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High-strength structural bolting assemblies for preloading – Part 10: System HRC – Bolt and nut assemblies with calibrated preload English version of DIN EN 14399-10:2009-07

Hochfeste planmäßig vorspannbare Schraubenverbindungen für den Metallbau –
Teil 10: System HRC –
Garnituren aus Schrauben und Muttern mit kalibrierter Vorspannung
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National foreword

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The DIN Standards corresponding to the International Standards referred to in clause 2 of the EN are as follows:

ISO 261	DIN ISO 261
ISO 965-2	DIN ISO 965-2
ISO 965-5	DIN ISO 965-5

National Annex NA
(informative)

Bibliography

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

DIN ISO 272, *Fasteners — Width across Flats for Hexagon Products*

DIN ISO 965-2, *ISO general purpose metric screw threads — Tolerances — Part 2: Limits of sizes for general purpose external and internal screw threads; medium quality*

DIN ISO 965-5, *ISO general purpose metric screw threads — Tolerances — Part 5: Limits of sizes for internal screw threads to mate with hot-dip galvanized external screw threads with maximum size of tolerance position h before galvanizing*

EUROPEAN STANDARD

NORME EUROPÉENNE

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EN 14399-10

March 2009

ICS 21.060.01

English Version

High-strength structural bolting assemblies for preloading - Part 10: System HRC - Bolt and nut assemblies with calibrated preload

Boulonnerie de construction métallique à haute résistance apte à la précontrainte - Partie 10: Système HRC - Boulons (vis + écrou + rondelle) à précontrainte calibrée

Hochfeste planmäßig vorspannbare Schraubenverbindungen für den Metallbau - Teil 10: System HRC - Garnituren aus Schrauben und Muttern mit kalibrierter Vorspannung

This European Standard was approved by CEN on 24 January 2009.

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Foreword

This document (EN 14399-10:2009) has been prepared by Technical Committee CEN/TC 185 “Fasteners”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2009, and conflicting national standards shall be withdrawn at the latest by September 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

EN 14399 consists of the following parts, under the general title *High-strength structural bolting assemblies for preloading*:

— *Part 1: General requirements*

— *Part 2: Suitability test for preloading*

— *Part 3: System HR - Hexagon bolt and nut assemblies*

— *Part 4: System HV - Hexagon bolt and nut assemblies*

— *Part 5: Plain washers*

— *Part 6: Plain chamfered washers*

— *Part 7: System HR - Countersunk head bolt and nut assemblies*

— *Part 8: System HV - Hexagon fit bolt and nut assemblies*

— *Part 9: System HR or HV – Direct tension indicators for bolt and nut assemblies*

— *Part 10: System HRC - Bolt and nut assemblies with calibrated preload*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This part of this European Standard completes the series of European standards EN 14399 parts 1 to 10 which specify high-strength structural bolting for preloading; it belongs to the system HR. The specificity of bolt and nut assemblies with a calibrated preload, compared with the system HR as defined in EN 14399-3, is the preload in the bolt which is controlled during tightening by the fracture of the spline-end of the bolt under torsional stress, this fracture occurring for a precise predetermined stress.

Preloaded bolted assemblies are very sensitive to differences in manufacture and lubrication. Therefore it is important that the assembly is supplied by one manufacturer who is always responsible for the function of the assembly.

For the same reason it is important that the coating of the assembly is under the control of the manufacturer.

Besides the mechanical properties of the components, the functionality of the assembly requires that the specified preload can be achieved when the fracture of the break neck at the spline-end of the bolt occurs under the predetermined torsional stress when the assembly is tightened with the appropriate procedure. For this purpose a test method for the suitability of the components for preloading was created which will demonstrate whether the function of the assembly is fulfilled.

It should be pointed out that, compared to ISO 272, the widths across flats (large series) for M12 and M20 have been changed to 22 mm and 32 mm respectively. These changes are justified by the following reasons:

— under the specific conditions of structural bolting the compressive stresses under the bolt head or nut for the sizes M12 may become too large with the width across flats of 21 mm, especially if the washer is fitted eccentrically to the bolt axis;

— for the size M20 the width across flats of 34 mm is very difficult to be produced; the change to 32 mm is primarily motivated by economics but it should also be pointed out that the width across flats of 32 mm is already common practice in Europe.

1 Scope

This part of this European Standard specifies, together with EN 14399-1, the requirements for assemblies of high-strength structural bolts and nuts of system HRC suitable for preloaded joints, with hexagon head (large widths across flats) or cup head, thread sizes M12 to M30 and property class 10.9/10.

