

User Manual

HV Solution for safe connections

HV high strength bolt sets
for preloading in accordance
with EN 14399-1:2015

SB SETS

Non-preloaded structural bolting assemblies
in accordance with EN 15048:2007

RAWLPLUG®
Koelner Łańcucka Fabryka Śrub






KISTLER













Practice, advanced technology and 60 years of experience - these three factors make Rawlplug Koelner Lancucka Fabryka Srub one of the leading manufacturers of fasteners in Europe. The history of the plant dating back to 1957 is invaluable capital, which, combined with the latest technology and the best specialists, mean that the fasteners manufactured here are of the highest quality, reliability and innovation, meeting the requirements of customers from industries where safety and confidence are the basis.

Koelner Lancucka Fabryka Srub is part of the Rawlplug Group, which brings together numerous production plants and marketing companies covering all continents. Marked with the LF trademark, the solutions are used in many industries and in the largest, most prestigious investments around the world, which is proof of the highest level of quality and service ability.

Our mission is to provide customers with products they can trust. We make this possible by continuously implementing product and production innovations. Due to the systematic reconstruction and modernization of the machine park and technological processes, we have become one of the most modern production plants in its category, employing highly qualified engineering and technical staff. Moreover we perform most of the processes on site giving us independence and absolute certainty of maintaining the highest production standards. We have our own modern research and development facilities. Our team consists of the following laboratories: Chemical, Length and Angle Measurement, Metallographic, Testing and Simulation, as well as Construction. In turn, the implemented quality management system, obtained certificates and approvals, as well as our own Quality Control Department ensure a tight and accurate control process of our fasteners and their appreciated reliability. The confirmation of our efforts is the Quality Management System implemented by the company, based on models compatible with **IATF 16949:2016, ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018**. It is the basis for maintaining the highest level of quality of products and services, minimizing the impact on the environment, as well as maintaining occupational safety.

We have been building our product portfolio for many years based on products from the medium and higher priced segments. In addition to standard products (such as welding bolts, flange bolts with serrations, bolts with rolled washer or inch bolts) we also manufacture highly special fasteners, which constitute up to 70% of the plant's production and are made according to drawings and specifications of our customers. Special products are used in many industries, for instance, the automotive industry, where the highest quality and flawless, precise workmanship count. Bolts with the LF mark contribute to the trouble-free operation of vehicles manufactured by leading European and global automotive manufacturers, which is the best confirmation of their highest quality. Rawlplug Koelner Lancucka Fabryka Srub is also a certified manufacturer of HV high strength sets in accordance with the harmonized standard EN 14399;2015 and the guidelines of CPR Directive no. 305/2011.

In addition to technical excellence, the values we follow as a company reflect our way of thinking and determine all our actions. Every day, we strive for excellence, we are open to change and constantly ready to take on new challenges. We are constantly looking for newer, even better solutions, continuing the rich tradition of both Koelner Lancucka Fabryka Srub, as well as the Rawlplug Group - a reputable manufacturer of fasteners with a 100-year history. We focus on teamwork and motivate our employees to excel, because we are convinced that their knowledge and competences are one of the keys to our success. Our highly skilled team of specialists have developed innovative solutions which we have incorporated into our daily production processes.

As an expert in the fasteners industry, we treat our position very seriously. The needs, requirements and expectations of our customers, both internal and external, are our priority, thanks to which - as well as thanks to the partnership approach - we create long-lasting and satisfying relationships with them. We proudly continue the history of Lancucka Fabryka Srub - this valuable heritage is a challenge, inspiration and driving force for the constant search for even better, more reliable and more accurate innovations. Innovations you can trust.


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TÜV NORD

CERTIFICATE

OF CONFORMITY OF THE FACTORY PRODUCTION CONTROL

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HV HIGH-STRENGTH STRUCTURAL BOLTING ASSEMBLIES FOR PRELOADING

HV set consists of:
- bolt and nut according to EN 14399-4
- 2 washers according to EN 14399-6

FEATURES AND ADVANTAGES

- Property grade 10.9 (Heat treatment process according to automotive specification CQI-9)
- Suitable for preloading according to DIN EN 1090-2
- K-class: K1, 0,10 ≤ k ≤ 0,16 K-class: K2, 0,10 ≤ km≤0,23; Vk≤0,06
- Hot dip galvanization (additional process in accordance with Deutscher Schraubenverband e.V. requirements)
- Defined and controlled friction properties
- High fatigue resistance due to lack of ferrite delta



