Spanish standard

UNE-EN 14399-9

April 2019

High-strength structural bolting assemblies for preloading

Part 9: System HR or HV

Direct tension indicators for bolt and nut assemblies

This standard has been prepared by the Technical Committee CTN 17 *Fasteners* the Secretariat of which is held by ASEFI.

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UNE-EN 14399-9

High-strength structural bolting assemblies for preloading
Part 9: System HR or HV
Direct tension indicators for bolt and nut assemblies

Conjuntos de elementos de fijación estructurales de alta resistencia para precarga. Parte 9: Sistema HR o HV. Conjuntos de tornillo y tuerca con indicadores directos de tensión.

Boulonnerie de construction métallique à haute résistance apte à la précontrainte. Partie 9: Système HR ou HV. Boulons avec rondelles indicatrices de précontrainte.

This standard is the official English version of EN 14399-9:2018.

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EUROPEAN STANDARD

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May 2018

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English Version

High-strength structural bolting assemblies for preloading - Part 9: System HR or HV - Direct tension indicators for bolt and nut assemblies

Boulonnerie de construction métallique à haute résistance apte à la précontrainte - Partie 9 : Système HR ou HV - Boulons avec rondelles indicatrices de précontrainte

Hochfeste vorspannbare Garnituren für Schraubverbindungen im Metallbau - Teil 9: System HR oder HV - Direkte Kraftanzeiger für Garnituren aus Schrauben und Muttern

This European Standard was approved by CEN on 22 October 2017.

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Contents

Page

European foreword

This document (EN 14399-9:2018) has been prepared by Technical Committee CEN/TC 185 "Fasteners", the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by November 2018 and conflicting national standards shall be withdrawn at the latest by November 2018.

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

This document supersedes EN 14399-9:2009.

In comparison with EN 14399-9:2009, the following modifications have been made:

— Table 1 containing the overview of the composition of bolting assemblies and component marking has been revised;

— the test method for measuring compression loads on direct tension indicators has been revised;

— the suitability test for bolting assemblies including direct tension indicators has been revised;

— Informative Annex A has been deleted;

— Informative Annex on the use of direct tension indicators has been added.

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 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, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This document is part of the EN 14399 series which specify high-strength structural bolting for preloading; this part belongs to both types, HR and HV. Direct tension indicators (known formerly as load indicating washers) used in conjunction with nut face washers (HN) and bolt face washers (HB) are load indicating devices which are placed under the bolt head or under the nut. The direct tension indicators have protrusions on one face which compress under load and thus may be used to indicate that at least the required preload has been achieved in the bolting assembly.

Direct tension indicators are only to be sold as components of structural bolting assemblies comprised of bolts, nuts and associated washers that otherwise complies with EN 14399-3, EN 14399–4, EN 14399–7 or EN 14399–8. The composition of bolt/nut/washer/direct tension indicator assemblies is shown in Table 1.

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

For the same reason it is important that the coating of the bolting assemblies is under the control of one manufacturer.

Beside the mechanical properties of the components, the functionality of the bolting assemblies requires that the specified preload can be achieved when the gap remaining after tightening (compressed protrusions) is less than the specified values in this standard, if the assembly is tightened with a suitable procedure. For this purpose the test method given in this standard was developed, which demonstrates whether the functionality of the bolting assemblies is fulfilled.

Table 1 — Composition of high-strength structural bolting assemblies and component marking

Type of bolting assembly		**System HR**				**System HV**		**System HRC**	
General requirements		EN 14399-1							
Suitability for preloading		EN 14399-2 and, if any, additional testing specified in the product standard							
Bolt and nut		EN 14399-3		EN 14399-7		EN 14399-4	EN 14399-8	EN 14399-10	
Marking	Bolt	HR8.8	HR10.9	HR8.8	HR10.9	HV10.9	HVP10.9	HRC10.9	
Marking	Nut	HR8 or HR10	HR10	HR8 or HR10	HR10	HV10	HV10	HR10	HRD10
Washer(s)		EN 14399-5 [a] or EN 14399-6				EN 14399-6			EN 14399-5 [a] or EN 14399-6
Marking		H or HR [b]				H or HV [b]		H or HR [b]	H or HR [b] or HD [c]
Direct tension indicator and nut face washer or bolt face washer, if any		EN 14399-9						Not applicable	
Marking	Direct tension indicator	H8	H10	H8	H10	H10			
Marking	Nut face washer	HN				HN			
Marking	bolt face washer	HB		Not applicable		HB			

[a] EN 14399–5 can only be used under the nut.

[b] At the choice of the manufacturer.

[c] Mandatory mark for washers with enlarged outer diameter according to EN 14399–5 only.

1 Scope

This document specifies, together with EN 14399-1 and EN 14399-2, the requirements for direct tension indicators, nut face washers (HN) and bolt face washers (HB) as part of high-strength structural bolting assemblies suitable for preloaded joints.

These direct tension indicators are specified as part of high-strength structural bolting assemblies of system HR or HV in accordance with EN 14399-3, EN 14399-4, EN 14399-7 or EN 14399-8, with nominal thread sizes M12 up to and including M36 and property classes 8.8/8 or 8.8/10 and 10.9/10.

It specifies two property designations H8 and H10 for direct tension indicators, together with general dimensions, tolerances, materials and functional property/ies.

