

HIGH-STRENGTH STRUCTURAL BOLTING ASSEMBLIES FOR PRE-LOADING

BS EN 14399 PART 3,4,5,6,9

CE



HIGH-STRENGTH STRUCTURAL BOLTING ASSEMBLIES FOR PRELOADING

INTRODUCTION

Structural bolting in Europe comprises two technical solutions to achieve the necessary ductility of bolt/nut/washer assemblies. These solutions utilize different systems (HR and HV) of bolt/nut/washer assemblies, see table below. Both systems are well proved and it is up to the experts responsible for structural bolting whether they use the one or the other system.

It is, however, important for the performance of the assembly to avoid mixing up the components of both systems. Therefore, the bolts and nuts for both systems are standardized in one single part of this European Standard each and the marking of the components of the same system is uniform.

	Bolt/Nut/Washer Assembly System HR		Bolt/Nut/Washer Assembly System HV
General Requirements	EN 14399-1		
Bolt/Nut Assembly	EN 14399-3		EN 14399-4
Marking	HR		HV
Property Class	8.8/8	10.9/10	10.9/10
Washer(s)	EN 14399-5 or EN 14399-6		EN 14399-5 or EN 14399-6
Marking	H		H
Suitability Test for Preloading	EN 14399-2		

Preloaded bolted assemblies are very sensitive to differences in manufacture and lubrication. Therefore it is very 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 one manufacturer.

Beside the mechanical properties of the components, the functionality of the assembly requires that the specified preload can be achieved if the assembly is tightened with a suitable procedure. For this purpose a test method for the suitability of the components for the preloading was created which will demonstrate whether the function of the assembly is fulfilled.

EN 14399 | PRE-LOAD FASTENERS



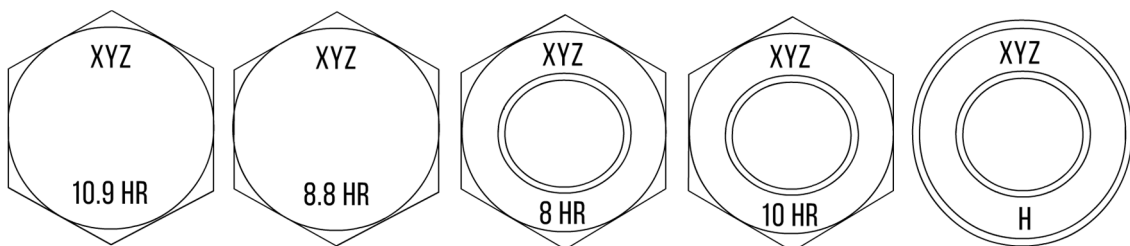
EN 14399 PARTS 1-10

There are currently 10 parts BS EN 14399 which are listed in the table below. Products manufactured to BS EN 14399 must comply with the constructive directive 89/106/EEC which requires that all products are CE approved and marked. All products supplied by Studbolt Scotland Ltd will come with a label showing the 'CE' mark and lot numbers for traceability.

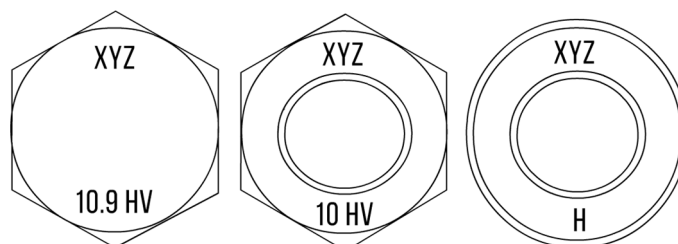
BS EN 14399 Part One	General Requirements
BS EN 14399 Part Two	Suitability test for Preloading (assembly test)*
BS EN 14399 Part Three	Hexagon Bolt and Nut Assemblies (HR 8.8 and 10.9)
BS EN 14399 Part Four	Hexagon Bolt and Nut Assemblies (HV 10.9)
BS EN 14399 Part Five	Plain Washers
BS EN 14399 Part Six	Plain Chamfered Washers
BS EN 14399 Part Seven	Countersunk Bolt and Nut (HR 8.8 and 10.9)
BS EN 14399 Part Eight	Hexagon Fitted Bolt and Nut Assemblies (HV 10.9)
BS EN 14399 Part Nine	Direct Tension Indicators
BS EN 14399 Part Ten	Tension Control Bolt and Nut Assemblies (HRC 10.9)