Bolt and nut assemblies conforming to this part of this European Standard have been designed to allow preloading of at least $0{,}7\, f_{ub} \times A_s$ [1)] according to EN 1993-1-8:2005 (*Eurocode 3*) and to obtain ductility predominantly by plastic elongation of the bolt. For this purpose the components have the following characteristics:

— nut according to EN 14399-3, or

— nut with height m = 1 d,

— thread length of the bolt according to ISO 888.

Bolt and nut assemblies conforming to this part of this European Standard include washer(s) according to EN 14399-6 or to EN 14399-5 (under the nut only).

NOTE Attention is drawn to the importance of ensuring that the bolts are correctly used if a satisfactory result is to be obtained.

The test method for suitability for preloading is specified in EN 14399-2 and in Clause 8.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10045-1, *Metallic materials – Charpy impact test – Part 1: Test method*

EN 14399-1, *High-strength structural bolting assemblies for preloading – Part 1: General requirements*

EN 14399-2:2005, *High-strength structural bolting assemblies for preloading – Part 2: Suitability test for preloading*

EN 14399-3:2005, *High-strength structural bolting assemblies for preloading – Part 3: System HR – Hexagon bolt and nut assemblies*

EN 14399-5, *High-strength structural bolting assemblies for preloading – Part 5: Plain washers*

EN 14399-6, *High-strength structural bolting assemblies for preloading – Part 6: Plain chamfered washers*

EN 20898-2, *Mechanical properties of fasteners – Part 2: Nuts with specified proof load values – Coarse thread (ISO 898-2:1992)*

EN 26157-1, *Fasteners – Surface discontinuities – Part 1: Bolts, screws and studs for general requirements (ISO 6157-1:1988)*

EN ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel – Part 1: Bolts, screws and studs (ISO 898-1:1999)*

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1) f_{ub} is the nominal tensile strength (R_m) and A_s the stress area of the bolt.

EN ISO 3269, *Fasteners – Acceptance inspection (ISO 3269:2000)*

EN ISO 4759-1, *Tolerances for fasteners – Part 1: Bolts, screws, studs and nuts – Product grades A, B and C (ISO 4759-1:2000)*

EN ISO 6157-2, *Fasteners – Surface discontinuities – Part 2: Nuts (ISO 6157-2:1995)*

EN ISO 10684, *Fasteners – Hot dip galvanized coatings (ISO 10684:2004)*

ISO 148-1, *Metallic materials – Charpy pendulum impact test – Part 1: Test method*

ISO 261, *ISO general purpose metric screw threads – General plan*

ISO 965-2, *ISO general purpose metric screw threads – Tolerances – Part 2: Limits of sizes for general purpose external and internal screw threads – Medium quality*

ISO 965-5, *ISO general purpose metric screw threads – Tolerances – Part 5: Limits of sizes for internal screw threads to mate with hot-dip galvanized external screw threads with maximum size of tolerance position h before galvanizing*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
shear wrench
electric or manual tool equipped with two co-axial sockets which react by torque one against the other:

— the outer socket which engages the nut rotating clockwise;

— the inner socket which engages the spline-end of the bolt (i.e. bi-hexagonal) rotating anticlockwise

NOTE The shear wrench operates as follows:

− during the tightening operation of an assembly, the socket in rotation is the one that finds the least resistance to it;

− from the outset and right up to the final tightening stage, the outer socket on the nut rotates clockwise while the inner socket holds the spline-end without rotating, the result being that the bolt assembly is progressively tightened by the increasing torque applied to the nut;