Bolting assemblies in accordance with this document have been designed to allow preloading of at least 0,7 $f_{ub} \times A_s$[1)] according to EN 1993-1-8 (*Eurocode 3*) and to obtain ductility predominantly by plastic elongation of the bolt for system HR in accordance with EN 14399-3 or EN 14399-7, or by plastic deformation of the engaged threads for system HV in accordance with EN 14399-4 or EN 14399-8.

Bolting assemblies conforming to this document may include washer(s) according to EN 14399-6 or to EN 14399-5 (under the nut only).

NOTE 1 Attention is drawn to the importance of ensuring that the bolting assemblies are correctly used if satisfactory results are to be obtained. For recommendations concerning proper application, reference to EN 1090–2 is made.

General requirements and requirements for suitability for preloading are specified in EN 14399-2 together with Clause 5 of this document.

NOTE 2 Direct tension indicators are also known as load indicating washers.

2 Normative references

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

EN ISO 17668, *Zinc diffusion coatings on ferrous products — Sherardizing — Specification (ISO 17668)*

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

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

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

EN 14399-4, *High-strength structural bolting assemblies for preloading — Part 4: System HV — 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*

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

EN 14399-7, *High-strength structural bolting assemblies for preloading — Part 7: System HR - Countersunk head bolt and nut assemblies*

EN 14399-8, *High-strength structural bolting assemblies for preloading — Part 8: System HV - Hexagon fit bolt and nut assemblies*

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

EN ISO 4759-3, *Tolerances for fasteners — Part 3: Washers for bolts, screws and nuts — Product grades A, C and F (ISO 4759-3)*

EN ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method (ISO 6507-1)*

EN ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (ISO 6508-1)*

EN ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system (ISO 7500-1)*

3 Direct tension indicators

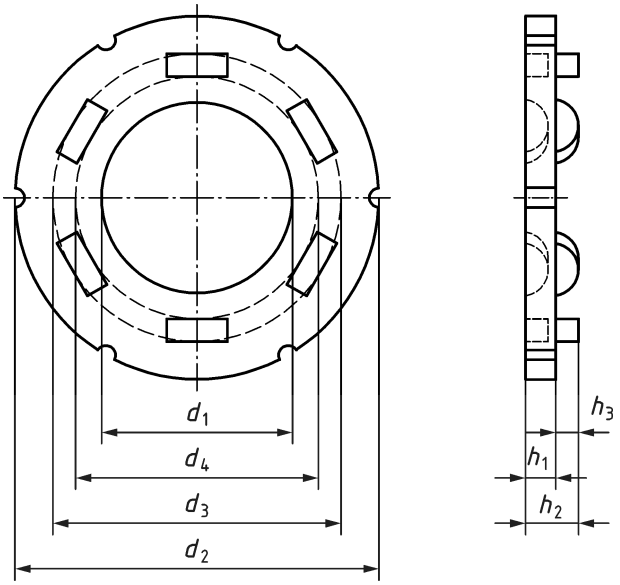
3.1 General

The purpose of direct tension indicators is to show that a defined preload is achieved in the bolting assemblies. The direct tension indicator shall be used as specified in 5.1, with or without nut face washers (HN), and with or without bolt face washers (HB). The direct tension indicators shall be qualified as components of bolting assemblies, in accordance with EN 14399-1.

To comply with EN 14399-2 the bolting assemblies shall be supplied by one manufacturer, and shall include bolts, nuts, washers and direct tension indicators. Bolting assemblies may also include nut face washers (HN) and/or bolt face washers (HB), if required.

3.2 Dimensions

Before installation, the dimensions and tolerances of direct tension indicators shall be as specified in Table 2 and Figure 1. The size and number of protrusions on the direct tension indicator shall be sufficient to meet the requirements of 3.4 and their number shall be not less than four. The protrusions on the direct tension indicator shall be spaced at equal angular intervals. The shape of the protrusions is at the choice of the manufacturer.



Key

d_1 internal diameter
d_2 external diameter
d_3 protrusion tangential external diameter
d_4 protrusion tangential internal diameter
h_1 material thickness (excluding protrusions)
h_2 height over protrusions (including protrusions)
h_3 height of protrusions

Figure 1 — Dimensions of direct tension indicator (example with six protrusions)

Figure 1 shows a schematic representation of the protrusions (other forms including curved may be used).

For coated direct tension indicators, the dimensions apply prior to coating.

Direct tension indicators may have indentations or other features on the outside diameter that correspond to and are aligned with feeler gauge entry spaces to indicate where feeler gauges shall be inserted.

Table 2 — Dimensions of direct tension indicators

Dimensions in millimetres

Nominal size d (nominal thread diameter of associated bolt)	**Internal diameter** d_1		**External diameter** d_2		**Material thickness** (excluding protrusions) h_1	**Height over protrusions** (including protrusions) h_2	**Height of protrusions** h_3	**Protrusion tangential external diameter** d_3	**Protrusion tangential internal diameter** d_4
	min.	max.	min.	max.	min.	max.	min.	max.	min.
M12	12,75	12,85	26,0	32,5	2,5	5,5	0,8	20,0	13,85
M16	16,75	16,85	35,0	36,8	3,0	6,0	0,8	25,0	17,85
M20	20,95	21,05	41,0	46,0	3,5	6,5	0,8	29,0	22,05
M22	23,05	23,15	46,5	50,6	4,0	7,0	0,8	33,0	24,15
M24	25,15	25,25	50,0	55,2	4,0	7,0	0,8	38,0	26,25
M27	28,30	28,40	54,0	62,1	4,0	7,0	0,8	43,0	29,40
M30	31,45	31,55	59,0	69,0	4,0	7,0	0,8	46,5	32,55
M36	37,75	37,85	78,0	83,0	4,0	7,5	0,8	56,0	38,85

3.3 Specifications and reference standards for direct tension indicators

The specifications and reference standards are given in Table 3.