* The suitability test is required to allow the CE approval

HEAD MARKINGS

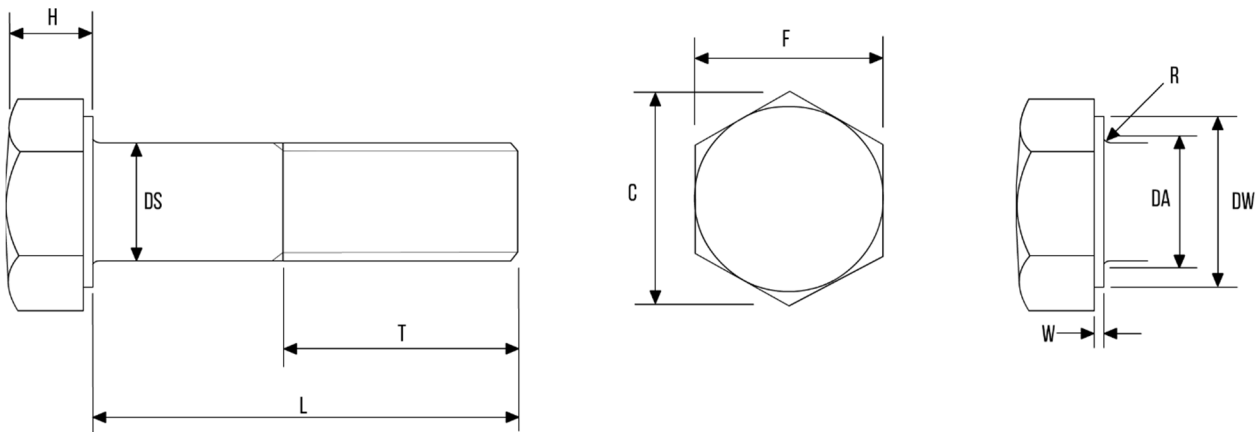


Note: The '8.8 HR, 10.9 HR, 8 HR, 10 HR' means that the product was manufactured to BS EN 14399-3



Note: The '10.9 HV and 10 HV' means that the product was manufactured to BS EN 14399-4

EN14399-3 DIMENSIONS OF BOLTS



Diameter	Pitch	Thread Length (T)			Depth of Washer Face (W)		Transition Diameter (DA)	Diameter of Washer Face (DW)
		Bolt ≤ 125	Bolt 125-200	Bolt >200	Min.	Max.		
M12	1.75	30	-	-	0.4	0.8	15.20	20.10
M16	2.00	38	44	-	0.4	0.8	19.20	24.90
M20	2.50	46	52	65	0.4	0.8	24.40	29.50
M22	2.50	50	56	69	0.4	0.8	26.40	33.30
M24	3.00	54	60	73	0.4	0.8	28.40	38.00
M27	3.00	60	66	79	0.4	0.8	32.40	42.80
M30	3.50	66	72	85	0.4	0.8	35.40	46.60
M36	4.00	78	84	97	0.4	0.8	42.40	55.90

Diameter	Pitch	Dia. of Unthreaded Shank (DS)		Width Across Corners (C)	Thickness of Head (H)		Radius (R)	Width Across Flats (F)	
		Min.	Max.	Min.	Min.	Max.		Min.	Max.
M12	1.75	11.30	12.70	23.91	7.05	7.95	1.2	21.16	22.00
M16	2.00	15.30	16.70	29.56	9.25	10.75	1.2	26.16	27.00
M20	2.50	19.16	20.84	35.03	11.60	13.40	1.5	31.00	32.00
M22	2.50	21.16	22.84	39.55	13.10	14.90	1.5	35.00	36.00
M24	3.00	23.16	24.84	45.20	14.10	15.90	1.5	40.00	41.00
M27	3.00	26.16	27.84	50.85	16.10	17.90	2.0	45.00	46.00
M30	3.50	29.16	30.84	55.37	17.65	19.75	2.0	49.00	50.00
M36	4.00	35.00	37.00	66.44	21.45	23.55	2.0	58.80	60.00

