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To the members of
Technical committee: FME/9
Bolts, nuts and accessories

Draft Resolution C3/2008 Adoption of prEN 14399-9 for formal vote

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

The Secretariat of CEN/TC 185 proposes the adoption of the attached draft Resolution C3/2008 on the adoption of prEN 14399-9 as given in document N 272 for formal vote.

Please inform me of your vote on the attached draft Resolution C3/2008 a by NO LATER than

19th June 2008

The UK vote has to be one of the following:

- Agrees
- Disagrees
- Abstains

Responses by e-mail are now essential.

Yours sincerely,

SUE BARDEN
Programme Manager
Secretary to FME/9

CEN/TC 185 N 272

CEN/TC 185
Fasteners
E-mail of Secretary: tim.hofmann@din.de
Secretariat: DIN

prEN 14399-9 for adoption for formal vote

Date of document	2008-05-21
Expected action	Info

Background

NOTE:

This document was finalized for formal vote by CEN/TC 185/WG 6 on 2008-04-08.

CEN/TC 185 is requested to vote on the adoption of this document for the 2-months formal vote (see document N 273).

CEN/TC 185

Date: 2008-04

prEN 14399-9:2008

CEN/TC 185

Secretariat: DIN

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

Hochfeste planmäßig vorspannbare Schraubenverbindungen für den Metallbau — Teil 9: System HR oder HV - Direkte Kraftanzeiger für Garnituren aus Schrauben und Muttern

Boulonnerie de construction métallique à haute résistance apte à la précontrainte - Partie 9 : Système HR ou HV - Rondelles indicatrices de précontrainte pour les boulons

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Foreword

This document (prEN 14399-9:2008) has been prepared by Technical Committee CEN/TC 185 “Fasteners”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

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*

Introduction

This part of this European Standard is part of a series of European Standards EN 14399 parts 1 to 10 which specify high-strength structural bolting for preloading; this part belongs to both systems, HR and HV. Direct tension indicators (known formerly as load indicating washers) used in conjunction with bolt and nut face washers are a load indicating device 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 the magnitude of the preload in the assembly.

Direct tension indicators are only to be sold as part of a complete assembly that comprises bolts and nuts and that otherwise complies with EN 14399-3, -4, -7 or -8. The systems of bolt/nut/washer assemblies is described in Table 1.

Table 1 — Systems of bolt/nut/washer assemblies

	Bolt/nut/washer assembly System HR		Bolt/nut/washer assembly System HV
General requirements	EN 14399-1		
Bolt/nut assembly	EN 14399-3 or prEN 14399-7		EN 14399-4 or prEN 14399-8
Marking	HR		HV
Property classes	8.8/8 or 8.8/10	10.9/10	10.9/10
Washers	EN 14399-5 or EN 14399-6		EN 14399-5 or EN 14399-6
Marking	H		H
Direct tension indicator	EN 14399-9		
Marking	H8	H10	H10
Suitability test for preloading	EN 14399-2		EN 14399-2

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 hot dip galvanizing or other surface coatings of the assembly are under the control of one manufacturer.

Beside the mechanical properties of the components, the functionality of the assembly requires that the specified preload can be achieved when the average gap remaining after tightening (compressed protrusions) is less than the specified values in this standard, if the assembly is tightened with a suitable procedure. The test method given in this standard has been developed to demonstrate the suitability of the components for preloading.

1 Scope

This document specifies, together with EN 14399-1, the requirements for assemblies of high-strength structural bolts and nuts, with large width across flats, of system HR or HV, including the requirements for the general dimensions, tolerances, materials and performance for two grades, H8 and H10, of compressible washer-type direct tension indicators, nut face washers and bolt face washers suitable for preloaded joints. The assemblies include the nominal thread sizes M12 up to and including M36 and property classes 8.8/8, 8.8/10 and 10.9/10.

Bolt and nut assemblies to 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 according to EN 14399-3 or by plastic deformation of the engaged threads for system HV according to EN 14399-4; also countersunk and fit bolts according to EN 14399-7 and -8 respectively.

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

The purpose of the direct tension indicators is to show that a defined preload is achieved in the bolt. The direct tension indicator can be used alone or with bolt face washers or nut face washers conforming to this standard.

