

HSFG Bolts (Gr. 8.8)

Sl. No.	Thread Type	Thread Length (mm)	Length (mm)	TOTAL
1	M16	37	45	220
2	M16	42	50	4850
3	M16	47	55	300
4	M20	40	50	100
5	M20	45	55	2100
6	M20	50	60	1400
7	M20	55	65	2330
8	M20	46	70	2167
9	M20	50	60	200
10	M20	46	70	350
11	M22	50	75	2874
12	M22	40	60	820
13	M22	40	80	1225
14	M22	40	85	480
15	M22	40	90	557
16	M22	40	100	178
17	M22	40	105	60
18	M22	40	120	123
19	M22	40	145	129
TOTAL				20463

(A) GENERAL:

1. COMPLETE HSFG BOLTING ASSEMBLY INCLUDING DIRECT TENSION INDICATOR (DTI) WASHER, SHALL BE SUPPLIED BY SINGLE MANUFACTURER WHO IS ALWAYS RESPONSIBLE FOR THE FUNCTION OF THE ASSEMBLY. IT IS ALSO IMPORTANT THAT HOT DIP GALVANIZING OR OTHER SURFACE COATINGS OF THE ASSEMBLY SHALL BE UNDER THE CONTROL OF THIS SINGLE MANUFACTURER.
2. USE OF DTI WASHER SHALL BE MANDATORY IN HSFG BOLTING ASSEMBLIES. 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 BELOW:

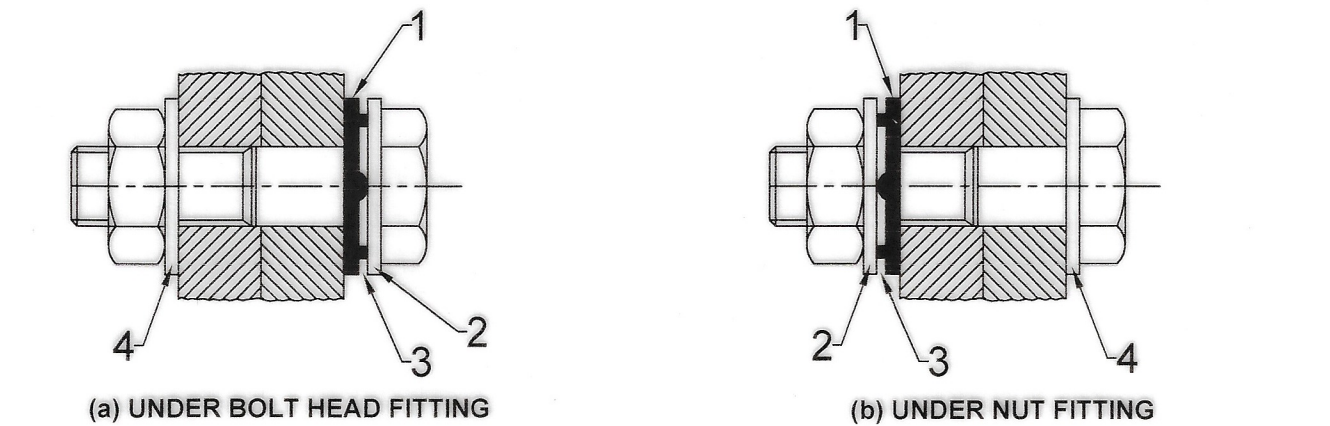
TYPE OF BOLTING ASSEMBLY		SYSTEM HR	
GENERAL REQUIREMENTS		EN 14399-1	
SUITABILITY FOR PRELOADING		EN 14399-2 AND, IF ANY, ADDITIONAL TESTING SPECIFIED IN THE PRODUCT STANDARD	
BOLT & NUT		EN 14399-3	
MARKING	BOLT	HR8.8	HR10.9
	NUT	HR8 or HR10	HR10
WASHERS		EN 14399-5 ^a or EN 14399-6	
MARKING		H or 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	

^aEN 14399-5 CAN ONLY BE USED UNDER THE NUT.

^bAT THE CHOICE OF THE MANUFACTURER.

