जारी किया गया
07/05/19

Rajeev Verma
राजीव वर्मा
Executive Director/B&S
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सत्यमेव जयते

भारत सरकार–रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
लखनऊ– 226011
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Lucknow- 226011
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SM-270

No.CBS/GSP **Dated: 07.05.2019**

Railway	Principal Chief Engineer	Chief Administrative Officer (Constn.)
Central	Mumbai CSMT-400001.	New Administrative Building, Mumbai CSMT-400001
Eastern	Fairlie Place, Kolkata-700001.	14, Strand Road, Kolkata-700001.
East Central	Hazipur-844101.(Bihar)	(i) CAO/C/North, Mahendru Ghat, Patna- 800004 (ii) CAO/C/South, Mahendru Ghat, Patna- 800004
East Coast	Rail Vihar, Bhubaneshwar-751016.	Rail Vihar, Bhubaneshwar-751016.
Northern	Baroda House, New Delhi - 110001.	(i) CAO/C-I, Kashmere Gate, Delhi- 110006. (ii) CAO/C-II, Kashmere Gate, Delhi- 110006. (iii) USBRL Project, Satyam Resort Complex, Trikuta Nagar Extn., Jammu Tawi- 180012
North Central	Subedar Ganj, Allahabad-211001.	Subedar Ganj, Allahabad-211001.
North Eastern	Gorakhpur- 273 001.	Gorakhpur- 273001.
Northeast Frontier	Maligaon, Guwahati - 781011.	Maligaon, Guwahati-781011.
North Western	Jaipur- 302017.	Jaipur-302017.
Southern	Park Town, Chennai-600 003	(i) CAO/C, Egmore, Chennai- 600008 (ii) CAO/C/ERS, Ernakulam (Kerala)
South Central	Rail Nilayam,Secunderabad-500371.	Rail Nilayam, Secunderabad-500 371.
South Eastern	Garden Reach, Kolkata-700 043	Garden Reach, Kolkata-700 043
South East Central	Bilaspur-495004	Bilaspur-495004
South Western	Hubli-580023	18, Millers Road, Bangalore-560 046.
Western	Churchgate, Mumbai-400020.	Churchgate, Mumbai-400 020.
West Central	Jabalpur -482001	Jabalpur -482001

Sub: Addendum and Corrigendum Slip no. 11 to IRS Fabrication Specification (B1-2001)

Ref: (i) Railway Board's letter no. 2018/03/CE-III/BR/STR/HSGF dated 01.08.2018.

(ii)This office letter no. CBS/G/Reg. dated 27.12.2018.

(iii)This office letter no. CBS/G/Reg. dated 10.04.2019.

(iv)Railway Board's letter no. 2018/03/CE-III/BR/STR/HSGF dated 24.04.2019.

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With reference to above subject, Addendum and Corrigendum Slip no. 11 dated 07.05.2019 to IRS Fabrication Specification (B1-2001) regarding change in provisions related to High Strength Friction Grip (HSFG) bolting assembly from IS codes to EN 14399 series code (HR System).

This Addendum and Corrigendum Slip can also be accessed through rail net at following link:

http://10.100.2.4/drawing/index.aspx ⟶ Codes/Manuals

This is for your information and further necessary action.

Encl: Copy of A&C no. 11 to IRS B1 (15 Pages)

07/5/14

(Rajeev Verma)
Executive Director/(B&S)

Copy to:

SC

i) OSD/ME for kind information of Member Engineering, Railway Board, Rail Bhawan, New Delhi-110001.

ii) Chief Commissioner of Railway Safety, N.E.Railway Office Compound, Ashok Marg, Lucknow-226001.

iii) Additional Member (Civil Engg.), Railway Board, Rail Bhawan, New Delhi-110001.

iv) Additional Member (Works), Railway Board, Rail Bhawan, New Delhi-110001.

v) Director, IRICEN, Pune-411001

vi) Executive Director (Civil Engg.) B&S, Railway Board, New Delhi-110001.

vii) General Manager (Con.) N. F. Railway, Maligaon, Guwahati-781011

viii) Chief Engineer, Metro Railway, Jawahar Lal Nehru Road, Kolkata-700 071.

ix) Chief Bridge Engineer:

1. Central Railway, Mumbai CST-400 001.
2. Eastern Railway, Fairlie Place, Kolkata-700 001.
3. East Central Railway, Hazipur-844 101.
4. East-Coast Railway, Bhubaneshwar-751 016 (Orissa).
5. Northern Railway, Baroda House, New Delhi- 110 001.
6. North-Central Railway, Allahabad-211 001.
7. North Eastern Railway, Gorakhpur-273 001.
8. Northeast Frontier Railway, Maligaon, Guwahati-781 011.
9. North western Railway, Jaipur-302017.
10. Southern Railway, Park Town, Chennai-600 003.
11. South Central Railway, Rail Nilayam, Secunderabad-500 371.
12. South East Central Railway, Bilaspur-495 004
13. South Eastern Railway, Garden Reach, Kolkata-700 043
14. South West Railway, Hubli-580 023.
15. Western Railway, Mumbai-400 020.
16. West Central Railway, Jabalpur-482 001.

x) Commissioner of Railway Safety:

