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EN 14399-3/6

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HR-sets

Introduction

Publication of prestressed bolting standards for steel construction (EN 14399) as well as the execution standards for steel structures (Eurocode 3 EN 1090-1 and 2) has changed the use of bolts in metal construction.

The European HR-product standards are so called harmonized standards (published in the Official Journal of the European Union) according to the Construction Product Regulation. Structural design notes must be formulated according to the Eurocode in conformity with Annex A of EN 1090-1.

The designations HR apply to pre-loaded bolt sets (class 10.9). The term HR stands for 'High Resistance'. HR bolts are used in both static and predominantly dynamic steel constructions. By pre-tensioning the bolts at the right tightening torque, a strong connection is made.

HR hex bolts have a larger hexagonal width than standard bolts and therefore have a larger bearing surface under the head to better distribute the tension on the bolts. The defined coefficient of friction makes it possible to pre-tension them.

Where joints have not been calculated with the slip factor included, pre-loading is not required. However, it is usual to pre-load joints in order to reduce the slack, increase the resistance to dynamic loads and limit the deformation of the whole structure.

pgb Hot-dip galvanized HV, HR, and SB bolts are galvanized according to ISO 10684 with a minimum of 50 microns thickness and have an excellent corrosion resistance. SB bolts are also available zinc plated.

HR bolted connections can be used in both predominantly static constructions and predominantly dynamic constructions. Examples of predominantly static structures are halls, steel skeleton buildings and scaffolding where no high loads are required. These connections are therefore mainly loaded on shear.

Predominantly dynamic constructions include cranes, rails, bridges, pylons or wind turbines. These constructions are subjected to greater forces and therefore the bolt connection must be fully pre-tensioned. The connection is then not loaded on shear, but on tensile force in the bolted connection.

Standards

The EN 14399 standard has been developed for high strength pre-loaded fasteners. Parts 1 and 2 of this standard describe the requirements and the process to get the “CE” marking. The screws, nuts and washers composing the HR sets can be found in parts 3 and 6 of this standard.

In compliance with the European standard, hot dip galvanized HR nuts are always treated with a special molybdenum disulphide lubricant giving this characteristic black color.

An HR set consists of the following elements:

- 1 HR 10.9 hexagon head screw, hot-dip galvanized, in accordance with EN 14399–3
- 1 hexagonal nut HV 10, hot-dip galvanized, in accordance with standard EN 14399–3
- 2 HV 300–370 HV washers, hot-dip galvanized, in accordance with EN 14399–6

The pgb HR bolts must be pre-tensioned according to the class K2 method in two steps.

Identification

In order to allow a clear identification of the HR sets, each element bears a marking to identify the product and limit the risk of error. In addition, the indication of the manufacturing batch number guarantees traceability before and after assembly. The marking must therefore always remain visible. When mounting the washers and nuts, it is mandatory to ensure that the face bearing the marking is facing outward.

- HR designation
- Resistance class 10.9
- Manufacturer’s symbol ‘PGB’
- Batch number (eg 11)

- HR designation
- Resistance class ‘10Z’
- Manufacturer’s symbol ‘PGB’
- Batch number (eg 07)

- Designation ‘H’
- Manufacturer’s symbol ‘PGB’
- Batch number (eg 15)

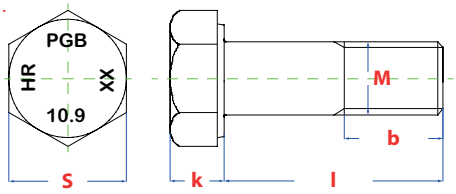
Standard range

HR 10.9 bolt, EN 14399-3	HR 10 nut, EN 14399-3	HR washer, EN 14399-6
M12 x 30 – 90	M12	M12
M14 x 30 – 70	M14	M14
M16 x 40 – 110	M16	M16
M18 x 50 – 100	M18	M18
M20 x 45 – 160	M20	M20
M22 x 50 – 110	M22	M22
M24 x 60 – 280	M24	M24
M27 x 70 – 170	M27	M27
M30 x 80 – 195	M30	M30
M36 x 100 – 200	M36	M36

HR-combinations are delivered pre-assembled with 2 washers and 1 nut.

