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

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Schrauben und Muttern

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

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EN 14399-9:2009 (E)**Foreword**

This document (EN 14399-9:2009) 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of an identical text or by endorsement, at the latest by September 2009, and conflicting national standards shall be withdrawn at the latest by September 2011.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 document is part of 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 are 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 EN 14399-7		EN 14399-4 or EN 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
Bolt/nut face washer	EN 14399-9		
Marking	HB/HN		HB/HN
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.

EN 14399-9:2009 (E)**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 1993-1-8:2005 (*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. In either case it is essential that the direct tension indicators are used as part of an assembly in accordance with EN 14399-1.

To comply with EN 14399-1, it is essential that the assemblies are supplied by one manufacturer and 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 EN 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.

EN 13811, *Sherardizing – Zinc diffusion coatings on ferrous products – Specification*

EN 14399-1:2005, *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, *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*

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

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 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: Plain washers for bolts, screws and nuts – Product grades A and C (ISO 4759-3:2000)*

EN ISO 6507-1, *Metallic materials – Vickers hardness test – Part 1: Test method (ISO 6507-1:2005)*

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 6508-1:2005)*

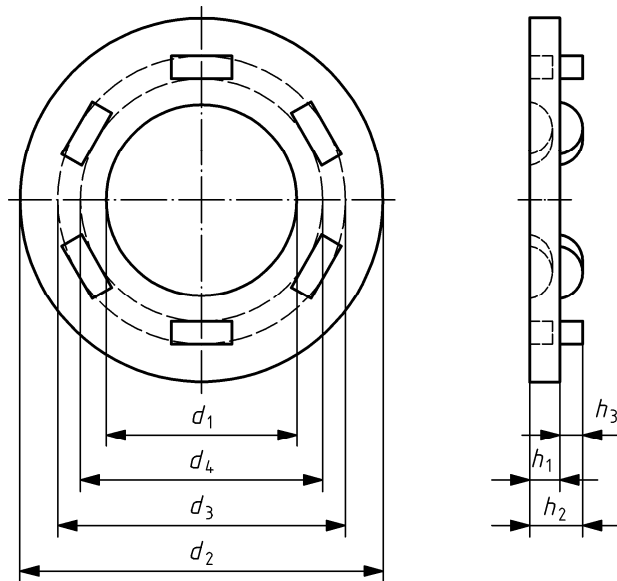
EN ISO 7500-1, *Metallic materials – Verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Verification and calibration of the force-measuring system (ISO 7500-1:2004)*

3 Direct tension indicators

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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

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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		External diameter		Material thickness	Height over protrusions	Height of protrusions	Protrusion tangential diameter	Protrusion internal diameter
	d_1		d_2		h_1	h_2	h_3	d_3	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 3269:2000 ^e .	
<p>^a The direct tension indicators shall not be electroplated or subjected to any process that could result in hydrogen embrittlement.</p> <p>^b Sherardizing is considered to provide corrosion protection equivalent to hot dip galvanizing.</p> <p>^c "As processed" means the normal finish resulting from manufacture with a light oil coating.</p> <p>^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.</p> <p>^e For acceptance criteria use 0,65 AQL, Ac No 0; see EN ISO 3269:2000, Tables 5 and 6.</p>		

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.