1. Central Circle, 2nd Floor, Churchgate Station Building, Mumbai-400020.

2. Eastern Circle, Multistoried Building of Eastern Railway, 12th Floor, Strand Road, Kolkata-700001.
3. Northern Circle, near Centre for Railway Information System, Safdarjung Railway Station, New Delhi-110021.
4. North Eastern Circle, DRM Compound, Northern Railway, Hazratganj, Lucknow-226001.
5. Northeast Frontier Circle, 12 Strand Road, Multistoried Building of Eastern Railway, Kokata-700001.
6. Southern Circle, 7 Seshadri Road, Gandhi Nagar, Bangalore-560009.
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xiv) Managing Director, IRCON, Palika Bhawan, Sector-XIII, R K Puram, New Delhi-110066.

xv) Chairman & Managing Director, Konkan Railway Corporation Ltd., Belapur Bhavan, Plot no. 6, Sect.-II CBD Belapur, Navi Mumbai-400614.

xvi) Managing Director, RVNL, C-2/10, Safdarjang Development Area, Arvindo Marg, New Delhi-110016.

xvii) Managing Director, Dedicated Freight Corridor Corporation of India Ltd., 5th Floor, Pragati Maidan, Metro Station Building Complex, New Delhi-110001.

Encl: Copy of A&C no. 11 to IRS B1 (15 Pages)

07/5/14

(Rajeev Verma)
Executive Director/(B&S)

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
(RAILWAY BOARD)

INDIAN RAILWAYS STANDARD SPECIFICATION FOR FABRICATION AND ERECTION OF STEEL GIRDER BRIDGES AND LOCOMOTIVE TURNTABLES

Fabrication Specification (B1-2001)

Adopted-1934
Revised-2001

Addendum and Corrigendum Slip No. 11 dated 07.05.2019

Para 28.9 and 28.10 added vide A&C no. 6 and subsequently modified vide A&C no. 9 and 10 shall be replaced by new para 28.9 and 28.10 as given below:

28.9 Supply of High Strength Friction Grip (HSFG) bolting assemblies with Direct Tension Indicator washers:

28.9.1 Provisions in this code cover the norms for manufacture of HSFG bolting assemblies with DTI washers used in friction type joints for Railway Bridges, Road Over Bridges as well as Rail cum Road Bridges, from sizes M12 to M36. This para is intended to help better understanding of the codal provisions of the reference codes as given in para 28.9.2 below. In case of any confusion, clarification or difference of opinion etc., the provisions given in the relevant reference codes as given in para 28.9.2 below shall prevail.

28.9.2 Reference Codes:

(a) EN 14399 Series (High strength structural bolting assemblies for preloading):

i) EN 14399-1:2015- General requirements.

ii) EN 14399-2:2015- Suitability for preloading.

iii) EN 14399-3:2015- System HR- Hexagonal bolt and nut assemblies.

iv) EN 14399-5:2015- Plain washers.

v) EN 14399-6:2015- Plain chamfered washers.

vi) EN 14399-9:2009- Direct Tension Indicator for bolt and nut assembly.

(b) EN-1090-2: 2008, Execution of Steel Structures and Aluminum Structures part 2 – Technical Requirements for Steel Structures.

28.9.3 Preloaded HSFG bolting assemblies are very sensitive to differences in manufacture and lubrication. Therefore it is important that the complete HSFG bolting assembly including Direct Tension Indicator (DTI) washer, shall be 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 shall be under the control of one manufacturer.

DTI washers are to be sold as part of a complete assembly only that comprises bolts and nuts and that otherwise complies with EN 14399-3. The systems of bolt/nut/washer assemblies are described in Table 28.9.3. Use of DTI washer shall be mandatory in HSFG bolting assemblies.

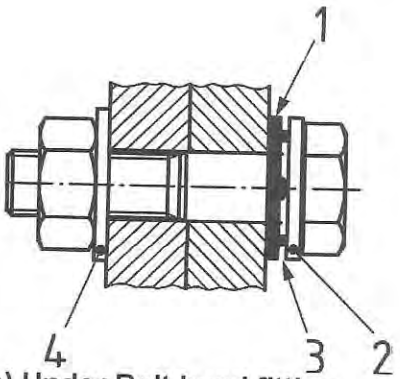
Beside the mechanical properties of the components, the functionality of the assembly requires that the specified preload can be achieved when the average gap remaining after tightening (compressed protrusions in DTI washers) is less than the specified values in para 28.9.7 (g), if the assembly is tightened with a suitable procedure. The test method given in EN 14399-2 and EN 14399-9 has been developed to demonstrate the suitability of the components for preloading.

Table 28.9.3 — Composition of high-strength structural bolting assembly and its component marking

Type of bolting assembly		System HR	
General requirements		EN 14399-1	
Suitability for preloading		EN 14399–2 and, if any, additional testing specified in the product standard	
Bolt & Nut		EN 14399-3	
Marking	Bolt	HR8.8	HR10.9
	Nut	HR8 or HR10	HR10
Washers		EN 14399-5[a] or EN 14399-6	
Marking		H or HR[b]	
Direct tension indicator and nut face washer or bolt face washer		EN 14399-9	
Marking	Direct Tension Indicator	H8	H10
	Nut Face Washer	HN	
	Bolt Face Washer	HB	

[a] EN 14399–5 can only be used under the nut.
[b] At the choice of the manufacturer.

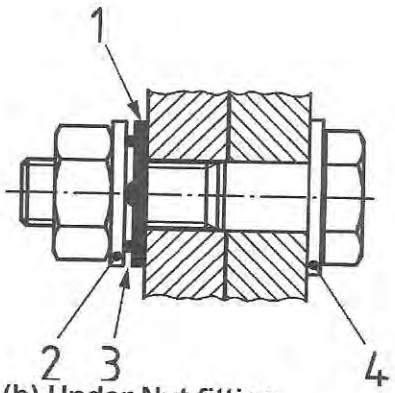
28.9.3.1 **Type of HSFG bolting assemblies with DTI:** Bolting assemblies according to this code consist of bolts and nuts which shall meet all the requirements of EN 14399-3 (HR System). The functional characteristics of the bolting assemblies shall be achieved when tested together with direct tension indicators. The assembly may include washers according to EN 14399-6 or EN 14399-5 (under the nut only) and/or nut face or bolt face washers in accordance with Clause 4 of EN 14399-9.