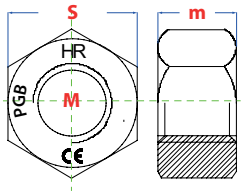
HR combinations

HR hexagonal head screw - 10.9 – Hot dip galvanized – EN 14399-3



Size	M12	M14	M16	M18	M20	M22	M24	M27	M30	M36
Socket wrench (S)	22	24	27	30	32	36	41	46	50	60
Pitch (P)	1,75	2,0	2,0	2,5	2,5	2,5	3,0	3,0	3,5	4,0
Head thickness (k)	7,5	8,8	10	11,5	12,5	14	15	17	18,7	22,5
Thread length (b) l ≤ 125	30	34	38	42	46	50	54	60	66	78
Thread length (b) l > 125 ≤200	-	40	44	48	52	56	60	66	72	84
Thread length (b) l > 200	-	-	-	-	65	69	73	79	85	97

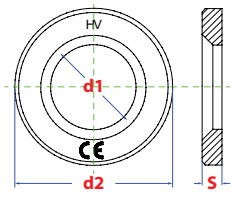
HR nut – classe 10 – Hot dip galvanized + lubricant (MoS2) black – EN 14399-3



Size	M12	M14	M16	M18	M20	M22	M24	M27	M30	M36
Socket wrench (S)	22	24	27	30	32	36	41	46	50	60
Height (m)	10,8	12,8	14,8	16	18	20	21,5	23,8	25,6	31

MoS2 is a common dry or powder lubricant and has a black graphite colour. This explains why the nuts have a black colour after adding this lubricant.

HV washer – 300-370 hv – Hot dip galvanized – EN 14399-6



Size	M12	M16	M18	M20	M22	M24	M27	M30	M36
Inner diameter (d1)	13	17	19	21	23	25	28	31	37
Outer diameter (d2)	24	30	34	37	39	44	50	56	66
Thickness (S)	3	4	4	4	4	4	5	5	6

Choice of length according to clamping capacity

Important remarks about clamping capacity

As the thread length of HR bolts is relatively short, a particular attention should be paid to the choice of length according to clamping capacity. If an HR bolt is too long, the body (non-threaded part) of the bolt may exceed the thickness of the steel structure thickness, preventing the required pre-stressing force to be applied. Conversely, in case the bolt is too short, the available thread length is insufficient to effectively resume the pre-stressing force.

Therefore, the following conditions must be fulfilled:

$$(l_{gmax} + 2\,P) < \sum t < (l_{min} - P - m_{max})$$

- l_{gmax} = maximum body length
- P = screw pitch
- $\sum t$ = clamping capacity
- m_{max} = maximum nut height
- l_{min} = nominal screw length

In other words:

(body length + 2 pitch) < clamping capacity < (nominal length - 1 pitch - 1 nut height)

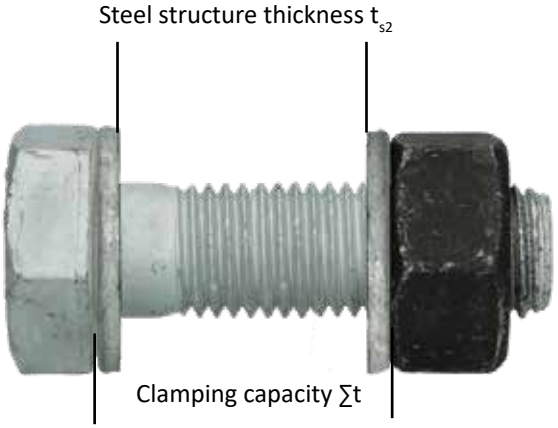
The values indicated in the table on the next page ∑tmin and ∑tmax are within this perimeter. The values for ∑t max are fixed so that the screw protrudes 1 pitch from the free face of the nut.

Clamping capacity with HR-sets

The definition of the clamping capacity according to EN 14399-3 includes two washers. We must therefore distinguish the tightening capacity of the bolt and the thickness of the steel structure.

Clamping capacity is the distance between the head of the screw and the nut.

Steel structure thickness is the distance between the 2 washers. According to EN 1090-2, to compensate the clamping length, up to three washers of a total thickness not exceeding 12 mm can be installed on the end which is not turned.



