–2B	internal (nut) class 2B
1–8 UN–2A	1", 8-pitch series
Class 1A/1B	loose · 2A/2B standard · 3A/3B close

Class 2A/2B is standard commercial. Class 3 is used where the fit must be tight, at extra cost.

Never mix systems

- A ½–13 UNC nut will start on an M12 bolt and strip. The pitch is close, the profile is not.
- Inch hex sizes are not metric sizes: a ½" bolt takes a ¾" spanner, not 19 mm (they differ by 0.55 mm).
- Inch socket screws take inch keys. A 5/16" key is not 8 mm.

▲ **Note:** Check the tabulated UNC/UNF stress areas above 1½" against ASME B1.1; the 8UN column is described in the panel and not tabulated in this edition.

Sources ASME B1.1 · ASME B18.2.1 · ASTM F3125 · ASTM A193/A193M

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Torque, preload and tightening methods

Guide values * for clamp load and torque · derived, not published in any standard

No fastener standard publishes a torque table. Torque is calculated from the preload you want and the friction you expect: **T = K · d · F**, where F is the clamp load and K the nut factor. Everything below is a guide value derived that way, from the proof stresses in ISO 898-1, at 75 % of proof load.

Size	4.6 clamp* kN	4.6 torque* N·m · K 0.20	4.6 lubed* N·m · K 0.14	8.8 clamp* kN	8.8 torque* N·m · K 0.20	8.8 lubed* N·m · K 0.14	10.9 clamp* kN	10.9 torque* N·m · K 0.20	10.9 lubed* N·m · K 0.14	12.9 clamp* kN	12.9 torque* N·m · K 0.20	12.9 lubed* N·m · K 0.14
M10	10	20	14	25	50	35	36	72	51	42	84	59
M12	14	34	24	37	88	62	52	126	88	61	147	103
M16	26	85	59	68	219	153	98	313	219	114	365	256
M20	41	165	116	110	441	309	153	610	427	178	713	499
M24	60	286	200	159	762	534	220	1,055	738	257	1,233	863
M30	95	568	398	252	1,515	1,060	349	2,095	1,467	408	2,449	1,714
M36	138	993	695	368	2,647	1,853	509	3,662	2,563	594	4,279	2,996

The four tightening methods

Torque wrench	simplest; ±25–35 % scatter in preload because K varies
Turn-of-nut	snug tight then a defined rotation; ±10–15 %, no K needed
DTI washer	ASTM F959 / EN 14399-9; gap measured with a feeler gauge
Tension control	TCB bolts, spline shears at preload; or hydraulic tensioner

Torque is the least accurate method and the most used. Where preload matters, use turn-of-nut or DTIs.

What K actually is

Plain, dry, as received	0.20
Light oil	0.15 – 0.18
Moly or wax	0.10 – 0.14
Hot-dip galvanized, plain	0.25 – 0.35
Galvanized + lubricant (dyed)	0.14 – 0.19
PTFE / Xylan	0.08 – 0.12

K is not a property of the bolt — it is a property of the joint that day. These are starting points for a calibration, not values to design to.

Practical rules

- Torque to 75 % of proof load is the usual target for a reusable joint; 65 % where the joint is disturbed often.
- Never torque a galvanized assembly to a plain-finish table — you will under-tension it badly.
- Retorque after gasket seating or thermal cycling, not as routine.
- A torque wrench reads friction. If the nut is dry and galled, the reading is meaningless.

▲ **Note:** All torque figures on this page are derived by MF from proof stresses using T = K·d·F. No standard publishes a torque table. Confirm MF wishes to publish K values in these ranges.

Sources ISO 898-1:2013 (proof stresses) · ISO 16047 (torque/clamp testing) · EN 1090-2 · ASTM F3125 Annex · RCSC Specification

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Inspection and reading a mill test certificate

EN 10204 document types · what to check at goods-in

Reading a mill test certificate

EN 10204 2.1	declaration of compliance, no test results
EN 10204 2.2	maker's test results, not on your batch
EN 10204 3.1	maker's results, on your batch, signed by the maker's QA
EN 10204 3.2	as 3.1, countersigned by an independent inspector

MF issues 3.1 with every batch. Where a project needs 3.2, the third-party inspection must be arranged before production.

Check these on every certificate

- **Heat number** on the certificate matches the tag on the box.
- **Standard and edition** — a 1999 edition result against a 2013 requirement is not compliance.
- **Every required property** present: tensile, yield, elongation, reduction, hardness, and impact where the grade demands it.
- **Chemistry within limits**, including P and S.
- **Test temperature** stated for low-temperature grades.
- **Tempering temperature** stated where the standard fixes a minimum.
- Values that are suspiciously round, or identical across heats, deserve a question.

Incoming inspection at goods-in

Marking	class and maker's mark present and legible
Dimensions	across flats, head height, length, thread by ring/plug gauge
Hardness	core hardness on a sample; the fastest fraud check there is
Coating	thickness by magnetic gauge; ISO 1461 / ASTM F2329 minima
Thread fit	nut runs by hand the full length
Documentation	certificate matches the delivery

Hardness plus marking catches most counterfeit product. Tensile testing confirms it.

Sources EN 10204:2004 · ISO 898-1:2013 clause 9 · ISO 3269 (acceptance) · ISO 1461 · ASTM F2329

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Why bolts fail

Recognising the mode from the fracture face

A broken bolt usually tells you why it broke. Reading the fracture face correctly saves replacing the wrong thing.

Fatigue

Looks like	beach marks, a smooth zone then a rough final tear
Where	first engaged thread, or the head-to-shank radius
Cause	too little preload — the bolt sees the fluctuating load
Fix	more preload, rolled threads, larger root radius

The commonest structural bolt failure. Counter-intuitively, tighter bolts fatigue less.

Hydrogen embrittlement

Looks like	brittle fracture, no necking, often hours or days after fitting
Where	under the head or at the first thread
Cause	hydrogen from acid pickling or electroplating, in hard parts
Risk above	class 10.9 / 39 HRC
Fix	bake after plating to ISO 4042; use zinc flake or HDG instead

Delayed failure with no warning. This is why 12.9 should not be electroplated without baking.

Other modes

- **Overload** — cup-and-cone fracture with necking. The part was too small or the torque too high.
- **Thread stripping** — wrong nut class, insufficient engagement, or a damaged thread.
- **Stress corrosion** — stainless in warm chlorides; 316 is better than 304, neither is immune.
- **Galling** — stainless on stainless, seized on assembly. Lubricate, slow the speed.
- **Loosening** — vibration or embedment. Preload loss, not a broken bolt.
- **Galvanic corrosion** — dissimilar metals plus an electrolyte; the anodic part goes first.

Sources ISO 898-1:2013 · ISO 4042 · ISO 15330 (embrittlement testing) · ISO 10684 · ASTM F1941 · ASTM F2329

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Property class 4.6 — bolts, screws and studs

ISO 898-1:2013 · carbon steel, not heat-treated · coarse thread M6 to M39

TENSILE RM MIN	YIELD REL MIN	PROOF STRESS SP	HARDNESS HRB	ELONGATION A	HEAT TREATMENT
400 MPa · M6 – M39	240 MPa · M6 – M39	225 MPa · M6 – M39	67–95 core, all sizes	22 % min · machined test piece	none not heat-treated

Size	Pitch mm	Stress area As mm²	Proof stress Sp MPa	Proof load kN · As × Sp	Tensile Rm min MPa	Min. breaking load kN · As × Rm	Hardness HV	Hardness HRB	Clamp load* kN · 75 % proof	Guide torque* N·m · K = 0.20
M6	1.00	20.1	225	4.5	400	8.0	120–220	67–95	3.4	4
M8	1.25	36.6	225	8.2	400	14.6	120–220	67–95	6.2	10
M10	1.50	58.0	225	13.1	400	23.2	120–220	67–95	9.8	20
M12	1.75	84.3	225	19.0	400	33.7	120–220	67–95	14.2	34
M14	2.00	115.0	225	25.9	400	46.0	120–220	67–95	19.4	54
M16	2.00	157.0	225	35.3	400	62.8	120–220	67–95	26.5	85
M18	2.50	192.0	225	43.2	400	76.8	120–220	67–95	32.4	117
M20	2.50	245.0	225	55.1	400	98.0	120–220	67–95	41.3	165
M22	2.50	303.0	225	68.2	400	121.2	120–220	67–95	51.1	225
M24	3.00	353.0	225	79.4	400	141.2	120–220	67–95	59.6	286
M27	3.00	459.0	225	103.3	400	183.6	120–220	67–95	77.5	418
M30	3.50	561.0	225	126.2	400	224.4	120–220	67–95	94.7	568
M33	3.50	694.0	225	156.2	400	277.6	120–220	67–95	117.1	773
M36	4.00	817.0	225	183.8	400	326.8	120–220	67–95	137.9	993
M39	4.00	976.0	225	219.6	400	390.4	120–220	67–95	164.7	1,285

One property range for M6 – M39 in class 4.6

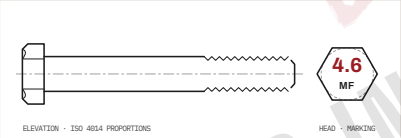
Sizes above M39: by agreement per ISO 898-1 clause 1

Chemistry & heat treatment

Carbon C max	0.55 %
Phosphorus P max	0.050 %
Sulphur S max	0.060 %
Heat treatment	none — as rolled or normalised
Material	Carbon steel, not heat-treated

Free-cutting steel is not permitted. The class is achieved by the base steel, not by hardening.

Marking



Class symbol	4.6, from M5 up
Maker's mark	beside it, raised/indented
Studs	unthreaded shank end
Left-hand thread	arrow or notched corners

Pair with

Nut	Class 5 (d ≤ M16) · class 4 (d > M16) · ISO 898-2
Nut form	ISO 4032 style 1
Washer	ISO 7089 · 200 HV
Bolt form	ISO 4014 · ISO 4017
Nearest ASTM	A307 Gr A
Nearest SAE	J429 Grade 1

Low-strength general-purpose class. Do not substitute where a drawing calls for 8.8 or above.

1. ISO 898-1 mechanical properties apply to d ≤ 39 mm. Larger sizes are supplied by agreement; ask for the test report.

2. Yield for class 4.6 is the lower yield stress ReL, measured on the full-size fastener where possible.

3. * Clamp load and torque are guide values only: torque = K × d × (75 % of proof load) with K = 0.20 for plain, dry, as-received steel. Verify by calibration on the joint.

4. Hardness is the core value. Minimum hardness applies only to fasteners ≥ 3 d in length; shorter fasteners are judged on tensile.

5. No hydrogen-embrittlement precautions are required for electroplating at this strength.

Sources ISO 898-1:2013 Tables 2, 3, 5 · ISO 898-2:2012 · ISO 4014 · ISO 4017 · ISO 4032 · ISO 7089

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Property class 5.8 — bolts, screws and studs

ISO 898-1:2013 · carbon steel, cold worked · coarse thread M6 to M39

TENSILE RM MIN	YIELD RP0.2 MIN	PROOF STRESS SP	HARDNESS HRB	ELONGATION AF	HEAT TREATMENT
520 MPa · M6 – M39	420 MPa · M6 – M39	380 MPa · M6 – M39	82–95 core, all sizes	0.22 min · whole fastener	none cold worked

Size	Pitch mm	Stress area As mm²	Proof stress Sp MPa	Proof load kN · As × Sp	Tensile Rm min MPa	Min. breaking load kN · As × Rm	Hardness HV	Hardness HRB	Clamp load* kN · 75 % proof	Guide torque* N·m · K = 0.20
M6	1.00	20.1	380	7.6	520	10.5	160–220	82–95	5.7	7
M8	1.25	36.6	380	13.9	520	19.0	160–220	82–95	10.4	17
M10	1.50	58.0	380	22.0	520	30.2	160–220	82–95	16.5	33
M12	1.75	84.3	380	32.0	520	43.8	160–220	82–95	24.0	58
M14	2.00	115.0	380	43.7	520	59.8	160–220	82–95	32.8	92
M16	2.00	157.0	380	59.7	520	81.6	160–220	82–95	44.7	143
M18	2.50	192.0	380	73.0	520	99.8	160–220	82–95	54.7	197
M20	2.50	245.0	380	93.1	520	127.4	160–220	82–95	69.8	279
M22	2.50	303.0	380	115.1	520	157.6	160–220	82–95	86.4	380
M24	3.00	353.0	380	134.1	520	183.6	160–220	82–95	100.6	483
M27	3.00	459.0	380	174.4	520	238.7	160–220	82–95	130.8	706
M30	3.50	561.0	380	213.2	520	291.7	160–220	82–95	159.9	959
M33	3.50	694.0	380	263.7	520	360.9	160–220	82–95	197.8	1,305
M36	4.00	817.0	380	310.5	520	424.8	160–220	82–95	232.8	1,676
M39	4.00	976.0	380	370.9	520	507.5	160–220	82–95	278.2	2,170

One property range for M6 – M39 in class 5.8

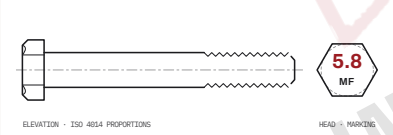
Sizes above M39: by agreement per ISO 898-1 clause 1

Chemistry & heat treatment

Carbon C max	0.55 %
Phosphorus P max	0.050 %
Sulphur S max	0.060 %
Heat treatment	none — strength from cold work
Material	Carbon steel, cold worked

Free-cutting steel is not permitted. Strength comes from cold heading and thread rolling, so re-cutting threads lowers it.

Marking



Class symbol	5.8, from M5 up
Maker's mark	beside it, raised/indented
Studs	unthreaded shank end
Left-hand thread	arrow or notched corners

Pair with

Nut	Class 5 · ISO 898-2
Nut form	ISO 4032 style 1
Washer	ISO 7089 · 200 HV
Bolt form	ISO 4014 · ISO 4017
Nearest ASTM	–
Nearest SAE	J429 Grade 2 (nearest)

Common on machine screws and small hex screws. Not a substitute for 8.8.

1. ISO 898-1 mechanical properties apply to d ≤ 39 mm.
2. Elongation for cold-worked classes is Af, measured on the whole fastener (min 0.22), not A on a machined test piece.
3. * Clamp load and torque are guide values only: torque = K × d × (75 % of proof load) with K = 0.20 for plain, dry, as-received steel. Verify by calibration on the joint.
4. Hardness is the core value; minimum hardness applies to fasteners ≥ 3 d long.
5. No hydrogen-embrittlement precautions are required for electroplating at this strength.

Sources ISO 898-1:2013 Tables 2, 3, 5 · ISO 898-2:2012 · ISO 4014 · ISO 4017 · ISO 4032 · ISO 7089

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Property class 8.8 — bolts, screws and studs

ISO 898-1:2013 · carbon or alloy steel, quenched and tempered · coarse thread M6 to M39

TENSILE RM MIN	YIELD RP0.2 MIN	PROOF STRESS SP	HARDNESS HRC	ELONGATION A	TEMPERING
800 / 830	640 / 660	580 / 600	22–32 · 23–34	12 %	≥ 425 °C
MPa · ≤M16 / >M16	MPa · ≤M16 / >M16	MPa · ≤M16 / >M16	≤M16 / >M16	min · reduction Z 52 %	quench and temper

Size	Pitch mm	Stress area As mm²	Proof stress Sp MPa	Proof load kN · As × Sp	Tensile Rm min MPa	Min. breaking load kN · As × Rm	Hardness HV	Hardness HRC	Clamp load* kN · 75 % proof	Guide torque* N·m · K = 0.20
M6	1.00	20.1	580	11.7	800	16.1	250–320	22–32	8.7	10
M8	1.25	36.6	580	21.2	800	29.3	250–320	22–32	15.9	25
M10	1.50	58.0	580	33.6	800	46.4	250–320	22–32	25.2	50
M12	1.75	84.3	580	48.9	800	67.4	250–320	22–32	36.7	88
M14	2.00	115.0	580	66.7	800	92.0	250–320	22–32	50.0	140
M16	2.00	157.0	580	91.1	800	125.6	250–320	22–32	68.3	219
M18	2.50	192.0	600	115.2	830	159.4	255–335	23–34	86.4	311
M20	2.50	245.0	600	147.0	830	203.3	255–335	23–34	110.2	441
M22	2.50	303.0	600	181.8	830	251.5	255–335	23–34	136.3	600
M24	3.00	353.0	600	211.8	830	293.0	255–335	23–34	158.8	762
M27	3.00	459.0	600	275.4	830	381.0	255–335	23–34	206.6	1,115
M30	3.50	561.0	600	336.6	830	465.6	255–335	23–34	252.4	1,515
M33	3.50	694.0	600	416.4	830	576.0	255–335	23–34	312.3	2,061
M36	4.00	817.0	600	490.2	830	678.1	255–335	23–34	367.6	2,647
M39	4.00	976.0	600	585.6	830	810.1	255–335	23–34	439.2	3,426

M6 – M16: ISO 898-1 range "8.8, d ≤ 16 mm"

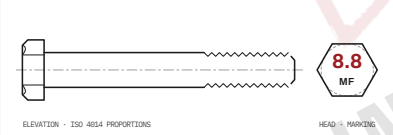
M18 – M39: range "8.8, d > 16 mm" — the rule line marks the change

Chemistry & heat treatment

Carbon C, d ≤ M16	0.15 – 0.40 %
Carbon C, d > M16	0.25 – 0.55 %
Phosphorus P max	0.025 %
Sulphur S max	0.025 %
Boron B max	0.003 %
Tempering temperature min	425 °C
Material	Carbon or alloy steel, Q&T

Boron steel permitted if the boron is effective in the finished part. Free-cutting steel not permitted.

Marking



Class symbol	8.8, from M5 up
Maker's mark	beside it, raised/indented
Studs	unthreaded shank end
Left-hand thread	arrow or notched corners

Pair with

Nut	Class 8 · ISO 898-2
Nut form	ISO 4032 style 1
Washer	ISO 7089 · 200 HV
Bolt form	ISO 4014 · ISO 4017
Nearest ASTM	A449 · F3125 Gr A325
Nearest SAE	J429 Grade 5

A class 8 nut is proof-loaded above the bolt's tensile minimum, so the bolt fails before the thread strips. Never fit a lower class.

1. ISO 898-1 mechanical properties apply to d ≤ 39 mm. Larger sizes in class 8.8 are supplied by agreement; ask for the test report.