All dimensions in millimetres

EN14399-3 MECHANICAL PROPERTIES BOLTS

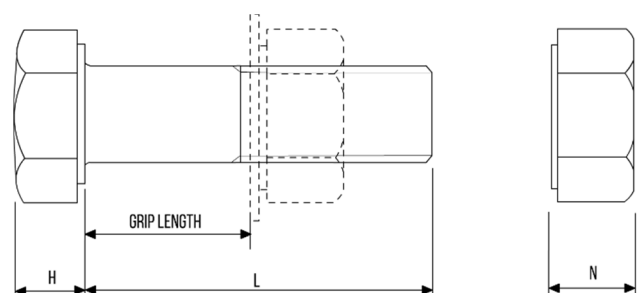
8.8	Stress Area mm ²	Proof Load Min. kN	Ultimate Load Min. kN	Hardness Rockwell HRC	
				Min.	Max.
M12	84.30	50.70	70.00	22.00	32.00
M16	157.00	94.50	130.00	22.00	32.00
M20	245.00	147.00	203.00	23.00	34.00
M22	303.00	182.00	252.00	23.00	34.00
M24	353.00	212.00	293.00	23.00	34.00
M27	459.33	275.00	381.00	23.00	34.00
M30	561.00	337.00	466.00	23.00	34.00
M36	817.00	490.00	678.00	23.00	34.00

10.9	Stress Area mm ²	Proof Load Min. kN	Ultimate Load Min. kN	Hardness Rockwell HRC	
				Min.	Max.
M12	84.30	70.00	87.70	32.00	39.00
M16	157.00	130.00	163.00	32.00	39.00
M20	245.00	203.00	255.00	32.00	39.00
M22	303.00	252.00	315.00	32.00	39.00
M24	353.00	293.00	367.00	32.00	39.00
M27	459.33	381.00	477.00	32.00	39.00
M30	561.00	466.00	583.00	32.00	39.00
M36	817.00	678.00	850.00	32.00	39.00

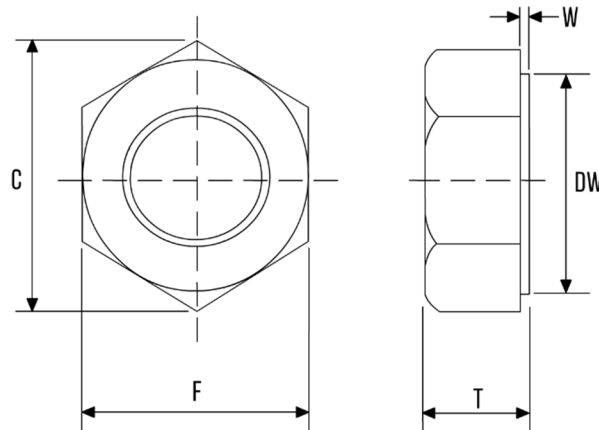
CALCULATION OF CORRECT BOLT LENGTHS

The 'Grip Length' or the total thickness to be bolted, should be added to the length indicated in the table below. This measurement allows for the inclusion of one nut and one flat round hardened washer. An additional allowance should be made for the inclusion of a load indicating washer, nut faced washer or additional hardened washers by adding 3mm in each case.