(a) Under Bolt head fitting

Key

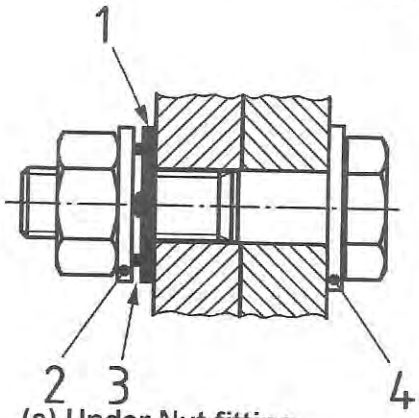
1. Direct Tension Indicator
2. Bolt face washer (not required for property class 8.8)
3. Gap
4. washer according to EN 14399–5 or –6



(b) Under Nut fitting

1. Direct Tension Indicator
2. Nut face washer
3. Gap
4. washer according to EN 14399–6 (not required for property class 8.8)

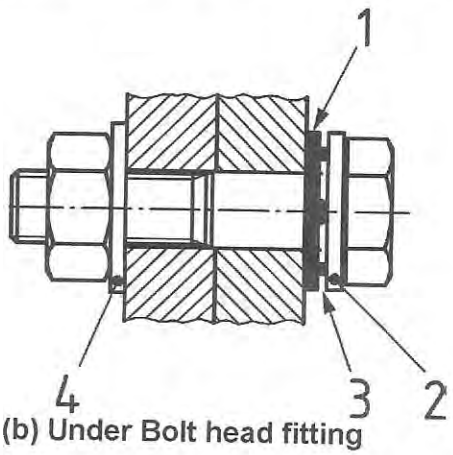
Fig.28.9.3.1-1: Tightening of the assembly by rotation of the nut (Normal method of assembly)



(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

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)

Fig.28.9.3.1-2: Tightening of the assembly by rotation of the bolt head (Alternative method of assembly)

Composition of high-strength structural bolting assembly (HR System) and its component marking has been given in Table 28.9.3 of this code. The assembly configurations which can be used with direct tension indicators shall be according to Fig. 28.9.3.1-1 and Fig. 28.9.3.1-2 above.

28.9.3.2 **Functional characteristics of the bolt/nut/washer(s)/DTI assembly:** 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: (a) Relative rotation between the nut and the bolt (b) 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.

28.9.3.3 **Suitability test for preloading with direct tension indicator in an assembly:** Direct tension indicators conforming to EN 14399-9 are suitable according to EN 14399-2 provided they are used in an assembly comprised of matched components in accordance with Table 28.9.3 of this code and with EN 14399-3 (System HR) that have been tested in accordance with EN 14399-2 to determine the relative rotation between the bolt and nut. 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 %.

28.9.3.4 **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. The assembly shall be assembled in accordance with Fig 28.9.3.1-1 (a) of this code horizontally; the bolt force (F_{bi}) shall be determined in accordance with clause 28.9.7 (g) of this code and not be less than the minimum bolt force specified in Table 4 of EN 14399-9.

28.9.4 **Bolts:**

For the purpose of HSFG connections, only high strength structural bolts confirming to the requirements for assemblies of high-strength structural bolts and nuts of system HR suitable for preloaded joints with large width across flats as specified in EN 14399-3 together with EN 14399-1 and 14399-2 shall be used. Specification for bolts and reference standards for material, general requirements, thread, mechanical properties, tolerances, finish-coatings, surface integrity, acceptability etc. has been given in Table 3 of EN 14399-3. EN 14399-3 gives two property classes: 8.8 or 10.9 for the same. The bolts have the following characteristics:

(a) **Property class:** A property class has two parts separated by a decimal in the form x.y. The first part, x, indicates 1/100 of the nominal tensile strength in Newton per sq mm and y indicates ten times the ratio of the lower yield stress and nominal tensile strength. For example, property class 8.8 means that the bolt will have nominal Ultimate Tensile strength of 800 N/mm^2, and lower yield stress of 80% of 800 N/mm^2, i.e. 640 N/mm^2.

(b) **Identification/Marking:** High strength structural bolts manufactured according to EN 14399-3 shall be marked with: (a) Property class marking with the letters HR e.g. 8.8HR or 10.9HR (b) Identification mark of the manufacturer of bolting assembly. It is permissible for the marking to be either embossed or indented on top surface of the head. For having better traceability, heat mark of the raw material shall be embossed on the bolt head. Heat mark may also be embossed on nut and washers if sufficient space

for embossing heat mark is available on nuts and washers. Apart from heat mark, length of bolt shall be embossed on bolt head. This will be in addition to name of manufacture and property class of bolt material.