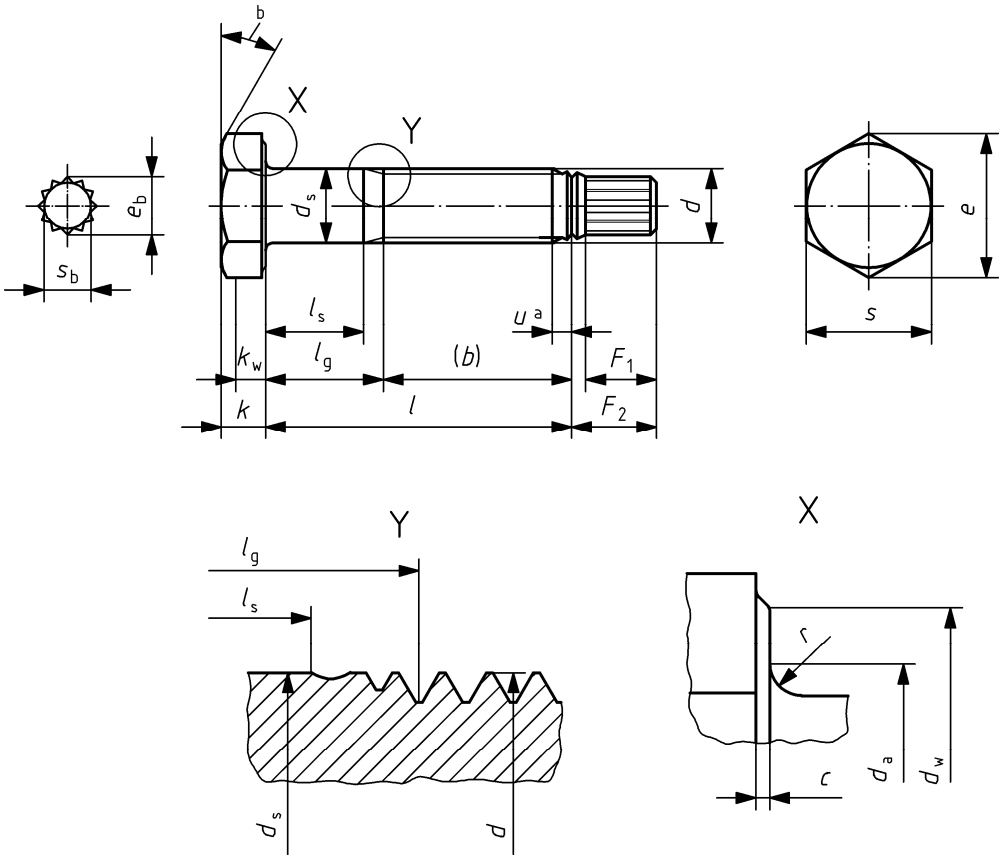
− at the final stage of tightening, i.e. when the torsional resistance plateau of the break-neck section is attained, the inner socket rotates anticlockwise while the outer socket on the nut provides the reaction without rotating;

− the bolt assembly installation is complete when the spline-end shears off at the break-neck section.

4 Bolts

4.1 Dimensions of bolts

See Figures 1 and 2. Dimensions of bolts are in accordance with the relevant dimensions specified in EN 14399-3:2005, see Tables 1 and 2. Dimensions of the spline-end are specified in Table 3.



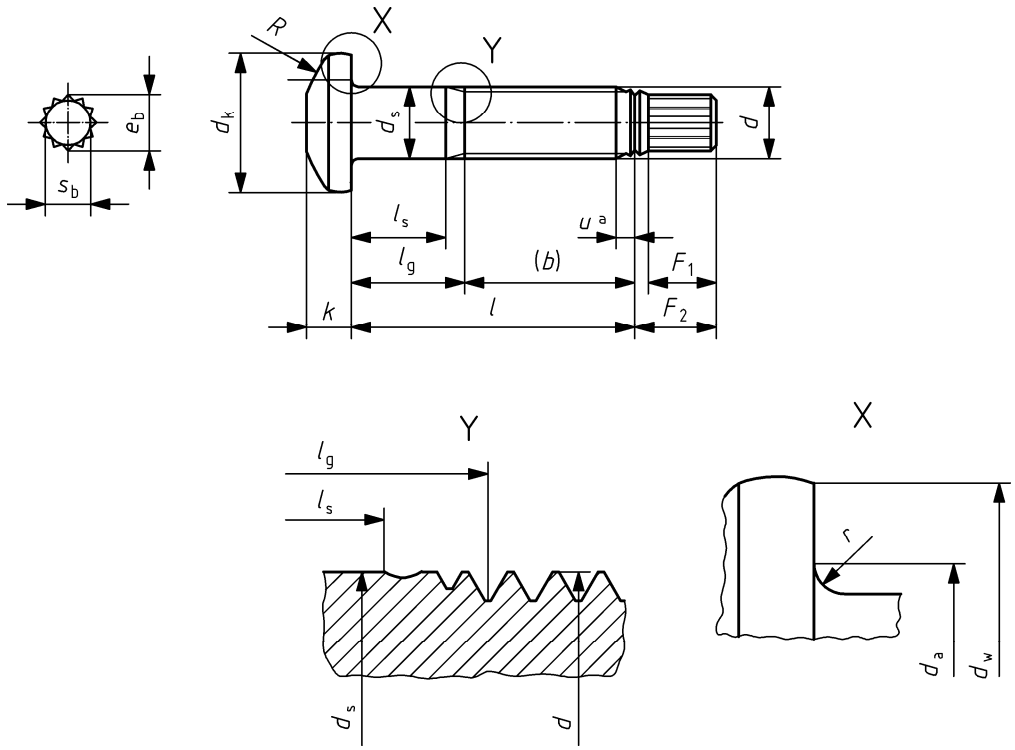
Key

a Incomplete thread $u \leq 2\,P$

b 15° to 30°

NOTE The difference between l_g and l_s should not be less than 1,5 P.