2. Proof load and minimum breaking load are calculated from As,nom × the standard's stress values; the standard's tables list the same quantities rounded.

3. * Clamp load and torque are guide values only: torque = K × d × (75 % of proof load) with K = 0.20 for plain, dry, as-received steel. Lubrication lowers K to about 0.10–0.15; hot-dip galvanizing raises it to about 0.25. Verify by calibration on the joint.

4. Hardness ranges are for the core. Surface hardness may not exceed the core maximum by more than 30 HV (test at HV 0.3).

5. Hot-dip galvanized 8.8 nuts are tapped oversize (ISO 10684) — order galvanized nuts with galvanized bolts; do not mix.

Sources ISO 898-1:2013 Tables 2, 3, 5 · ISO 898-2:2012 · ISO 4014:2022 · ISO 4017:2022 · ISO 4032:2012 · ISO 7089 · ISO 10684

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Property class 10.9 — bolts, screws and studs

ISO 898-1:2013 · alloy steel or carbon steel with additives, Q&T · coarse thread M6 to M39

TENSILE RM MIN	YIELD RP0.2 MIN	PROOF STRESS SP	HARDNESS HRC	ELONGATION A	TEMPERING
1040 MPa · M6 – M39	940 MPa · M6 – M39	830 MPa · M6 – M39	32–39 core, all sizes	9 % min · reduction Z 48 %	≥ 425 °C quench and temper

Size	Pitch mm	Stress area As mm²	Proof stress Sp MPa	Proof load kN · As × Sp	Tensile Rm min MPa	Min. breaking load kN · As × Rm	Hardness HV	Hardness HRC	Clamp load* kN · 75 % proof	Guide torque* N·m · K = 0.20
M6	1.00	20.1	830	16.7	1040	20.9	320–380	32–39	12.5	15
M8	1.25	36.6	830	30.4	1040	38.1	320–380	32–39	22.8	36
M10	1.50	58.0	830	48.1	1040	60.3	320–380	32–39	36.1	72
M12	1.75	84.3	830	70.0	1040	87.7	320–380	32–39	52.5	126
M14	2.00	115.0	830	95.5	1040	119.6	320–380	32–39	71.6	200
M16	2.00	157.0	830	130.3	1040	163.3	320–380	32–39	97.7	313
M18	2.50	192.0	830	159.4	1040	199.7	320–380	32–39	119.5	430
M20	2.50	245.0	830	203.3	1040	254.8	320–380	32–39	152.5	610
M22	2.50	303.0	830	251.5	1040	315.1	320–380	32–39	188.6	830
M24	3.00	353.0	830	293.0	1040	367.1	320–380	32–39	219.7	1,055
M27	3.00	459.0	830	381.0	1040	477.4	320–380	32–39	285.7	1,543
M30	3.50	561.0	830	465.6	1040	583.4	320–380	32–39	349.2	2,095
M33	3.50	694.0	830	576.0	1040	721.8	320–380	32–39	432.0	2,851
M36	4.00	817.0	830	678.1	1040	849.7	320–380	32–39	508.6	3,662
M39	4.00	976.0	830	810.1	1040	1,015.0	320–380	32–39	607.6	4,739

One property range for M6 – M39 in class 10.9

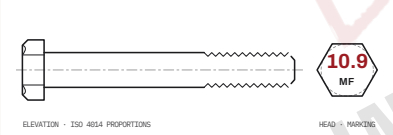
Sizes above M39: by agreement per ISO 898-1 clause 1

Chemistry & heat treatment

Carbon C, alloy / + additives	0.20 – 0.55 %
Carbon C, plain carbon	0.25 – 0.55 %
P max · S max	0.025 % · 0.025 %
Boron B max	0.003 %
Tempering temperature min	425 °C
Material	Alloy steel or carbon steel + additives, Q&T

Plain carbon steel only up to M20. Boron effective in the finished part; free-cutting steel not permitted.

Marking



Class symbol	10.9, from M5 up
Maker's mark	beside it, raised/indented
Studs	unthreaded shank end
Left-hand thread	arrow or notched corners

Pair with

Nut	Class 10 · ISO 898-2
Nut form	ISO 4032 style 1
Washer	ISO 7089 · **300 HV**
Bolt form	ISO 4014 · ISO 4017
Nearest ASTM	F3125 Gr A490 · A354 BD
Nearest SAE	J429 Grade 8

Use 300 HV washers — a 200 HV washer embeds under a 10.9 head and preload relaxes. A class 8 nut strips first.

1. ISO 898-1 mechanical properties apply to d ≤ 39 mm.
2. Proof load and minimum breaking load are calculated from As,nom × the standard's stress values.
3. * Clamp load and torque are guide values only: torque = K × d × (75 % of proof load), K = 0.20 plain and dry. Verify on the joint.
4. Hardness ranges are for the core; surface may not exceed core maximum by more than 30 HV.
5. **Hydrogen embrittlement:** electroplated parts must be baked after plating (ISO 4042). Hot-dip galvanizing of 10.9 needs the manufacturer's agreement.

Sources ISO 898-1:2013 Tables 2, 3, 5 · ISO 898-2:2012 · ISO 4014 · ISO 4017 · ISO 4032 · ISO 7089 · ISO 4042 · ISO 10684

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Property class 12.9 — bolts, screws and studs

ISO 898-1:2013 · alloy steel, quenched and tempered · coarse thread M6 to M39

TENSILE RM MIN	YIELD RP0.2 MIN	PROOF STRESS SP	HARDNESS HRC	ELONGATION A	TEMPERING
1220 MPa · M6 – M39	1100 MPa · M6 – M39	970 MPa · M6 – M39	39–44 core, all sizes	8 % min · reduction Z 44 %	≥ 425 °C quench and temper

Size	Pitch mm	Stress area As mm²	Proof stress Sp MPa	Proof load kN · As × Sp	Tensile Rm min MPa	Min. breaking load kN · As × Rm	Hardness HV	Hardness HRC	Clamp load* kN · 75 % proof	Guide torque* N·m · K = 0.20
M6	1.00	20.1	970	19.5	1220	24.5	385–435	39–44	14.6	18
M8	1.25	36.6	970	35.5	1220	44.7	385–435	39–44	26.6	43
M10	1.50	58.0	970	56.3	1220	70.8	385–435	39–44	42.2	84
M12	1.75	84.3	970	81.8	1220	102.8	385–435	39–44	61.3	147
M14	2.00	115.0	970	111.5	1220	140.3	385–435	39–44	83.7	234
M16	2.00	157.0	970	152.3	1220	191.5	385–435	39–44	114.2	365
M18	2.50	192.0	970	186.2	1220	234.2	385–435	39–44	139.7	503
M20	2.50	245.0	970	237.7	1220	298.9	385–435	39–44	178.2	713
M22	2.50	303.0	970	293.9	1220	369.7	385–435	39–44	220.4	970
M24	3.00	353.0	970	342.4	1220	430.7	385–435	39–44	256.8	1,233
M27	3.00	459.0	970	445.2	1220	560.0	385–435	39–44	333.9	1,803
M30	3.50	561.0	970	544.2	1220	684.4	385–435	39–44	408.1	2,449
M33	3.50	694.0	970	673.2	1220	846.7	385–435	39–44	504.9	3,332
M36	4.00	817.0	970	792.5	1220	996.7	385–435	39–44	594.4	4,279
M39	4.00	976.0	970	946.7	1220	1,190.7	385–435	39–44	710.0	5,538

One property range for M6 – M39 in class 12.9

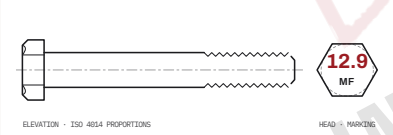
Sizes above M39: by agreement per ISO 898-1 clause 1

Chemistry & heat treatment

Carbon C, alloy steel	0.30 – 0.50 %
Phosphorus P max	0.025 %
Sulphur S max	0.025 %
Boron B max	0.003 %
Tempering temperature min	425 °C
Material	Alloy steel, Q&T

Alloy steel only. Boron effective in the finished part; free-cutting steel not permitted.

Marking



Class symbol	12.9, from M5 up
Maker's mark	beside it, raised/indented
Studs	unthreaded shank end
Left-hand thread	arrow or notched corners

Pair with

Nut	Class 12 · ISO 898-2
Nut form	ISO 4032 style 1
Washer	ISO 7089 · **300 HV**
Bolt form	ISO 4014 · ISO 4017
Nearest ASTM	A574 (socket screws)
Nearest SAE	–

Mostly socket head cap screws (ISO 4762). A class 12 nut is required; class 10 strips first.

1. ISO 898-1 mechanical properties apply to d ≤ 39 mm.

2. Proof load and minimum breaking load are calculated from As,nom × the standard's stress values.

3. * Clamp load and torque are guide values only: torque = K × d × (75 % of proof load) with K = 0.20 plain and dry. Class 12.9 is normally tightened to a calculated preload, not a catalogue torque — verify on the joint.

4. Hardness ranges are for the core. Surface hardness may not exceed the core maximum by more than 30 HV, and a white phosphorus-enriched surface layer is not permitted.

5. Hydrogen embrittlement: the most susceptible class. Electroplating only with baking (ISO 4042); hot-dip galvanizing is not recommended. Prefer zinc-flake or plain oiled finish.

Sources ISO 898-1:2013 Tables 2, 3, 5 · ISO 898-2:2012 · ISO 4762 · ISO 4032 · ISO 7089 · ISO 4042

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ISO 898-2 nuts — classes 5, 8, 10 and 12

ISO 898-2:2012 · style 1 nuts, coarse thread M6 to M39 · proof loads computed from As × Sp

CLASS 5 SP	CLASS 8 SP	CLASS 10 SP	CLASS 12 SP	HARDNESS CL.8	HARDNESS CL.10
580 MPa proof stress	800 MPa	1040 MPa	1150 MPa	180–302 HV	272–353 HV

Size	Stress area As mm²	Class 5 proof load kN	Class 8 proof load kN	Class 10 proof load kN	Class 12 proof load kN
M6	20.1	11.7	16.1	20.9	23.1
M8	36.6	21.2	29.3	38.1	42.1
M10	58.0	33.6	46.4	60.3	66.7
M12	84.3	48.9	67.4	87.7	96.9
M14	115.0	66.7	92.0	119.6	132.2
M16	157.0	91.1	125.6	163.3	180.6
M18	192.0	111.4	153.6	199.7 ▲	220.8 ▲
M20	245.0	142.1	196.0	254.8 ▲	281.8 ▲
M22	303.0	175.7	242.4	315.1 ▲	348.4 ▲
M24	353.0	204.7	282.4	367.1 ▲	405.9 ▲
M27	459.0	266.2	367.2	477.4 ▲	527.9 ▲
M30	561.0	325.4	448.8	583.4 ▲	645.1 ▲
M33	694.0	402.5	555.2	721.8 ▲	798.1 ▲
M36	817.0	473.9	653.6	849.7 ▲	939.5 ▲
M39	976.0	566.1	780.8	1,015.0 ▲	1,122.4 ▲

Proof load = As × the class proof stress, ISO 898-2 style 1 nuts ▲ flagged: confirm proof stress above M16 for classes 10 and 12

Which nut with which bolt

Bolt 4.6 / 4.8	class 4 or 5
Bolt 5.6 / 5.8	class 5
Bolt 8.8	class 8
Bolt 10.9	class 10
Bolt 12.9	class 12
Rule	never below the bolt class

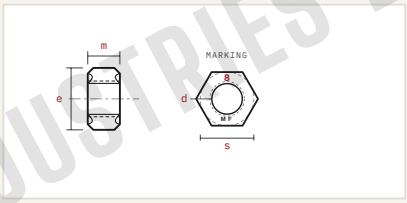
The nut is proof-loaded above the bolt's tensile minimum so the bolt breaks before the thread strips.

Nut styles & heights

Style 1 · ISO 4032	m ≈ 0.9 d — the standard nut
Style 2 · ISO 4033	taller, for classes 9 and 12
Thin · ISO 4035	m ≈ 0.5 d — **not** load bearing
DIN 934	m ≈ 0.8 d — shorter than ISO 4032
Heavy hex	ASME B18.2.2, wider A/F

A thin nut is a jam nut, not a substitute; its class mark refers to a reduced proof load.

Marking & galvanizing



Class mark	5, 8, 10, 12 on a face or side, from M5
Maker's mark	MF alongside
Left-hand thread	notch or arrow
Galvanized	tapped oversize to ISO 10684

Galvanized nuts are tapped oversize **after** coating — do not fit a plain nut to a galvanized bolt.

1. Proof load = As × class proof stress. The nut is loaded on a hardened mandrel and must not strip.

2. ▲ ISO 898-2:2012 restructured the classes and proof stresses for larger sizes — confirm values above M16.

3. Classes 05 and 04 exist for hardened, non-proof-loaded nuts; not covered here. Thread engagement of at least 0.8 d of sound thread is needed for the nut to develop its rating.

▲ Note: ▲ Confirm the proof stress for each nut class, and whether any class steps with diameter above M16, against the current ISO 898-2.

Sources ISO 898-2:2012 · ISO 4032:2012 · ISO 4033 · ISO 4035 · ISO 898-1:2013 Table 5 · ISO 10684

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Stainless steel bolts — ISO 3506-1

A2 and A4 property classes · austenitic stainless · M1.6 to M39

A2	A4	-50	-70	-80	SIZE LIMIT
304 · 1.4301	316 · 1.4401	500 MPa	700 MPa	800 MPa	M24
18/8 chrome-nickel	with 2–3 % Mo	soft, annealed	the common grade	high strength	for -70 and above

Grade	Size range	Tensile min MPa	Yield Rp0.2 min MPa	Elongation min mm	Condition	Nearest ASTM
A2-50 · A4-50	≤ M39	500	210	0.6 d	solution annealed	Class 1 (A193 B8 / B8M)
A2-70 · A4-70	≤ M24	700	450	0.4 d	cold worked	Class 2 (nearest)
A2-80 · A4-80	≤ M24	800	600	0.3 d	cold worked, high	—
A2-100 · A4-100	≤ M24	1000	800	0.2 d	cold worked, very high	—

ISO 3506-1 property classes for bolts, screws and studs

Above M24, -70 and -80 are by agreement — check availability

A2 or A4 — choosing

A2 · 304	general, indoor, fresh water, food
A4 · 316	chlorides, coastal, marine, chemical
Gulf coastal	A4 as the default
Swimming pools	neither — use A4L or duplex
Above 60 °C + chloride	risk of stress corrosion cracking

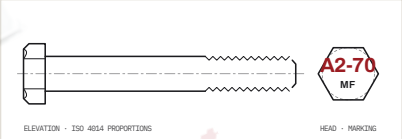
The extra cost of A4 over A2 is small against the cost of replacing corroded fixings in a coastal building.

Galling

Cause	stainless has no oxide film to prevent metal-to-metal seizure
When	fast run-down, dirty threads, high torque
Prevention	anti-seize compound
Also	slow the driver, avoid impact drivers
If it seizes	stop — do not force; the stud will twist off

Galling is the most common stainless failure on site and is entirely preventable.

Marking



Head	grade and class, e.g. A2-70
Maker's mark	MF alongside, from M5
Nuts	same system, ISO 3506-2
Non-magnetic	annealed; slight magnetism after cold work is normal

1. Stainless property classes are **not** comparable to 8.8 or 10.9. A2-70 is roughly 8.8 in tensile but has quite different yield and ductility.

2. ▲ Confirm the elongation requirement (expressed as a multiple of d for the whole fastener) against the current ISO 3506-1.

3. ISO 3506 was revised in 2020 and the class structure changed; check which edition the project specifies.

4. Stainless is not immune to corrosion: chloride pitting and stress corrosion cracking both occur.

5. Never mix stainless and carbon steel in a wet joint — the carbon part corrodes preferentially.

▲ Note: ▲ ISO 3506-1 was revised in 2020 with changes to the class structure and size limits. Confirm the tensile, yield, size limits and elongation against the edition MF holds, and state which edition the book cites.

Sources ISO 3506-1 · ISO 3506-2 · EN 10088-3 · ASTM A193/A193M · ASTM F593

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EN 14399 structural bolting assemblies

HR and HV systems for preloaded joints · EN 1090-2 execution

HR SYSTEM	HV SYSTEM	SUPPLIED AS	K-CLASS	WASHER	NEAREST ASTM
8.8 · 10.9	10.9 only	an assembly	K0 · K1 · K2	300 HV	F3125 A325 / A490
EN 14399-3	EN 14399-4	bolt + nut + washer	friction certification	EN 14399-6	

Standard	Class	System	Geometry	Certification	Use
EN 14399-3 HR	8.8 / 10.9	system HR	hexagon, thread longer	k-class K0 / K1 / K2	preloaded joints
EN 14399-4 HV	10.9 only	system HV	hexagon, thread shorter	k-class K1 / K2	preloaded joints
EN 14399-6	–	washer, chamfered	300 HV	with HR or HV	under head and nut
EN 14399-9	–	DTI washer	–	with HR or HV	direct tension indication
EN 14399-10	10.9	HRC, tension control	spline end	–	shears at preload

HR against HV — the practical difference

HR head and nut	taller; longer thread engagement
HV head and nut	thinner; shorter engagement
HR failure mode	bolt breaks in the thread
HV failure mode	thread strips – ductile warning
Interchange	**never** – do not mix HR and HV parts
Spanner sizes	differ from ISO 4014 at some sizes

HR and HV are two complete systems. An HR bolt with an HV nut is neither, and the assembly certification is void.

The k-class

K0	no friction requirement declared
K1	k value declared per lot, tested
K2	mean and scatter of k declared, tested
Why it matters	torque method needs K2
Combined method	requires K2

The k-class is the manufacturer's certified friction figure. It is the reason a preloaded assembly must be bought as a set from one maker.

Tightening

- **Torque method** — needs K2 assemblies.
- **Combined method** — torque then a defined part-turn; the usual European practice.
- **DTI method** — EN 14399-9 washers, gap checked with a feeler gauge.
- **HRC tension control** — EN 14399-10, the spline shears at the design preload.
- Follow EN 1090-2 for execution; it governs, not the fastener standard.

1. EN 14399 assemblies are certified as a **set**. Loose components from different makers do not form a certified assembly.

2. DIN 6914 / 6915 / 6916 are the older German designations; EN 14399-4 and -6 supersede them.

3. HV nuts and heads are dimensionally thinner than HR — check clearances before substituting.

4. ▲ Confirm which k-classes the project requires; EN 1090-2 sets this by execution class.