CONNECTIONS

Shear connections

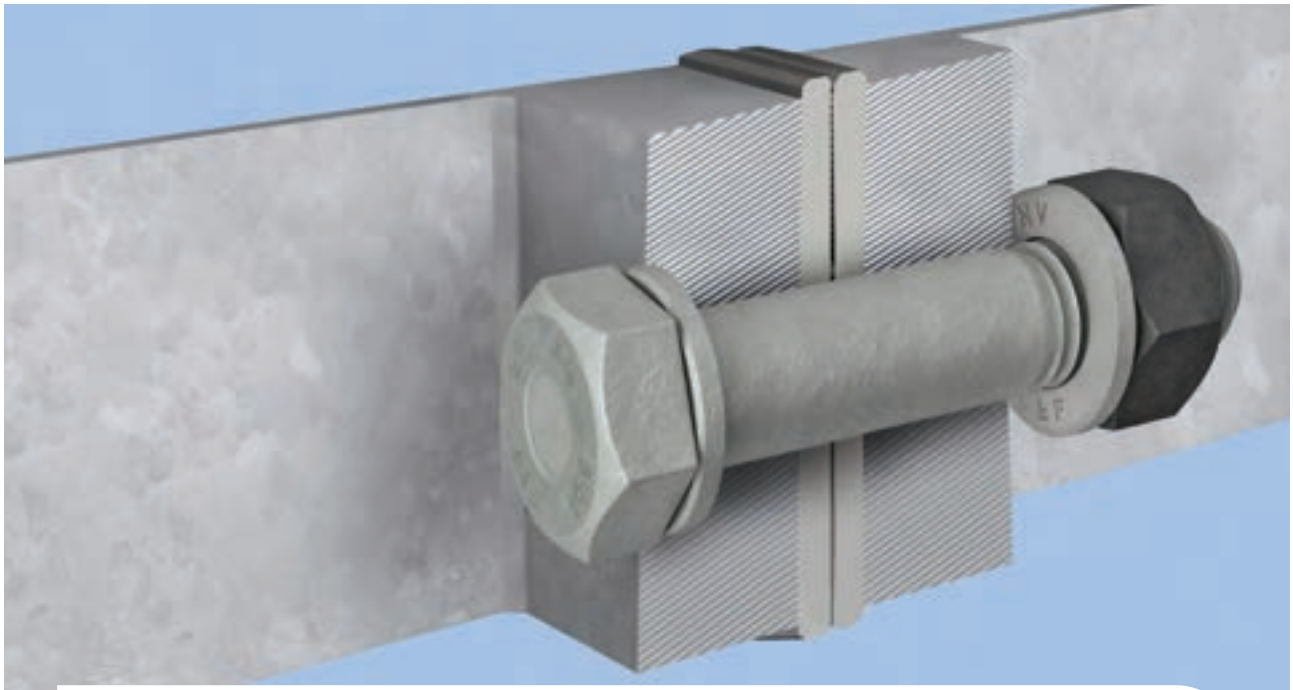
- Category A: Bearing Type connections
- Category B: Slip-resistant at serviceability limit state
- Category C: Slip-resistant at ultimate limit state

Tension connections

- Category D: Non-preloaded
- Category E: Preloaded



Full product traceability



HV sets enable reliable, fast and simple connection of steel constructions. Simplicity of connection and safe longterm usage are main advantages.

APPLICATIONS

- Halls
- Bridges
- Trading centres
- Roof constructions
- Internal building skeletons with large lateral spread
- Multi-level parkings
- Wind turbines
- Industrial installations