Table 3 — Specifications and reference standards for direct tension indicators

Material		Steel
General requirements		EN 14399–1 and EN 14399–2
Heat treatment		hardened and tempered or controlled rolled and tempered
Maximum hardness		380 HV
Finish — Coating [a]	Uncoated	as processed [c]
	Sherardized [b]	EN ISO 17668
	Others	to be agreed [d]
Associated bolts and nuts		EN 14399–3, EN 14399–4, EN 14399–7 or EN 14399–8
Associated washers		EN 14399–5 or EN 14399–6
Acceptability		For acceptance procedure, see EN ISO 3269:2000 [e].

[a] The direct tension indicators shall not be electroplated or subjected to any process that could result in hydrogen embrittlement.

[b] Sherardizing is considered to provide corrosion protection equivalent to hot dip galvanizing.

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

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

[e] For acceptance criteria use 0,65 AQL, Ac = 0; see EN ISO 3269:2000, Table 5 and Table 6.

3.4 Functional test of direct tension indicators

The direct tension indicators shall be tested on a calibrated load-measuring device; see 3.5 for the test procedure. The load requirement of Table 4 shall be met when the direct tension indicators are compressed to the gap of 0,40 mm.

Samples of direct tension indicators shall be tested by the manufacturer after the final production process including the surface finish, if any. The minimum number of direct tension indicators tested per manufacturing lot shall be eight and all samples shall pass the test.

Table 4 — Test compression loads at 0,40 mm gap

Load in kN

Nominal size d (nominal thread diameter of associated bolt)	Compression load			
	Designation H8		Designation H10	
	min.	max.	min.	max.
M12	47	56	59	71
M16	88	106	110	132
M20	137	164	172	206
M22	170	204	212	254
M24	198	238	247	296
M27	257	308	321	385
M30	314	377	393	472
M36	458	550	572	688
NOTE These minimum values are equal to $0{,}7\,f_{ub} \times A_s$ in accordance with EN 1993–1–8.				

3.5 Test method for measuring compression loads (all finishes) on direct tension indicators

3.5.1 General

This test method is for the measurement of applied compressive loads at a defined deformation state of direct tension indicators. The method involves an initial operation (step 1) to zero the direct reading gauge depending on the actual material thickness h_1, which is followed by compressing the protrusions of the direct tension indicator (step 2) to the specified gap and measuring the resulting compression load.

3.5.2 Testing apparatus

Testing apparatus shall include a compression loading system allowing direct tension indicators to be measured using a direct reading gauge. It comprises a top bearing block (key 3 in Figure 4), a bottom bearing block (key 9 in Figure 4), and a support block for each nominal size of direct tension indicators (key 6 in Figure 4).

The compression loading system shall transmit a compressive load axially from the testing apparatus to the direct tension indicator.

The force-measuring system of the testing apparatus shall be calibrated in accordance with EN ISO 7500-1, class 1 or better.

The gap shall be measured with a direct reading gauge with an accuracy of at least 0,0125 mm.

NOTE Because of acceptable variations in bolt dimensions and coating characteristics, bolts cannot be used as a means of gauging the direct tension indicator measured minimum and maximum functional properties.

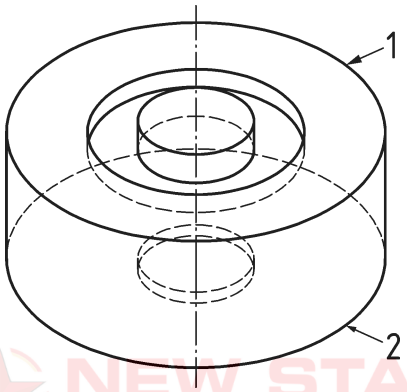
3.5.3 Support blocks

Support blocks (key 6 in Figure 4) shall be grooved on one side so that the direct reading gauge can be zeroed without compressing the direct tension indicator protrusions (see Figure 2). Thus, the exact material thickness h_1 of the direct tension indicator being tested is taken into account, and the flat surface of the side of the direct tension indicator having protrusions is made to relate exactly to the zero point of the gauge that shall be located at the centre of the direct tension indicator support block.

Support blocks shall have a minimum Rockwell hardness of 50 HRC.

Support blocks shall conform to the dimensions shown in Figure 3 and Table 5, and shall have a minimum diameter of 75 mm, which shall be larger than the outside diameter of the direct tension indicator.

The surfaces of support blocks shall be parallel to within 0,005 mm across the diameter of the support block.