5. ASTM F3125 A325 / A490 are the American counterparts but are not dimensionally identical to either HR or HV.

▲ **Note:** Confirm the k-class definitions and the classes EN 1090-2 requires for each tightening method against the current EN 14399-1 and EN 1090-2.

Sources EN 14399-1 to -10 · EN 1090-2 · ISO 898-1:2013 · DIN 6914 / 6915 / 6916 (superseded)

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Sizes above M39 — what is covered and what is not

The limit of the ISO property classes, and the routes available for large diameters

ISO property classes stop at M39. This is the most important thing to know about large fasteners: above M39 the ISO 898-1 classes do not apply, and a certificate claiming "class 8.8, M56" is claiming something the standard does not define. Dimensions continue to M64; strength must come from elsewhere.

ISO 898-1 CLASSES	ISO 4014 / 4017	ISO 4032 NUTS	ISO 898-2 NUT CLASSES	ASTM A193 / A320	ASTM F1554
to M39	**to M64**	**to M64**	**to M39**	**to 7 in**	**to 4 in**
mechanical properties	dimensions	dimensions	mechanical	≈ M180, stepped	≈ M100

Size	Coarse pitch mm	Stress area As mm² · computed	ISO 898-1 class	ISO 4014 / 4017 dims	ISO 4032 nut dims	ASTM A193 B7	ASTM F1554
M39	4.0	976	yes	yes	yes	yes	yes
M42	4.5	1,121	by agreement	yes	yes	yes	yes
M45	4.5	1,306	by agreement	yes	yes	yes	yes
M48	5.0	1,473	by agreement	yes	yes	yes	yes
M52	5.0	1,758	by agreement	yes	yes	yes	yes
M56	5.5	2,030	by agreement	yes	yes	yes	yes
M60	5.5	2,362	by agreement	yes	yes	yes	yes
M64	6.0	2,676	by agreement	yes	yes	yes	yes
M68	6.0	3,055	by agreement	–	–	yes	yes
M72	6.0	3,460	by agreement	–	–	yes	yes

Stress areas computed from ISO 724 geometry: $As = (\pi/4)\cdot((d2+d3)/2)^2$ The dividing line is M39 — above it, ISO property classes stop

What stops at M39

ISO 898-1	property classes 4.6 to 12.9 apply to d ≤ 39 mm
Above M39	properties are by agreement between maker and purchaser
ISO 898-2	nut classes likewise limited
EN 14399	structural assemblies to M36
What this means	a "class 8.8 M56 bolt" is not a standard product

A large bolt can still be made to 8.8 **values**, but the certificate must say so by agreement and state the test results — it is not covered by the class.

What continues above M39

ISO 4014 / 4017	hex bolt and screw dimensions to M64
ISO 4032	hex nut dimensions to M64
ISO 7089	plain washers to 64 mm
ASTM A193 B7 / B16	to 7 in (≈ M180), stepped strength
ASTM A320 L7 / L43	large diameters, stepped
ASTM F1554	anchor bolts to 4 in (≈ M100)
ASTM A354 BC / BD	large-diameter alloy rod

For large-diameter high-strength work the ASTM material specifications, not the ISO classes, are the correct route.

How to specify above M39

- Give the **dimensional** standard (ISO 4014 to M64) and the **material** specification separately.
- For alloy studs and anchor rod, name an ASTM grade — A193 B7, A354 BD or F1554 Gr 105 — which does cover the size.
- Where 8.8 or 10.9 **values** are wanted above M39, state them as agreed properties with the test requirement, not as a class.
- Confirm nut and washer availability at the same time; these are often the constraint.
- MF manufactures anchor bolts and studs to M100 to drawing.

1. ISO 898-1:2013 states its scope as bolts, screws and studs with nominal thread diameter **up to and including 39 mm**. Beyond that the standard does not assign properties.

2. ▲ Confirm the exact upper size limits of ISO 4014, ISO 4017, ISO 4032 and ISO 7089 against the editions MF holds; the tables in this book stop at M64.

3. Stress areas above M39 in the table are computed from ISO 724 thread geometry, not read from a property table.

4. Large-diameter fasteners are hot forged and machined rather than cold headed — this changes lead time and cost, not the specification. Above M64 the governing document is normally the structural drawing plus a material specification.

▲ Note: ▲ Confirm the upper diameter limit of each standard named in the right-hand column against the current editions.

Sources ISO 898-1:2013 clause 1 · ISO 898-2:2012 · ISO 724 · ISO 4014 · ISO 4017 · ISO 4032 · ISO 7089 · ASTM A193/A193M · A320/A320M · A354 · F1554 · EN 14399-1

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SAE J429 Grades 2, 5 and 8

SAE J429 · inch series · carbon and alloy steel

GRADE 2 TENSILE	GRADE 5 TENSILE	GRADE 8 TENSILE	GRADE 5 PROOF	GRADE 8 PROOF	MARKING
74 / 60 ksi	120 / 105 ksi	150 ksi	85 / 74 ksi	120 ksi	3 / 6 lines
≤¾" / >¾"	≤1" / 1–1½"	¼"–1½"	≤1" / 1–1½"	all sizes	Gr 5 / Gr 8

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/2	0.142	120	92	17.0	76	827	634
5/8	0.226	120	92	27.1	121	827	634
3/4	0.334	120	92	40.1	178	827	634
7/8	0.462	120	92	55.4	247	827	634
1	0.606	120	92	72.7	323	827	634
1 1/8	0.790	105	81	83.0	369	724	558
1 1/4	1.000	105	81	105.0	467	724	558
1 3/8	1.233	105	81	129.5	576	724	558
1 1/2	1.492	105	81	156.7	697	724	558

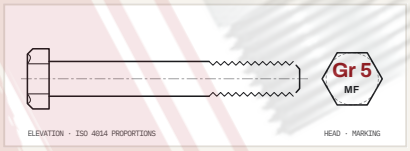
Table above is Grade 5. Grade 2: 74 ksi ≤¾", 60 ksi above. Grade 8: 150 ksi to 1½". Grade 5 steps down above 1" — ISO class 8.8 does not

Chemistry & heat treatment

Grade 2	low or medium carbon, not heat-treated
Grade 5	medium carbon, quenched and tempered
Grade 8	medium carbon alloy, quenched and tempered
Grade 8 tempering min	800 °F (427 °C)
Phosphorus max	0.048 % (Gr 5, Gr 8)
Sulphur max	0.058 % (Gr 5, Gr 8)

J429 fixes the mechanical grade, not the alloy. The maker chooses a steel that meets it.

Marking



Grade 2	no radial lines
Grade 5	3 radial lines
Grade 8	6 radial lines
Maker's mark	required with the lines

Pair with & equivalents

Nut for Gr 5	SAE J995 Grade 5 or ASTM A563 Gr A
Nut for Gr 8	SAE J995 Grade 8 or A563 DH
Washer	SAE flat, or F436 where hardened
Nearest ISO — Gr 5	8.8
Nearest ISO — Gr 8	10.9
Nearest ISO — Gr 2	5.8 (approx)

J429 is an automotive and general-purpose series. It is not a structural specification; do not substitute for A325 or A490.

1. Grade 5 drops from 120 to 105 ksi above 1" diameter; ISO class 8.8 keeps 830 MPa to M39.

2. Grade 2 also drops with length as well as diameter — check the specific table.

3. SAE J429 covers inch series only. There is no SAE metric equivalent; use ISO 898-1.

4. Grade 8 is susceptible to hydrogen embrittlement if electroplated — bake per ASTM F1941.

5. Proof load, not yield, is the working limit for a J429 fastener.

▲ **Note:** Confirm the Grade 2 length limits and the Grade 5 proof stresses above 1" against the current SAE J429.

Sources SAE J429 · SAE J995 (nuts) · ASME B1.1 · ASME B18.2.1 · ASTM F1941

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ASTM F3125 Grade A325 and A325M

ASTM F3125/F3125M · structural bolts, 120 ksi / 830 MPa · heavy hex

TENSILE MIN	YIELD MIN	METRIC A325M	HARDNESS	TYPES	NUT · WASHER
120 ksi	92 / 81 ksi	830 MPa	25–34 HRC	1 · 3	A563 DH · F436
½" – 1½", all sizes	≤1" / >1"	M16 – M36	≤1"	plain/galv · weathering	

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/2	0.142	120	92	17.0	76	827	634
5/8	0.226	120	92	27.1	121	827	634
3/4	0.334	120	92	40.1	178	827	634
7/8	0.462	120	92	55.4	247	827	634
1	0.606	120	92	72.7	323	827	634
1 1/8	0.790	120	81	94.8	422	827	558
1 1/4	1.000	120	81	120.0	534	827	558
1 3/8	1.233	120	81	148.0	658	827	558
1 1/2	1.492	120	81	179.0	796	827	558

A325 keeps 120 ksi at every size — unlike A449 and SAE Grade 5

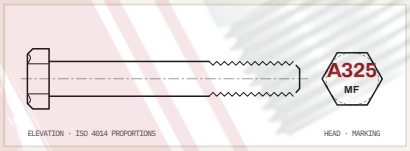
A325M: 830 MPa, M16 to M36, same assembly rules

Chemistry & heat treatment

Type 1	medium carbon, carbon boron or alloy steel, Q&T
Type 3	weathering steel, atmospheric corrosion resistant
Tempering min	800 °F (427 °C)
Carbon max, Type 1	0.30 – 0.52 % by class
Phosphorus max	0.040 %
Sulphur max	0.050 %

Type 2 (low carbon martensite) was withdrawn in 1991 and must not be supplied.

Marking



Head	A325 + maker's mark
Type 3	A325 underlined, or A325 with type 3 mark
Metric	A325M
Galvanized	marked as the standard requires plus finish record

F3125 replaced the separate A325 and A325M standards in 2015; the head mark remains A325.

Pair with & equivalents

Nut, galvanized	A563 DH, tapped oversize, lubricated (dyed)
Nut, plain	A563 C, D or DH
Washer	F436 Type 1 (or Type 3 with weathering bolts)
Nearest ISO	8.8 · EN 14399-3 HR
Metric nut	A563M 10S or 12S
DTI	F959 Type 325

Structural assemblies are supplied and tested as a set. Mixing a loose nut with an A325 bolt breaks the assembly certification.

1. A325 is a **structural** grade: heavy hex head, short thread length, intended for pretensioned joints.

2. Galvanized A325 must be supplied as an assembly with a lubricated oversize DH nut — the lubricant is usually dyed so it is visible.

3. Thread length is deliberately short so the shear plane can fall in the shank; check grip length carefully.

4. Turn-of-nut, DTI or tension control is preferred to torque for pretensioning. See RCSC.

5. A325 heavy hex dimensions are ASME B18.2.6 — wider across flats than a standard hex bolt.

▲ **Note:** Confirm the A325 yield values above 1" and the Type 1 carbon ranges against the current F3125.

Sources ASTM F3125/F3125M (supersedes A325, A325M, A490, A490M, F1852, F2280) · ASTM A563/A563M · F436/F436M · F959 · ASME B18.2.6 · RCSC Specification

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ASTM F3125 Grade A490 and A490M

ASTM F3125/F3125M · structural bolts, 150–173 ksi / 1040 MPa · heavy hex

TENSILE	YIELD MIN	METRIC A490M	HARDNESS	GALVANIZING	NUT · WASHER
150 – 173 ksi minimum and maximum	130 ksi ½" – 1½"	1040 MPa min M16 – M36	33–38 HRC	not permitted any hot-dip process	A563 DH · F436

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/2	0.142	150	130	21.3	95	1,034	896
5/8	0.226	150	130	33.9	151	1,034	896
3/4	0.334	150	130	50.1	223	1,034	896
7/8	0.462	150	130	69.3	308	1,034	896
1	0.606	150	130	90.9	404	1,034	896
1 1/8	0.790	150	130	118.5	527	1,034	896
1 1/4	1.000	150	130	150.0	667	1,034	896
1 3/8	1.233	150	130	185.0	823	1,034	896
1 1/2	1.492	150	130	223.8	996	1,034	896

A490 has a tensile **maximum** of 173 ksi as well as a minimum — A490M: 1040–1210 MPa

Chemistry & heat treatment

Material	alloy steel, quenched and tempered
Carbon	0.30 – 0.53 %
Tempering min	900 °F (482 °C)
Phosphorus max	0.040 %
Sulphur max	0.050 %
Type 3	weathering steel, same mechanicals

The tensile maximum and hardness cap exist to limit hydrogen-embrittlement risk at this strength.

Marking

Head	A490 + maker's mark
Type 3	A490 underlined or marked type 3
Metric	A490M
Finish	plain or mechanically galvanized only

Pair with & equivalents

Nut	A563 DH (plain or mechanically galvanized)
Washer	F436
Nearest ISO	10.9 · EN 14399-4 HV
Metric nut	A563M 12S
DTI	F959 Type 490
Never	hot-dip galvanized

Hot-dip galvanizing of A490 is prohibited. Where corrosion protection is needed, specify Type 3 weathering steel or a coating system that involves no acid pickling.

1. A490 carries a tensile **maximum**: an over-strength bolt is a reject, not a bonus.

2. Hot-dip galvanizing is not permitted — the pickling introduces hydrogen into a very hard part.

3. Reuse is not permitted once an A490 has been fully pretensioned.

4. Turn-of-nut or DTI is the normal pretensioning method.

5. A354 Grade BD is the same strength level for non-structural use, without the assembly rules.

▲ **Note:** Confirm the A490 tensile maximum and hardness range, and the reuse prohibition wording, against the current F3125.

Sources ASTM F3125/F3125M · ASTM A563/A563M · F436/F436M · F959 · ASME B18.2.6 · RCSC Specification

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ASTM A193 Grade B7 and B7M

ASTM A193/A193M · alloy steel bolting for high temperature and pressure service

B7 TENSILE	B7 YIELD	B7M TENSILE	B7M HARDNESS	MATERIAL	TEMPERING MIN
125 / 115 / 100 ksi	105 / 95 / 75 ksi	100 ksi	235 HBW max	42CrMo4 / AISI 4140	1150 °F (621 °C
≤2½" / 2½–4" / 4–7"	same steps	all sizes ≤ 4"	sour service cap	Cr-Mo alloy	B7M: 1150 °F

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/4	0.032	125	105	4.0	18	862	724
3/8	0.077	125	105	9.7	43	862	724
1/2	0.142	125	105	17.7	79	862	724
5/8	0.226	125	105	28.2	126	862	724
3/4	0.334	125	105	41.8	186	862	724
7/8	0.462	125	105	57.8	257	862	724
1	0.606	125	105	75.8	337	862	724
1 1/8	0.790	125	105	98.8	439	862	724
1 1/4	1.000	125	105	125.0	556	862	724
1 1/2	1.492	125	105	186.5	830	862	724
1 3/4	2.080	125	105	260.0	1,157	862	724
2	2.770	125	105	346.2	1,540	862	724
2 1/2	4.440	125	105	555.0 ▲	2,469 ▲	862	724
3	6.510	115	95	748.6 ▲	3,330 ▲	793	655
4	11.900	115	95	1,368.5 ▲	6,087 ▲	793	655

B7 steps down twice with diameter — the table shows the step at 2½"

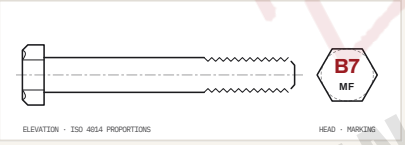
▲ flagged rows: confirm the step boundaries against A193

Chemistry & heat treatment

Grade	AISI 4140 / 4142 / 4145 (Cr-Mo)
EN equivalent	42CrMo4 · 1.7225
Carbon	0.37 – 0.49 %
Chromium	0.75 – 1.20 %
Molybdenum	0.15 – 0.25 %
Phosphorus max	0.035 %
Sulphur max	0.040 %
Condition	quenched and tempered

B7M is the same steel, tempered higher and hardness-capped at 235 HBW for NACE MR0175 sour service. Every B7M part is hardness tested.

Marking



Stud end	B7 or B7M + maker's mark
B7M additional	required hardness test record
Bolt head	B7 on the head top
Metric	A193M, same grade names

Pair with & equivalents

Nut	A194 Grade 2H (B7) · 2HM (B7M)
Washer	F436 hardened
Nearest EN	EN 10269 42CrMo4
Nearest ISO class	none — B7 is a material spec, not a class
Low temperature	use A320 L7 instead
High temperature	above 400 °C consider B16

2H nuts with B7, 2HM with B7M. A563 DH is not a substitute on a pressure flange.

1. B7 is a **material and service** specification, not a strength class. "10.9 rod" is not B7.

2. The minimum tempering temperature is part of the specification and must appear on the certificate.

3. B7M requires hardness testing of every stud (or a defined sampling per A193) — the test record is part of the supply.

4. Above about 400 °C, B16 is the correct grade; B7 loses strength through creep.

5. For low-temperature service the impact-tested equivalent is A320 L7 — see page 3.11.

▲ Note: ▲ Confirm the exact diameter steps for B7 (2½" and 4") and the B7M tensile and yield values against the current A193/A193M. These steps differ between editions.

Sources ASTM A193/A193M · ASTM A194/A194M · NACE MR0175 / ISO 15156 · EN 10269 · ASME B16.5 · ASME B18.31.3

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ASTM A193 Grade B8 — Class 1

ASTM A193/A193M · AISI 304 stainless · solution annealed (Class 1)

TENSILE MIN	YIELD MIN	ELONGATION MIN	REDUCTION MIN	CONDITION	HARDNESS
75 ksi 515 MPa · all sizes	30 ksi 205 MPa	30 %	50 %	solution annealed carbide solution treated	223 HBW max

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/4	0.032	75	30	2.4	11	517	207
3/8	0.077	75	30	5.8	26	517	207
1/2	0.142	75	30	10.6	47	517	207
5/8	0.226	75	30	16.9	75	517	207
3/4	0.334	75	30	25.1	111	517	207
7/8	0.462	75	30	34.6	154	517	207
1	0.606	75	30	45.4	202	517	207
1 1/8	0.790	75	30	59.2	264	517	207
1 1/4	1.000	75	30	75.0	334	517	207
1 1/2	1.492	75	30	111.9	498	517	207
1 3/4	2.080	75	30	156.0	694	517	207
2	2.770	75	30	207.8	924	517	207
2 1/2	4.440	75	30	333.0	1,481	517	207
3	6.510	75	30	488.2	2,172	517	207
4	11.900	75	30	892.5	3,970	517	207

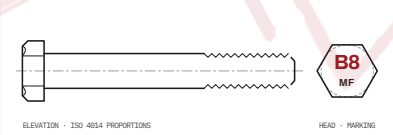
Class 1 does not step down with diameter — the strength is the same at every size Class 2 (page 3.10) is strain hardened and much stronger

Chemistry & heat treatment

Type	AISI 304 · UNS S30400
EN equivalent	X5CrNi18-10 · 1.4301
Carbon max	0.08 %
Chromium	18.0 – 20.0 %
Nickel	8.0 – 11.0 %
Phosphorus max	0.045 %
Sulphur max	0.030 %
Condition	solution annealed, cooled rapidly

Solution annealing maximises corrosion resistance and makes the part non-magnetic. It also makes it weak: 75 ksi against 125 ksi for Class 2 in small sizes.