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

In either case the direct tension indicators shall be used as part of an assembly in accordance with EN 14399-1.

To comply with EN 14399-1, the assemblies shall be supplied by one manufacturer include bolts, nuts, washers and direct tension indicators.

NOTE 1 Attention is drawn to the importance of ensuring that the assemblies are correctly used if satisfactory results are to be obtained.

The test method for suitability for preloading is specified in EN 14399-2 and supplemented by Clause 5.

Guidance on the use of compressible washer-type direct tension indicators is given in prEN 1090-2.

NOTE 2 Compressible washer-type direct tension indicators are also known as load indicating washers.

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.

prEN 1090-2, *Execution of steel structures and aluminium structures — Part 2: Technical requirements for the execution of steel structures*

EN 1993-1-1, *Eurocode 3, Design of steel structures — Part 1-1: General rules and rules for buildings*

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

EN 10204, *Metallic products — Types of inspection documents*

EN 13811, *Sherardizing — Zinc diffusion coatings on ferrous product — Specification*

EN 14399-1:2005, *High-strength structural bolting for preloading — Part 1: General requirements*

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

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

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

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

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

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

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

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

EN ISO 4759-3, *Tolerance for fasteners — Part 3: Plain washers for bolts, screws and nuts — Product grades A and C*

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

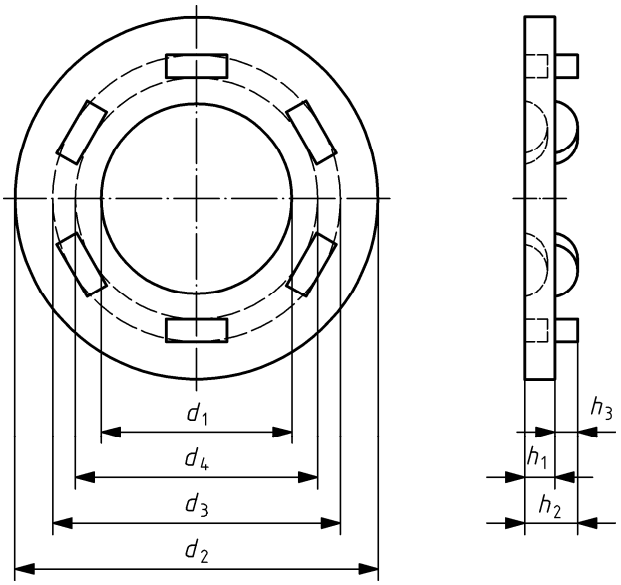
EN ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

3 Direct tension indicators

3.1 Dimensions

Before installation, the dimensions and tolerances of compressible washer-type direct tension indicators shall be as given in Table 2 and Figure 1. The size and number of protrusions on the direct tension indicator shall be sufficient to meet the performance requirements of 3.3 and their number shall be not less than four. The protrusions on a direct tension indicator shall be spaced at equal angular intervals. The shape of the protrusions is at the discretion of the manufacturer.



Key

d_1 Internal diameter
d_2 External diameter
d_3 Protrusion tangential diameter
d_4 Protrusion internal diameter
h_1 Material thickness
h_2 Height over protrusions
h_3 Height of protrusions

Figure 1 — Dimensions of compressible washer-type direct tension indicator (example with six protrusions)

Table 2 — Dimensions of compressible washer-type direct tension indicator

Dimensions in millimetres

For use with bolts of designation	Internal diameter d_1		External diameter d_2		Material thickness h_1	Height over protrusions h_2	Height of protrusions h_3	Protrusion tangential diameter d_3	Protrusion internal diameter d_4
	min.	max.	min.	max.	min.	max.	min.	max.	min.
M12	12,75	12,85	26,0	32,5	2,50	5,50	0,80	20	13,85
M16	16,75	16,85	35,0	36,8	3,00	6,00	0,80	25	17,85
M20	20,95	21,05	41,0	46,0	3,50	6,50	0,80	29	22,05
M22	23,05	23,15	46,5	50,6	4,00	7,00	0,80	33	24,15
M24	25,15	25,25	50,0	55,2	4,00	7,00	0,80	38	26,25
M27	28,30	28,40	54,0	62,1	4,00	7,00	0,80	43	29,40
M30	31,45	31,55	59,0	69,0	4,00	7,00	0,80	46,5	32,55
M36	37,75	37,85	78,0	83,0	4,00	7,50	0,80	56	38,85

3.2 Specifications and reference standards

The specifications and reference standards are given in Table 3.