Diameter	Addition to Grip Length
M12	22.00
M16	26.00
M20	30.00
M22	34.00
M24	36.00
M27	39.00
M30	42.00
M36	48.00



EN14399-3 DIMENSIONS OF NUTS



Diameter	Pitch	DW	C	T		W		F	
		Min.	Min.	Min.	Min.	Min.	Max.	Min.	Max.
M12	1.75	20.10	23.91	10.37	10.80	0.4	0.8	21.16	22.00
M16	2.00	24.90	29.56	14.10	14.80	0.4	0.8	26.16	27.00
M20	2.50	29.50	35.03	16.90	18.00	0.4	0.8	31.00	32.00
M22	2.50	33.30	39.55	18.10	19.40	0.4	0.8	35.00	36.00
M24	3.00	38.00	45.20	20.20	21.50	0.4	0.8	40.00	41.00
M27	3.00	42.80	50.85	22.50	23.80	0.4	0.8	45.00	46.00
M30	3.50	46.60	55.37	24.30	25.60	0.4	0.8	49.00	50.00
M36	4.00	55.90	66.44	29.40	31.00	0.4	0.8	58.80	60.00

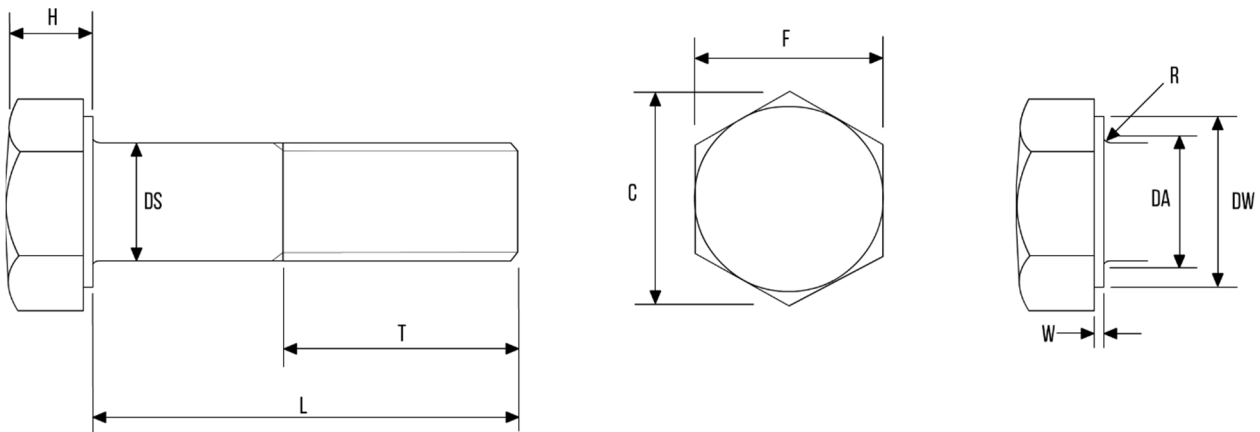
For hot-dip galvanised nuts, the dimensions apply before galvanising.

EN14399-3 PROOF LOAD VALUES OF NUTS

Diameter	Nominal Stress area of standard test mandrel (mm ²)	Proof Load kN	
		8	10
M12	84.30	84.30	97.80
M16	157.00	157.00	182.10
M20	245.00	245.00	284.20
M22	303.00	303.00	351.20
M24	353.00	353.00	409.50
M27	459.00	459.00	532.40
M30	561.00	561.00	650.80
M36	817.00	817.00	947.70

Bolt/nut assemblies according to this standard shall be assembled with washers in accordance with EN 14399-6 or in accordance with EN 14399-5 (under the nut only)