Figure 1 — Bolt HRC with hexagon head



Key

a Incomplete thread $u \leq 2\,P$

NOTE The difference between l_g and l_s should not be less than 1,5 P.

Figure 2 — Bolt HRC with cup head

Table 1 — Dimensions of hexagon bolts [a]

Dimensions in millimetres

Thread d		M12	M16	M20	M22	M24	M27	M30
P [b]		1,75	2	2,5	2,5	3	3	3,5
b (ref.)	[c]	30	38	46	50	54	60	66
	[d]	—	44	52	56	60	66	72
	[e]	—	—	65	69	73	79	85
c	max.	0,8	0,8	0,8	0,8	0,8	0,8	0,8
	min.	0,4	0,4	0,4	0,4	0,4	0,4	0,4
d_a	max.	15,2	19,2	24,4	26,4	28,4	32,4	35,4
d_s	max.	12,70	16,70	20,84	22,84	24,84	27,84	30,84
	min.	11,30	15,30	19,16	21,16	23,16	26,16	29,16
d_w	max.	[f]						
	min.	20,1	24,9	29,5	33,3	38,0	42,8	46,6
e	min.	23,91	29,56	35,03	39,55	45,20	50,85	55,37
k	nom.	7,5	10	12,5	14	15	17	18,7
	max.	7,95	10,75	13,40	14,90	15,90	17,90	19,75
	min.	7,05	9,25	11,60	13,10	14,10	16,10	17,65
k_w	min.	4,9	6,5	8,1	9,2	9,9	11,3	12,4
r	min.	1,2	1,2	1,5	1,5	1,5	2,0	2,0
s	max.	22	27	32	36	41	46	50
	min.	21,16	26,16	31	35	40	45	49

Table 1 *(continued)*

Dimensions in millimetres

Thread d			M12		M16		M20		M22		M24		M27		M30	
l			l_s and l_g [g] [h]													
nom.	max.	min.	l_s min.	l_g max.	l_s min.	l_g max.	l_s min.	l_g max.	l_s min.	l_g max.	l_s min.	l_g max.	l_s min.	l_g max.	l_s min.	l_g max.
40	41,25	38,75	6	11,25	8	14										
50	51,25	48,75	11,25	20	8	14	10	17,5	11	18,5						
60	61,5	58,5	21,25	30	12	22	10	17,5	11	18,5	12	21	13,5	22,5		
70	71,5	68,5	31,25	40	22	32	11,5	24	11	18,5	12	21	13,5	22,5	15	25,5
80	81,5	78,5	41,25	50	32	42	21,5	34	17,5	30	12	21	13,5	22,5	15	25,5
90	91,75	88,25	51,25	60	42	52	31,5	44	27,5	40	21	36	15	30	15	25,5
100	101,75	98,25	61,25	70	52	62	41,5	54	37,5	50	31	46	25	40	16,5	34
110	111,75	108,25			56	66	45,5	58	41,5	54	35	50	29	44	20,5	38
120	121,75	118,25			66	76	55,5	68	51,5	64	45	60	39	54	30,5	48
130	132	128			76	86	65,5	78	61,5	74	55	70	49	64	40,5	58
140	142	138			86	96	75,5	88	71,5	84	65	80	59	74	50,5	68
150	152	148			96	106	85,5	98	81,5	94	75	90	69	84	60,5	78
160	164	156									85	100	79	94	70,5	88
170	174	166									95	110	89	104	80,5	98
180	184	176									105	120	99	114	90,5	108
190	194	186									115	130	109	124	100,5	118
200	204	196									125	140	119	134	110,5	128

NOTE The popular lengths are defined in terms of lengths $l_{s\ min.}$ and $l_{g\ max.}$

[a] For hot-dip galvanized bolts, the dimensions apply before galvanizing.

[b] P is the pitch of thread.

[c] For lengths $l_{nom.} \leq 125$ mm.

[d] For lengths 125 mm < $l_{nom.} \leq 200$ mm.

[e] For lengths $l_{nom.} > 200$ mm.

[f] $d_{w\ max.} = s_{actual.}$

[g] $l_{g\ max.} = l_{nom.} - b$, $l_{s\ min.} = l_{g\ max.} - 5\,P$

[h] When $l_{s\ min.}$ as calculated by the formula in g is less than 0,5 d then its value shall be 0,5 d and $l_{g\ max.} = l_{s\ min.} + 3\,P$. They are shown above the stepped line.