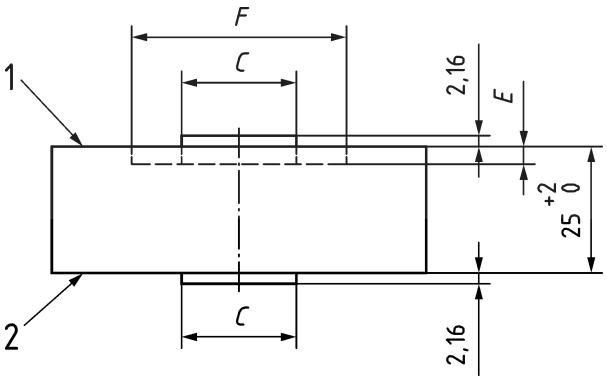
Key

1 side A

2 side B

Figure 2 — Support block

Dimensions in millimetres



Key

1 side A

2 side B

Figure 3 — Support block dimensions

Table 5 — Support block dimensions

Dimensions in millimetres

Nominal size *d* (nominal thread diameter of associated bolt)	*C* [a]		*E*	*F*	
	min.	max.	min.	min.	max.
M12	10,5	11	3	23	23,5
M16	15	15,5	3	30	30,5
M20	19	19,5	3	34	34,5
M22	21	21,5	3	38	38,5
M24	23	23,5	3	43	43,5
M27	26	26,5	3	49	49,5
M30	29	29,5	3	53,5	54
M36	35	35,5	3,5	63	63,5

[a] Height of the cylindrical boss = 2,16 mm ± 0,0125 mm with no more than 0,005 mm difference in height between side "A" and "B".

3.5.4 Bearing blocks

The top bearing block (key 3 in Figure 4) shall have a minimum diameter of 75 mm and shall be larger than the outside diameter of the direct tension indicator.

The bottom bearing block (key 9 in Figure 4) shall be larger than the outside diameter of the corresponding support block, and shall be able to accept the cylindrical boss of the support block (see dimension *c* of Figure 3).

The top and bottom bearing block surfaces shall be parallel to within 0,012 5 mm across the width of the support block.

Top and bottom bearing blocks shall have a minimum Rockwell hardness of 50 HRC.

3.5.5 Calibration

The force-measuring system and the direct reading gauge of the testing apparatus shall be calibrated at least once per year.

The calibration certificates shall be retained.

3.5.6 Test procedure

3.5.6.1 General

The test shall be carried out at an ambient temperature range of 10 °C to 35 °C.

The support block shall be selected corresponding to the nominal size of direct tension indicator to be tested.

3.5.6.2 Zero direct reading gauge

See Step 1 of Figure 4.

The direct tension indicator shall be placed against Side A (see Figure 2) of the support block, with protrusions facing down, into the grooves of the support block.

The support block and direct tension indicator shall be placed into the test apparatus with Side B of the support block seated in the bottom bearing block (key 9 of Figure 4) of the test apparatus.

The direct reading gauge spindle shall be in contact with the centre of the direct tension indicator support block during the test (see Figure 4).

A compression load equal to the minimum required load for the nominal size and property designation (H8 or H10) of the direct tension indicator being tested (see Table 4) shall be applied and, while this load is applied, the direct reading gauge shall be set at zero.

The load shall be released and the support block and direct tension indicator shall be removed from the test apparatus.

The support block shall be inverted so that Side A with the groove is facing down.

3.5.6.3 Measure compression load

See Step 2 of Figure 4.

The flat surface of the same direct tension indicator shall be placed against Side B of the support block with protrusions facing up.

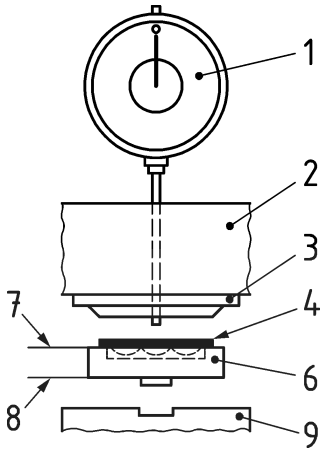
The support block and direct tension indicator shall be placed into the test apparatus with Side A of the support block seated in the bottom bearing block (key 9 in Figure 4) of the test apparatus.

The direct reading gauge spindle shall be in contact with the centre of the direct tension indicator support block during the test (see Figure 4).

During step 2, the compression load shall be applied until the gauge reading is equal to 0,40 mm. The rate of loading shall be of such that the direct tension indicator is compressed within 30 s from the start of the loading until the gauge reading of 0,40 mm is achieved.

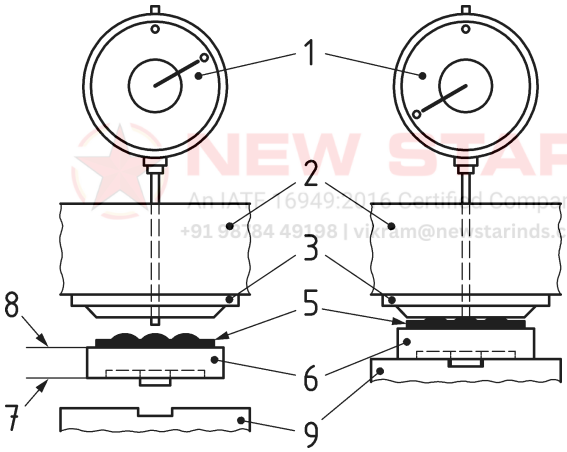
3.5.6.4 Read and record

The compression load corresponding to the gauge reading of 0,40 mm shall be read and the results shall be recorded.



a) Step 1: Zero direct reading gauge

Before compression After compression



b) Step 2: Turn direct tension indicator over, compress to specified gauge reading, and read compression load

Key

1 direct reading gauge
2 machine frame
3 top bearing block
4 direct tension indicator protrusions facing down
5 direct tension indicator protrusions facing up
6 support block
7 side A
8 side B
9 bottom bearing block

Figure 4 — Steps for determining compression load

3.6 Marking of the direct tension indicator

Direct tension indicators shall be marked with the identification mark of the manufacturer of the bolting assembly, and H8 or H10 as appropriate.