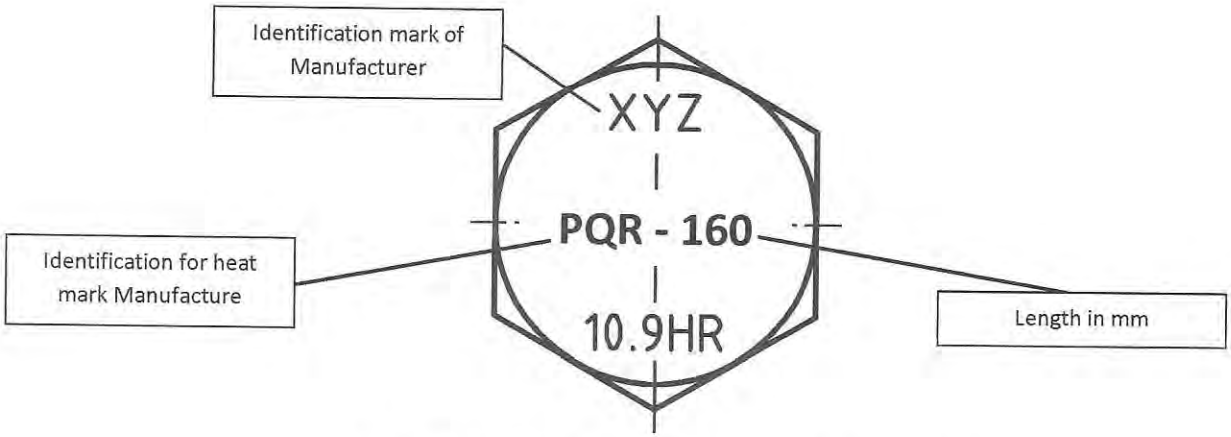


Fig. 28.9.4 (b): Typical Marking on bolt-heads

(c) Dimensions: Dimensions of bolts shall be as per Table 2 of EN14399-3. The bolt length shall be chosen such that after tightening the following requirements are met for bolt end protrusion beyond the nut face and the thread length: (a) The length of protrusion shall be at least the length of one thread pitch measured from outer face of the nut to the end of the bolt. (b) For preloaded bolts according to EN 14399-3, at least four full threads (in addition to the thread run out) shall remain clear between the bearing surface of the nut and the unthreaded part of the shank.

(d) Surface Finish & Coatings: Wherever property class 8.8 bolts are used these shall be hot dip galvanized as per ISO: 10684 (latest version) to provide salt spray resistance suitable as per site condition depending upon severity of environment. Property class 10.9 bolts shall not be hot dip galvanized since this may cause hydrogen embrittlement. So these bolts should be coated with Zinc flakes as per ISO: 10683 (latest version), to provide salt spray resistance suitable as per site condition depending upon severity of environment. However, depending on the site conditions, locations of the bolts in the structure and corrosion proneness, use of Zinc flake spray coating as per ISO 10683 (latest version) can be adopted even for property class 8.8 bolts as well.

28.9.5 Nut:

For the purpose of HSFG connections, only high strength structural nuts confirming to the requirements for assemblies of high-strength structural bolts and nuts of system HR suitable for preloaded joints with large width across flats as specified in EN 14399-3 together with EN 14399-1 and 14399-2 shall be used. Specification for nuts and reference standards for material, general requirements, thread, mechanical properties, tolerances, finish-coatings, surface integrity, acceptability etc. has been given in Table 5 of EN 14399-3. Nuts shall run freely on their partnering bolt, which is easily checked during hand assembly. Any nut and bolt assembly where nut does not run freely shall be discarded. If a power tool is used, either of the following two checks may be used: (a) For each new batch of nuts or bolts their compatibility may be checked by hand

assembly before installation (b) For mounted bolt assemblies but prior to tightening, sample nuts may be checked for free running by hand after initial loosening. The nuts have the following characteristics:

(a) Property Class: Nuts are designated by property class designation, which is equal to 1/100 of the minimum tensile strength in Newton per square mm of the bolt. For HSFG bolting assemblies, the property classes to be used are 8 and 10 as specified in EN 14399-3. Property class 8 nut to be used with bolts of property class 8.8 only whereas property class 10 nuts can be used with bolts of property class 8.8 and 10.9 both. Dimensions of the nuts shall be as per the table 4 of EN 14399-3.

(b) Identification of Nut: High strength structural nuts manufactured according to EN 14399-3 shall be marked with: (a) Property class marking with the letters HR e.g. 8HR or 10HR (b) Identification mark of the manufacturer of bolting assembly. The marking shall be indented on either bearing face of chamfered nuts and shall be either indented or embossed on the non-bearing face of washer faced nuts.

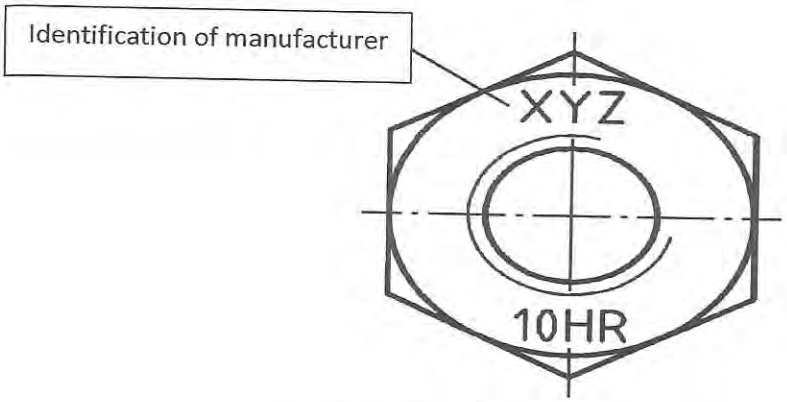


Fig. 28.9.5 (b): Typical markings on nuts

(c) Surface finish and coatings of Nut: HSFG nuts of property class 8 shall be hot dip galvanized as per ISO 10684 (latest version) to provide salt spray resistance suitable as per site condition depending upon severity of environment. Property class 10 nuts shall not be hot dip galvanized since this may cause hydrogen embrittlement. So these nuts should be coated with Zinc flakes as per ISO: 10683, to provide salt spray resistance suitable as per site condition depending upon severity of environment. However, depending on the site conditions, locations of the nuts in the structure and corrosion proneness, use of Zinc flake spray coating can be adopted even for property class 8 nuts as well. In nuts the thread type depends on the type of coating adopted for nuts. In case of hot dip galvanization of nuts, the thread in nuts shall be as per tolerance class 6AZ as per ISO 261, ISO 965-5 and in other type of coatings the threads shall be as per tolerance class 6H as per ISO 261, ISO 965-2, ISO 965-5.