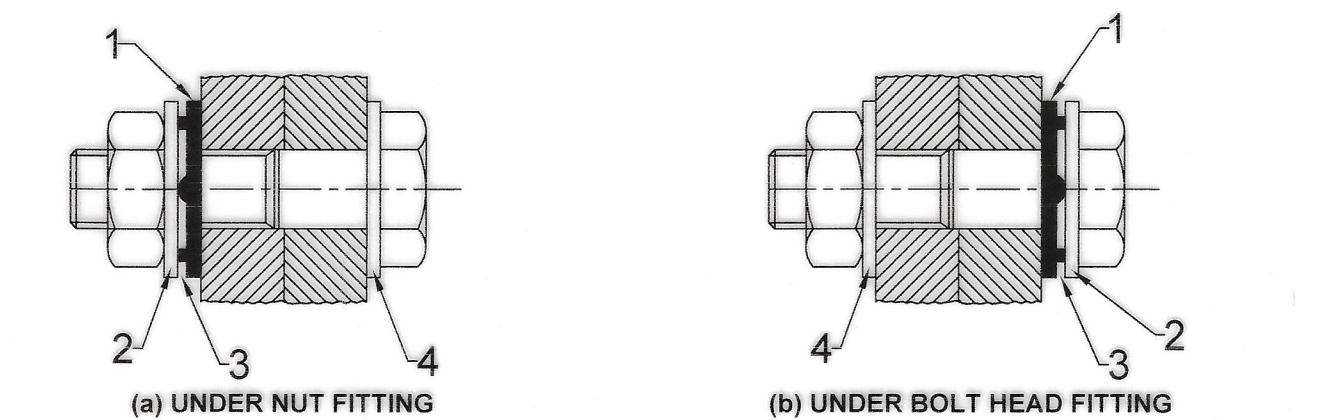
^aEN 14399-5 CAN ONLY BE USED UNDER THE NUT.
^bAT THE CHOICE OF THE MANUFACTURER.

3. TYPE OF HSFG BOLTING ASSEMBLIES WITH DTI:



- 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
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.1: TIGHTENING OF THE ASSEMBLY BY ROTATION OF THE NUT (NORMAL METHOD OF ASSEMBLY)



- KEY
1. DIRECT TENSION INDICATOR
2. NUT FACE WASHER
3. GAP
4. WASHER ACCORDING TO EN 14399-6
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.2: TIGHTENING OF THE ASSEMBLY BY ROTATION OF THE BOLT HEAD (ALTERNATIVE METHOD OF ASSEMBLY)

(B) BOLTS

1. 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.
- 2.

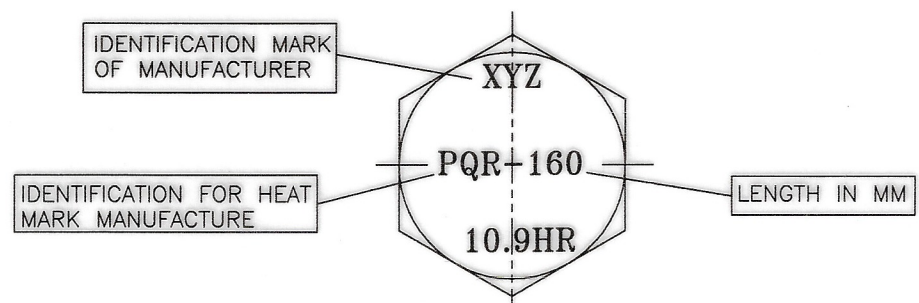


FIG.3: TYPICAL MARKING ON BOLT-HEADS FOR IDENTIFICATION

3. TABLE 2 OF EN14399-3 GIVES THE DIMENSIONS OF THE BOLT.
4. **LENGTH:** 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.
5. **SURFACE FINISH & COATINGS:** WHEREVER PROPERTY CLASS 8.8 BOLTS ARE USED THESE SHOULD BE HOT DIP GALVANIZED AS PER ISO: 10684 (LATEST VERSION). PROPERTY CLASS 10.9 BOLTS SHOULD 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). HOWEVER, DEPENDING ON THE SITE CONDITIONS, LOCATIONS OF THE BOLTS IN THE STRUCTURE AND CORROSION PRONESS, USE OF ZINC FLAKE SPRAY COATING AS PER ISO 10683 (LATEST VERSION) CAN BE ADOPTED EVEN FOR PROPERTY CLASS 8.8 BOLTS AS WELL.

(C) NUT:

1. 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.
2. 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.
3. 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.
4. DIMENSIONS OF THE NUTS SHOULD BE AS PER THE TABLE 4 OF EN 14399-3.