Marking



Stud end	B8 + maker's mark
Class	the class is not always struck — check the certificate
Do not assume	an unmarked B8 is Class 2
Metric	A193M B8

▲ The commonest stainless error in the field: assuming a B8 stud is Class 2 when it is Class 1, and designing to 125 ksi against an actual 75 ksi.

Pair with & equivalents

Nut	A194 Grade 8
Washer	matching stainless, or F436 where hardness needed
Nearest ISO	A2-50 (ISO 3506-1)
Not	A2-70 — that is nearer Class 2
Anti-galling	lubricant or anti-seize essential
Service	cryogenic to about 540 °C

Stainless on stainless galls readily. Use anti-seize and assemble slowly.

1. Class 1 is solution annealed — maximum corrosion resistance, minimum strength.

2. Strength does **not** step down with diameter for Class 1; it is 75 ksi at every size.

3. Non-magnetic in the annealed condition; slight magnetism after cold work is normal and not a rejection cause on its own.

4. For chloride and marine exposure use B8M (316) — see pages 3.11 and 3.12.

5. Class 1 is the correct choice for high-temperature service where Class 2 would over-age.

▲ Note: ▲ Confirm the Class 1 elongation and reduction minima and the maximum hardness against the current A193/A193M.

Sources ASTM A193/A193M · ASTM A194/A194M · ISO 3506-1 · ASTM F593 · EN 10088-3

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ASTM A193 Grade B8 — Class 2

ASTM A193/A193M · AISI 304 stainless · strain hardened (Class 2)

TENSILE MIN	STEPS TO	YIELD MIN	ELONGATION MIN	CONDITION	SIZE LIMIT
125 ksi ≤¾" · 860 MPa	115 / 105 / 100 ksi ¾–1" / 1–1¼" / 1¼–1½"	100 ksi ≤¾" · 690 MPa	12 % ≤¾"	strain hardened cold worked after annealing	1½" max Class 2 not made above

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/2	0.142	125	100	17.7	79	862	689
5/8	0.226	125	100	28.2	126	862	689
3/4	0.334	125	100	41.8 ▲	186 ▲	862	689
7/8	0.462	115	80	53.1 ▲	236 ▲	793	552
1	0.606	115	80	69.7 ▲	310 ▲	793	552
1 1/8	0.790	105	65	83.0 ▲	369 ▲	724	448
1 1/4	1.000	105	65	105.0 ▲	467 ▲	724	448
1 3/8	1.233	100	50	123.3 ▲	548 ▲	689	345
1 1/2	1.492	100	50	149.2 ▲	664 ▲	689	345

▲ Class 2 steps down at ¾", 1" and 1¼" — the flagged rows carry the steps

Above 1½" only Class 1 is available

Chemistry & heat treatment

Type	AISI 304 · UNS S30400
EN equivalent	X5CrNi18-10 · 1.4301
Carbon max	0.08 %
Chromium	18.0 – 20.0 %
Nickel	8.0 – 11.0 %
Condition	solution annealed then strain hardened
Hardness	321 HBW max

Same chemistry as Class 1. The strength comes entirely from cold work, so it is lost if the part is re-annealed or exposed to high temperature for long.

Marking

Stud end	B8 + maker's mark
Class 2	should be identified; verify on the certificate
Metric	A193M B8 Class 2
Nearest ISO mark	A2-70

Pair with & equivalents

Nut	A194 Grade 8 (strain hardened where matched)
Washer	stainless or F436
Nearest ISO	A2-70 (ISO 3506-1)
Max service temp	about 400 °C before strength drops
Anti-galling	essential
Above 1½"	use Class 1 or a different grade

A Class 2 stud with a Class 1 nut is a common and acceptable pairing; the reverse is not, since the nut must not be the weaker part.

1. Class 2 strength **steps down with diameter** — 125, 115, 105 then 100 ksi. Class 1 does not.

2. Cold-worked strength is lost if the part is heated: not for sustained service much above 400 °C.

3. Class 2 is not manufactured above 1½" — larger studs are Class 1 unless another grade is used.

4. Elongation falls to 12 % against 30 % for Class 1; the part is stronger but less ductile.

5. Certificates must state the class. If it does not, treat the part as Class 1 for design.

▲ **Note:** ▲ Confirm every Class 2 diameter step (¾", 1", 1¼") and the yield values against the current A193/A193M. This table is the one most often printed wrongly.

Sources ASTM A193/A193M · ASTM A194/A194M · ISO 3506-1 · ASTM F593 · EN 10088-3

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ASTM A193 Grade B8M — Class 1

ASTM A193/A193M · AISI 316 stainless · solution annealed (Class 1)

TENSILE MIN	YIELD MIN	ELONGATION MIN	MOLYBDENUM	CONDITION	CHLORIDE RESISTANCE
75 ksi 515 MPa · all sizes	30 ksi 205 MPa	30 %	2.0 – 3.0 % the difference from B8	solution annealed	better than 304

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/4	0.032	75	30	2.4	11	517	207
3/8	0.077	75	30	5.8	26	517	207
1/2	0.142	75	30	10.6	47	517	207
5/8	0.226	75	30	16.9	75	517	207
3/4	0.334	75	30	25.1	111	517	207
7/8	0.462	75	30	34.6	154	517	207
1	0.606	75	30	45.4	202	517	207
1 1/8	0.790	75	30	59.2	264	517	207
1 1/4	1.000	75	30	75.0	334	517	207
1 1/2	1.492	75	30	111.9	498	517	207
1 3/4	2.080	75	30	156.0	694	517	207
2	2.770	75	30	207.8	924	517	207
2 1/2	4.440	75	30	333.0	1,481	517	207
3	6.510	75	30	488.2	2,172	517	207
4	11.900	75	30	892.5	3,970	517	207

Same mechanical values as B8 Class 1 — the difference is the alloy, not the strength

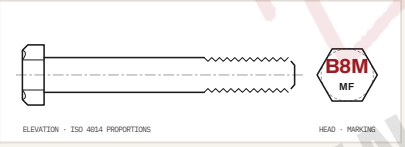
316 resists pitting in chlorides; 304 does not

Chemistry & heat treatment

Type	AISI 316 · UNS S31600
EN equivalent	X5CrNiMo17-12-2 · 1.4401
Carbon max	0.08 %
Chromium	16.0 – 18.0 %
Nickel	10.0 – 14.0 %
Molybdenum	2.00 – 3.00 %
Condition	solution annealed

The molybdenum is what buys chloride pitting resistance. In Gulf coastal and desalination service this is the grade to specify, not 304.

Marking



Stud end	B8M + maker's mark
Class	verify Class 1 or 2 on the certificate
Metric	A193M B8M
Nearest ISO mark	A4-50

Pair with & equivalents

Nut	A194 Grade 8M
Washer	316 stainless
Nearest ISO	A4-50 (ISO 3506-1)
Service	seawater, desalination, chemical
Anti-galling	essential — 316 galls worse than 304
Do not pair	with 304 nuts in chloride service

Match the nut alloy to the stud. A 304 nut on a 316 stud in seawater fails at the nut.

1. B8M Class 1 has the same mechanical minima as B8 Class 1 — 75 ksi at every size.
2. The value of B8M is corrosion resistance, not strength.
3. 316 galls more readily than 304. Anti-seize compound is not optional.
4. For higher strength in 316, use B8M Class 2 (page 3.12), noting the diameter steps.
5. Chloride stress corrosion cracking is still possible in 316 above about 60 °C — duplex may be required.

▲ **Note:** ▲ Confirm B8M Class 1 mechanical minima and the molybdenum range against the current A193/A193M.

Sources ASTM A193/A193M · ASTM A194/A194M · ISO 3506-1 · ASTM F593 · EN 10088-3 · NACE MR0175

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ASTM A193 Grade B8M — Class 2

ASTM A193/A193M · AISI 316 stainless · strain hardened (Class 2)

TENSILE MIN	STEPS TO	YIELD MIN	ELONGATION MIN	CONDITION	SIZE LIMIT
110 ksi	100 / 95 / 90 ksi	95 ksi	15 %	strain hardened	1½" max
≤¾" · 760 MPa	¾–1" / 1–1¼" / 1¼–1½"	≤¾"	≤¾"		

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/2	0.142	110	95	15.6	69	758	655
5/8	0.226	110	95	24.9	111	758	655
3/4	0.334	110	95	36.7 ▲	163 ▲	758	655
7/8	0.462	100	80	46.2 ▲	206 ▲	689	552
1	0.606	100	80	60.6 ▲	270 ▲	689	552
1 1/8	0.790	95	65	75.0 ▲	334 ▲	655	448
1 1/4	1.000	95	65	95.0 ▲	423 ▲	655	448
1 3/8	1.233	90	50	111.0 ▲	494 ▲	621	345
1 1/2	1.492	90	50	134.3 ▲	597 ▲	621	345

▲ B8M Class 2 is **lower** than B8 Class 2 at the same size — 110 against 125 ksi

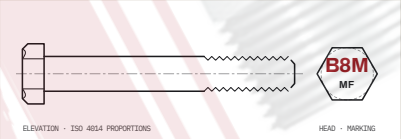
Every step boundary is flagged for QC

Chemistry & heat treatment

Type	AISI 316 · UNS S31600
EN equivalent	X5CrNiMo17-12-2 · 1.4401
Carbon max	0.08 %
Chromium	16.0 – 18.0 %
Nickel	10.0 – 14.0 %
Molybdenum	2.00 – 3.00 %
Condition	annealed then strain hardened

316 work-hardens less readily than 304, which is why Class 2 values are lower for B8M than for B8.

Marking



Stud end	B8M + maker's mark
Class 2	verify on the certificate
Metric	A193M B8M Class 2
Nearest ISO mark	A4-70

Pair with & equivalents

Nut	A194 Grade 8M
Washer	316 stainless
Nearest ISO	A4-70 (ISO 3506-1)
Max service temp	about 400 °C
Above 1½"	Class 1 only
Anti-galling	essential

Do not assume B8M Class 2 matches B8 Class 2. It is a lower-strength grade at every diameter.

1. B8M Class 2 is **weaker than B8 Class 2** at every size — 110 against 125 ksi in the smallest range.
2. Strength steps down with diameter, as for B8 Class 2.
3. Not manufactured above 1½".
4. Cold-worked strength is lost on heating; not for sustained high-temperature service.
5. Where both chloride resistance and high strength are needed above 1½", consider duplex (A182 F51/F55) instead.

▲ **Note:** ▲ Confirm all four B8M Class 2 strength steps and their diameter boundaries against the current A193/A193M.

Sources ASTM A193/A193M · ASTM A194/A194M · ISO 3506-1 · EN 10088-3

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ASTM A193 Grade B16

ASTM A193/A193M · chromium-molybdenum-vanadium alloy · high temperature service

TENSILE MIN	YIELD MIN	MATERIAL	TEMPERING MIN	SERVICE	HARDNESS
125 / 110 / 100 ksi	105 / 95 / 85 ksi	21CrMoV5-7	1200 °F (650 °C)	above 400 °C	321 HBW max
≤2½" / 2½–4" / 4–7"	same steps	Cr-Mo-V		where B7 creeps	

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/4	0.032	125	105	4.0	18	862	724
3/8	0.077	125	105	9.7	43	862	724
1/2	0.142	125	105	17.7	79	862	724
5/8	0.226	125	105	28.2	126	862	724
3/4	0.334	125	105	41.8	186	862	724
7/8	0.462	125	105	57.8	257	862	724
1	0.606	125	105	75.8	337	862	724
1 1/8	0.790	125	105	98.8	439	862	724
1 1/4	1.000	125	105	125.0	556	862	724
1 1/2	1.492	125	105	186.5	830	862	724
1 3/4	2.080	125	105	260.0	1,157	862	724
2	2.770	125	105	346.2	1,540	862	724
2 1/2	4.440	125	105	555.0 ▲	2,469 ▲	862	724
3	6.510	110	95	716.1 ▲	3,185 ▲	758	655
4	11.900	110	95	1,309.0 ▲	5,823 ▲	758	655

B16 steps with diameter like B7, but holds strength at temperature

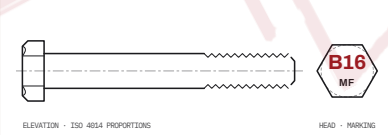
▲ confirm step boundaries against A193

Chemistry & heat treatment

EN equivalent	21CrMoV5-7 · 1.7709
Carbon	0.36 – 0.47 %
Chromium	0.80 – 1.15 %
Molybdenum	0.50 – 0.65 %
Vanadium	0.25 – 0.35 %
Phosphorus max	0.035 %
Sulphur max	0.040 %
Condition	quenched and tempered

The vanadium gives creep resistance. This is the difference between B16 and B7 and the reason B16 costs more.

Marking



Stud end	B16 + maker's mark
Certificate	tempering temperature must be stated
Metric	A193M B16
Do not substitute	B7 above 400 °C

Pair with & equivalents

Nut	A194 Grade 4 or 7
Washer	F436 or matching alloy
Service temperature	to about 540 °C
Below 400 °C	B7 is adequate and cheaper
Low temperature	B16 is not impact tested — use A320 L7
Nearest EN	EN 10269 21CrMoV5-7

2H nuts are used with B16 in many refinery specifications, but A194 Gr 4 or 7 is the matched choice. Follow the project specification.

1. B16 is specified where sustained temperature would cause B7 to creep — typically above 400 °C.

2. It is not a low-temperature grade: no impact requirement.

3. The minimum tempering temperature (1200 °F) must appear on the certificate.

4. Cost is materially higher than B7; do not specify it by default.

5. B16 studs are usually 8UN threaded above 1" like other flange bolting.

▲ Note: ▲ Confirm the B16 tensile and yield steps, the tempering minimum and the matched nut grade against the current A193/A193M and A194/A194M.

Sources ASTM A193/A193M · ASTM A194/A194M · EN 10269 · ASME B16.5 · ASME B31.3

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ASTM A320 Grade L7

ASTM A320/A320M · alloy steel bolting for low-temperature service · impact tested

TENSILE MIN	YIELD MIN	IMPACT TEST	IMPACT MIN	MATERIAL	TEMPERING MIN
125 ksi 860 MPa · ≤2½"	105 ksi 725 MPa	−101 °C −150 °F, Charpy V	20 ft·lbf 27 J, average of 3	42CrMo4 / 4140 same steel as B7	1150 °F (621 °C)

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/4	0.032	125	105	4.0	18	862	724
3/8	0.077	125	105	9.7	43	862	724
1/2	0.142	125	105	17.7	79	862	724
5/8	0.226	125	105	28.2	126	862	724
3/4	0.334	125	105	41.8	186	862	724
7/8	0.462	125	105	57.8	257	862	724
1	0.606	125	105	75.8	337	862	724
1 1/8	0.790	125	105	98.8	439	862	724
1 1/4	1.000	125	105	125.0	556	862	724
1 1/2	1.492	125	105	186.5	830	862	724
1 3/4	2.080	125	105	260.0	1,157	862	724
2	2.770	125	105	346.2	1,540	862	724
2 1/2	4.440	125	105	555.0 ▲	2,469 ▲	862	724
3	6.510	115	95	748.6 ▲	3,330 ▲	793	655
4	11.900	115	95	1,368.5 ▲	6,087 ▲	793	655

Mechanically identical to B7 — the difference is the impact test

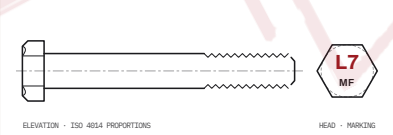
▲ confirm the diameter step against A320

Chemistry & heat treatment

Grade	AISI 4140 / 4142 / 4145
EN equivalent	42CrMo4 · 1.7225
Carbon	0.37 – 0.49 %
Chromium	0.75 – 1.20 %
Molybdenum	0.15 – 0.25 %
Condition	quenched and tempered
Impact	Charpy V-notch at −101 °C

L7 is B7 chemistry with a mandatory low-temperature impact test. A B7 stud is not an L7 stud even though the steel is the same.

Marking



Stud end	L7 + maker's mark
Test temperature	marked where below −150 °F
Certificate	must carry the Charpy results
Metric	A320M L7

Pair with & equivalents

Nut	A194 Grade 4 or 7, impact tested
Washer	F436
Service	LNG, cryogenic, cold climate
L43	same properties, tested at −73 °C, larger sizes
Sour service	L7M — see page 3.15
Nearest EN	EN 10269 42CrMo4 + impact

The nut must also be impact tested for the joint to be a low-temperature assembly. An untested 2H nut defeats the specification.

1. L7 is B7 **plus** a Charpy impact test at −101 °C (−150 °F).

2. The impact results must appear on the certificate — this is the whole point of the grade.

3. Nuts must be impact tested too; specify A194 Gr 4 or 7 with the same test.

4. L43 is the equivalent for larger diameters, tested at −73 °C.

5. Do not accept a B7 certificate against an L7 order.

▲ Note: ▲ Confirm the L7 impact energy minimum, the test temperature and the diameter limit for L7 against the current A320/A320M.