(d) Position of nut in bolt: HSFG bolt cannot be easily opened out except by use of torque wrench. Still, as an additional precaution, it may be ensured that the nut is not easily accessible for opening out by anti-social elements, the same shall be provided preferably as follows:

i. In girder web: Towards outside of the girder.
ii. In flanges: Towards bottom (Except when in composite construction).
iii. In composite construction: Towards inside of concrete.
iv. In bracing: Towards the rolled section side so that the space for rotation of the nut is not readily available.
v. Where Tapered washer is used, the nut shall preferably be on the other side.

28.9.6 Plain and Plain Chamfered Washer:

Washers used under heads of preloaded bolts shall be chamfered according to EN 14399-6 and positioned with the chamfer towards the bolt head. Washers according to the EN 14399-5 shall only be used under nuts. Washers according to EN 14399-5 and EN 14399-6 are not intended to be used in direct contact with oversized or slotted holes. Specification and reference standards for plain washers and plain chamfered washers regarding material, general requirements, mechanical properties, tolerances, finish-coatings, workmanship, acceptability etc. has been given in Table 3 of EN 14399-5 and EN 14399-6 respectively. Dimensions of plain and plain chamfered washers have been given in table 2 of EN 14399-5 and EN 14399-6 respectively. Plain Washers (or if necessary hardened taper washers) shall be used for HSFG bolting assemblies as follows: (a) For 8.8 bolts a washer shall be used under the bolt head or the nut, whichever is to be rotated (b) For 10.9 bolts washers shall be used under both the bolts and the nut.

Plate washers shall be used for connections with long slotted and oversized holes. One additional plate washers or up to three washers with a maximum combined thickness of 12 mm may be used in order to adjust the grip length of bolt assemblies. They shall be placed on the side that is not turned. Dimensions and steel grades of plate washers shall be specified. They shall not be thinner than 4 mm.

Taper washers shall be used if the surface of the constituent product is at an angle to a plane perpendicular to the bolt axis of more than: (a) 1/20 (3°) for bolts with $d \leq 20$ mm (b) 1/30 (2°) for bolts with $d > 20$ mm. Dimensions and steel grades for taper washers shall be specified.

Washers have the following characteristics:

(a) Identification: Hardened and tempered plain washers shall be marked with at least manufacturer's identification mark and letter H. Alternatively; these may also be marked with HR in place of H when supplied as component of bolting assembly of system HR. Marking shall be indented on one of the bearing surfaces. The marking of washers with enlarged outer diameter shall be HD.

Similarly for hardened and tempered chamfered washers shall be marked with at least manufacturer's identification mark and letter H. Alternatively; these may also be marked with HR in place of H when supplied as component of bolting assembly of system HR. Marking shall be indented on non chamfered side.

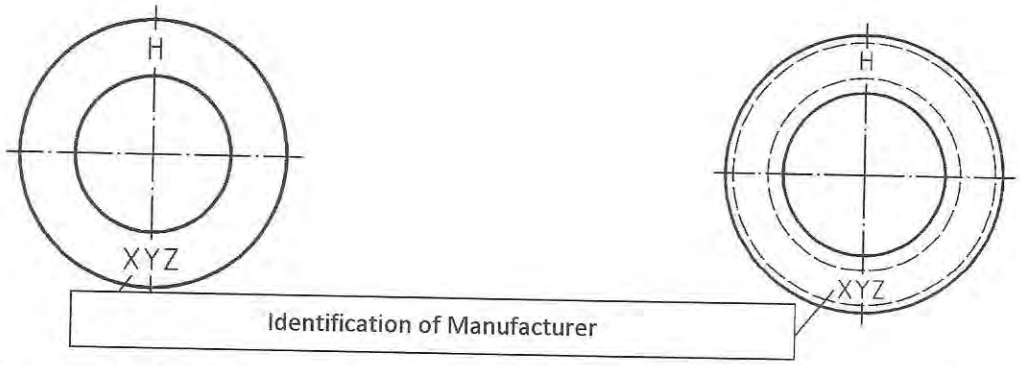


Fig. 28.9.6 (a): Typical markings/shapes on plain and plain chamfered washers

(b) Surface Finish and coatings: Washers as per EN 14399-5 and EN 14399-6 shall be hot dip galvanized as per ISO 10684 (latest version) to provide salt spray resistance suitable as per site condition depending upon severity of environment, however attention is drawn to the need to consider the risk of hydrogen embrittlement when selecting an appropriate surface treatment process (e.g. cleaning and coating) as per relevant coating standard. So these washers can also be coated with Zinc flakes as per ISO: 10683, to provide salt spray resistance suitable as per site condition depending upon severity of environment to avoid risk of hydrogen embrittlement.

28.9.7 Direct Tension Indicators (DTI) washers:

Compressible washer-type Direct Tension Indicators (DTI) as per EN 14399-9 (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. Use of DTI washers shall be mandatory in the HSFG bolting assemblies.