5. IDENTIFICATION OF NUT:

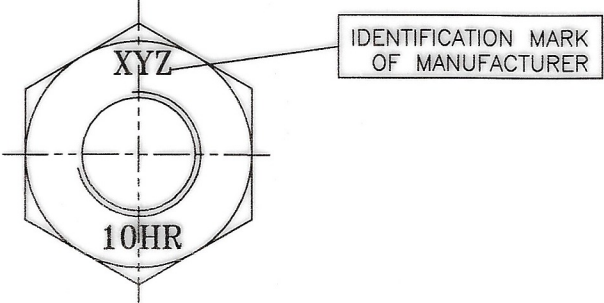


FIG.4: TYPICAL MARKING ON NUTS

6. **SURFACE FINISH AND COATINGS OF NUT:** HSFG NUTS OF PROPERTY CLASS 8 SHOULD BE HOT DIP GALVANIZED AS PER ISO 10684 (LATEST VERSION). PROPERTY CLASS 10 NUTS SHOULD NOT BE HOT DIP GALVANIZED SINCE THIS MAY CAUSE HYDROGEN EMBRITTLEMENT. SO THESE NUTS SHOULD BE COATED WITH ZINC FLAKES AS PER ISO: 10683. HOWEVER, DEPENDING ON THE SITE CONDITIONS, LOCATIONS OF THE NUTS IN THE STRUCTURE AND CORROSION PRONESS, USE OF ZINC FLAKE SPRAY COATING CAN BE ADOPTED EVEN FOR PROPERTY CLASS 8 NUTS AS WELL.
7. **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:
- a. **IN GIRDER WEB:** TOWARDS OUTSIDE OF THE GIRDER.
b. **IN FLANGES:** TOWARDS BOTTOM (EXCEPT WHEN IN COMPOSITE CONSTRUCTION).
c. **IN COMPOSITE CONSTRUCTION:** TOWARDS INSIDE OF CONCRETE.
d. **IN BRACING:** TOWARDS THE ROLLED SECTION SIDE SO THAT THE SPACE FOR ROTATION OF THE NUT IS NOT READILY AVAILABLE.
e. WHERE **TAPERED WASHER** IS USED, THE NUT SHALL PREFERABLY BE ON THE OTHER SIDE.

(D) PLAIN AND PLAIN CHAMFERED WASHER:

1. 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.
2. 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.
3. DIMENSIONS OF PLAIN AND PLAIN CHAMFERED WASHERS HAVE BEEN GIVEN IN TABLE 2 OF EN 14399-5 AND EN 14399-6 RESPECTIVELY.
4. 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.
5. 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 $d_s \leq 20$ MM (b) 1/30 (2°) FOR BOLTS WITH $d > 20$ MM. DIMENSIONS AND STEEL GRADES FOR TAPER WASHERS SHALL BE SPECIFIED.
6. **IDENTIFICATION:**

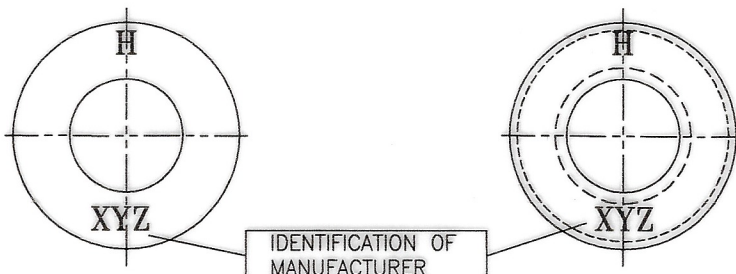


FIG.5: TYPICAL MARKING/SHAPES ON PLAIN AND PLAIN CHAMFERED WASHERS

7. **SURFACE FINISH AND COATINGS:** WASHERS AS PER EN 14399-5 AND EN 14399-6 CAN BE HOT DIP GALVANIZED AS PER ISO 10684 (LATEST VERSION). 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.

(E) DTI

1. 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.
2. 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.
3. 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.
4. **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 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 INDENTED INTO ONE FACE.
5. **SURFACE FINISH AND COATINGS:** FOR CORROSION PROTECTION OF DTI, NUT FACE WASHERS AND BOLT FACE WASHERS; HOT DIP GALVANIZATION SHOULD 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 SHOULD BE SHERADIZED ACCORDING TO EN 13811 OR ZINC FLAKE COATING AS PER ISO 10683 SHOULD BE DONE.