Table 3 — Specifications and reference standards

Material		Steel
General requirements		EN 14399-1
Heat treatment		hardened and tempered or controlled rolled and tempered
Maximum hardness		380 HV
Surface finish[a]	normal	as processed[c]
	sherardized[b]	EN 13811
	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[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 No 0; see EN ISO 3269:2000, Tables 5 and 6.

3.3 Performance test of direct tension indicators

The direct tension indicators shall be tested on a calibrated load-measuring device, see 3.4 for the test procedure. The load requirement of Table 4 shall be met when the direct tension indicators are compressed to the average gaps given in Table 9.

Samples of direct tension indicators shall be tested by the manufacturer after the final production process including the surface finish, if any. Instead of five tests according to EN 14399-1:2005, 6.2.5.2, the minimum number of direct tension indicators tested per manufacturing lot shall be eight and all samples shall pass the test.

Table 4 — Indicator compression loads at appropriate gap (see Table 9)

Load in kN

For use with bolts of designation	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
These minimum values are equal to 0,7 f_{ub} × A_s in accordance with EN 1993-1-1.				

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

3.4.1 General

This test method is for the measurement of compressive loads developed with direct tension indicators. The method involves a pressing/flattening operation to remove variations due to the manufacturing process which is followed by measurement of the compression load when the protrusions are deformed to the specified gap.

3.4.2 Testing apparatus

Testing apparatus shall include a compression loading system, top and bottom bearing blocks, and support blocks that allow each direct tension indicator to be measured using a direct reading gauge.

The testing apparatus shall be in accordance with EN ISO 7500-1 and shall be at least class 1.

The direct reading gauge of the testing apparatus shall be capable of measuring the gap variation to within 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 performance.

3.4.3 Compression loading system

The compression loading system shall transmit a compressive load axially from the testing apparatus to the direct tension indicator. The bottom bearing block of the loading system shall be able to accept the cylindrical protrusions of the direct tension indicator support blocks.

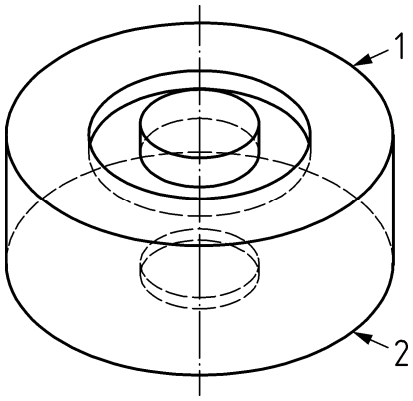
3.4.4 Support blocks

Support blocks 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 thickness 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 react on 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.

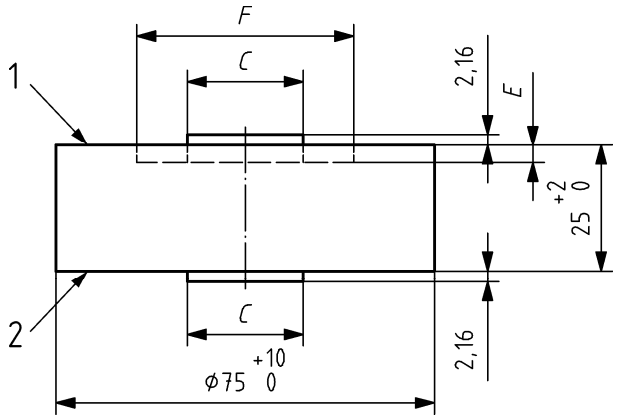


Key

1 Side A
2 Side B

Figure 2 — Support block

Dimensions in millimeters



Key

1 Side A
2 Side B

Figure 3 — Support block dimensions

Table 5 — Support block dimensions

Dimensions in millimetres

For use with bolts of designation	*C*		*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
NOTE Height of boss = 2,16 mm ± 0,0125 mm with no more than 0,005 mm difference in height between side "A" and "B".					