Salient features of DTI as per EN 14399-9 are as below:

(a) Dimensions of DTI: Before installation, the dimensions and tolerances of compressible washer-type direct tension indicators shall be as given in Table 2 of EN 14399-9. The size and number of protrusions on the direct tension indicator shall be sufficient to meet the performance requirements of clause 3.3 of EN 14399-9 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.

(b) Specifications and reference standards for DTI: Specifications and reference standards regarding material, general requirements, heat treatment, maximum hardness, surface finish, associated bolts and nuts, associated washers, acceptability etc. have been given in Table 3 of EN 14399-9.

(c) Performance test of DTI: The direct tension indicators shall be tested on a calibrated load-measuring device as per description given in clause 3.4 of EN 14399-9 for the test procedure. The load requirement of Table 4 of EN 14399-9 shall be met when the direct tension indicators are compressed to the average gaps given in Table 9 of EN 14399-9. 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.

(d) Marking of DTI: 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. It is recommended to stamp lot numbers on the face of the direct tension indicator.

(e) Nut face washers and Bolt face washers: Dimensions and tolerances of Nut face washers and Bolt face washers shall be as given in Table 6 and 7 of EN 14399-9 respectively. Specification and reference standards for Nut face washers and Bolt face washers regarding material, general requirements, heat treatment, hardness alternatives, tolerances, surface finish, associated bolts and nuts, associated washers, acceptability etc. have been given in Table 8 of EN 14399-9. Nut face washers 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. Bolt face washers 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.

(f) Surface finish and coatings: For corrosion protection of DTI, Nut face washers and Bolt face washers hot dip galvanization shall not be done because in case of hot dip galvanization it is difficult to accurately control the thickness of coating as well as risk of hydrogen embrittlement. Moreover excessive coating of DTI washers may lead to erroneous tensioning of HSFG bolt assembly. Hence in DTI, Nut face washer and Bolt face washer surface finish shall be sherardized according to EN 13811 (latest version) or zinc flake coating as per ISO 10683 (latest version) shall be done.

(g) Functional characteristics of DTI in bolting assembly: A specified feeler gauge as per Table 9 of EN 14399-9 which is reproduced below shall be used to determine that the required bolt preload has been achieved by the assembly after it has been tightened.

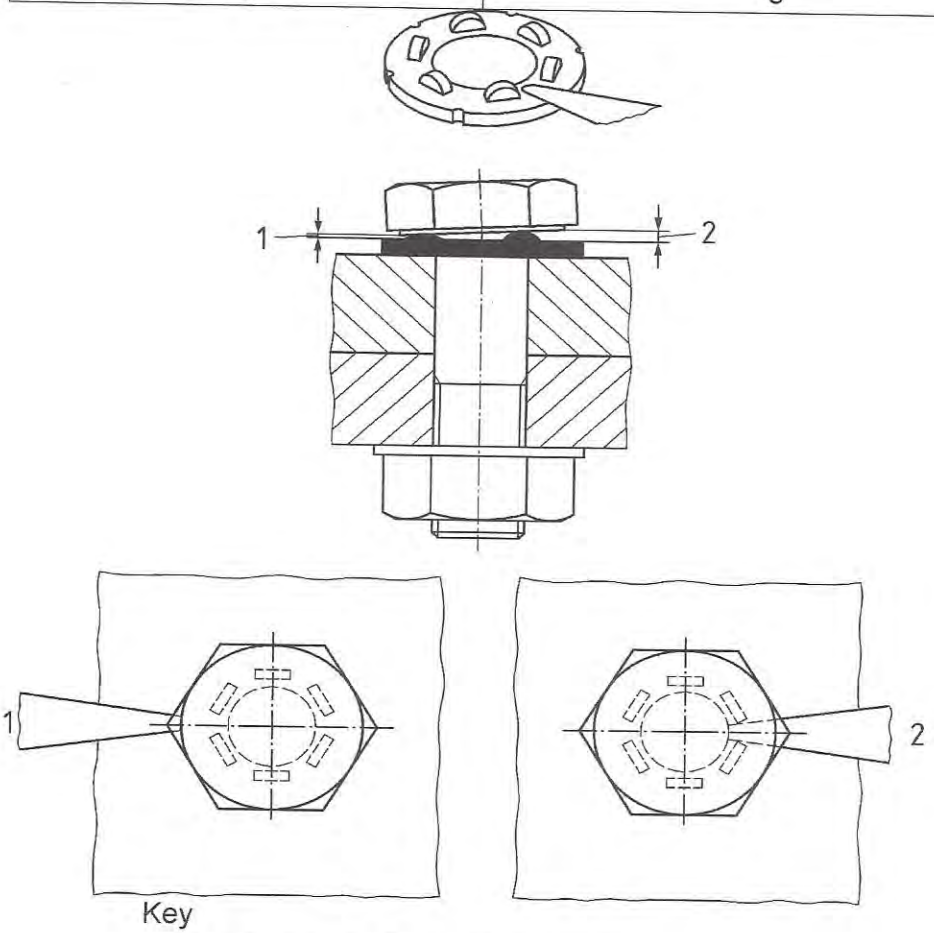
Table 28.9.7 (g)-1: Thickness of the feeler gauge

Direct tension indicator positions	Designation H8 and H10 Thickness of feeler gauge (mm)
Under bolt head, when nut is rotated [Fig. 28.9.3.1-1(a)]	0.40
Under nut, when bolt is rotated [Fig. 28.9.3.1-2(a)]	
Under nut, when nut is rotated [Fig. 28.9.3.1-1(b)]	0.25
Under bolt head, when bolt is rotated [Fig. 28.9.3.1-2(b)]	

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 as per Figure 9 of EN 14399-9 and shall refuse to enter the number of refusal spaces specified in Table 10 of EN 14399-9.