The marking shall be indented into the direct tension indicator face from which the protrusions project.

It is recommended to stamp lot number on the face of the direct tension indicator.

3.7 Designation of the direct tension indicator

When designating for the purpose of an enquiry or order, the following information shall be given:

a) general product description for direct tension indicators, DTI;

b) the associated nominal bolt diameter (M12, etc.);

c) DTI property designation “H8” or “H10” as appropriate;

d) the number of this European Standard, EN 14399-9;

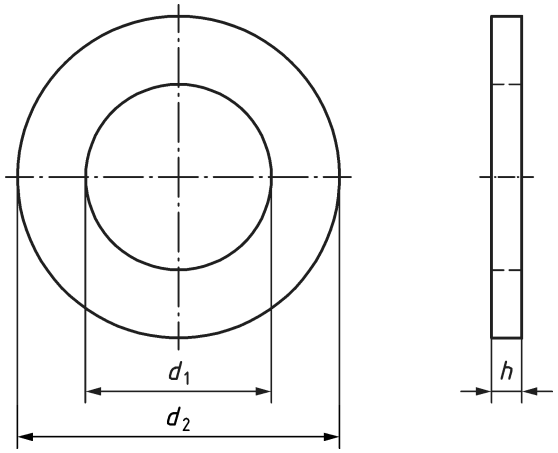
e) the coating, if any, and the relevant European Standard.

EXAMPLE DTI EN 14399–9 — M12 – sherardized EN ISO 17668, class 30

4 Nut face washers (HN) and bolt face washers (HB)

4.1 Dimensions

The dimensions and tolerances of nut face washers (HN) and bolt face washers (HB) shall be as specified in Table 6 and Table 7 and Figure 5 and Figure 6.



Key

d_1 internal diameter

d_2 external diameter

h thickness

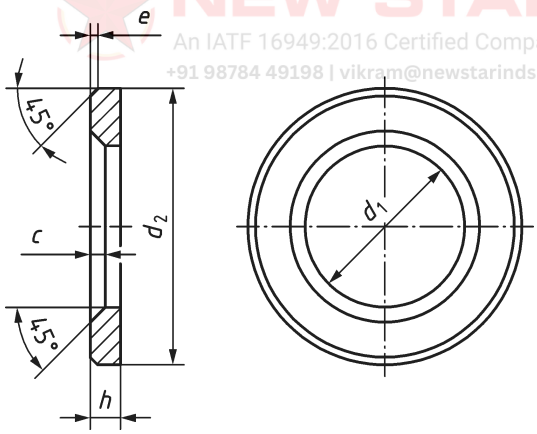
Figure 5 — Dimensions of nut face washers (HN)

Table 6 — Dimensions of nut face washers (HN)

Dimensions in millimetres

Nominal size d (nominal thread diameter of associated bolt)	Internal diameter d_1		External diameter d_2		Thickness h	
	min.	max.	min.	max.	min.	max.
M12	12,1	12,35	22,7	24	2,7	4,3
M16	16,1	16,35	27,7	29	3,7	4,3
M20	20,1	20,40	34,4	36	3,7	4,3
M22	22,3	22,60	37,4	39	3,7	4,3
M24	24,2	24,50	41,4	43	3,7	4,3
M27	27,2	27,55	46,4	48	4,4	5,6
M30	30,2	30,55	50,1	52	4,4	5,6
M36	36,2	36,55	60,1	62	5,4	6,6

NOTE The washers are intended to fit over the threaded portion of the shank only. In some cases the washer internal diameter, d_1, is less than the bolt shank maximum diameter specified in EN 14399–3 and EN 14399–4.



Key

d_1 internal diameter
d_2 external diameter
h thickness
c inside chamfer
e outside chamfer

Figure 6 — Dimensions of bolt face washers (HB)

Table 7 — Dimensions of bolt face washers (HB)

Dimensions in millimetres

Nominal size d (nominal thread diameter of associated bolt)	Internal diameter d_1		External diameter d_2		Thickness h		Inside chamfer c		Outside chamfer e	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
M12	13	13,27	23,48	24	2,7	3,3	1,6	1,9	0,50	1,0
M16	17	17,27	29,48	30	3,7	4,3	1,6	1,9	0,75	1,50
M20	21	21,33	36,38	37	3,7	4,3	2,0	2,5	0,75	1,50
M22	23	23,33	38,38	39	3,7	4,3	2,0	2,5	0,75	1,50
M24	25	25,33	43,38	44	3,7	4,3	2,0	2,5	0,75	1,50
M27	28	28,52	49	50	4,4	5,6	2,5	3,0	1,0	2,0
M30	31	31,62	54,80	56	4,4	5,6	2,5	3,0	1,0	2,0
M36	37	37,62	64,80	66	5,4	6,6	2,5	3,0	1,25	2,50

4.2 Specifications and reference standards for nut face washers (HN) and bolt face washers (HB)

The specifications and reference standards specified in Table 8.