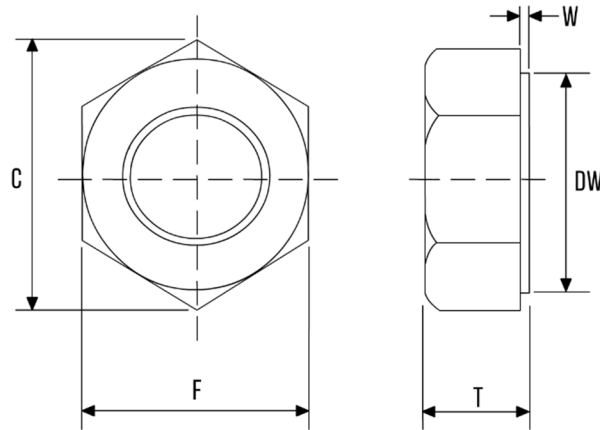
EN14399-4 DIMENSIONS OF BOLTS



Diameter	Pitch	Bolt ≤ 125	Depth of Washer Face (W)		Transition Diameter (DA)	Diameter of Washer Face (DW)	Width Across Corners (C)
			Min.	Max.			Min.
M12	1.75	23	0.4	0.8	15.20	20.10	23.91
M16	2.00	28	0.4	0.8	19.20	24.90	29.56
M20	2.50	33	0.4	0.8	24.00	29.50	35.03
M22	2.50	34	0.4	0.8	26.00	33.30	39.55
M24	3.00	39	0.4	0.8	28.00	38.00	45.20
M27	3.00	41	0.4	0.8	32.00	42.80	50.85
M30	3.50	44	0.4	0.8	35.00	46.60	55.37
M36	4.00	52	0.4	0.8	41.00	55.90	66.44

Diameter	Pitch	Dia. of Unthreaded Shank (DS)		Thickness of Head (H)		Radius (R)	Width Across Flats (F)	
		Min.	Max.	Min.	Max.		Min.	Max.
M12	1.75	11.30	12.70	7.55	8.45	1.2	21.16	22.00
M16	2.00	15.30	16.70	9.25	10.75	1.2	26.16	27.00
M20	2.50	19.16	20.84	12.10	13.90	1.5	31.00	32.00
M22	2.50	21.16	22.84	13.10	14.90	1.5	35.00	36.00
M24	3.00	23.16	24.84	14.10	15.90	1.5	40.00	41.00
M27	3.00	26.16	27.84	16.10	17.90	2.0	45.00	46.00
M30	3.50	29.16	30.84	17.95	20.05	2.0	49.00	50.00
M36	4.00	35.00	37.00	21.95	24.05	2.0	58.80	60.00

EN14399-4 DIMENSIONS OF NUTS



Diameter	Pitch	DW	C	T		F	
		Min.	Min.	Min.	Max.	Min.	Max.
M12	1.75	20.10	23.91	9.64	10.00	21.16	22.00
M16	2.00	24.90	29.56	12.30	13.00	26.16	27.00
M20	2.50	29.50	35.03	14.90	16.00	31.00	32.00
M22	2.50	33.30	39.55	16.90	18.00	35.00	36.00
M24	3.00	38.00	45.20	18.70	20.00	40.00	41.00
M27	3.00	42.80	50.85	20.70	22.00	45.00	46.00
M30	3.50	46.60	55.37	22.70	24.00	49.00	50.00
M36	4.00	55.90	66.44	27.70	29.00	58.80	60.00

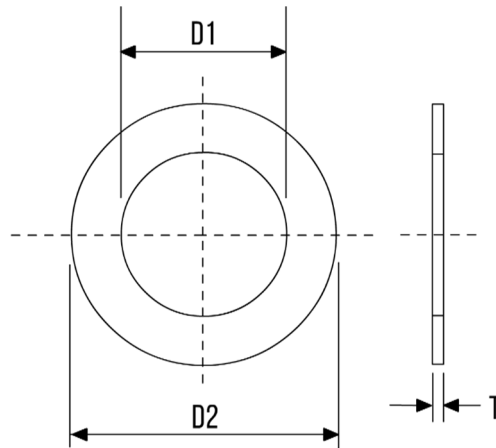
For hot-dip galvanised nuts, the dimensions apply before galvanising.

EN14399-4 PROOF LOAD VALUES OF NUTS

Diameter	Nominal Stress area of standard test mandrel (mm ²)	Proof Load kN
		10
M12	84.30	97.80
M16	157.00	182.10
M20	245.00	284.20
M22	303.00	351.20
M24	353.00	409.50
M27	459.00	532.40
M30	561.00	650.80
M36	817.00	947.70

Bolt/nut assemblies according to this standard shall be assembled with washers in accordance with EN 14399-6 or in accordance with EN 14399-5 (under the nut only)