Sources ASTM A320/A320M · ASTM A194/A194M · ASME B31.3 · EN 10269

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ASTM A320 Grade L7M

ASTM A320/A320M · low-temperature bolting, hardness capped for sour service

TENSILE MIN	YIELD MIN	HARDNESS MAX	IMPACT TEST	MATERIAL	TESTING
100 ksi 690 MPa	80 ksi 550 MPa	235 HBW sour service cap	−101 °C Charpy V	42CrMo4 / 4140	every stud hardness, 100 %

Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
1/4	0.032	100	80	3.2	14	689	552
3/8	0.077	100	80	7.8	34	689	552
1/2	0.142	100	80	14.2	63	689	552
5/8	0.226	100	80	22.6	101	689	552
3/4	0.334	100	80	33.4	149	689	552
7/8	0.462	100	80	46.2	206	689	552
1	0.606	100	80	60.6	270	689	552
1 1/8	0.790	100	80	79.0	351	689	552
1 1/4	1.000	100	80	100.0	445	689	552
1 1/2	1.492	100	80	149.2	664	689	552
1 3/4	2.080	100	80	208.0	925	689	552
2	2.770	100	80	277.0	1,232	689	552
2 1/2	4.440	100	80	444.0	1,975	689	552
3	6.510	100	80	651.0	2,896	689	552
4	11.900	100	80	1,190.0	5,293	689	552

L7M does not step down within its size range

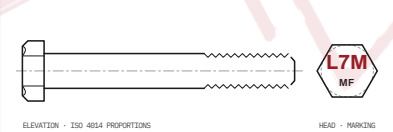
Lower strength than L7 — the hardness cap costs strength

Chemistry & heat treatment

Grade	AISI 4140 / 4142 / 4145
EN equivalent	42CrMo4 · 1.7225
Carbon	0.37 – 0.49 %
Chromium	0.75 – 1.20 %
Molybdenum	0.15 – 0.25 %
Condition	quenched and tempered, tempered higher than L7
Hardness	235 HBW maximum

L7M is L7 tempered higher to bring hardness under 235 HBW for NACE MR0175 sour service. The higher temper costs about 25 ksi of tensile strength.

Marking



ELEVATION · ISO 4014 PROPORTIONS — HEAD · MARKING

Stud end	L7M + maker's mark
Hardness record	required for every part
Certificate	Charpy plus hardness
Metric	A320M L7M

Pair with & equivalents

Nut	A194 Grade 7M
Washer	F436
Service	sour + low temperature
Standard service	use L7 instead
Non-cryogenic sour	B7M — see page 3.08
NACE	MR0175 / ISO 15156

Pair with 7M nuts. A 2H nut is too hard for sour service and defeats the purpose of specifying L7M.

1. L7M is the sour-service, low-temperature grade: hardness capped at 235 HBW and impact tested.

2. Every stud is hardness tested — not a sample. The records form part of the supply.

3. Strength is materially lower than L7: 100 ksi against 125 ksi.

4. Use only where H_2S service requires it; elsewhere L7 is stronger and cheaper.

5. Nuts must be 7M, similarly capped and tested.

▲ **Note:** ▲ Confirm the L7M tensile and yield minima, the 235 HBW cap and the 100 % hardness testing requirement against the current A320/A320M.

Sources ASTM A320/A320M · ASTM A194/A194M · NACE MR0175 / ISO 15156 · ASME B31.3

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Brass and copper alloy fasteners

ASTM B16 · B21 · B98 · B150 · non-ferrous bolting for electrical and marine service

TYPICAL TENSILE	CONDUCTIVITY	MAGNETIC	SPARKING	SEAWATER	STANDARD
55 – 75 ksi 380 – 515 MPa, alloy dependent	high copper alloys	no	non-sparking	good in bronzes	no single ISO class

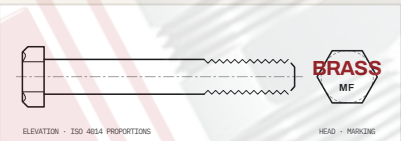
Size	Stress area in²	Tensile min ksi	Yield min ksi	Min. breaking load kip · A × Rm	kN	Tensile min MPa	Yield min MPa
Naval brass C46400	ASTM B21	–	–	–	–	~ 55 ksi	~ 380 MPa
Silicon bronze C65100	ASTM B98	–	–	–	–	~ 55 ksi	~ 380 MPa
Silicon bronze C65500	ASTM B98	–	–	–	–	~ 70 ksi	~ 480 MPa
Aluminium bronze C63000	ASTM B150	–	–	–	–	~ 100 ksi	~ 690 MPa
Free-cutting brass C36000	ASTM B16	–	–	–	–	~ 50 ksi	~ 340 MPa
Copper Cu-ETP C11000	ASTM B187	–	–	–	–	~ 32 ksi	~ 220 MPa

Chemistry & heat treatment

Naval brass C46400	Cu 59–62 %, Sn 0.5–1.0 %, Zn balance
Silicon bronze C65500	Cu 94.8 % min, Si 2.8–3.8 %
Aluminium bronze C63000	Cu 78–85 %, Al 9–11 %, Fe 2–4 %, Ni 4–5.5 %
Copper C11000	Cu 99.90 % min
Condition	as drawn, or annealed
Temper	strength depends on temper, not heat treatment

▲ Mechanical values above are typical for the alloy and temper and are **not** minima from a fastener standard. Copper alloy fasteners are ordered to the material standard plus a dimensional standard.

Marking



Marking	no standard class mark exists
Identification	by colour, alloy certificate and dimensional standard
Dimensions	usually DIN 933 / 934 / 125A form
Certificate	material analysis is the only proof

Because there is no class mark, the certificate is the identification. Keep it with the batch.

Pair with & equivalents

Nut	matching alloy
Washer	matching alloy
Use	earthing, busbars, battery terminals
Marine	silicon and aluminium bronze
Avoid	steel washers in contact – galvanic couple
Torque	much lower than steel; brass strips easily

Never fit steel washers or nuts with copper alloy bolts in a wet environment: the galvanic couple destroys the joint.

1. There is no ISO property class for copper alloy fasteners. Strength comes from the alloy and its temper.

2. ▲ The values on this page are typical, not standard minima. Specify the material standard (B16, B21, B98, B150) and require a certificate.

3. Torque figures for steel do not apply — brass threads strip at a fraction of steel torque.

4. Copper is chosen for conductivity, bronzes for seawater and strength, brass for machinability.

5. All copper alloys are non-magnetic and non-sparking — the reason they appear in hazardous areas.

▲ Note: ▲ This page carries typical values, not standard minima. MF to decide whether to publish it with typical values clearly labelled, or to restrict it to the alloys MF actually stocks with values from the supplier certificates.

Sources ASTM B16 · B21 · B98 · B150 · B187 · DIN 933 · DIN 934 · DIN 125A (dimensions)

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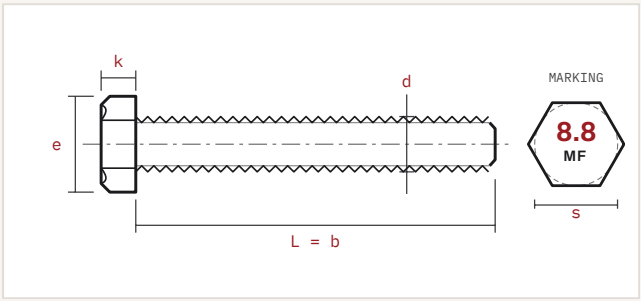
Hex bolts, screws, socket cap screws and hex nuts

Dimension plate · four products, two views each · metric · M6 to M24 shown

Hex screw, thread to head

ISO 4017 · DIN 933 · ASME B18.2.3.1M — product grades A and B

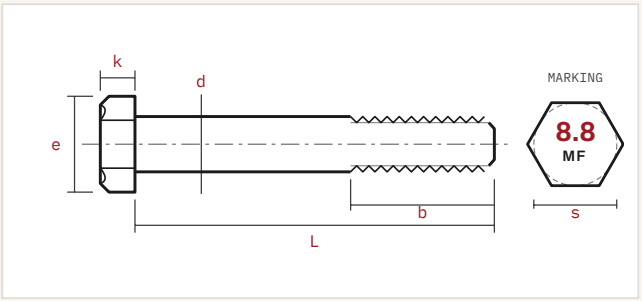


Size	M6	M8	M10	M12	M16	M20	M24
ISO s (A/F)	10	13	16	18	24	30	36
ISO k	4.0	5.3	6.4	7.5	10.0	12.5	15.0
ISO e min	11.05	14.38	17.77	20.03	26.75	33.53	39.98
DIN s (A/F)	10	13	17	19	24	30	36

Marking: property class (e.g. 8.8) and maker's mark **MF** on the head top, raised or indented, from M5. Full-length thread. DIN 933 differs from ISO 4017 at M10, M12, M14 and M22 across flats only.

Hex bolt, part thread

ISO 4014 · DIN 931 · ASME B18.2.3.1M — product grades A and B

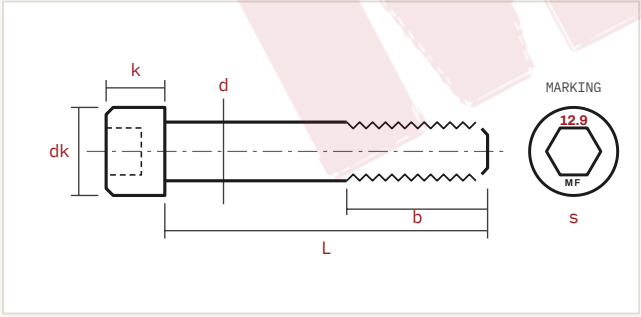


Size	M6	M8	M10	M12	M16	M20	M24
ISO s (A/F)	10	13	16	18	24	30	36
ISO k	4.0	5.3	6.4	7.5	10.0	12.5	15.0
DIN k	4.0	5.5	7.0	8.0	10.0	13.0	15.0
b, L ≤ 125	18	22	26	30	38	46	54

Marking: property class and **MF** on the head top, from M5. Thread length b = 2d + 6 for L ≤ 125 mm, 2d + 12 for 125 < L ≤ 200, 2d + 25 above 200 (ISO 4014).

Socket head cap screw

ISO 4762 · DIN 912 · ASME B18.3 — property class 8.8 · 10.9 · 12.9

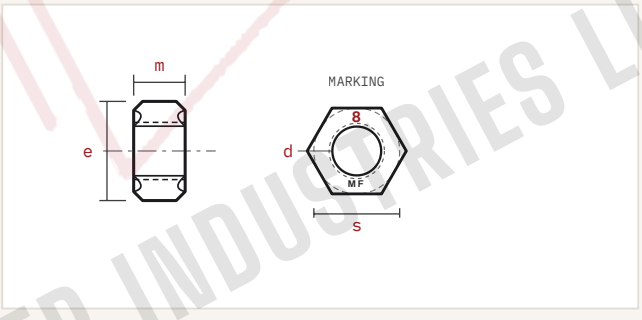


Size	M6	M8	M10	M12	M16	M20	M24
dk max	10	13	16	18	24	30	36
k max	6	8	10	12	16	20	24
s key	5	6	8	10	14	17	19

Marking: property class (12.9 usual) and **MF** on the head top around the socket, from M5. Head diameter dk = 1.5d, height k = d, hexagon socket s.

Hex nut, style 1

ISO 4032 · DIN 934 · ASME B18.2.4.1M — classes 5 · 8 · 10 · 12



Size	M6	M8	M10	M12	M16	M20	M24
ISO s (A/F)	10	13	16	18	24	30	36
ISO m max	5.2	6.8	8.4	10.8	14.8	18.0	21.5
DIN s (A/F)	10	13	17	19	24	30	36
DIN m	5.0	6.5	8.0	10.0	13.0	16.0	19.0

Marking: class number (5, 8, 10, 12) and **MF** on a bearing face or a side, from M5 (ISO 898-2). ISO 4032 is taller than DIN 934 (m ≈ 0.9d against 0.8d) and changes across flats at M10, M12, M14 and M22.

d nominal thread diameter

s width across flats

e width across corners

k head height · **m** nut height

b thread length · **L** length under head · marks as struck

▲ **Note:** Confirm the ISO and DIN across-flats and head-height columns at every size against the product standards.

Sources ISO 4014:2022 · ISO 4017:2022 · ISO 4762:2004 · ISO 4032:2012 · DIN 931-1 · DIN 933 · DIN 912 · DIN 934 · ASME B18.2.3.1M · B18.2.4.1M · B18.3 · Dimensions in mm, nominal or max as stated

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Hex bolts and screws — dimensions M6 to M64

ISO 4014 · ISO 4017 · DIN 931 · DIN 933 · product grades A and B

Size	Pitch mm	s across flats mm	k head height mm	e across corners mm ▲	b, L ≤ 125 mm	b, L ≤ 200 mm	Stress area As mm²
M6	1.00	10	4.0	11.00 ▲	18	24	20
M8	1.25	13	5.3	14.30 ▲	22	28	37
M10	1.50	16	6.4	17.60 ▲	26	32	58
M12	1.75	18	7.5	19.80 ▲	30	36	84
M14	2.00	21	8.8	23.10 ▲	34	40	115
M16	2.00	24	10.0	26.40 ▲	38	44	157
M18	2.50	27	11.5	29.70 ▲	42	48	192
M20	2.50	30	12.5	33.00 ▲	46	52	245
M22	2.50	34	14.0	37.40 ▲	50	56	303
M24	3.00	36	15.0	39.60 ▲	54	60	353
M27	3.00	41	17.0	45.10 ▲	60	66	459
M30	3.50	46	18.7	50.60 ▲	66	72	561
M33	3.50	50	21.0	55.00 ▲	72	78	694
M36	4.00	55	22.5	60.50 ▲	78	84	817
M39	4.00	60	25.0	66.00 ▲	84	90	976
M42	4.50	65	26.0	71.50 ▲	90	96	1,121
M45	4.50	70	28.0	77.00 ▲	96	102	1,306
M48	5.00	75	30.0	82.50 ▲	102	108	1,473
M52	5.00	80	33.0	88.00 ▲	110	116	1,758
M56	5.50	85	35.0	93.50 ▲	118	124	2,030
M60	5.50	90	38.0	99.00 ▲	126	132	2,362
M64	6.00	95	40.0	104.50 ▲	134	140	2,676

ISO 4014 (part thread) and ISO 4017 (full thread) share s, k and e

▲ e is computed as 1.1 s for this draft — to be replaced from the standard's table

Thread length b — ISO 4014

L ≤ 125 mm	b = 2d + 6
125 < L ≤ 200 mm	b = 2d + 12
L > 200 mm	b = 2d + 25
ISO 4017	thread runs to the head — no b
Short bolts	where L is too short for b, the bolt is threaded to the head

Thread length is a formula, not a free choice — the wrong b puts thread in the shear plane.

Product grades

Grade A	d ≤ 24 mm and L ≤ 10d or 150 mm — tighter tolerance
Grade B	larger sizes and longer lengths
Grade C	ISO 4016 / 4018 — coarse tolerance, hot forged
Effect	head and shank tolerances, not strength
Marking	unchanged by grade

ISO 4016 / 4018 is the coarse-tolerance equivalent, common in structural work at class 4.6 and 5.6.

DIN differences

M10	DIN 17 · ISO 16
M12	DIN 19 · ISO 18
M14	DIN 22 · ISO 21
M22	DIN 32 · ISO 34
All other sizes	identical
DIN upper limit	DIN 931 / 933 to M52

Four sizes differ, and only in across flats. Every other dimension matches.

1. ISO 4014 is the part-threaded hex bolt, ISO 4017 the full-threaded hex screw; head and thread dimensions are common to both.

2. ▲ Across-corners e here is computed as 1.1 s. use the tabulated e min from ISO 4014 / 4017, which varies by product grade.

3. Stress areas are computed from ISO 724 geometry and match ISO 898-1 Table 5 where that table extends. Above M39 dimensions remain valid but the ISO property classes do not — see page 2.12.

4. Galvanized bolts are made to the same dimensions; the nut is tapped oversize, not the bolt undersized (ISO 10684).

▲ Note: ▲ Replace the computed across-corners column with the tabulated e min from ISO 4014 / 4017 for each product grade, and confirm k and s at every size above M36.

Sources ISO 4014 · ISO 4017 · ISO 4016 · ISO 4018 · ISO 724 · ISO 898-1:2013 Table 5 · DIN 931-1 · DIN 933 · ISO 10684

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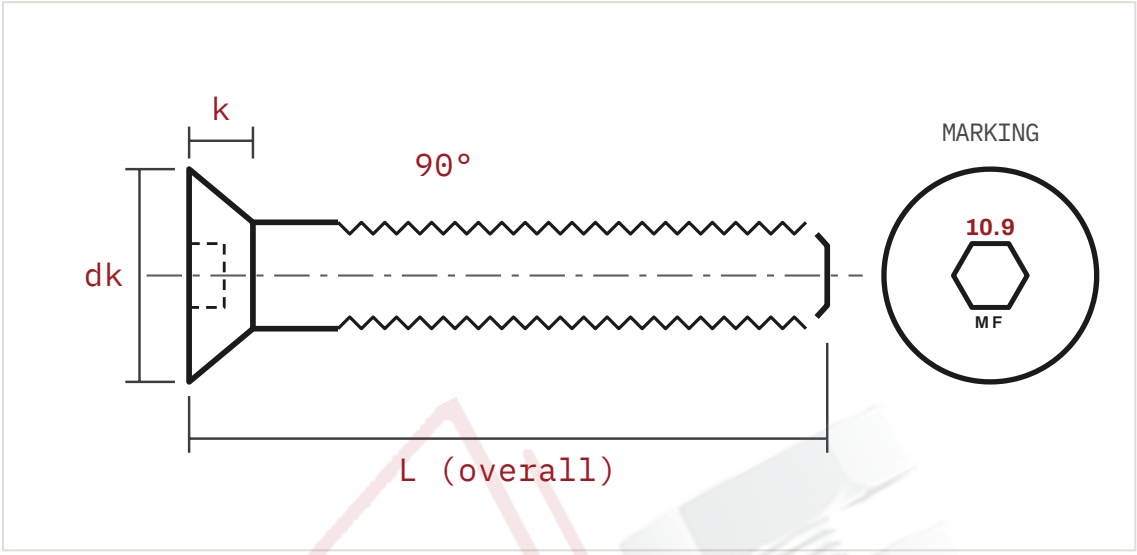
Countersunk socket head cap screws — CSK Allen

ISO 10642 · DIN 7991 · 90° head, hexagon socket · M6 to M24



Size	Pitch mm	dk head dia mm · max ▲	k head height mm · max ▲	s socket mm	Head angle	Stress area As mm²
M6	1.00	12.8	3.3	4	90°	20
M8	1.25	17.3	4.4	5	90°	37
M10	1.50	20.0	5.5	6	90°	58
M12	1.75	24.0	6.5	8	90°	84
M14	2.00	27.0	7.0	10	90°	115
M16	2.00	30.0	7.5	10	90°	157
M20	2.50	36.0	8.5	12	90°	245
M24	3.00	43.0	14.0	14	90°	353

ISO 10642 · DIN 7991 — countersunk (flat) head hexagon socket cap screw

▲ dk and k to be confirmed against the standard table

Why the head angle matters

ISO 10642 · DIN 7991	90° included angle
Inch series	82° (ASME B18.3)
Effect of mixing	the head sits proud or bottoms on the edge
Countersink	must match the screw, not the drill
Never	fit a 90° screw in an 82° countersink

A 90° metric screw in an 82° countersink bears on the rim only and cracks the plate or the head.