NOTE Dimensions of the break-neck of the bolt are not specified for the following reasons: dimensions and tolerances of the break-neck are defined by the manufacturer of the bolt according to material, manufacturing process and lubrication. The precise dimensions and tolerances of the break-neck ensure that the specified preload is achieved when the fracture of the spline-end of the bolt occurs under torsional stress.

Table 2 — Dimensions of cup head bolts [a] [b]

Dimensions in millimetres

Thread d		M12	M16	M20	M22	M24	M27	M30
d_k	min.	21	27	34	38,5	43	48	52
d_w	min.	20	26	33	37	41	46	50
k	nom.	8	10	13	14	15	17	19
	max.	8,8	10,8	13,9	14,9	15,9	17,9	20,0
	min.	7,2	9,2	12,1	13,1	14,1	16,1	18,0
R	nom.	18	20	22	23	25	27	30

a For hot-dip galvanized bolts, the dimensions apply before galvanizing.

b For all other dimensions, see Table 1.

Table 3 — Dimensions of spline-end [a]

Dimensions in millimetres

Thread *d*		M12	M16	M20	M22	M24	M27	M30
Width across flats of spline-end, s_b [a]	nom.	7,7	11,3	14,1	15,4	16,8	19,0	21,1
	max.	8,0	11,6	14,4	15,7	17,1	19,3	21,4
	min.	7,4	11,0	13,8	15,1	16,5	18,7	20,8
Width across corners of spline-end, e_b [b]	min.	8,36	12,43	15,60	17,06	18,65	21,13	23,50
Length of spline-end, F_1	min.	11,0	13,0	15,0	15,5	16,0	19,0	21,0
Break off length, F_2	max.	16,0	18,0	20,0	21,0	21,5	24,0	26,0

a For hot-dip galvanized bolts, the dimensions apply before galvanizing except for $s_{b\ max.}$ which applies after galvanizing.

b $e_{b\ min.} = 1{,}13\ s_{b\ min.}$

4.2 Specification for bolts and reference standards

The specifications for bolts and reference standards are given in Table 4.

Table 4 — Specifications for bolts and reference standards

Material		Steel
General requirements		EN 14399-1
Thread	Tolerance	6 g [a]
	Standards	ISO 261, ISO 965-2
Mechanical properties	Property class	10.9
	Standard	EN ISO 898-1
Impact strength	Value	$K_{V,\,min}$ = 27 J at – 20 °C
	Test piece [b]	ISO 148-1
	Test	EN 10045-1
Tolerances	Product grade	C except: dimensions c and r. Tolerance for lengths ≥ 150 mm: ± 4,0 mm
	Standard	EN ISO 4759-1
Surface finish [c]	Normal	as processed [d]
	Hot dip galvanized	EN ISO 10684
	Others	to be agreed [e]
	Additional protection against corrosion	After tightening, the non-coated area appearing at the end of the bolt resulting from the fracture of the spline-end may be protected against corrosion by applying an efficient protective treatment (e.g. by a complementary zinc-rich paint).
Surface discontinuities		Limits for surface discontinuities are covered in EN 26157-1.
Acceptability		For acceptance procedure, see EN ISO 3269.

a The tolerance class specified applies before hot-dip galvanizing. Hot-dip galvanized bolts are intended for assembly with oversize tapped nuts.

b The location of Charpy V-notch test pieces in the bolt shank shall be as specified in EN ISO 898-1.

c Attention is drawn to the need to consider the risk of hydrogen embrittlement in the case of bolts of property class 10.9, when selecting an appropriate surface treatment process (e.g. cleaning and coating); see the relevant coating standards.

d "As processed" means the normal finish resulting from manufacture with a light coating of oil.

e Other coatings may be negotiated between the purchaser and the manufacturer provided they do not impair the mechanical properties or the functional characteristics. Coatings of cadmium or cadmium alloy are not permitted.

4.3 Marking of bolts

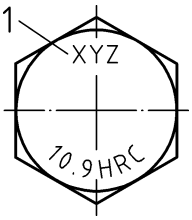
High-strength structural bolts according to this part of this European Standard shall be marked with (see Figure 3 for marking examples):

a) the property class marking in accordance with EN ISO 898-1 and the letters HRC;

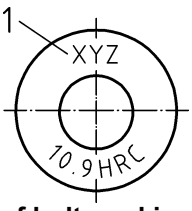
EXAMPLE 10.9 HRC

b) the identification mark of the manufacturer of the assembly.