EN14399-5 DIMENSIONS OF PLAIN WASHERS



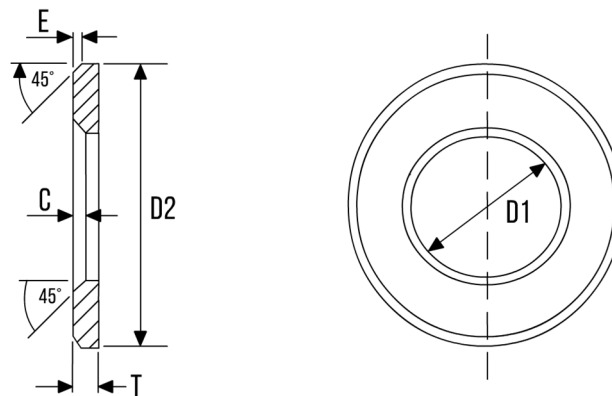
Diameter	Inside Diameter (D1)		Outside Diameter (D2)		Thickness (T)		
	Max.	Min.	Max.	Min.	Nom.	Max.	Min.
M12	13.27	13.00	24.00	23.48	3.00	3.30	2.70
M16	17.27	17.00	30.00	29.48	4.00	4.30	3.70
M20	21.33	21.00	37.00	36.38	4.00	4.30	3.70
M22	23.33	23.00	39.00	38.38	4.00	4.30	3.70
M24	25.33	25.00	44.00	43.38	4.00	4.30	3.70
M27	28.52	28.00	50.00	49.00	5.00	5.60	4.40
M30	31.62	31.00	56.00	54.80	5.00	5.60	4.40
M36	37.62	37.00	66.00	64.80	6.00	6.60	5.40

Characteristic		Standard
Material		Steel
General Requirements		EN 14399-1
Hardness Range		300 HV to 370 HV
Tolerances (International Standard)		EN ISO 4759-3
Surface Finish	Self Colour	Finished result from manufacturing with a light coating of oil
	Hot Dipped Galvanised	EN ISO 10684
	Others	As agreed. Cadmium or cadmium alloy are not permitted.

EN 14399-6 | PLAIN CHAMFERED WASHERS



EN14399-6 DIMENSIONS OF PLAIN CHAMFERED WASHERS



Diameter	Inside Diameter (D1)		Outside Diameter (D2)		Thickness (T)		External Chamfer (E)		Internal Chamfer (C)	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
M12	13.27	13.00	24.00	23.48	3.30	2.70	1.00	0.50	1.90	1.60
M16	17.27	17.00	30.00	29.48	4.30	3.70	1.50	0.75	1.90	1.60
M20	21.33	21.00	37.00	36.38	4.30	3.70	1.50	0.75	2.50	2.00
M22	23.33	23.00	39.00	38.38	4.30	3.70	1.50	0.75	2.50	2.00
M24	25.33	25.00	44.00	43.38	4.30	3.70	1.50	0.75	2.50	2.00
M27	28.52	28.00	50.00	49.00	5.60	4.40	2.00	1.00	3.00	2.50
M30	31.62	31.00	56.00	54.80	5.60	4.40	2.00	1.00	3.00	2.50
M36	37.62	37.00	66.00	64.80	6.60	5.40	2.50	1.25	3.00	2.50

Characteristic	Standard	
Material	Steel	
General Requirements	EN 14399-1	
Hardness Range	300 HV to 370 HV	
Tolerances (International Standard)	EN ISO 4759-3	
Surface Finish	Self Colour	Finished result from manufacturing with a light coating of oil
	Hot Dipped Galvanised	EN ISO 10684
	Others	As agreed. Cadmium or cadmium alloy are not permitted.