PR 3

HV1 LIST OF APPLICABLE STANDARDS

LIST OF APPLICABLE STANDARDS

Standard number	Year of issue*	Full name
EN 14399-1	2015	High-strength structural bolting assemblies for preloading - Part 1: General requirements
EN 14399-2	2015	High-strength structural bolting assemblies for preloading - Part 2: Suitability for preloading
EN 14399-4	2015	High-strength structural bolting assemblies for preloading - Part 4: Hexagon bolt and nut assemblies
EN 14399-6	2015	High-strength structural bolting assemblies for preloading - Part 6: Plain chamfered washers
EN 1090-2	2018	Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures
ISO 898-1		Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread
ISO 898-2		Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes — Coarse thread and fine pitch thread
ISO 898-3		Mechanical properties of fasteners made of carbon steel and alloy steel — Part 3: Flat washers with specified property classes
ISO 9001		Quality management systems - Requirements
IATF 16949	2016	Quality management system standard in the automotive industry
DIN 50602		Metallographic examination; microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions
ISO 148-1		Metallic materials — Charpy pendulum impact test — Part 1: Test method
ISO 6157-3		Fasteners — Surface discontinuities — Part 3: Bolts, screws and studs for special requirements
ISO 6157-2		Fasteners - Surface discontinuities - Part 2: Nuts
ISO 10684		Fasteners — Hot dip galvanized coatings
EN 1993-1-8		Eurocode 3: Design of steel structures -Part 1-8: Design of joints
EN ISO 6789		Assembly tools for screws and nuts — Hand torque tools — Requirements and test methods for design conformance testing, quality conformance testing and recalibration procedure
EN 10204	2004	Metallic Products: Types of Inspection Documents
ISO 2859-5		Sampling procedures for inspection by attributes - Part 5: System of sequential sampling plans indexed by acceptance quality limit (AQL) for lot-by-lot inspection
EN 15048-1	2007	Non-preloaded structural bolting assemblies - Part 1: General requirements
EN 15048-2	2007	Non-preloaded structural bolting assemblies - Part 2: Fitness for purpose
ISO 4014		Hexagon head bolts — Product grades A and B
ISO 4017		Hexagon head bolts with thread up to head - Product grades A and B
ISO 4032		Hexagon regular nuts (style 1) — Product grades A and B

* The latest issue applies to standards for which no date of issue is given.

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HV2 SALE OF HV PRODUCTS

SALE OF HV PRODUCTS

HV sets are available for sale from the warehouse in the M12 - M36 range, in accordance with the following table. Confirmation of product availability when bidding is required. Possibility to manufacture other sizes for verification after request for proposal.

Size	12	16	20	22	24	27	30	36
30								
35								
40								
45								
50								
55								
60								
65								
70								
75								
80								
85								
90								
95								
100								
105								
110								
115								
120								
125								
130								
140								
145								
150								
155								
160								
165								
170								
175								
180								
185								
190								
195								
200								
210								
220								
230								
240								
250								
260								

Standard range Additional range outside the standard





HV2 SALE OF HV PRODUCTS

Bolts, nuts and washers are packed separately. Alternative packaging options (e.g. set of components in one box, packaging of pre-assembled sets) available on request.

Tab. 1. Number of pieces in packages - bolts.