It is permissible for the marking to be either embossed or indented on the top surface of the head.



a) EXAMPLE of bolt marking for hexagonal head



b) EXAMPLE of bolt marking for cup head

Key

1 Identification mark of the manufacturer of the assembly

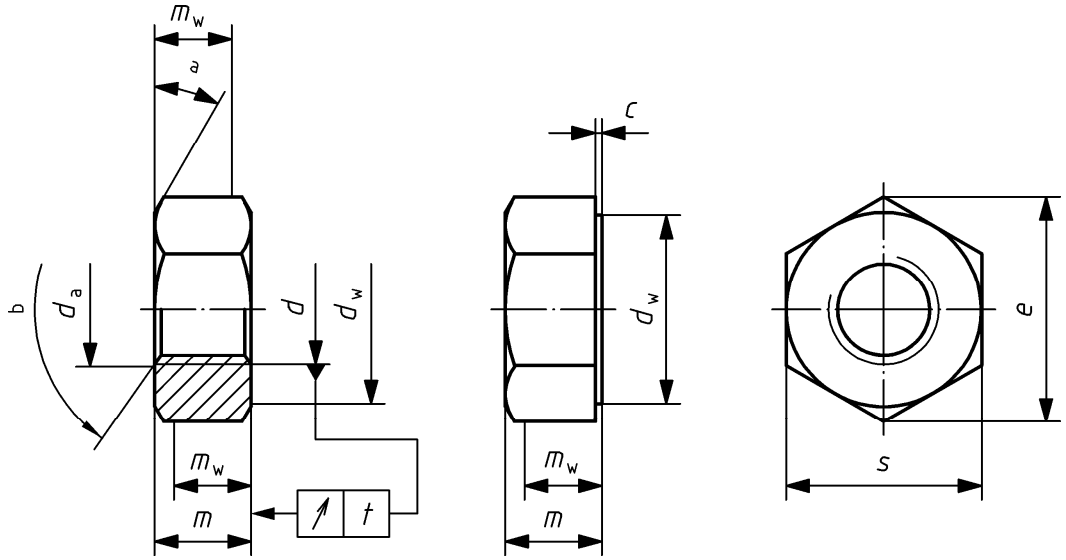
Figure 3 — Examples for bolt marking

5 Nuts

5.1 Dimensions of nuts

Dimensions of nuts (see Figure 4), shall be in accordance with Table 5 or Table 6 at the manufacturer's option.

Alternative form permissible



Key

a 15° to 30°

b 110° to 130°

Figure 4 — Dimension of the nut

Table 5 — Dimensions of nuts according to EN 14399-3:2005 (HR) [a]

Dimensions in millimetres

Thread d		M12	M16	M20	M22	M24	M27	M30
P [b]		1,75	2	2,5	2,5	3	3	3,5
d_a	max.	13	17,3	21,6	23,7	25,9	29,1	32,4
	min.	12	16	20	22	24	27	30
d_w	max.				[c]			
	min.	20,1	24,9	29,5	33,3	38,0	42,8	46,6
e	min.	23,91	29,56	35,03	39,55	45,20	50,85	55,37
m	max.	10,8	14,8	18	19,4	21,5	23,8	25,6
	min.	10,37	14,1	16,9	18,1	20,2	22,5	24,3
m_w	min.	8,3	11,3	13,5	14,5	16,2	18,1	19,5
c	max.	0,8	0,8	0,8	0,8	0,8	0,8	0,8
	min.	0,4	0,4	0,4	0,4	0,4	0,4	0,4
s	max.	22	27	32	36	41	46	50
	min.	21,16	26,16	31	35	40	45	49
t		0,38	0,47	0,58	0,63	0,72	0,80	0,87

[a] For hot dip galvanized nuts, the dimensions apply before galvanizing.

[b] P is the pitch of thread.

[c] $d_{w,\,max.} = s_{actual.}$

When nuts with height m = 1 d are used, they shall be according to Table 5 except for dimensions m and m_w, which shall be according to Table 6.

Table 6 — Dimensions of nuts with height m = 1 d (HRD) [a]

Dimensions in millimetres

Thread d		M12	M16	M20	M22	M24	M27	M30
m	max.	12,35	16,35	20,65	22,65	24,65	27,65	30,65
	min.	11,65	15,65	19,35	21,35	23,35	26,35	29,35
m_w	min.	9,32	12,52	15,48	17,08	18,68	21,08	23,48

[a] For hot dip galvanized nuts, the dimensions apply before galvanizing.

5.2 Specification for nuts and reference standards

The specifications for nuts and reference standards are given in Table 7.