Table 28.9.7 (g)-2: 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



Key

1 "No go" gap if refusal occurs

2 "Go" gap if refusal does not occur

Fig.28.9.7 (g): Checking the indicator gap (example with six protrusions)

28.10 Fabrication and Assembly of High Strength Friction Grip (HSFG) bolting assemblies with Direct Tension Indicator washers:

28.10.1 Holes for HSFG Bolts:

Normal holes in the steel members being connected by the rivets shall be used for HSFG bolts also, subject to the following:

I. **Making of holes:** The holes shall be made by drilling only.

II. **Nominal Diameter of Hole:** The actual diameter of hole shall be 1.5 mm more than the bolt diameter for less than 25mm dia. bolts and 2 mm more than nominal dia. of HSFG bolts for larger diameters i.e. for 20 mm dia HSFG bolt, the hole shall be 21.5 mm in diameter.

III. **Oversize Holes:** In case the bolts are to be provided in existing structure, the maximum size of hole shall not exceed 1.25 d or d + 4 mm whichever is less

28.10.2 Surface preparation for steel interface before providing HSFG bolts: The steel interface between the plies which form a joint having HSFG bolts shall have special surface preparation so that sufficient slip factor is available. The surface preparation shall be as assumed by designer in design, based on slip factor specified in Table XIII of Indian Railways Steel Bridge Code. The following surface preparation shall be done:

I. **New construction:** The interface between the plies which are connected together by the HSFG bolts shall be "Aluminium metallised without any over coating". The aluminium metallising shall be as per para 39.2.1 of this code.

II. **Existing structures:** The interface of plies which are to be included in the HSFG bolts shall be cleaned by wire brushing/ flame cleaning equivalent to the surface specified in IRBM para 217, 1 (b), (i) to (iv). The surfaces shall be cleaned to remove all loose rust and paint layers (Only isolated patches of coatings/ rust can remain). If, however, in existing structures, rivets are to be replaced by bolts but no surface preparation is possible, the slip factor shall be suitably reduced as per Table XIII of IRS Steel Bridge Code.

28.10.3 Installation of HSFG bolting assemblies: Installation/tightening of preloaded bolting assemblies to be carried out in accordance with clause 8.3, clause 8.5 of EN 1090-2 and clause 5.2 of EN 14399-9. The salient provisions of these are given below:

I. **General:** Unless otherwise specified the nominal minimum preloading force (F_{pC}) shall be taken as given in Table 19 of EN 1090-2. This level of preload shall be used for all slip resistant preloaded connections. As per this code, only the DTI method shall be used due to its simplicity in application in field. Details related to installation of bolting assemblies as per DTI method is elaborated below as per relevant provisions of EN 1090-2 and EN 14399-9.

The as delivered calibration is valid for tightening by rotation of the nut. If tightening is done by rotation of the bolt head, in case of DTI method the same has been taken care by specifying different thickness of feeler gauges in different position of DTI with respect to tightening by nut or bolt head. So in case of DTI method no need for calibration if tightening is done by rotation of bolt head.

Burrs, loose materials and excessive thickness of paint that would prevent solid seating of the connecting parts shall be removed before assembly.

Before commencement of preloading, the connected components shall be fitted together and bolts in a bolt group shall be tightened in accordance with clause 8.3 of EN 1090-2 but the residual gap shall be limited to 2 mm with the necessary corrective action on steel components. The connected components shall be drawn together such that they achieve firm contact. Shims may be used to adjust the fit. For constituent products with $t \geq 4$ mm for plates and sheeting and $t \geq 8$ mm for sections, unless full contact bearing specified, residual gaps of up to 2 mm may be left at the edges on condition that contact bearing is achieved at the central part of connection. Each bolt assembly brought at least to a "Snug-Tight condition", with special care being given to avoid over-tightening. The tightening process shall be carried out from bolt to bolt of the group, starting from the most rigid part of the connection and moving progressively towards the least rigid part. To achieve a uniform "Snug-Tight condition", more than one cycle of tightening may be necessary. The most rigid part of a cover plate connection of an I section is commonly in the middle of connection bolt group. The most rigid parts of end plate connections of I sections are usually besides the flanges. The term "Snug-Tight condition" can generally be taken as that achievable by the effort of one man using a normal sized spanner without an extension arm, and can be set as the point at which a percussion wrench starts hammering.

If a bolt assembly has been tightened to the minimum preload and later un-tightened, it shall be removed and whole bolting assembly shall be discarded. Bolt assemblies used for achieving initial fit up should not generally need to be tightened to the minimum preload or un-tightened, and would therefore still be usable in location in the final bolting up process.

The potential loss of preloading force from its initial value due to several factors e.g. relaxation, creep of surface coatings is considered in tightening methods. In case of thick surface coatings, it shall be specified if measures shall be taken to offset possible subsequent loss of preloading force.