Strength and class

Usual classes	8.8 · 10.9 · 12.9
Stainless	A2-70 · A4-70 (ISO 3506-1)
Reduced head	the head cannot carry full bolt tension
Design rule	the joint must not rely on head strength
Marking	class on the head top, around the socket

A countersunk head has less material than a cap head. For full tension capacity use ISO 4762.

Related socket screws

Cap head	ISO 4762 · DIN 912
Countersunk	ISO 10642 · DIN 7991
Button head	ISO 7380-1
Flanged button	ISO 7380-2
Low head	ISO 7984
Set screws	ISO 4026 flat · 4027 cone · 4028 dog · 4029 cup

All take the same hexagon key series but the head strengths differ widely.

1. ▲ The dk and k columns must be checked against ISO 10642 / DIN 7991; head dimensions differ slightly between the two.

2. The head angle is 90° in the metric standards and 82° in ASME B18.3 — these are not interchangeable.

3. Countersunk socket screws in class 12.9 are hydrogen-embrittlement sensitive; specify baking if electroplated (ISO 4042).

4. Socket key sizes follow ISO 2936; a worn key rounds the socket and the screw becomes unremovable. For stainless use A2-70 or A4-70 and expect lower head strength again.

▲ Note: ▲ Confirm every dk, k and socket size against ISO 10642 and note where DIN 7991 differs. Confirm the class range offered in countersunk form.

Sources ISO 10642 · DIN 7991 · ISO 4762 · ISO 7380-1 · ISO 4762 · ISO 2936 · ASME B18.3 · ISO 4042

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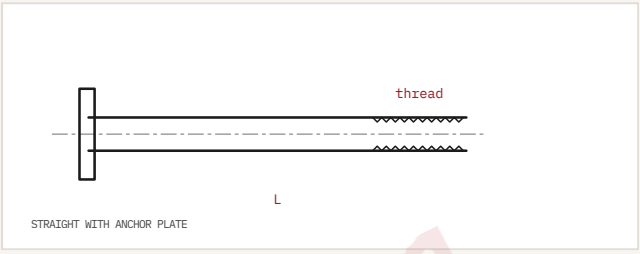
Anchor bolts — straight, L, J and headed

ASTM F1554 · BS 7419 · ISO 898-1 · manufactured to drawing in our own plant

Anchor bolts are made to the structural drawing, not to a dimensional standard: the specification is the **material grade**, the geometry and the finish. MF manufactures these in Umm Al Quwain — drawing, cutting, bending, threading, heat treatment and testing under one roof.

Straight anchor bolt with plate

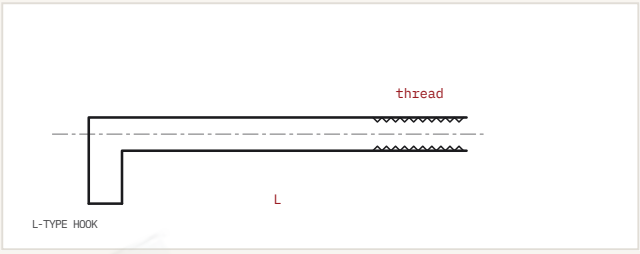
ASTM F1554 · to drawing · manufactured at MF, Umm Al Quwain



Anchor plate welded or nutted at the embedded end. Thread length on the projecting end to suit base plate, grout and two nuts.

L-type hook

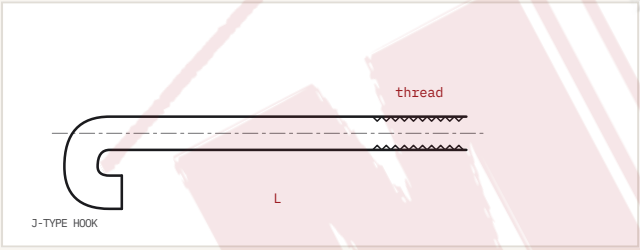
ASTM F1554 · BS 7419 · to drawing



Hook length and bend radius to the structural drawing. Minimum bend radius normally 3d for Grade 36 and 55; Grade 105 is not bent.

J-type hook

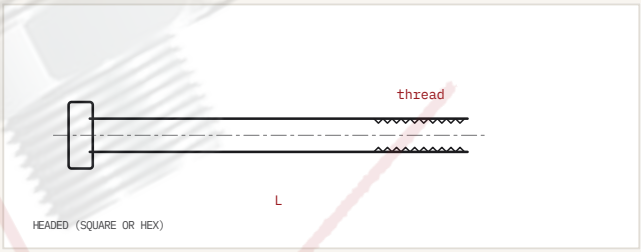
ASTM F1554 · to drawing



Traditional foundation hook. Pull-out capacity is governed by the concrete, not the bolt — refer to the structural design.

Headed anchor bolt

ASTM F1554 · BS 7419 square head · to drawing



Forged or welded head. Preferred where a calculable embedded bearing area is required.

F1554 grade	Yield min ksi	Tensile ksi	Yield min MPa	Tensile MPa	End colour	Welding
Grade 36	36	58 – 80	248	400 – 550	Blue	Weldable
Grade 55	55	75 – 95	380	515 – 655	Yellow	With supplement S1
Grade 105	105	125 – 150	724	860 – 1035	Red	Not weldable

d nominal diameter

L overall length

Thread projecting end

Sizes M12 – M100 · ½" – 4"

Supply loose or as complete foundation sets

▲ **Note:** Confirm the F1554 tensile ranges and the end colour codes against the current F1554.

Sources ASTM F1554 · ASTM A563 · ASTM F436 · BS 7419 · ISO 898-1:2013 · ISO 1461 · ASTM F2329

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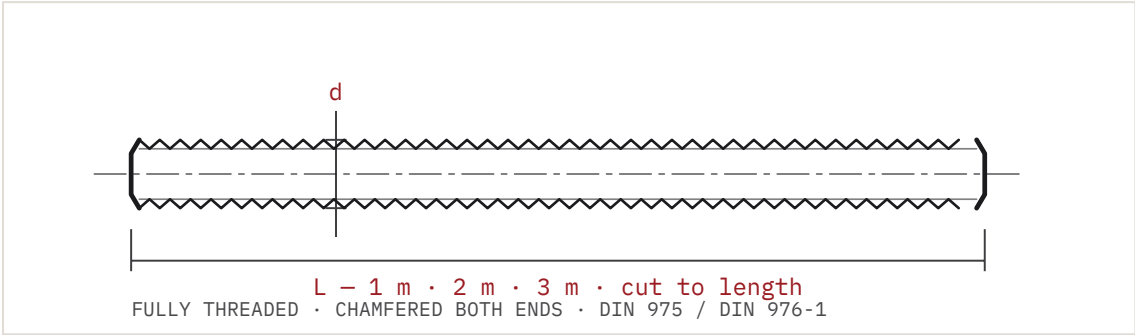
Threaded bar and studs — DIN 975 and DIN 976-1

Classes 4.6 · 8.8 · 10.9 · 12.9 and ASTM A193 B7 · B7M · M6 to M64



Size	Pitch mm	As mm²	4.6 proof kN	8.8 proof kN	10.9 proof kN	12.9 proof kN	B7 proof kN ▲	B7M proof kN ▲
M8	1.25	37	8	21	30	36	26 ▲	20 ▲
M10	1.50	58	13	34	48	56	42 ▲	32 ▲
M12	1.75	84	19	49	70	82	61 ▲	46 ▲
M16	2.00	157	35	91	130	152	113 ▲	86 ▲
M20	2.50	245	55	147	203	237	176 ▲	135 ▲
M24	3.00	353	79	212	293	342	254 ▲	194 ▲
M30	3.50	561	126	336	465	544	404 ▲	308 ▲
M36	4.00	817	184	490	678	792	588 ▲	449 ▲
M42	4.50	1,121	252 ▲	673 ▲	930 ▲	1,087 ▲	807 ▲	616 ▲
M48	5.00	1,473	331 ▲	884 ▲	1,223 ▲	1,429 ▲	1,061 ▲	810 ▲
M56	5.50	2,030	457 ▲	1,218 ▲	1,685 ▲	1,969 ▲	1,462 ▲	1,117 ▲
M64	6.00	2,676	602 ▲	1,606 ▲	2,221 ▲	2,596 ▲	1,927 ▲	1,472 ▲

Proof load = As × the proof stress of the grade. ▲ flagged: above M39 the ISO classes do not apply — see page 2.12

▲ B7 / B7M proof stresses and rod mass require QC confirmation

The two standards

DIN 975	threaded rod in stock lengths — 1 m, 2 m, 3 m
DIN 976-1	threaded studs cut to a specified length
Thread	ISO 965 metric coarse, tolerance 6g
Ends	chamfered both ends
No ISO	neither has an ISO successor
Inch series	ASME B18.31.3 (continuous thread stud)

DIN 975 is a stock-length product; DIN 976-1 is the same rod cut and finished to length. MF cuts studs from bar in-house.

Grades and what they mean here

4.6	general purpose, hanging and light bracing
8.8	structural and machine work — the common grade
10.9	high strength, tie rods and heavy bracing
12.9	rarely supplied as rod; embrittlement sensitive
A193 B7	pressure flange studs, alloy steel Q&T
A193 B7M	B7 hardness capped for sour service
Stainless	A2-70 / A4-70 to ISO 3506-1

Grade must be on the order and on the certificate. Ungraded rod is 4.6 at best — not for structural use.

Practical points

- Rod has **no head**, so all load is carried by thread engagement at each end — a minimum of 0.8 d of sound thread per nut.
- Cut ends must be chamfered or the nut will not start.
- Galvanized rod needs oversize-tapped nuts (ISO 10684).
- B7 studs for flanges are usually 8UN threaded above 1 inch, not metric coarse.
- Rod is not an anchor bolt: an anchor bolt is designed for its embedment, rod is not.

1. ▲ Above M39 the ISO 898-1 classes do not apply; flagged rows show what the same proof stress would give, for reference only — see page 2.12.

2. ▲ The B7 and B7M columns use the A193 proof stresses for the smallest size range; A193 steps down with diameter and the metric size equivalence must be confirmed against A193M.

3. DIN 975 and DIN 976-1 have no ISO equivalent and are ordered by the DIN number. For rod mass per metre see the weight tables in Section 5.

4. For tie rods in tension, check the design accounts for the thread root, not the nominal diameter.

▲ **Note:** ▲ Confirm the B7 and B7M proof stresses and their metric size steps against A193M, and verify the mass per metre against weighed samples.

Sources DIN 975 · DIN 976-1 · ISO 898-1:2013 · ISO 965 · ISO 724 · ASTM A193/A193M · ASME B18.31.3 · ISO 10684

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Hex nuts — every standard and type

ISO · DIN · ASME · ASTM · what each type is for and how tall it is

Standard	Type	Height	Classes	Where used	DIN / other
ISO 4032	Style 1, standard	m ≈ 0.9 d	5 · 6 · 8 · 10 · 12	the default metric nut	DIN 934 (m ≈ 0.8 d)
ISO 4033	Style 2, high	m ≈ 1.0 d	9 · 12	high classes, more thread engagement	—
ISO 4035	Thin / jam nut	m ≈ 0.5 d	04 · 05	locking and adjustment only	DIN 439
ISO 4036	Thin, chamfer one side	m ≈ 0.5 d	—	light duty	DIN 439 B
ISO 7040	Nyloc, full height	with insert	5 · 8 · 10	prevailing torque, reusable	DIN 982
ISO 10511	Nyloc, thin	with insert	04 · 05 · 8	where height is limited	DIN 985
ISO 7042	All-metal prevailing torque	deformed thread	8 · 10 · 12	above the nylon temperature limit	DIN 980
ISO 4161	Flange nut	integral washer face	8 · 10	spreads load, no separate washer	DIN 6923
DIN 935	Castle nut	slotted crown	5 · 8 · 10	split pin, positive locking	ISO 7035 / 7036
DIN 937	Slotted nut, thin	slots, low height	—	with split pin where height limited	—
DIN 928	Square weld nut	for projection welding	—	sheet metal assembly	—
DIN 929	Hexagon weld nut	for projection welding	—	sheet metal assembly	—
DIN 1587	Cap / dome nut	closed dome	6 · 8	protects thread, cosmetic	—
DIN 315	Wing nut	hand tightened	—	no tool required	—
DIN 6334	Coupling nut	3 d long	—	joins two threaded rods	—
ASME B18.2.2	Heavy hex nut	wider A/F, taller	A · C · DH (A563)	structural and pressure service	—
ASTM A194	2H · 2HM · 4 · 7 · 8 · 8M	heavy hex	—	flange bolting to A193 studs	—

Choosing

- **Never** use a thin nut as the load-carrying nut — it has roughly half the thread engagement.
- Nyloc nuts are limited by the nylon: about 120 °C. Above that use an all-metal prevailing-torque nut.
- A castle nut plus split pin is the only truly positive lock in this list.
- Flange nuts remove the washer but need a clean, flat bearing face.
- Heavy hex is not "a bigger nut" — it is a different standard with its own across-flats.

ISO 4032 dimensions M6 – M64

Size	s mm	m max mm	As mm²
M6	10	5.2	20
M8	13	6.8	37
M10	16	8.4	58
M12	18	10.8	84
M16	24	14.8	157
M20	30	18.0	245
M24	36	21.5	353
M30	46	25.6	561
M36	55	31.0	817
M42	65	34.0	1,121
M48	75	38.0	1,473
M56	85	45.0	2,030
M64	95	51.0	2,676

1. Nut class must equal or exceed the bolt class — see page 2.06 for proof loads. ▲ Confirm ISO 4032 m max above M36 and the ISO 4035 thin-nut heights.
2. Galvanized nuts are tapped oversize after coating (ISO 10684); they feel loose on a plain bolt and must not be mixed.
3. Prevailing-torque nuts have a maximum number of reuses in ISO 2320 — after that the locking feature is spent.
4. ASTM A194 is a material specification for pressure service; A563 is the structural nut standard. Not interchangeable.

▲ **Note:** ▲ Confirm the ISO 4032 m max values above M36, the ISO 4035 thin-nut heights, and the class availability listed for each nut type.

Sources ISO 4032 · 4033 · 4035 · 4036 · 4161 · 7040 · 7042 · 10511 · ISO 898-2:2012 · ISO 2320 · ISO 10684 · DIN 315 · 439 · 928 · 929 · 935 · 937 · 980 · 982 · 985 · 1587 · 6334 · 6923 · ASME B18.2.2 · ASTM A194/A194M · A563/A563M

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Plain washers — normal, large and extra-large series

ISO 7089 · 7090 · 7091 · 7093 · 7094 · DIN 125 · 126 · 9021 · 433

Size	d1 inside mm	d2 outside mm · ISO 7089	h thickness mm	d2 outside mm · ISO 7093 large ▲	h thickness mm · large ▲	Standard hardness	For 10.9 / 12.9
M6	6.4	12	1.6	18	1.6	200 HV	300 HV
M8	8.4	16	1.6	24	1.6	200 HV	300 HV
M10	10.5	20	2.0	30	2.0	200 HV	300 HV
M12	13.0	24	2.5	37	2.5	200 HV	300 HV
M16	17.0	30	3.0	50	3.0	200 HV	300 HV
M20	21.0	37	3.0	60	3.0	200 HV	300 HV
M24	25.0	44	4.0	72	4.0	200 HV	300 HV
M30	31.0	56	4.0	92	4.0	200 HV	300 HV
M36	37.0	66	5.0	110	5.0	200 HV	300 HV

ISO 7089 form A (normal series) and ISO 7093-1 (large series) ▲ large-series outside diameters to be confirmed against ISO 7093-1

The plain washer standards

ISO 7089	normal series, 200 HV, chamfer-free — DIN 125 A
ISO 7090	normal series, chamfered — DIN 125 B
ISO 7091	normal series, product grade C — DIN 126
ISO 7093-1	large series, 200 HV — DIN 9021
ISO 7093-2	large series, 300 HV
ISO 7094	extra large series
DIN 433	small series, reduced outside diameter

The series is the outside diameter. The hardness class is separate and is what matters under a high-strength head.

Hardness — the point most often missed

200 HV	for classes up to 8.8
300 HV	required under 10.9 and 12.9
What happens otherwise	the washer embeds, the bolt relaxes, preload is lost
Structural	F436 / EN 14399-6 — 38–45 HRC, harder again
Stainless	A2 / A4 to ISO 7089, softer than steel

A 200 HV washer under a 10.9 bolt is the commonest silent cause of preload loss on site.

Function

- Spreads the bearing load over a larger area of the joint.
- Provides a smooth, consistent friction surface under the turning face.
- Bridges an oversize or slotted hole.
- Protects a coated or soft surface from the turning nut.
- A washer is **not** a locking device and does not prevent loosening.

1. ▲ The large-series columns must be confirmed against ISO 7093-1; DIN 9021 dimensions differ slightly at some sizes.

2. Under a nut, the washer goes on the turning side. Under a bolt head that turns, use one at each end.

3. ISO 7089 covers nominal sizes to 64 mm; above M36 the table on this page must be extended from the standard.

4. Hot-dip galvanized washers are supplied to the same dimensions with the coating on top — check hole clearance.

5. For structural preloaded joints use F436 or EN 14399-6, not a plain washer — see page 4.24.

▲ Note: ▲ Confirm d1, d2 and h against ISO 7089 and ISO 7093-1; the standard extends to 64 mm.