Table 8 — Specifications and reference standards for nut face washers (HN) and bolt face washers (HB)

Material		Steel
General requirements		EN 14399–1 and EN 14399–2
Heat treatment		hardened and tempered
Hardness [a]	Rockwell hardness	38 HRC to 45 HRC
	European Standard	EN ISO 6508-1
	Vickers hardness	372 HV30 to 448 HV30
	European Standard	EN ISO 6507-1
Tolerances	Product grade	C [b]
	Standard	EN ISO 4759-3
Finish — Coating [c]	Uncoated	as processed [d]
	Sherardized	EN ISO 17668
	Others	to be agreed [e]
Associated bolts and nuts		EN 14399–3, EN 14399–4, EN 14399–7 or EN 14399–8
Associated washers		EN 14399–5 or EN 14399–6
Acceptability		For acceptance procedure, see EN ISO 3269:2000.

[a] In case of dispute, the Vickers hardness test shall be the referee test method.

[b] Except as otherwise specified in Tables 6 and 7.

[c] These washers shall not be electroplated or subjected to any process that could result in hydrogen embrittlement.

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

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

4.3 Marking

4.3.1 Nut face washers (HN)

Nut face washers (HN) shall be marked with the identification mark of the manufacturer of the bolting assembly and the letters HN. The marking shall be indented into one face.

4.3.2 Bolt face washers (HB)

Bolt face washers (HB) shall be marked with the identification mark of the manufacturer of the bolting assembly and the letters HB. The marking shall be indented into one face.

4.4 Designation of nut face washers (HN) and bolt face washers (HB)

Example 1: A nut face washer (HN) for high-strength structural bolting assemblies, of nominal size d = 20 mm, sherardized, is designated as follows:

Washer HN EN 14399–9 — M20 sherardized EN ISO 17668, class 30

Example 2: A bolt face washer (HB) for high-strength structural bolting assemblies, of nominal size d = 20 mm, as processed, is designated as follows:

Washer HB EN 14399–9 — M20

5 Functional characteristics

5.1 Bolting assemblies

Bolting assemblies according to this document consist of bolts and nuts which shall meet all the requirements of EN 14399-3, EN 14399-4, EN 14399-7 or EN 14399-8.

The functional characteristics of the bolting assemblies shall be achieved when tested together with direct tension indicators; the assembly may include washers according to EN 14399-6 or EN 14399-5 (under the nut only) and/or nut face washers (HN) or bolt face washers (HB) in accordance with Clause 4.

The assembly configurations which can be used with direct tension indicators shall be according to Figures 7 and 8.

Used with bolting assemblies in accordance with EN 14399-7, the direct tension indicator can only be fitted under the nut.

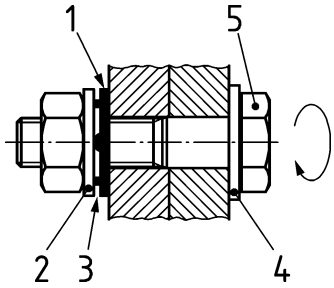
a) DTI under bolt head **b) DTI under nut**

Key

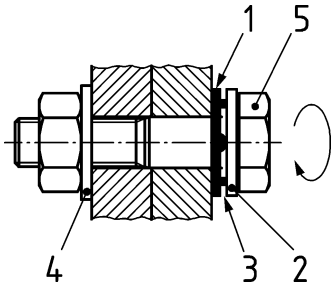
1 direct tension indicator
2 bolt face washer (HB) (not required for property class 8.8)
3 gap
4 washer in accordance with EN 14399-5 or EN 14399-6
5 turned component

1 direct tension indicator
2 nut face washer (HN)
3 gap
4 washer in accordance with EN 14399-6 (not required for property class 8.8)
5 turned component

Figure 7 — Tightening of the assembly by turning the nut



a) DTI under nut



b) DTI under bolt head

Key

1 direct tension indicator
2 nut face washer (HN)
3 gap
4 washer in accordance with EN 14399-6
5 turned component

1 direct tension indicator
2 bolt face washer (HB)
3 gap
4 washer in accordance with EN 14399-5 or EN 14399-6 (not required for property class 8.8)
5 turned component

Figure 8 — Tightening of the assembly by turning the bolt

5.2 Functional characteristics of direct tension indicators in the assembly

A feeler gauge as specified in Table 9 shall be used to determine that the minimum preload has been achieved, when the bolting assembly is tightened to the specified gap.

Table 9 — Thickness of the feeler gauge

Dimensions in millimetres

Direct tension indicator positions	Thickness of feeler gauge for H8 and H10
Under bolt head, when nut is turned (Figure 7a)	0,40
Under nut, when bolt is turned (Figure 8a)	
Under nut, when nut is turned (Figure 7b)	0,25
Under bolt head, when bolt is turned (Figure 8b)	

NOTE Tests have shown the need for a smaller gap when the direct tension indicator is used under the turned component.

The specified indicator gap shall be determined using the following measurement procedure; the feeler gauge shall be used as a “no go” inspection tool. The feeler gauge shall be pointed at the centre of the bolt (see Figure 9) and shall refuse to enter the number of feeler gauge refusals specified in Table 10.