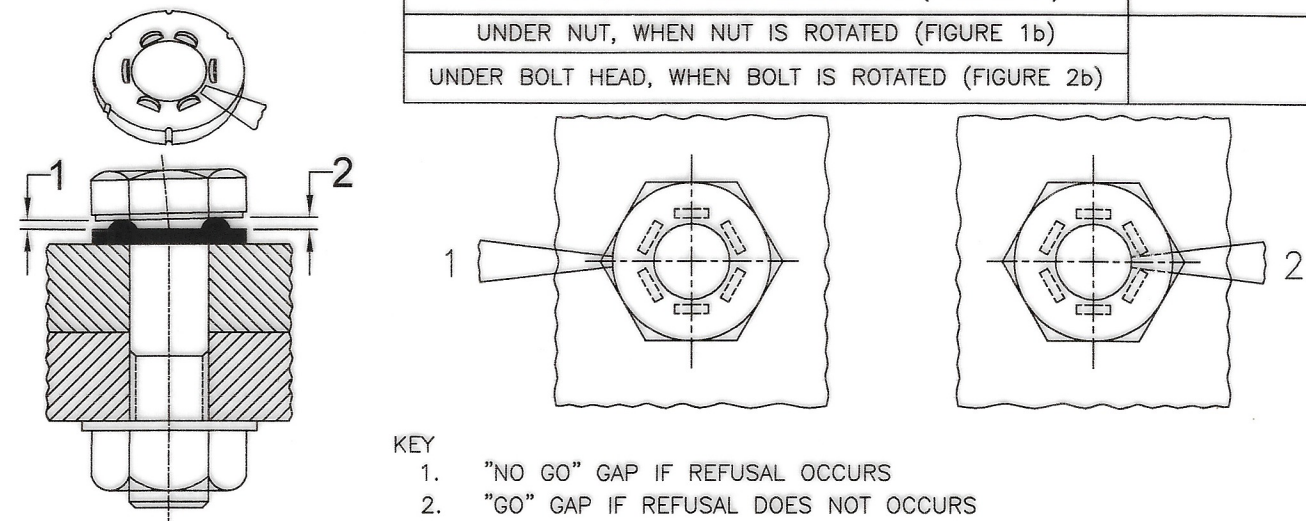
(F) INSTALLATION OF HSFG BOLTING ASSEMBLIES:

1. 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.
2. ONLY THE DTI METHOD TO BE USED DUE TO ITS SIMPLICITY IN APPLICATION IN FIELD. THE AS DELIVERED CALIBRATION IS VALID FOR TIGHTENING BY ROTATION OF THE NUT. HOWEVER 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.
3. BURRS, LOOSE MATERIALS AND EXCESSIVE THICKNESS OF PAINT THAT WOULD PREVENT SOLID SEATING OF THE CONNECTING PARTS SHALL BE REMOVED BEFORE ASSEMBLY.
4. 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. "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.
5. **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.
6. **PROCEDURE FOR INSTALLATION OF HSFG BOLTS USING DIRECT TENSION INDICATOR:**
- i. **PERFORMANCE TEST 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 PERFORMANCE TEST SHALL BE BROUGHT TO SITE FOR WORK.
- ii. **PROCEDURE:** THE TIGHTENING IS DONE IN TWO STAGES SO THAT THE BOLTS ALREADY TIGHTENED DO NOT GET LOOSE WHEN THE SUBSEQUENT BOLTS ARE TIGHTENED.
- a. **FIRST STAGE OF TIGHTENING:** AS A FIRST STAGE, ALL BOLTS IN THE JOINT SHALL BE TIGHTENED TO "SNUG-TIGHT" CONDITION. SNUG TIGHT CONDITION MEANS THE NUT IS TIGHTENED USING AN ORDINARY WRENCH BY AN AVERAGE WORKER, APPLYING MAXIMUM FORCE ON THE WRENCH. THIS STAGE IS REQUIRED TO BRING THE PLIES IN CLOSE CONTACT.
- b. **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.
- c. **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.
- d. **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 (REFER TABLE 1). 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. 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