Table 7 — Specifications for nuts and reference standards

Material		Steel
General requirements		EN 14399-1
Thread	Tolerance	6H or 6AZ [a]
	Standards	ISO 261, ISO 965-2, ISO 965-5
Mechanical properties	Property class	10 [b]
	Standard	EN 20898-2
Tolerances	Product grade	B except dimensions m and c
	Standard	EN ISO 4759-1 [c]
Surface finish	Normal	as processed [d]
	Hot dip galvanized	EN ISO 10684
	Others	to be agreed [e]
Surface discontinuities		Limits for surface discontinuities are covered in EN ISO 6157-2.
Acceptability		For acceptance procedure, see EN ISO 3269.

[a] Thread tolerance is 6 H for non-coated nuts and 6 AZ for hot-dip galvanized nuts.

[b] For proof load values, see 5.3. All other mechanical properties as specified in EN 20898-2.

[c] Except tolerance on perpendicularity of bearing face, see tolerance t in Table 5.

[d] "As processed" means the normal finish resulting from manufacture with a light coating of oil.

[e] Other coatings may be negotiated between the purchaser and the manufacturer provided they do not impair the mechanical properties or the functional characteristics. Coatings of cadmium or cadmium alloys are not permitted.

5.3 Proof load values of nuts

Proof load values of nuts are specified in Table 8.

Table 8 — Proof load values of nuts

Thread d	Nominal stress area of standard test mandrel A_s mm^2	Property class 10 Tolerance class 6 H or 6 AZ	
		Proof load ($A_s \times S_p$), N	
		Nuts according to EN 14399-3 (HR) [a]	Nuts with height m = 1 d (HRD) [b]
M12	84,3	97 800	104 900
M16	157	182 100	195 500
M20	245	284 200	305 000
M22	303	351 200	377 200
M24	353	409 500	439 500
M27	459	532 400	571 500
M30	561	650 800	698 400

[a] The proof load values are based on the stress under proof load of 1 160 MPa.

[b] The proof load values are based on the stress under proof load of 1 245 MPa.

5.4 Decarburization of the nut thread

The decarburization of the nut thread, when measured analogously to external threads as given in EN ISO 898-1, shall not exceed G = 0,015 mm.

5.5 Marking of nuts

High-strength structural nuts according to this part of this European Standard shall be marked with (see Figure 5 for marking examples):

a) the property class marking in accordance with EN 20898-2, and

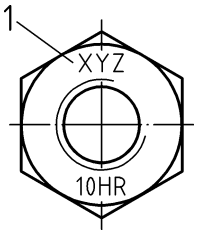
   1) the letters HR for nuts according to EN 14399-3, or

   2) the letters HRD for nuts with height m = 1 d with dimension according to Table 6;

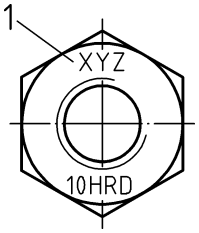
EXAMPLE 10 HR

b) the identification mark of the manufacturer of the assembly.

The marking shall be indented on either the top or bottom face of chamfered nuts and shall be either indented or embossed on the non-bearing face of washer faced nuts.



a) EXAMPLE of nut marking for nut according to EN 14399-3



b) EXAMPLE of nut marking for nut with height m = 1 d:

Key

1 Identification mark of the manufacturer of the assembly

Figure 5 — Examples for nut marking

6 Designation of the bolt/nut assembly

EXAMPLE 1 Designation of a bolt/nut assembly for high-strength structural bolting with calibrated preload, system HRC, consisting of hexagon head bolt with thread M16, nominal length l = 80 mm, property class 10.9, and a hexagon nut with large width across flats, height according to EN 14399-3, thread M16 and property class 10:

Hexagon head bolt/nut assembly EN 14399-10 — M16 × 80 — 10.9/10 — HRC

EXAMPLE 2 Designation of a bolt/nut assembly for high-strength structural bolting with calibrated preload, system HRC, consisting of a cup head bolt with thread M16, nominal length l = 80 mm, property class 10.9, and a hexagon nut with large width across flats, height m = 1 d (symbol D), thread M16 and property class 10:

Cup head bolt/nut assembly EN 14399-10 — M16 × 80 — 10.9/10D — HRC

If surface finishes other than "as processed" are required, the specified surface finish shall be added to the designation, e.g. for hot dip galvanizing (tZn):

Hexagon head bolt/nut assembly EN 14399-10 — M16 × 80 — 10.9/10 — HRC — tZn

7 Associated washers

Bolt/nut assemblies according to this part of this European Standard shall be assembled with washers according to EN 14399-6 or according to EN 14399-5. Washers according to EN 14399-5 shall only be used under the nut.

8 Functional characteristics of the bolt/nut/washer assembly

8.1 General

There shall be sufficient suitable lubricant on the nuts or on the bolts and washers in the as delivered condition to ensure that seizure will not take place on tightening the assembly and that the required preload is obtained.