EN 14399-9 | DIRECT TENSION INDICATOR WASHER

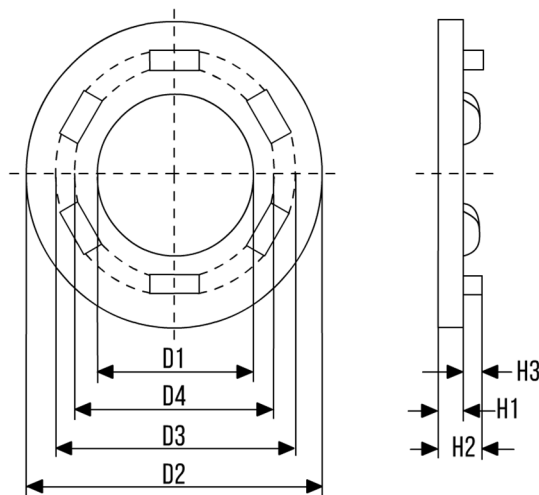


EN14399-9 DIRECT TENSION INDICATOR WASHER - SYSTEM HR OR HV

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 BS EN 14399-9. In either case it is essential that the direct tension indicators are used as part of an assembly in accordance with BS EN 14399-1.

To comply with BS EN 14399-1, it is essential that the assemblies are supplied by one manufacturer and include bolts, nuts, washers and direct tension indicators.

EN14399-9 DIMENSIONS OF COMPRESSIBLE WASHER TYPE DTI



Diameter	Internal Diameter D1		External Diameter D2		Material Thickness H1	Height over Protrusions H2	Height of Protrusions H3	Protrusion tangential diameter D3	Protrusion internal diameter D4
	Min.	Max.	Min.	Max.					
M12	12.75	12.85	26.00	32.50	2.50	5.50	0.80	20.00	13.85
M16	16.75	16.85	35.00	36.80	3.00	6.00	0.80	25.00	17.85
M20	20.95	21.05	41.00	46.00	3.50	6.50	0.80	29.00	22.05
M22	23.05	23.15	46.50	50.60	4.00	7.00	0.80	33.00	24.15
M24	25.15	25.25	50.00	55.20	4.00	7.00	0.80	38.00	26.25
M27	28.30	28.40	54.00	62.10	4.00	7.00	0.80	43.00	29.40
M30	31.45	31.55	59.00	69.00	4.00	7.00	0.80	46.50	32.55
M36	37.75	37.85	78.00	83.00	4.00	7.50	0.80	56.00	38.85

EN 14399-9 | DIRECT TENSION INDICATOR WASHER



SPECIFICATIONS AND REFERENCE STANDARDS

Characteristic		Standard
Material		Steel
General Requirements		EN 14399-1
Heat Treatment		Hardened & tempered or controlled rolled & tempered
Maximum Hardness		380 HV
Associated bolts & nuts		EN14399-3, EN14399-4, EN14399-7 or EN14399-8
Tolerances (International Standard)		EN ISO 4759-3
Surface Finish	Self Colour	Finished result from manufacturing with a light coating of oil
	Sherardized	EN 13811
	Others	As agreed. Cadmium or cadmium alloy are not permitted.

PERFORMANCE TEST OF DIRECT TENSION INDICATORS

The direct tension indicators shall be tested on a calibrated load-measuring device for the test procedure. The load requirement of the table below shall be met when the direct tension indicators are compressed to the average gaps given in table on the next page.

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 the minimum number of direct tension indicators tested per manufacturing lot shall be eight and all samples shall pass the test.

INDICATOR COMPRESSION LOADS AT APPROPRIATE GAP

Diameter	Compressed Load			
	Designation H8		Designation H10	
	Min.	Max.	Min.	Max.
M12	47.00	56.00	59.00	71.00
M16	88.00	106.00	110.00	132.00
M20	137.00	164.00	172.00	206.00
M22	170.00	204.00	212.00	254.00
M24	198.00	238.00	247.00	296.00
M27	257.00	308.00	321.00	385.00
M30	314.00	377.00	393.00	472.00
M36	458.00	550.00	572.00	688.00

EN 14399-9 | DIRECT TENSION INDICATOR WASHER

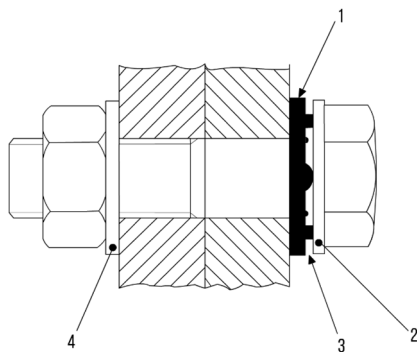


ASSEMBLIES INCLUDING DTI WASHER

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.