Table 10 — Feeler gauge requirements

Number of indicator protrusions	Minimum number of feeler gauge refusals
4	3
5	3
6	4
7	4
8	5
9	5

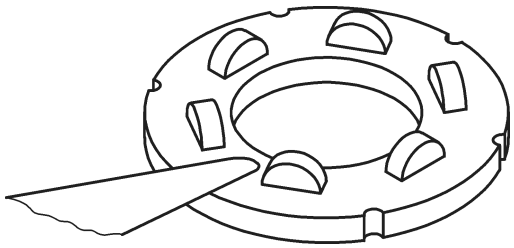


Figure 9 — Checking the indicator gap (example with six protrusions)

5.3 Functional characteristics of bolting assemblies with direct tension indicator

5.3.1 General

The functional characteristics of the bolting assembly (comprising of a bolt, a nut, a direct tension indicator and applicable washers, as required) shall be achieved when tested in accordance with the following.

The principle of the test is to tighten the bolting assembly and to measure, during tightening, the following parameters:

— the relative rotation between the nut and the bolt;

— the bolt force.

This test procedure is based on the requirements according to EN 14399-2 and incorporates requirements applicable to assemblies which include direct tension indicators; where necessary special testing conditions and procedures according to EN 14399-2:2015, Annex A may be applied.

5.3.2 Suitability test procedures

5.3.2.1 For preloading with direct tension indicator in a bolting assembly

Direct tension indicators conforming to EN 14399-9 are suitable according to EN 14399-2 provided they are used in bolting assemblies, comprised of matched components in accordance with Table 1 and with EN 14399-3, EN 14399–4, EN 14399–7 or EN 14399–8, that have been tested in accordance with EN 14399-2 to determine the relative rotation between the bolt and nut.

The *k*-class shall be declared as K0.

Type tests shall be carried out separately for the direct tension indicator under the bolt head and under the nut. The type test shall be used to demonstrate that $\Delta\theta_2$ measured with assemblies incorporating a direct tension indicator exceeds the appropriate $\Delta\theta_{2,\,min}$, by at least 10 %.

5.3.2.2 For verifying of the number of feeler gauge refusals

The test shall be carried out in a calibrated load cell as specified in EN 14399-2, except that the use of hydraulic measuring devices is permitted. If shims are required to adjust the length between bolt head and nut, these shall be used as specified in EN 14399-2. During the bolt force test the stiffness of the test equipment on which the assembly is mounted is not critical.

The components shall be assembled in accordance with Figure 7a, horizontally. The test shall be conducted by turning of the nut.

Step 1: The assembly shall be tightened to the required minimum compression load specified in Table 4; the gap shall be determined using a feeler gauge as specified in Table 9, the number of feeler gauge refusals shall be less than the minimum number of feeler gauge refusals as specified in Table 10.

Step 2: The assembly shall be further tightened to the required maximum compression load specified in Table 4; the gap shall be determined using a feeler gauge as specified in Table 9, the number of feeler gauge refusals shall be equal to or more than the minimum number of feeler gauge refusals as specified in Table 10.

Annex A
(informative)

Use of structural bolting assemblies for preloading with direct tension indicators

A.1 General

This annex gives recommendations for the installation and inspection of structural bolting assemblies for preloading using direct tension indicators. The use of bolting assemblies fitted with direct tension indicators and the tightening procedure should be in accordance with EN 1090-2.

A.2 Bolting assembly configurations

A.2.1 Tightening by turning the nut

Direct tension indicators are generally fitted under the bolt head and the bolting assembly is generally tightened by turning of the nut, as shown in Figure A.1 a). Limited access to the bolt head for the purposes of inspecting the direct tension indicator gap may require the direct tension indicator to be fitted under the nut. If used in this manner the appropriate nut face washer (HN) is fitted between the direct tension indicator protrusions and the nut (Figure A.1 b)).

a) DTI under bolt head, before tightening

b) DTI under nut, before tightening

Key

1 direct tension indicator
2 bolt face washer (HB) (not required for property class 8.8)
3 gap
4 washer in accordance with EN 14399–5 or EN 14399–6
5 turned component

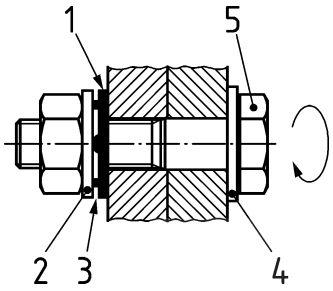
1 direct tension indicator
2 nut face washer (HN)
3 gap
4 washer in accordance with EN 14399–6 (not required for property class 8.8)
5 turned component

Figure A.1 — Tightening of the assembly by turning the nut (usual method of assembly)

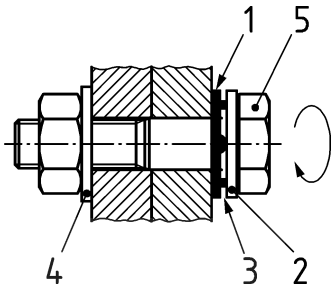
A.2.2 Tightening by turning the bolt

Conditions of limited access may require the bolting assembly to be tightened by turning the bolt head. In this case a nut face washer (HN) is fitted between the direct tension indicator protrusions and the bearing surface of the nut as shown in Figure A.2 a).