3.4.5 Bearing blocks

The upper bearing block shall have a minimum diameter of 75 mm and shall be larger than the outside diameter of the direct tension indicator.

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

The upper and bottom bearing block surfaces shall be parallel to within 0,0125 mm across the width of the support block.

3.4.6 Calibration

The testing apparatus and its direct reading gauge shall be calibrated at least once per year.

The calibrated test data shall be retained.

3.4.7 Test Procedure

3.4.7.1 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 size and type of direct tension indicator to be tested.

3.4.7.2 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 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 size and type of direct tension indicator being tested (see Table 4) shall be applied and whilst 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.

3.4.7.3 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.

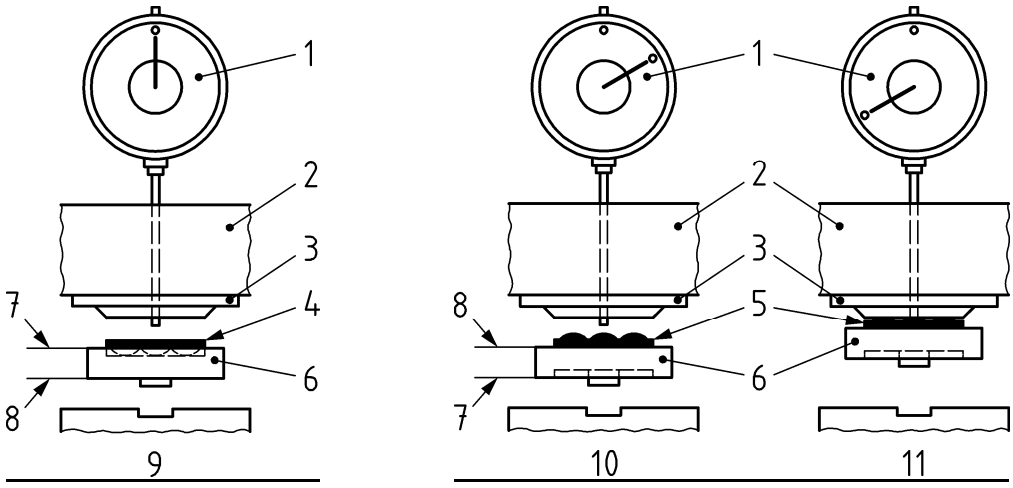
The support block and direct tension indicator shall be placed into the test apparatus with Side A of the support block seated in the bottom bearing block of the test apparatus.

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).

The compression load shall be applied until the gauge reading is equal to the gap of 0,40 mm. The compression load shall be applied at such a rate that the direct tension indicator is compressed within 30 s from the time the compression load is first applied until the 0,40 mm gap is achieved.

3.4.7.4 Read and record

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



Step 1

Zero direct reading gauge

Step 2

Turn direct tension indicator over compress to test gap and read compression load

Key

1 Direct reading gauge
2 Test frame
3 Bearing block
4 Protrusion facing down
5 Protrusion facing up
6 Support block
7 Side A
8 Side B
9 Bottom bearing block
10 Bottom bearing block before compression
11 Bottom bearing block after compression

Figure 4 — Steps for determining compression load

3.5 Marking of the direct tension indicator

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

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

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

3.6 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, i.e. direct tension indicators;

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

c) H8 or H10 as appropriate;

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

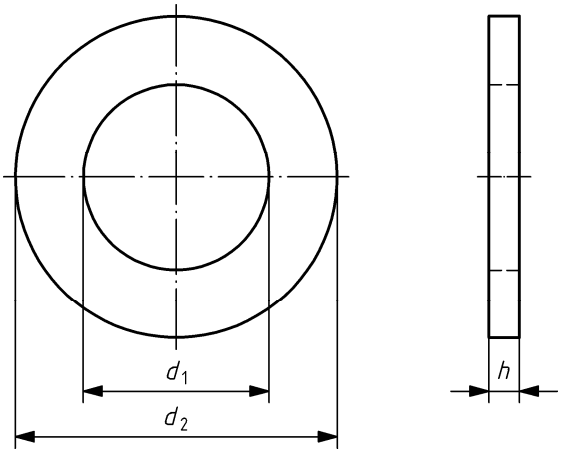
e) details of coating (if required), and the relevant European Standard.