Sources ISO 7089 · ISO 7090 · ISO 7091 · ISO 7093-1 · ISO 7093-2 · ISO 7094 · DIN 125 · DIN 126 · DIN 433 · DIN 9021 · ISO 898-1:2013

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Spring, lock and tab washers

DIN 127 · 7980 · 128 · 137 · 6796 · 432 · 93 · 463 — no ISO equivalents

Size	d1 inside mm ▲	d2 outside mm ▲	s thickness mm ▲	Form	Material	Hardness
M6	6.1	11.8	1.6	B	spring steel	≈ 44 HRC
M8	8.1	14.8	2.0	B	spring steel	≈ 44 HRC
M10	10.2	18.1	2.2	B	spring steel	≈ 44 HRC
M12	12.2	21.1	2.5	B	spring steel	≈ 44 HRC
M16	16.2	27.4	3.5	B	spring steel	≈ 44 HRC
M20	20.2	33.6	4.0	B	spring steel	≈ 44 HRC
M24	24.5	40.0	5.0	B	spring steel	≈ 44 HRC
M30	30.5	48.2	6.0	B	spring steel	≈ 44 HRC
M36	36.5	58.2	6.0	B	spring steel	≈ 44 HRC

DIN 127 form B — the common single-coil spring washer ▲ every dimension on this page requires QC confirmation against DIN 127

The lock washer family

DIN 127 B	single coil spring, square section — the usual one
DIN 7980	high collar, for socket cap screws
DIN 128 A	curved spring washer
DIN 137 A / B	wave / curved spring washer, light
DIN 6796	conical spring washer, high load
DIN 432	external tab washer
DIN 93	tab washer with long tab
DIN 463	tab washer with two tabs
No ISO	DIN 127 was withdrawn without an ISO successor

DIN 127 remains in daily trade use despite withdrawal — order it by the DIN number.

What a spring washer actually does

- At full preload a split washer is flattened solid and adds nothing to the joint.
- Its value is in **low-preload** joints and during assembly, keeping tension while parts settle.
- It is not a substitute for correct preload; a properly tightened bolt does not need one.
- Structural codes generally do not accept split washers as a locking device.
- Where positive locking is required use a castle nut and split pin, or a prevailing-torque nut.

Tab and conical washers

Tab washer	bent up against a nut flat after tightening — positive
Use	bearings, wheel hubs, marine
Reuse	no — the tab work-hardens and cracks
DIN 6796 conical	high spring rate, maintains load through thermal cycling
Direction	conical washers have a right way up

1. ▲ All dimensions on this page require confirmation against DIN 127, DIN 7980 and the related standards.

2. DIN 127 was withdrawn as a standard but is still specified and supplied by that number.

3. Spring and lock washers are made of spring steel and are typically zinc plated; hot-dip galvanizing is unusual.

4. Under a 10.9 or 12.9 head a spring washer should not replace a 300 HV plain washer.

5. Stainless spring washers have a lower spring rate than carbon steel — do not assume equivalence.

▲ Note: ▲ Dimensions on this page are indicative; confirm each against DIN 127 and the related standards before relying on them.

Sources DIN 127 · DIN 128 · DIN 137 · DIN 432 · DIN 463 · DIN 93 · DIN 6796 · DIN 7980 · EN 1090-2 (locking devices)

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Hardened structural washers and plate washers

ASTM F436 / F436M · EN 14399-6 · DIN 6916 · F959 DTI · plate washers to drawing

Bolt size	Inside dia in ▲	Outside dia in ▲	Thickness in ▲	Hardness	Types
1/2"	17/32	1 1/16	0.097 – 0.177	38 – 45 HRC	Type 1 carbon · Type 3 weathering
5/8"	21/32	1 5/16	0.122 – 0.177	38 – 45 HRC	Type 1 · Type 3
3/4"	13/16	1 15/32	0.122 – 0.177	38 – 45 HRC	Type 1 · Type 3
7/8"	15/16	1 3/4	0.136 – 0.177	38 – 45 HRC	Type 1 · Type 3
1"	1 1/16	2	0.136 – 0.177	38 – 45 HRC	Type 1 · Type 3
1 1/8"	1 1/4	2 1/4	0.136 – 0.177	38 – 45 HRC	Type 1 · Type 3
1 1/4"	1 3/8	2 1/2	0.136 – 0.177	38 – 45 HRC	Type 1 · Type 3

ASTM F436 hardened structural washer, inch series — F436M is the metric version ▲ all dimensions require confirmation against F436

Structural washer standards

ASTM F436 / F436M	hardened, 38–45 HRC, for F3125 assemblies
EN 14399-6	chamfered hardened washer, 300 HV, HR and HV systems
DIN 6916	the older German designation, superseded by EN 14399-6
ASTM F959	direct tension indicator washer
EN 14399-9	DTI washer, European equivalent
Bevelled	for sloped flanges — F436 covers these

A structural washer is a hardened component of a certified assembly, not a generic flat washer.

Plate washers — made to drawing

What	thick square or rectangular plate with a hole
Why	bridges the oversize hole in a base plate
Material	S275JR · S355JR · A36 · A572 Gr 50
Thickness	to the structural drawing, typically 8 – 25 mm
Hole	bolt diameter + 3 to 6 mm, or to drawing
Manufactured	at MF, Umm Al Quwain

Plate washers have no dimensional standard: the structural drawing is the specification. The material grade is what must be certified.

When each is required

- **F436 / EN 14399-6** — under the turned element of every preloaded structural assembly.
- **Two washers** — where both head and nut are turned, or where a slotted hole is used.
- **Bevelled washer** — where the bearing face slopes more than 1:20.
- **Plate washer** — anchor bolts through oversize holes in base plates.
- **DTI** — where preload must be verified visually.

1. ▲ Every F436 dimension on this page must be confirmed against ASTM F436/F436M before publication.

2. F436 Type 3 is weathering steel, to be used with Type 3 (weathering) bolts.

3. EN 14399-6 washers are chamfered on the inner edge to clear the head-to-shank radius — a plain washer may foul it.

4. Hardened washers are brittle by design; do not weld, cut or bend them.

5. MF manufactures plate washers to drawing in S275JR, S355JR and equivalent grades with EN 10204 3.1 certificates.

▲ Note: ▲ Confirm all F436 dimensions and the hardness range, and confirm the EN 14399-6 hardness class (300 HV) against the standard.

Sources ASTM F436/F436M · ASTM F959 · EN 14399-6 · EN 14399-9 · DIN 6916 · EN 1090-2 · EN 10025-2

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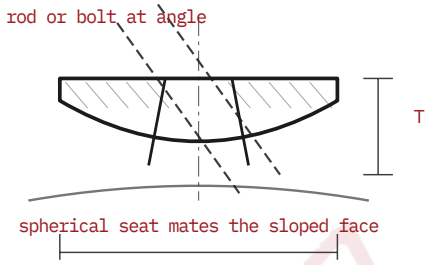
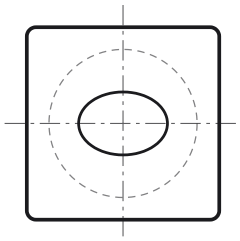
Hillside washers — sloped and spherical seat

No ISO or DIN standard · made to drawing · with DIN 434 / DIN 435 taper washers for fixed slopes

A hillside washer lets a rod or bolt pass through a connection **at an angle** while the nut still bears square. It has no dimensional standard — it is made to the structural drawing — which is exactly why it needs a page: the specification has to come from the engineer, item by item.



SECTION — SPHERICAL SEAT ON A SLOPED FLANGE



PLAN

For bolt / rod	A across flats mm ▲	T thickness mm ▲	Hole, oval mm ▲	Material	Standard
M16 · 5/8"	50 × 50	10	20 × 26	carbon steel	to drawing
M20 · 3/4"	60 × 60	12	24 × 32	carbon steel	to drawing
M22 · 7/8"	65 × 65	12	26 × 36	carbon steel	to drawing
M24 · 1"	70 × 70	14	28 × 38	carbon steel	to drawing
M27 · 1 1/8"	78 × 78	16	31 × 42	carbon steel	to drawing
M30 · 1 1/4"	85 × 85	16	34 × 46	carbon steel	to drawing
M36 · 1 1/2"	100 × 100	20	40 × 54	carbon steel	to drawing

▲ Hillside washers have no ISO or DIN dimensional standard — every size is made to the structural drawing

The dimensions above are a typical MF range, not a standard table

What it does

Problem	a rod or bolt meets the steel at an angle
Consequence	the nut bears on one edge; the rod bends at the hole
Solution	a washer with a spherical or sloped seat
Result	the nut face stays square to the rod
Hole	oval or slotted, to let the rod through at the angle
Also called	sloped · bevel · saddle washer

Without it the connection is a hinge with a bending moment in the rod, not a tension tie.

Where it is used

- Sag rods and tie rods running diagonally to a purlin or beam.
- Bracing rods entering a gusset at an angle.
- Cross-bracing on portal frames — a very common Gulf application.
- Anchor bolts through a sloping base plate, or where a sloped channel or I-beam flange is the bearing face.

Specifying one

Give	bolt or rod diameter
Give	the angle between rod and bearing face
Give	the plate thickness required
Give	material grade and finish
Do not	swap a taper washer for a spherical one

A square taper washer (DIN 434 channels, DIN 435 I-beams) handles a fixed 8 % or 14 % slope. A hillside washer handles an arbitrary angle.

1. ▲ No ISO or DIN standard exists for hillside washers; the structural drawing is the specification — A, T, hole size and angle must all be stated.

2. DIN 434 (channel flanges, 8 % slope) and DIN 435 (I-beam flanges, 14 % slope) are the standardised taper washers where the slope is fixed.

3. The spherical seat must match its mating surface; against a flat plate it provides no benefit.

4. Material is normally S275JR or S355JR to EN 10025-2, or A36 / A572, hot-dip galvanized for external work. MF manufactures these to drawing with EN 10204 3.1 certificates.

▲ Note: ▲ Confirm whether MF wishes to publish a standard size range for hillside washers, or to present the page as made-to-drawing only. The dimensions shown are indicative.

Sources DIN 434 · DIN 435 · EN 10025-2 · ASTM A36 · ASTM A572 · ISO 1461 · ASTM F2329 · EN 10204

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Self-drilling screws — cladding and stitching

ISO 15480 · 15481 · 15482 · 15483 · DIN 7504 · thread to ISO 1478

Self-drilling screws drill, tap and fasten in one operation. The **drill point number**, not the screw diameter, decides how thick a steel section the screw can fix into — get this wrong and the point burns out before the thread engages.

Nominal size mm	Drill point	Drilling capacity mm steel ▲	ISO standard	DIN standard	Typical application
3.5	No. 1	0.7 – 1.2	ISO 15480 / 15481 / 15482 / 15483	DIN 7504 K / N / P	light gauge, sheet to sheet
4.2	No. 2	0.7 – 2.0	ISO 15480 / 15481 / 15482 / 15483	DIN 7504 K / N / P	sheeting to light purlin
4.8	No. 2 / 3	0.7 – 3.0	ISO 15480 / 15481	DIN 7504 K / N	cladding to purlin
5.5	No. 3 / 4	1.75 – 4.5	ISO 15480	DIN 7504 K	sheeting to steel purlin
5.5	No. 5	4.5 – 6.0	—	—	heavy section, by agreement ▲
6.3	No. 4 / 5	2.0 – 6.0	ISO 15480	DIN 7504 K	heavy cladding, deck to beam

Drill point number sets the steel thickness the screw can drill before the thread engages ▲ capacities to be confirmed against ISO 15480 and DIN 7504

Head forms and standards

ISO 15480	hexagon washer head — the cladding screw
ISO 15481	cross-recessed pan head
ISO 15482	cross-recessed countersunk head
ISO 15483	cross-recessed raised countersunk head
DIN 7504 K	hexagon head with flange
DIN 7504 N	pan head
DIN 7504 P / O	countersunk / raised countersunk
Thread	ISO 1478 tapping screw thread

For sheeting the hexagon washer head (ISO 15480 / DIN 7504 K) is standard because it drives on a socket and seats a bonded washer.

Stitching against fixing

Stitching screw	joins sheet to sheet at the side lap
Stitch size	typically 4.8 mm, short, drill point No. 2
Fixing screw	sheet to purlin or structure
Fixing size	5.5 or 6.3 mm, drill point to suit the purlin
Spacing	to the cladding designer — not a fastener standard
Sealing washer	EPDM bonded to a steel cap

A stitching screw that is too long drills into the purlin and jams; one that is too short strips the lap. Length is set by the sheet profile.

Corrosion — the real issue in the Gulf

- Zinc plating alone is inadequate on an external roof; expect visible rust within a season.
- Specify a coating system with a stated salt-spray performance, or a bimetal screw.
- **Bimetal** — A2 or A4 stainless body with a hardened carbon steel drill point: drills steel, resists corrosion.
- The EPDM washer is a wear part; it degrades under UV and must be inspected.
- Never fix aluminium sheet with plain carbon steel screws — galvanic corrosion at every hole.

1. ▲ The drilling capacity column must be confirmed against ISO 15480 and DIN 7504; capacity is a function of the point, not the nominal size.

2. ISO 1478 defines the tapping screw thread used on these screws — it is not a metric machine thread.

3. Mechanical requirements for tapping and self-drilling screws are in ISO 2702 (case-hardened) and the drilling test in ISO 10666.

4. Screw length must allow the drill point to clear the substrate before the thread engages, otherwise the point burns out.

5. For cladding design — spacing, edge distance and pull-out capacity — the governing documents are EN 1993-1-3 and EN 508, not the fastener standard.

▲ **Note:** ▲ Confirm the drilling capacity for each point number and the size range of each ISO head form. Confirm which sizes MF stocks in bimetal.

Sources ISO 15480 · ISO 15481 · ISO 15482 · ISO 15483 · ISO 1478 · ISO 2702 · ISO 10666 · DIN 7504 · EN 1993-1-3 · EN 508

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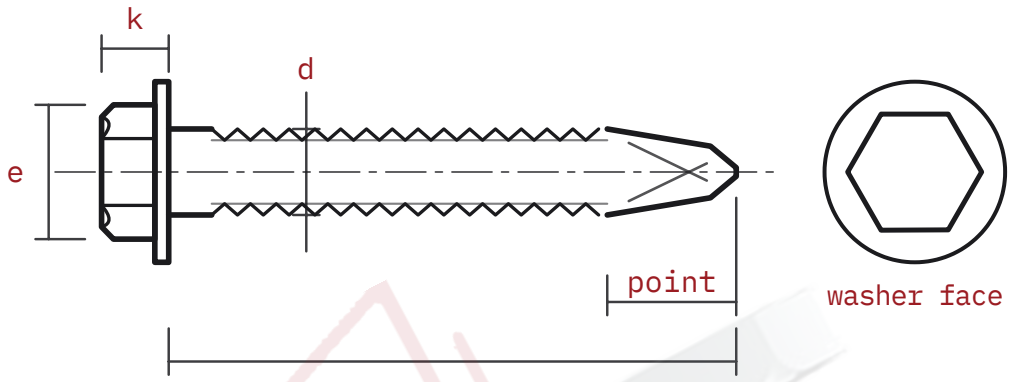
Self-drilling screws — dimensions and drill points

ISO 15480 · DIN 7504 K · hexagon washer head · 3.5 to 6.3 mm



HEXAGON WASHER HEAD · DRILL POINT · ISO 15480 / DIN 7504 K

Nominal d mm	Standard	Washer face dia mm ▲	A/F hex mm ▲	Drill point	Drill capacity mm steel ▲	Length range mm ▲
3.5	ISO 15480	8.0	5.5	No. 1	0.7 – 1.2	13 – 38
4.2	ISO 15480	9.5	7.0	No. 2	0.7 – 2.0	13 – 50
4.8	ISO 15480	11.0	8.0	No. 2 / 3	0.7 – 3.0	16 – 75
5.5	ISO 15480	12.5	8.0	No. 3 / 4	1.75 – 4.5	19 – 100
6.3	ISO 15480	14.0	10.0	No. 4 / 5	2.0 – 6.0	19 – 150

ISO 15480 hexagon washer head — the standard cladding and stitching screw

▲ every dimension requires confirmation against ISO 15480 / DIN 7504 K

Reading the drawing

d	nominal thread diameter over the crests
e	width across corners of the hexagon
k	head height including the washer face
Washer face	integral flange that seats the sealing washer
point	unthreaded drill point — must clear the steel before the thread engages
L	overall length including the point

Length is measured overall on a self-drilling screw, unlike a hex bolt where L excludes the head.

Choosing the point

No. 1	0.7 – 1.2 mm — sheet to sheet
No. 2	0.7 – 2.0 mm — sheet to light section
No. 3	1.75 – 3.0 mm — cladding to purlin
No. 4	2.0 – 4.5 mm — deck to beam
No. 5	4.5 – 6.0 mm — heavy section
Rule	point length must exceed the steel thickness

If the thread reaches the steel before the drill has broken through, the screw jams and the point burns off. This is the single commonest installation failure.

Sealing and corrosion

- EPDM bonded washer for all external roof and wall fixings; inspect on refurbishment.
- Plain zinc plating is not adequate for external Gulf exposure.
- Bimetal (A2 or A4 body, carbon steel point) for coastal and long-life work.
- Never fix aluminium sheet with plain carbon steel screws.
- Drive at controlled speed with a depth-stop nose — over-driving crushes the washer.

1. ▲ All dimensions on this page must be confirmed against ISO 15480 and DIN 7504 K before publication.

2. The thread is a tapping-screw thread to ISO 1478, not a metric machine thread — a machine nut will not fit.

3. Mechanical requirements are in ISO 2702 (case-hardened tapping screws); the drilling performance test is ISO 10666.

4. Cladding spacing, edge distance and pull-out capacity are set by EN 1993-1-3 and EN 508. See page 4.27 for stitching against structural fixing.

▲ Note: ▲ Confirm washer-face diameter, across-flats, drill capacity and length range for every size against ISO 15480 and DIN 7504 K.

Sources ISO 15480 · ISO 1478 · ISO 2702 · ISO 10666 · DIN 7504 · EN 1993-1-3 · EN 508

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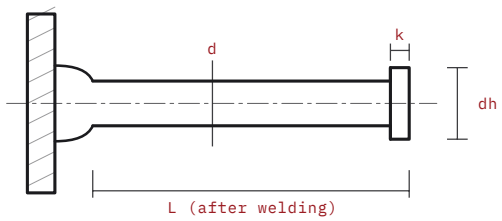
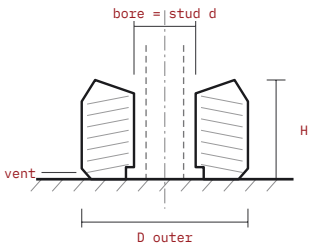
Shear connectors and ceramic ferrules

ISO 13918 type SD · arc stud welding to ISO 14555 · composite construction

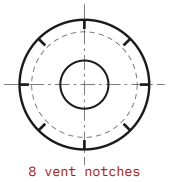
A shear connector is a headed stud welded through or onto the top flange of a steel beam so that the beam and the concrete slab act together. It is welded by drawn arc, and the **ceramic ferrule** is what makes that weld sound — it is part of the product, not an accessory.