TABLE 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 (FIGURE 1a)	0.40
UNDER NUT, WHEN BOLT IS ROTATED (FIGURE 2a)	
UNDER NUT, WHEN NUT IS ROTATED (FIGURE 1b)	0.25
UNDER BOLT HEAD, WHEN BOLT IS ROTATED (FIGURE 2b)	



- KEY
1. "NO GO" GAP IF REFUSAL OCCURS
2. "GO" GAP IF REFUSAL DOES NOT OCCURS

FIG.6: CHECKING THE INDICATOR GAP(EXAMPLE WITH SIX PROTRUSIONS)

THE PROCEDURE FOR CHECKING THE PROPER TIGHTENING OF BOLT USING DTI IS SHOWN IN THE FIG.6 ABOVE.

(G) IMPORTANT ISSUES:

1. BEFORE START OF WORK PARA 28.9 & 28.18 OF IRS B1, PARA -1107.5 (i) & 215A OF IRBM AND LATEST REVISION OF RDSO REPORT NO. BS-111 MAY BE REFERRED TO, IF REQUIRED.
2. **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:
- a. MAKING OF HOLES: THE HOLES SHALL BE MADE BY DRILLING ONLY.
b. 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.
3. **SURFACE PREPARATION FOR STEEL INTERFACE BEFORE PROVIDING HSFG BOLTS:** THE INTERFACE BETWEEN THE PLIES WHICH ARE CONNECTED TOGETHER BY THE HSFG BOLTS SHALL BE "ALUMINIUM METALLISING WITHOUT ANY OVER COATING". THE ALUMINIUM METALLISING SHALL BE AS PER PARA 39.2.1 OF IRS B1 AND SHALL HAVE NOMINAL THICKNESS OF 150 μ m. IN CASE THE METALLISED INTERFACE IS PAINTED BY MISTAKE OR ANY OTHER REASON, THE PAINTED SURFACE SHALL BE LIGHT SAND BLASTED TO REMOVE THE PAINT LEAVING METALLISING LAYER INTACT.
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.
5. **ANTI-THEFT AND ANTI-SABOTAGE MEASURES:** TACK WELDING IN HSFG BOLTS SHALL NOT BE RESORTED TO AS ANTI THEFT MEASURE FOR WHATSOEVER REASON. INSTEAD, SUITABLE BONDING AGENT TO SEIZE OR LOCK THE BOLT IN POSITION MAY BE APPLIED TO THE THREADS PROJECTING BEYOND THE NUT. ANY BONDING AGENT MUST INCREASE THE TORQUE REQUIRED FOR OPENING OF BOLT BY MINIMUM 200 Nm AND THESE PRODUCTS SHOULD BE TESTED EXPERIMENTALLY TO ASCERTAIN ITS TORQUE INCREASING CAPACITY AS MENTIONED ABOVE IN DIFFERENT SITE AND ENVIRONMENT CONDITIONS BEFORE ANY ACTUAL USE. MOREOVER USE OF LARGER BOLT DIAMETER (M22 AND ABOVE) WILL HELP IN ACHIEVING THE CONSIDERABLE SAFETY AGAINST ANTI THEFT. IT MAY BE NOTED THAT HAMMERING OF BOLTS TO DAMAGE ITS THREADS IS LIKELY TO AFFECT THE ENTIRE BOLT ASSEMBLY AND IS NOT RECOMMENDED.
6. **INSPECTION:** THE IDENTIFICATION OF LOOSE BOLTS SHALL NOT NORMALLY REQUIRE TESTING BY HITTING ETC. LOOSENESS SHALL BE IDENTIFIED BY LOOKING AT THE SIGNS SUCH AS WATER INGRESS IN THE JOINT, SIGNS OF RUST COMING FROM INSIDE THE JOINT AND FINE POWDERY MATERIAL COMING OUT OF JOINT ETC. IF LOOSE BOLTS ARE FOUND, THE SAME SHALL BE MARKED BY A ROUND CIRCLE ALL AROUND AND SHALL BE REPLACED EXPEDITIOUSLY.
7. **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) 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.
8. **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 $\pm 10\%$. THESE SHALL BE RE-CALIBRATED IN CASE OF ANY INCIDENT 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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R. D. S. O.

NOTES FOR USE OF
HIGH STRENGTH FRICTION GRIP (HSFG)
BOLTS IN BRIDGES

PROVISIONAL DATE:-24. 05. 2019

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NOTE

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