EXAMPLE Direct tension indicator, M12, H8 of EN 14399-9, sherardized to EN 13811 – class 30

4 Nut face washers and bolt face washers

4.1 Dimensions

The dimensions and tolerances of nut face washers and bolt face washers shall be as given in Tables 6 and 7 and Figures 5 and 6.



Key

d_1 Internal diameter
d_2 External diameter
h Thickness

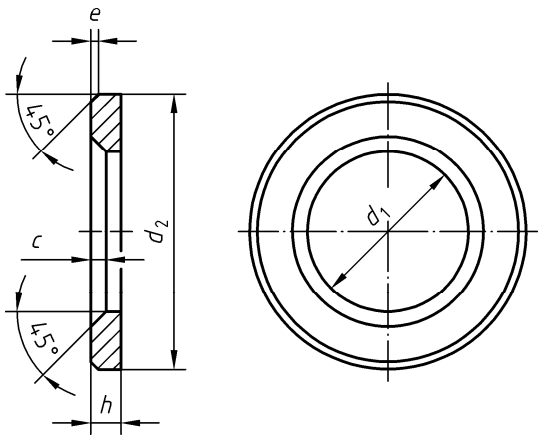
Figure 5 — Dimensions of nut face washers

Table 6 — Dimensions of nut face washers

Dimensions in millimetres

For use with bolts of designation	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

Table 7 — Dimensions of bolt face washers

Dimensions in millimetres

For use with bolts of designation	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 and bolt face washers

The specifications and reference standards are given in Table 8.

Table 8 — Specifications and reference standards

Material		Steel
General requirements		EN 14399-1
Heat treatment		hardened and tempered
Hardness alternatives[a]	Rockwell hardness	38 HRC to 45 HRC
	Standard	ISO 6508-1
	Vickers hardness	372 HV_{30} to 448 HV_{30}
	Standard	ISO 6507-1
Tolerances	Product grade	C[b]
	Standard	ISO 4759-3
Surface finish[c]	normal	as processed[d]
	sherardized	EN 13811
	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.

[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

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

4.3.2 Bolt face washers

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

4.4 Designation

4.4.1 Nut face washers

A nut face washer, nominal size d = 20 mm, for high-strength structural bolting, sherardized, is designated as follows:

Washer HN, M20, EN 14399-9, sherardized to EN 13811 class 30

4.4.2 Bolt face washers

A bolt face washer, nominal size d = 20 mm, for high-strength structural bolting, sherardized, is designated as follows:

Washer HB, M20, EN 14399-9, sherardized to EN 13811 class 30

5 Functional characteristics

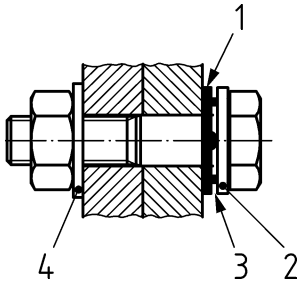
5.1 Assemblies

Bolt and nut 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 bolt/nut/washer(s) assembly 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 or bolt face washers in accordance with Clause 4.

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

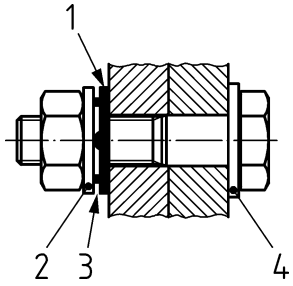
NOTE With EN 14399-7 the direct tension indicator can only be fitted under the nut of the assembly.



a) under bolt head fitting

Key

1 Direct tension indicator
2 Bolt face washer (not required for property class 8.8)
3 Gap
4 Washer according to EN 14399-5 or -6