HEADED STUD WELDED TO THE BASE PLATE · ISO 13918 TYPE SD



SECTION — ON THE PLATE, STUD GHOSTED



PLAN, FROM ABOVE

Shank d mm	Head dia dh mm ▲	Head height k mm ▲	Length L range mm · after welding	Type	Standard
13	25	8	65 – 175	SD1	ISO 13918 type SD
16	29	9	75 – 200	SD1	ISO 13918 type SD
19	32	10	75 – 300	SD1	ISO 13918 type SD
22	35	10	100 – 300	SD1	ISO 13918 type SD
25	41	12	100 – 300	SD1	ISO 13918 type SD
27	44	13	100 – 300	SD1	ISO 13918 type SD ▲
30	48	14	100 – 300	SD1	ISO 13918 type SD ▲

ISO 13918 type SD — headed stud for arc stud welding, 13 to 30 mm: confirm ISO 13918 covers these; head dimensions to be confirmed at all sizes

The ceramic ferrule

What it is	a single-use ceramic ring placed over the stud base before welding
Function 1	contains the molten pool and forms the weld collar
Function 2	shields the arc from air, preventing porosity
Function 3	shapes the fillet for visual inspection
Standard	ISO 13918 — specified with the stud
After welding	broken off, never reused
Storage	must be dry — damp ferrules cause porosity

Every stud diameter has its matched ferrule. The wrong size gives an unsound collar and the stud fails the bend test.

Welding and testing

Process	drawn arc stud welding, ISO 14555
Through-deck	permitted; deck clean, tight, single thickness
Bend test	30° from vertical, ISO 14555 / EN 1994
Visual	full 360° collar, no undercut
Procedure	welding procedure and operator approval

The bend test is the site acceptance test: struck over 30°, it must not crack at the collar.

Design and use

- Shear connectors transfer longitudinal shear between a steel beam and a concrete slab, making the two act as one composite section.
- Design capacity comes from **EN 1994-1-1** (Eurocode 4) or AISC 360, not from the fastener standard.
- Stud length after welding is what the standard quotes — welding consumes 4 to 6 mm.
- Minimum concrete cover and spacing are set by the code, not by the stud.
- 19 × 100 mm and 19 × 125 mm are the common sizes in building decks.

1. ▲ Studs to ISO 13918 type SD are low-carbon steel, tensile 450 MPa min, elongation 15 % — confirm the grade designation against ISO 13918.

2. Ceramic ferrules are matched to the stud diameter and are supplied with the studs. They are a consumable, not a spare part.

3. ▲ Confirm head diameter, head height and length ranges for each shank size against ISO 13918.

4. Welding is to ISO 14555; the welding procedure, operator approval and production tests are part of the works documentation.

5. For through-deck welding the deck must be clean, dry and tight to the flange; galvanized deck needs procedure qualification.

▲ Note: ▲ Confirm the head dimensions, length ranges and the material grade designation against ISO 13918, and the bend-test angle against ISO 14555.

Sources ISO 13918 · ISO 14555 · EN 1994-1-1 (Eurocode 4) · EN 1090-2 · AWS D1.1 (Type B studs)

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Round bar and material stock

EN 10060 · EN 10025-2 · EN 10083 · EN 10088-3 · EN 10269 · ASTM A29 · A576 · A276

Grade	Werkstoff	Material standard	Yield min MPa ▲	Tensile MPa ▲	Use at MF
S235JR	1.0038	EN 10025-2	235	360 – 510	Weldable structural — anchor bolts Gr 36
S275JR	1.0044	EN 10025-2	275	410 – 560	Structural, plate washers
S355J2	1.0577	EN 10025-2	355	470 – 630	Higher strength structural, anchor bolts Gr 55
C45E	1.1191	EN 10083-2	490	700 – 850	Medium carbon, Q&T — studs, shafts
42CrMo4	1.7225	EN 10083-3	900	1000 – 1200	Cr-Mo alloy — B7, L7, Gr 105 anchor bolts
34CrNiMo6	1.6582	EN 10083-3	900	1100 – 1300	High duty alloy, large sections
21CrMoV5-7	1.7709	EN 10269	—	—	Cr-Mo-V — A193 B16
X5CrNi18-10	1.4301	EN 10088-3	190	500 – 700	304 stainless — B8, A2
X5CrNiMo17-12-2	1.4401	EN 10088-3	200	500 – 700	316 stainless — B8M, A4

Bar stock grades used for the products in this book ▲ mechanical values vary with section size — confirm per the standard's size ranges

Bar dimension and tolerance standards

EN 10060	hot rolled round steel bars — dimensions and tolerances
EN 10278	bright steel products — dimensions and tolerances
ISO 1035-1	hot rolled steel bars, round
ASTM A29/A29M	general requirements for steel bars
ASTM A576	hot-wrought special quality bars
ASTM A108	cold-finished carbon steel bars
ASTM A276	stainless steel bars and shapes

The dimensional standard and the material standard are separate documents. A complete bar order names both.

Delivery condition matters

Hot rolled	as rolled, scale on, widest tolerance
Peeled / turned	machined surface, close tolerance
Bright drawn	cold drawn, close tolerance, work hardened
Q&T	quenched and tempered to a mechanical spec
Annealed	soft, for subsequent heat treatment
+QT / +N / +AR	the EN suffix stating the condition

For anchor bolts and studs the delivery condition determines whether the finished part meets its grade. 42CrMo4 as-rolled is not B7.

From bar to fastener

- The bar certificate is not the fastener certificate — properties are verified on the finished part.
- Heat treatment after threading changes both dimensions and properties.
- Thread rolling raises fatigue life; thread cutting does not. Roll where the standard permits.
- Traceability runs heat number → bar → batch → certificate. Each step must be recorded.
- MF holds bar in these grades for anchor bolt, stud and plate washer manufacture.

1. ▲ Yield and tensile values depend on the ruling section. Confirm the size ranges in EN 10025-2 and EN 10083 before quoting a value for a given diameter.

2. EN 10025-2 grades are structural steels specified by yield; EN 10083 grades are heat-treatable steels specified by chemistry and treatment.

3. 42CrMo4 to EN 10083-3 and AISI 4140 are close equivalents but not identical — confirm against the project specification.

4. For ASTM A193 B7 the bar must meet the A193 chemistry and be heat treated to the A193 requirements; an EN 10083 42CrMo4 certificate is not sufficient on its own.

5. Stainless bar to EN 10088-3 is supplied solution annealed; strength for A2-70 or B8 Class 2 comes from subsequent cold work.

▲ Note: ▲ Confirm the yield and tensile ranges for each grade against the ruling section tables in EN 10025-2, EN 10083-2/-3 and EN 10088-3.

Sources EN 10060 · EN 10278 · EN 10025-2 · EN 10083-2 · EN 10083-3 · EN 10088-3 · EN 10269 · ISO 1035-1 · ASTM A29/A29M · A108 · A276 · A576 · ASTM A193/A193M

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Metric hex bolts, nuts and washers — mass

Calculated from ISO geometry · carbon steel, plain finish · grams per piece

Size	20 mm	30 mm	40 mm	50 mm	60 mm	80 mm	100 mm	120 mm	150 mm	200 mm
M6	7	9	11	13	16	20	24	28	35	45
M8	14	17	21	25	29	36	44	52	63	82
M10	23	29	35	41	47	58	70	82	100	130
M12	34	42	51	59	68	85	102	119	144	187
M16	69	85	100	115	130	160	191	221	266	342
M20	124	148	171	195	219	266	313	361	432	550
M24	200	234	269	303	337	405	473	541	644	814
M30	376	429	482	535	589	695	802	908	1,068	1,334
M36	616	693	770	846	923	1,076	1,230	1,383	1,613	1,997

Mass of one hex bolt in **grams**, plain finish, ISO 4014 / 4017 form

Computed from geometry — see method below

Nuts and washers

Size	Hex nut ISO 4032 g	Washer ISO 7089 g	Nuts per kg	Washers per kg
M6	2.7	1.0	376	984
M8	5.8	1.8	173	547
M10	10.7	3.6	93	280
M12	16.5	6.3	60	159
M16	40.3	11.3	25	88
M20	76.5	17.2	13	58
M24	131.6	32.3	8	31
M30	260.7	53.6	4	19
M36	450.0	92.1	2	11

Method

Density	7.85 g/cm³ carbon steel
Head	regular hexagon prism, across-flats s × height k
Shank and thread	cylinder × 0.96 to allow for the thread
Nut	hexagon prism less the tapped bore
Washer	annulus × thickness
Stainless	multiply by 1.02 (A2/A4)
Hot-dip galvanized	add 4 – 6 % for the coating

▲ These are calculated masses, not weighed. Use them for freight and packing estimates; for invoicing weigh the batch.

▲ Note: ▲ Masses on this page are calculated from geometry, not weighed. MF QC to verify a sample against the weighbridge and confirm the 0.96 thread factor.

Sources ISO 4014:2022 · ISO 4017:2022 · ISO 4032:2012 · ISO 7089 · density 7.85 g/cm³

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Mechanical properties — every standard in this book

One table, standard by standard · values as published for the base size range · ▲ verify each against the standard before use

This page and the next collect, standard by standard, what is spread across the grade pages. They are for quick comparison only: **the individual grade page and the original standard govern**, and any grade that steps down with diameter is shown here at its base range only.

Standard	Grade / class	Tensile Rm min MPa	Yield min MPa	Proof stress MPa	Elong. min	Hardness	Condition
ISO 898-1	4.6	400	240 ReL	225	22 %	120–220 HV	Carbon steel, not heat treated
ISO 898-1	5.8	520	420	380	—	160–220 HV	Carbon steel, cold worked
ISO 898-1	8.8 ≤M16	800	640	580	12 %	250–320 HV	Carbon/alloy, Q&T
ISO 898-1	8.8 >M16	830	660	600	12 %	255–335 HV	Carbon/alloy, Q&T
ISO 898-1	10.9	1040	940	830	9 %	320–380 HV	Alloy, Q&T
ISO 898-1	12.9	1220	1100	970	8 %	385–435 HV	Alloy, Q&T
ISO 898-2	Nut class 5	—	—	580	—	130–302 HV	Proof stress
ISO 898-2	Nut class 8	—	—	800	—	180–302 HV	Proof stress
ISO 898-2	Nut class 10	—	—	1040	—	272–353 HV	Proof stress
ISO 898-2	Nut class 12	—	—	1150	—	295–353 HV	Proof stress
ISO 3506-1	A2-70 · A4-70	700	450	—	0.4 d	—	Austenitic, cold worked
ISO 3506-1	A2-80 · A4-80	800	600	—	0.3 d	—	Austenitic, cold worked
SAE J429	Grade 5 ≤1"	830 (120 ksi)	635 (92 ksi)	585 (85 ksi)	14 %	25–34 HRC	Medium carbon, Q&T
SAE J429	Grade 8	1040 (150 ksi)	895 (130 ksi)	825 (120 ksi)	12 %	33–39 HRC	Alloy, Q&T
ASTM F3125	A325 / A325M	830 (120 ksi)	635 (92 ksi)	—	14 %	25–34 HRC	Structural, Q&T
ASTM F3125	A490 / A490M	1040–1190	895 (130 ksi)	—	14 %	33–38 HRC	Alloy, tensile max applies
ASTM A193	B7 ≤2½"	860 (125 ksi)	725 (105 ksi)	—	16 %	321 HBW max	42CrMo4 Q&T
ASTM A193	B7M	690 (100 ksi)	550 (80 ksi)	—	18 %	235 HBW max	Sour service cap
ASTM A193	B16 ≤2½"	860 (125 ksi)	725 (105 ksi)	—	18 %	321 HBW max	21CrMoV5-7
ASTM A193	B8 Class 1	515 (75 ksi)	205 (30 ksi)	—	30 %	223 HBW max	304, solution annealed
ASTM A193	B8 Class 2 ≤¾"	860 (125 ksi)	690 (100 ksi)	—	12 %	321 HBW max	304, strain hardened
ASTM A193	B8M Class 1	515 (75 ksi)	205 (30 ksi)	—	30 %	223 HBW max	316, solution annealed
ASTM A193	B8M Class 2 ≤¾"	760 (110 ksi)	655 (95 ksi)	—	15 %	321 HBW max	316, strain hardened
ASTM A320	L7 ≤2½"	860 (125 ksi)	725 (105 ksi)	—	16 %	321 HBW max	Charpy at −101 °C
ASTM A320	L7M	690 (100 ksi)	550 (80 ksi)	—	18 %	235 HBW max	Charpy + hardness cap
ASTM A194	2H	—	—	—	—	248–327 HBW	Q&T carbon nut
ASTM F1554	Gr 36	400–550	248 (36 ksi)	—	23 %	—	Weldable, blue code
ASTM F1554	Gr 55	515–655	380 (55 ksi)	—	21 %	—	Yellow code
ASTM F1554	Gr 105	860–1035	724 (105 ksi)	—	15 %	—	Q&T alloy, red code

▲ Note: ▲ This summary is a convenience table assembled from the individual pages. Every row must be verified against its own page and its source standard. Where a grade steps with diameter, only the base range is shown here — use the grade page for the full table.

Sources ISO 898-1:2013 · ISO 898-2:2012 · ISO 3506-1 · SAE J429 · ASTM F3125/F3125M · A193/A193M · A320/A320M · A194/A194M · F1554

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Chemical composition — every standard in this book

One table, standard by standard · limits as published · ▲ verify each against the standard before use

Standard	Grade / material	C %	Cr %	Ni %	Mo / other %	P max	S max	Other	Condition
ISO 898-1	4.6	0.55 max	–	–	–	0.050	0.060	–	Not heat treated
ISO 898-1	8.8 ≤M16	0.15 – 0.40	–	–	–	0.025	0.025	0.003 B	Q&T, temper ≥ 425 °C
ISO 898-1	8.8 >M16	0.25 – 0.55	–	–	–	0.025	0.025	0.003 B	Q&T, temper ≥ 425 °C
ISO 898-1	10.9	0.20 – 0.55	–	–	–	0.025	0.025	0.003 B	Q&T, temper ≥ 425 °C
ISO 898-1	12.9	0.30 – 0.50	–	–	–	0.025	0.025	0.003 B	Alloy only, temper ≥ 425 °C
ISO 3506-1	A2 · 1.4301	0.08 max	17.0 – 19.0	8.0 – 11.0	–	0.05	0.03	–	304 austenitic
ISO 3506-1	A4 · 1.4401	0.08 max	16.0 – 18.5	10.0 – 15.0	2.0 – 3.0 Mo	0.05	0.03	–	316 austenitic
ASTM A193	B7 · 4140	0.37 – 0.49	0.75 – 1.20	–	0.15 – 0.25 Mo	0.035	0.040	–	Temper ≥ 621 °C
ASTM A193	B16	0.36 – 0.47	0.80 – 1.15	–	0.50 – 0.65 Mo	0.035	0.040	0.25 – 0.35 V	Temper ≥ 650 °C
ASTM A193	B8 · 304	0.08 max	18.0 – 20.0	8.0 – 11.0	–	0.045	0.030	–	Solution annealed
ASTM A193	B8M · 316	0.08 max	16.0 – 18.0	10.0 – 14.0	2.00 – 3.00 Mo	0.045	0.030	–	Solution annealed
ASTM A320	L7 · 4140	0.37 – 0.49	0.75 – 1.20	–	0.15 – 0.25 Mo	0.035	0.040	–	Impact tested −101 °C
ASTM F3125	A325 Type 1	0.30 – 0.52	–	–	–	0.040	0.050	–	Temper ≥ 427 °C
ASTM F3125	A490	0.30 – 0.53	–	–	–	0.040	0.050	–	Temper ≥ 482 °C
ASTM A194	2H	0.40 min	–	–	–	0.040	0.050	–	Q&T carbon
EN 10025-2	S235JR	0.17 max	–	–	–	0.035	0.035	0.012 N	Structural, weldable
EN 10025-2	S355J2	0.20 max	–	–	–	0.030	0.030	–	Structural, weldable
EN 10083-3	42CrMo4	0.38 – 0.45	0.90 – 1.20	–	0.15 – 0.30 Mo	0.025	0.035	–	Q&T alloy
EN 10269	21CrMoV5-7	0.17 – 0.25	1.20 – 1.50	–	0.50 – 0.70 Mo	0.025	0.015	0.25 – 0.35 V	High temperature
ISO 13918	Type SD stud	0.20 max	–	–	–	0.040	0.040	–	Arc stud welding

▲ **Note:** ▲ Every chemical limit in this table must be verified against its source standard. Element limits vary between editions and between size ranges within a grade.

Sources ISO 898-1:2013 Table 2 · ISO 3506-1 · ASTM A193/A193M · A320/A320M · A194/A194M · F3125/F3125M · EN 10025-2 · EN 10083-3 · EN 10269 · ISO 13918

MF Fastener Industries LLC

About this book

Every page states the standards it was compiled from. Loads are calculated from the standards' published stress values and areas; derived guide values such as torque are marked and their method printed alongside. This is a reference compilation: the original standard governs, and the reader is expected to verify against it.

How to use it

1. Identify the grade from the head marking (Section 1) before measuring anything.
2. Read the grade page for the mechanical minimums; read the product page for dimensions.
3. Where a drawing calls for a standard, supply that standard. Use the cross-reference to identify the nearest equivalent, then confirm it against the full text of both standards.
4. Guide values marked * depend on lubrication, finish and joint condition — verify on the joint.

Standards covered

ISO 898 · ISO 3506 · ISO 4014 / 4017 / 4032 / 4762 · ISO 7089 · EN 14399 · ASTM A193 / A194 / A320 / A307 / A449 / A563 / F3125 / F436 / F1554 / F593 · SAE J429 · DIN 931 / 933 / 934 / 912 / 125 / 127 / 975

The online library

Calculators, dimensioned datasheets, weight chart and the interactive standards cross-reference, kept current between editions.

https://mfindllc.com/technical-library/

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