If there is limited space for positioning of the bolting assembly, combined with limited access for inspection of the direct tension indicator gap, it may be necessary to fit the direct tension indicator under the bolt head and to tighten the bolting assembly by turning the bolt head. In this case a bolt face washer (HB) is fitted between the direct tension indicator protrusions and the bearing surface of the bolt head (see Figure A.2 b)).



a) DTI under nut, before tightening



b) DTI under bolt head, before tightening

Key

1 direct tension indicator
2 nut face washer (HN)
3 gap
4 washer in accordance with EN 14399–6
5 turned component

1 direct tension indicator
2 bolt face washer (HB)
3 gap
4 washer in accordance with EN 14399–5 or EN 14399–6 (not required for property class 8.8)
5 turned component

Figure A.2 — Tightening of the assembly by turning the bolt (alternative method of assembly)

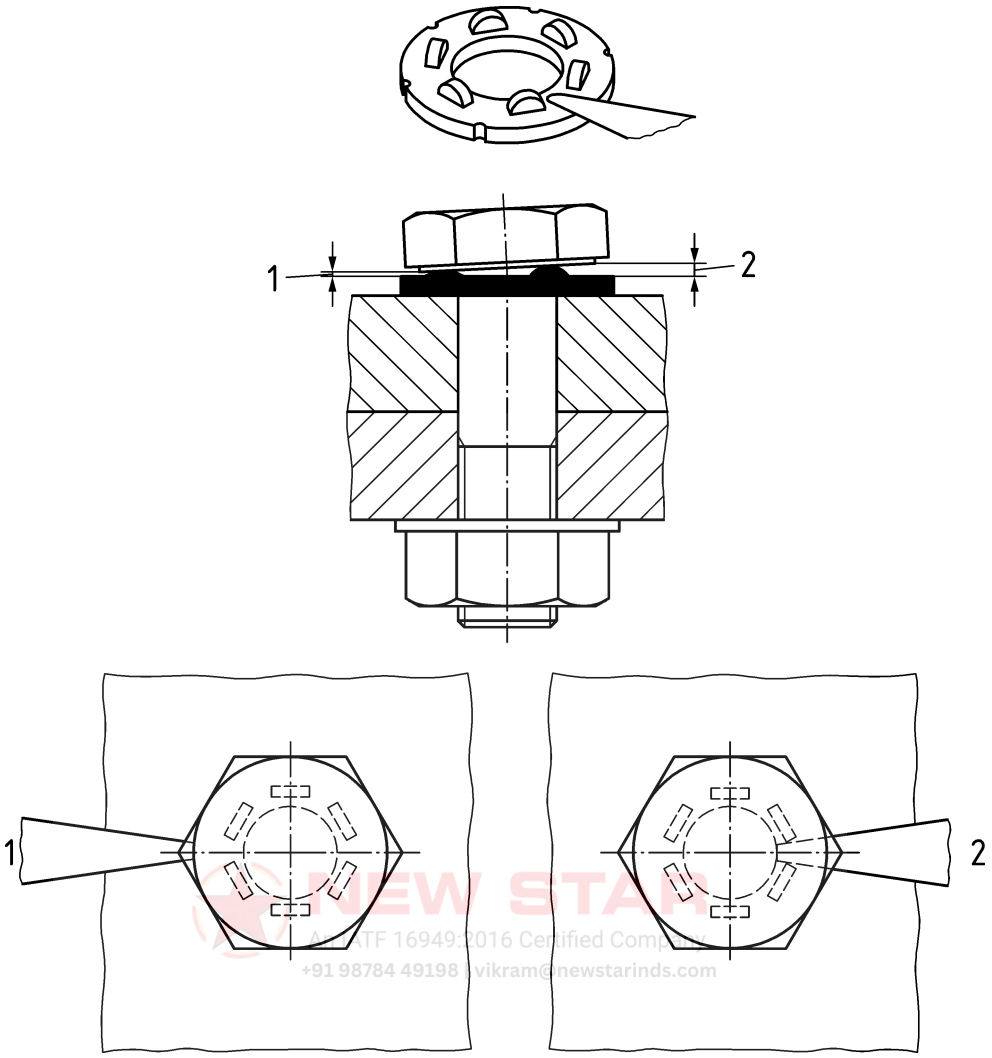
A.3 Checking

A feeler gauge as specified in Table A.1 should be used to determine whether the direct tension indicator has compressed in accordance with the requirements of this standard.

Table A.1 — Thickness of the feeler gauge

Dimensions in millimetres

Direct tension indicator positions	Thickness of feeler gauge for H8 and H10
Under bolt head, when nut is turned (Figure A.1 a)	0,40
Under nut, when bolt is turned (Figure A.2 a)	
Under nut, when nut is turned (Figure A.1 b)	0,25
Under bolt head, when bolt is turned (Figure A.2 b)	



Key

1 "No go" gap if refusal occurs

2 "Go" gap if refusal does not occur

Figure A.3 — Checking the indicator gap (example with six protrusions)

The direct tension indicator has been compressed sufficiently when the number of feeler gauge refusals meets the requirement given in Table A.2.

Table A.2 — Feeler gauge requirements

Number of indicator protrusions	Number of feeler gauge refusals	
	min.	max.
4	3	4
5	3	5
6	4	6
7	4	7
8	5	8
9	5	9

Bibliography

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

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

[3] EN 14399-10, *High-strength structural bolting assemblies for preloading — Part 10: System HRC — Bolt and nut assemblies with calibrated preload*

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