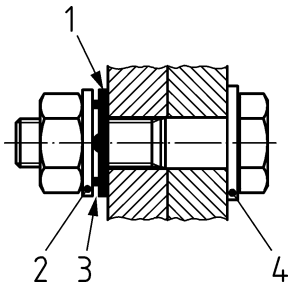


b) under nut fitting

Key

1 Direct tension indicator
2 Nut face washer
3 Gap
4 Washer according to EN 14399-6 (not required for property class 8.8)

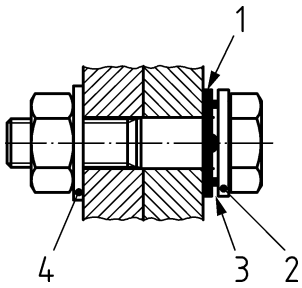
Figure 7 —Tightening of the assembly by rotation of the nut



a) under nut fitting

Key

1 Direct tension indicator
2 Nut face washer
3 Gap
4 Washer according to EN 14399-6



b) under bolt head fitting

Key

1 Direct tension indicator
2 Bolt face washer
3 Gap
4 Washer according to EN 14399-5 or -6 (not required for property class 8.8)

Figure 8 —Tightening of the assembly by rotation of the bolt head

5.2 Functional characteristics of direct tension indicators in the assembly

A specified feeler gauge, see Table 9, shall be used to determine that the required bolt preload has been achieved by the assembly.

Table 9 — Thickness of the feeler gauge

Dimensions in millimetres

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

NOTE Tests have shown the need for a smaller gap when the direct tension indicator is used under the rotated component. Direct tension indicators fitted as specified will result in the same loads being attained when the bolts are tightened to the specified gaps.

The average 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 refusal spaces 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

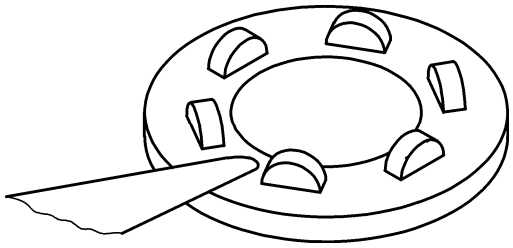


Figure 9 — Checking the indicator gap (example with six protrusions)

5.3 Functional characteristics of the bolt/nut/washer(s)/direct tension indicator assembly

5.3.1 General

The functional characteristics of the bolt/nut/washer(s)/direct tension indicator assembly shall be achieved when tested in accordance with the following.

The principle of the test is to tighten the bolt/nut/washer(s)/direct tension indicator 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 Annex A may be applied.

5.3.2 Test procedure

5.3.2.1 Suitability test for preloading with direct tension indicator in an assembly

Direct tension indicators conforming to EN 14339-9 are suitable according to EN 14399-2 provided they are used in an assembly that includes fasteners in accordance with EN 14399-3, -4, -7 or -8 that have been tested in accordance with EN 14399-2 to determine the relative rotation between the bolt and nut. The k-class values shall not be determined for K1 or K2 and shall be declared K0.

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

5.3.2.2 Suitability test for establishing bolt force

The test shall be carried out in a calibrated load cell with the requirements generally as specified in EN 14399-2. 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.

NOTE Hydraulic measuring devices should meet this requirement.

The assembly shall be assembled in accordance with Figure 7a, horizontally; the bolt force (F_{bi}) shall be determined in accordance with 5.2 and not be less than the minimum bolt force specified in Table 4.

Annex A
(informative)

Special testing conditions and procedures

By agreement between the supplier and the purchaser, the following special conditions may be applied. However, the test results obtained are not comparable with those for the standard test conditions:

a) Long bolts:

For the evaluation of bolts of a length > 10 d special evaluation criteria for rotation or deformation should be agreed.

b) Short bolts:

When the bolts are too short to meet the testing conditions defined in EN 14399-2:2005, Clause 8, one of the following possibilities may be considered:

1) The bolts may be tested provided that one thread pitch exists after tightening between the end of the bolt and the unloaded face of the nut.

2) Longer bolts from an otherwise similar lot may be tested using the standard test conditions. The difference in length should be as small as practicable.

c) Lubrication:

The as-delivered lubrication may be altered.

d) Tightening:

1) The speed of rotation may be altered.

2) Tightening by rotation of the head of the bolt may be carried out.

3) Discontinuous tightening may be carried out.