Clamping capacity HR-sets

Clamping capacity ∑t

Dim.	M12		M14		M16		M18		M20		M22		M24		M27		M30		M36	
L	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
30	14	16																		
40	14	26	16	23	16	21														
50	27	36	16	33	16	31	20	30	20	28	20	26								
60	37	45	34	43	30	41	20	40	20	38	20	36	24	34	24	31				
70	47	55	44	53	40	51	38	50	34	48	20	46	24	44	24	41	28	39		
80	57	65	54	63	50	61	48	60	44	58	40	56	24	54	24	51	28	49		
90	67	75	64	73	60	71	58	69	54	67	50	66	48	63	42	61	28	59	32	53
100	77	85	74	83	70	81	68	79	64	77	60	76	58	73	52	71	48	69	32	63
110			84	93	80	91	78	89	74	87	70	86	68	83	62	81	58	79	32	73
120			94	103	90	101	88	99	84	97	80	96	78	93	72	91	68	89	58	83
130			98	113	94	111	92	109	88	107	84	106	82	103	76	101	72	98	62	93
140			108	123	104	121	102	119	98	117	94	116	92	113	86	111	82	108	72	103
150			118	133	114	131	112	129	108	127	104	126	102	123	96	121	92	118	82	113
160																	102	126	92	121

Steel construction thickness HR-sets

Steel construction thickness t_{s2}

Dim.	M12		M14		M16		M18		M20		M22		M24		M27		M30		M36	
L	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max	min	max
30	9	9																		
40	9	19	11	17	9	13														
50	22	29	11	27	9	23	13	21	13	19	13	18								
60	32	39	29	37	23	33	13	31	13	29	13	28	17	25	16	20				
70	42	49	39	47	33	43	31	41	27	39	13	38	17	35	16	30	20	28		
80	52	59	49	57	43	53	41	51	37	49	33	48	17	45	16	40	20	38		
90	62	69	59	66	53	62	51	61	47	59	43	57	41	55	34	50	20	47	22	40
100	72	79	69	76	63	72	61	71	57	69	53	67	51	65	44	60	40	57	22	50
110			79	86	73	82	71	81	67	79	63	77	61	75	54	70	50	67	22	60
120			89	96	83	92	81	91	77	89	73	87	71	85	64	80	60	77	48	70
130			93	106	87	102	85	101	81	98	77	97	75	94	68	90	64	87	52	79
140			103	116	97	112	95	111	91	108	87	107	85	104	78	100	74	97	62	89
150			113	126	107	122	105	121	101	118	97	117	95	114	88	110	84	107	72	99
160																	94	115	82	107

Tightening torque HR-sets

Tightening torque for class K2 - method in two steps

Step 1 according to EN 1090-2

Initial tightening torque $M_{r,i}$ at 75% in Nm								
Size	$F_{p,c}$	With K=						
		0,1	0,11	0,12	0,13	0,14	0,15	0,16
M12	59	53	58	64	69	74	80	85
M14	81	85	93	101	110	118	127	135
M16	110	132	145	158	171	185	198	211
M18	134	181	200	218	236	254	272	290
M20	172	257	283	309	334	360	386	412
M22	212	350	385	420	455	490	525	560
M24	247	445	489	534	578	623	667	712
M27	321	651	716	781	846	911	976	1041
M30	393	884	972	1060	1149	1237	1325	1414
M36	572	1544	1699	1853	2007	2162	2316	2471

Step 2 according to EN 1090-2

Final tightening torque M_r to 110% in Nm								
Size	$F_{p,c}$	With K=						
		0,1	0,11	0,12	0,13	0,14	0,15	0,16
M12	59	78	86	93	101	109	117	125
M14	81	124	136	149	161	174	186	198
M16	110	193	213	232	251	271	290	309
M18	134	266	293	319	346	373	399	426
M20	172	377	415	453	490	528	566	604
M22	212	513	565	616	667	719	770	821
M24	247	652	718	783	848	913	979	1044
M27	321	954	1050	1145	1241	1336	1431	1527
M30	393	1296	1426	1555	1685	1814	1944	2073
M36	572	2265	2491	2718	2944	3171	3397	3624

Tip: Tightening torque on the label

The labels of pgb-fasteners show the recommended torque according to EN 14399 for the HR combinations.

Notes

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