The adequacy with which the preload is obtained on tightening calibrated preload bolt/nut/washer(s) assemblies depends on the satisfactory control of the behaviour of two main parameters:

— the lubrication performance,

— the spline-end torsion resistance.

Therefore the functional characteristics of the bolt/nut/washer(s) assembly with calibrated preload according to 8.4 shall be achieved when tested in accordance with 8.2 and 8.3.

NOTE 1 Experience has shown that, for certain preloaded bolted connection in metallic structures, installation conditions are such that it is not possible to use the shear wrench. In this case, tightening is usually carried out with the control torque method and k-class K2 (k-factor and V_k) is necessary.

Four full threads (in addition to the thread run out) shall remain clear between the bearing surface of the nut and the unthreaded part of the shank.

NOTE 2 For further background information as to these functional characteristics see EN 14399-2. Special testing conditions and procedures given in EN 14399-2:2005, Annex A, may be applied except c) and d) 2).

8.2 Suitability test for preloading

8.2.1 General

See EN 14399-2 and 8.2.2 to 8.4.

8.2.2 Test assemblies

The test shall be carried out on assemblies that include at least one washer, under the nut.

Test assemblies shall be taken from a single assembly lot or extended assembly lot (see EN 14399-1). Each component of a test assembly shall be used once only.

The test shall be carried out on test assemblies in the condition of delivery without alteration of the lubrication of the various components.

8.2.3 Test results

Evaluation of test results shall be in accordance with EN 14399-2.

$\Delta\theta_2$ shall be measured from the fracture of the spline-end and shall exceed the value of $\Delta\theta_2$ specified in EN 14399-3:2005.

8.3 Suitability test for calibrated preload

This additional part of the suitability test shall be carried out on test assemblies from the same assembly lot as for 8.2, in order to check that the spline-end breaks at the required preload value.

The test conditions defined in EN 14399-2:2005, Clauses 6 and 8, shall be used.

The test apparatus shall be according to one of the following:

— either the shear wrench according to 3.1 and the bolt force measurement device, or

— the shear wrench according to 3.1 and the test apparatus defined in EN 14399-2, or

— the test apparatus defined in EN 14399-2 equipped with co-axial sockets designed to fit the spline-end of the bolt, able to turn and break the spline-end similarly to the shear wrench.

NOTE This test may be combined with the suitability test for preloading as defined in 8.2.

The tightening stops when the spline-end fractures.

F_{ri} which is the individual value of the bolt force when failure by fracture occurs in the spline-end shall be measured.

8.4 Requirements

For assemblies with HR nuts, the requirements of EN 14399-3:2005, k-class K2, apply.

For assemblies with HRD nuts, the requirements of EN 14399-3:2005, k-class K0, apply.

The values for the bolt force at the fracture of the spline-end (F_r) shall fulfil the requirements specified in Table 9. The following requirements apply:

— Individual value of $F_{ri} \geq 0{,}7\, f_{ub} \times A_s$

— Mean value $F_{r\,mean} \geq 0{,}77\, f_{ub} \times A_s$

— Coefficient of variation of F_r

$V_{Fr} \leq 0{,}10$

with

$$V_{Fr} = \frac{s_{Fr}}{F_{r\,mean}} \tag{1}$$

where

s_{Fr} is the standard deviation

$$\left(s_{Fr} = \sqrt{\frac{\sum (F_{ri} - F_{r\,mean})^2}{n - 1}} \right) \tag{2}$$

Five tests shall be carried out.

Table 9 — Limiting values of bolt force at the fracture of the spline-end

Thread d	Nominal stress area of standard test mandrel A_s mm^2	$F_{r\ min}$ $0{,}7 \times f_{ub} \times A_s$ [a] N	$F_{r\ mean\ min}$ $0{,}77 \times f_{ub} \times A_s$ [a] N
M12	84,3	59 010	64 911
M16	157	109 900	120 890
M20	245	171 500	188 650
M22	303	212 100	233 310
M24	353	247 100	271 810
M27	459	321 300	353 430
M30	561	392 700	431 970

[a] f_{ub} is the nominal tensile strength of the bolt ($R_{m,\ nom}$).

Bibliography

[1] EN 1090-2, *Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures*

[2] EN 1993-1-8:2005, *Eurocode 3: Design of steel structures – Part 1-8: Design of joints*

[3] EN 14399-4, *High-strength structural bolting assemblies for preloading – Part 4: System HV – Hexagon bolt and nut assemblies*

[4] ISO 272, *Fasteners – Hexagon products – Widths across flats*

[5] ISO 888, *Bolts, screws and studs – Nominal lengths, and thread lengths for general purpose bolts*