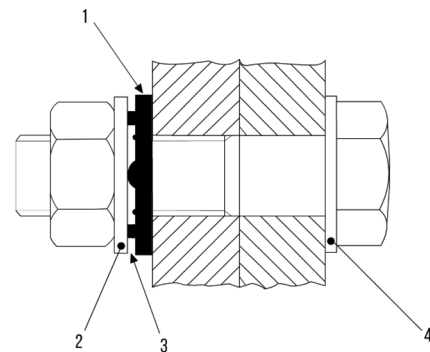
The functional characteristics of the bolt/nut/washer(s) assembly shall be achieved when tested together with direct tension indicators; the assembly may include washers according to EN 14399-6 or EN 14399-5 (under the nut only) and/or nut face or bolt face washers.

TIGHTENING OF THE ASSEMBLY BY ROTATION OF THE NUT



Under bolt head fitting

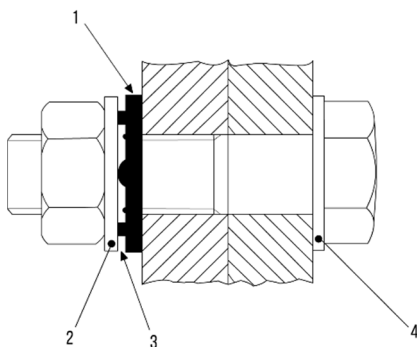
1. Direct Tension Indicator
2. Bolt Face Washer (not required for 8.8)
3. Gap
4. Washer according to EN14399-5 or 6



Under nut fitting

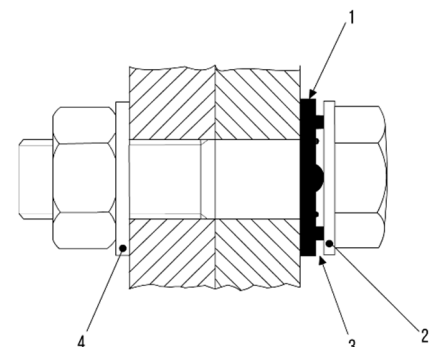
1. Direct Tension Indicator
2. Nut Face Washer
3. Gap
4. EN14399-6 Washer (Not required for 8.8)

TIGHTENING OF THE ASSEMBLY BY ROTATION OF THE BOLT HEAD



Under nut fitting

1. Direct Tension Indicator
2. Nut Face Washer (not required for 8.8)
3. Gap
4. Washer according to EN14399-6



Under bolt head fitting

1. Direct Tension Indicator
2. Bolt Face Washer
3. Gap
4. Washer according to EN14399-5 or 6 (Not required for 8.8)

FUNCTIONAL CHARACTERISTICS OF THE DTI WASHER IN THE ASSEMBLY

A specified feeler gauge shall be used to determine that the required bolt preload has been achieved by the assembly. The thickness of the gauge depends on the position of the direct tension indicator as shown in the table below.

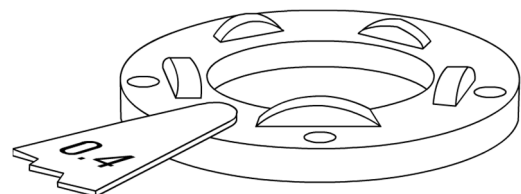
Direct tension indicator positions	Thickness of feeler gauge
Under bolt head, when nut is rotated	0.40
Under nut, when bolt is rotated	0.40
Under nut, when nut is rotated	0.25
Under bolt head, when bolt is rotated	0.25

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 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 illustration below) and shall refuse to enter the number of refusal spaces specified in table below.

Number of Indicator Protrusions	Minimum number of feeler gauge refusals
4	3
5	3
6	4
7	4
8	5
9	5

CHECKING THE INDICATOR GAP



Example with five protrusions

STUDBOLT 
SCOTLAND LIMITED
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