II. **Sequence of tightening:** The following steps shall be followed for tightening of bolts:

1. The holes shall be brought in alignment by using drifts etc such that the bolt threads are not damaged during insertion of bolts. Drifting shall not distort the metal or enlarge the holes.
2. The members being joined shall be held in position by insertion of few HSFG bolts (tightened to first stage only i.e. snug tight condition).These bolts shall not be tightened to second stage till all the bolts in a joint are inserted and tightened to first stage.
3. After the alignment/ geometry of members is verified to be correct as per drawings, balance bolts shall be inserted and tightened upto first stage of tightening. The drifts inserted as above shall also be replaced by HSFG bolts one by one.
4. The final tightening shall not proceed until the gap between the plates has been closed such that the residual gap, if any, is less than 2 mm at edges.

There shall, however, be no gap in the central portion. In case the central portion is not in close contact or gap at edges is more than 2 mm, straightening of members may be done after opening out the bolts inserted and the entire procedure 1 to 3 above shall be repeated.

5. During tightening of bolts also, the steel members can continue to deform and hence the tightening of subsequent bolts can lead to loosening of already tightened bolts. In order to minimize the loosening of already tight bolts, tightening in the two stages shall be done starting from the stiffest part to the free edges. Stiffest parts of joint are generally towards the center of the joint.

III. **Personnel for Tightening:** The tightening of HSFG bolts is a technical procedure. Only trained personnel who understand the procedure shall carry out the installation of HSFG bolts. Before any person is deployed for installation, his knowledge of the procedure for tightening shall be checked and if found satisfactory, a competency certificate shall be issued by an engineer not below the rank of ADEN or equivalent. The competency certificate once issued shall be valid for six months. Any person deployed for installation of HSFG bolts must possess a valid competency certificate.

IV. **Procedure for Installation of HSFG Bolts Using Direct Tension Indicator:**

a. **Calibration of Direct Tension Indicator:** The direct tension indicators shall be tested on a calibrated load-measuring device as per description given in clause 3.4 of EN 14399-9 for the test procedure. The load requirement of Table 4 of EN 14399-9 shall be met when the direct tension indicators are compressed to the average gaps given in Table 9 of EN 14399-9. 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. Only the lot of DTIs which satisfy the test shall be used in the HSFG bolting assemblies and brought to site for work.

b. **Procedure:** The tightening is done in two stages so that the bolts already tightened do not get loose when the subsequent bolts are tightened.

1. First Stage of Tightening: As a first stage, all bolts in the joint shall be tightened to 'snug tight' condition. The term "Snug-Tight condition" can generally be taken as that achievable by the effort of one man using a normal sized spanner without an extension arm. This stage is required to bring the plies in close contact.
2. Checks after First stage tightening: After first stage of tightening, the joint shall be checked to see if the plies are in close contact and the clearances are not exceeded.
3. Second Stage of Tightening: During the second stage of tightening, torque wrench is used to tighten the bolts until the indentations on the DTI indicate full tightening.
4. Checks after Second stage tightening: 0.40 mm/0.25 mm thick feeler gauge shall be used to check 100% of the bolts for proper tightening. If the DTI is provided on the part (nut/bolt head) not being rotated, then 0.40 mm thick

feeler gauge shall be used. Else if the DTI is being provided under the part (nut/bolt head) being rotated, 0.25 mm feeler gauge shall be used (Refer Table 28.9.7 (g)-1 and Figure 28.9.3.1-1 & 28.9.3.1-2). If this gauge cannot be inserted in the space between indicator positions on a DTI, it is called a 'refusal'. The feeler gauge shall be used to determine if the bolt has been sufficiently tightened, as follows:

Number of indicator positions in DTI washer	Minimum number of feeler gauge refusals
4	3
5	3
6	4
7	4
8	5
9	5

The procedure for checking the proper tightening of bolt using DTI is shown in the Fig. 28.9.7 (g) of this code.

28.10.4 Painting over HSFG Bolting assemblies after its installation: In case of new construction, the final coat in field applied on complete structure may be applied on HSFG bolts also. For in-service structures, HSFG bolts shall be painted as per normal painting schedule and painting methodologies as specified in the Indian Railways Bridge Manual for the girder as a whole.

28.10.5 Retensioning/ Reuse of bolts: The HSFG bolts are tightened beyond yield stress level and undergo plastic deformation once tightened fully. If the bolt is opened out after complete tightening, its length gets increased permanently as compared with the initial length. The initial few threads which transfer the load from the nut to the bolt suffer the maximum damage. Therefore, a bolt completely tightened shall not be reused under any circumstances.

The bolt tensioned completely can be identified by damage to the threads especially near the front end of nut where most of the load is transferred. The coating, if any, may also show signs of damage. The free running of the nut on the threads may also be affected.

A fully tensioned bolt, opened out for any reason whatsoever, needs to be rejected and removed from the site of work. Along with the bolt, the nut, washer(s) and DTI(s) used on that bolt also need to be rejected and removed from the site of work.

A HSFG bolting assembly which has been snug tightened (i.e. Tightened upto first stage as given in clause 28.10.3 above) and then opened out will not be considered to have been retensioned and reuse of such bolts will be permissible in the same or different holes, as required.

28.10.6 Specifications and calibration of torque wrench: Only mechanical torque wrenches (pneumatic, hydraulic, electronic etc.) shall be used for tightening of HSFG bolting assemblies, however preference should be given to electronic torque wrenches. Calibrated torque wrenches, accompanied with a certificate to the effect, shall be brought to site. Torque wrenches shall be calibrated periodically to an accuracy of ±10%. These shall be re-calibrated in case of any incidence involving the wrench during use resulting in heavy impact (such as fall, mishandling

etc.) or if the joint is found to have been improperly tightened using the same. The procedure for calibration of torque wrench shall be as specified by the manufacturer.

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BY ORDER

07/5/14

(Rajeev Verma)
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RDSO, Lucknow