Size	Box (pcs)	Pallet (pcs)
12x30	100	12500
12x35	100	10000
12x40	100	10000
12x45	100	10000
12x50	100	7500
12x55	100	7500
12x60	50	7500
12x65	50	6250
12x70	50	6250
12x75	50	6250
12x80	50	6250
12x85	50	6250
12x90	50	6250
12x95	50	6250
12x100	50	5000
12x105	50	5000
12x110	50	5000
12x115	50	5000
12x120	50	5000
12x125	50	5000
12x130	50	5000
12x135	50	5000
12x140	50	5000
12x145	50	5000
12x150	50	5000
12x155	50	5000
12x160	25	5000
12x165	25	5000
12x170	25	5000
12x175	25	5000
12x180	25	5000
12x185	25	5000
12x190	25	5000
12x195	25	5000
12x200	25	5000
16x35	50	5000
16x40	50	5000
16x45	50	5000
16x50	50	5000
16x55	50	5000
16x60	50	3750
16x65	50	3750
16x70	50	3400
16x75	50	3400
16x80	25	3125
16x85	25	3125
16x90	25	3125
16x95	25	3125
16x100	25	2500
16x105	25	2500
16x110	25	2500
16x115	25	2500
16x120	25	2500
16x125	25	2500
16x130	25	2500
16x135	25	2500
16x140	25	2500
16x145	25	1275
16x150	25	1275
16x155	25	1275
16x160	25	1275
16x165	25	1275
16x170	25	1275
16x175	25	1275
16x180	25	1275
16x185	25	1275
16x190	25	1275
16x195	25	1275
16x200	25	1275
16x210	25	1275
16x220	25	1275
20x40	25	2500
20x45	25	2500
20x50	25	2500
20x55	25	2500
20x60	25	2500
20x65	25	2500
20x70	25	2500
20x75	25	2125
20x80	25	2125
20x85	25	2125
20x90	25	2125
20x95	25	1700
20x100	25	1700
20x105	25	1700
20x110	25	1700
20x115	25	1700
20x120	25	1700
20x125	25	1275
20x130	25	1275
20x135	25	1275
20x140	25	1275
20x145	25	1275
20x150	25	1275
20x155	25	1275
20x160	20	640
20x165	20	640
20x170	20	640
20x175	20	640
20x180	20	640
20x185	20	640
20x190	20	640
20x195	20	640
20x200	20	640
20x210	20	640
20x220	20	640
20x230	20	640
20x240	20	640
20x250	20	640
20x260	20	640
22x50	25	1700
22x55	25	1700
22x60	25	1700
22x65	25	1700
22x70	25	1275
22x75	25	1275
22x80	25	1275
22x85	25	1275
22x90	25	1275
22x95	25	1200
22x100	25	1200
22x105	25	1200
22x110	25	1200
22x115	25	1200
22x120	20	960
22x125	20	960
22x130	20	960
22x135	20	960
22x140	20	960
22x145	20	960
22x150	20	960
22x155	20	960
22x160	20	960
22x165	20	960
22x170	10	850
22x175	10	850
22x180	10	850
22x185	10	850
22x190	10	850
22x195	10	850
22x200	10	850
22x210	10	850
22x220	10	850
22x230	10	850
22x240	10	850
24x50	25	1700
24x55	25	1700
24x60	25	1700
24x65	25	1700
24x70	25	1275
24x75	25	1275
24x80	25	1275
24x85	25	1275
24x90	25	1275
24x95	25	1200
24x100	25	1200
24x105	25	1200
24x110	25	1200
24x115	20	960
24x120	20	960
24x125	20	960
24x130	20	960
24x135	20	960
24x140	20	960
24x145	20	640
24x150	20	640
24x155	20	640
24x160	20	640
24x165	20	640
24x170	10	850
24x175	10	850
24x180	10	850
24x185	10	850
24x190	10	850
24x195	10	850
24x200	10	850
24x210	10	850
24x220	10	850
24x230	10	850
24x240	10	850
27x60	25	850
27x65	25	850
27x70	25	850
27x75	25	850
27x80	25	800
27x85	25	800
27x90	25	800
27x95	25	800
27x100	25	800
27x105	25	800
27x110	25	800
27x115	25	800
27x120	20	640
27x125	20	640
27x130	20	640
27x135	20	640
27x140	20	640
27x145	20	640
27x150	20	640
27x155	10	320
27x160	10	320
27x165	10	320
27x170	10	320
27x175	10	320
27x180	10	320
27x185	10	320
27x190	10	320
27x195	10	320
27x200	10	320
27x210	10	320
27x220	10	320
27x230	10	320
27x240	10	320
30x70	10	850
30x75	10	850
30x80	10	850
30x85	10	850
30x90	10	680
30x95	10	680
30x100	10	680
30x105	10	680
30x110	10	680
30x115	10	680
30x120	10	680
30x125	10	510
30x130	10	510
30x135	10	510
30x140	10	510
30x145	10	510
30x150	10	510
30x155	10	510
30x160	10	510
30x165	5	375
30x170	5	375
30x175	5	375
30x180	5	375
30x185	5	255
30x190	5	255
30x195	5	255
30x200	5	255
30x210	5	255
30x220	5	160
30x230	5	160
30x240	5	160
30x85	5	340
36x90	5	340
36x95	5	340
36x100	5	340
36x105	5	340
36x110	5	340
36x115	5	340
36x120	5	340
36x125	5	340
36x130	5	340
36x135	5	340
36x140	5	340
36x145	5	340
36x150	5	340
36x155	5	340
36x160	5	340
36x165	5	340
36x170	5	255
36x175	5	255
36x180	5	255
36x185	5	255
36x190	5	160
36x195	5	160
36x200	5	160

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HV2 SALE OF HV PRODUCTS

Tab. 2. Number of pieces in packages - washers and nuts.

Nuts			
Index	Size	Box (pcs)	Pallet (pcs)
EN 14399-4 (HV) -M12 -10Z HDG+MoS2	M12	200	20000
EN 14399-4 (HV) -M16 -10Z HDG+MoS2	M16	100	10000
EN 14399-4 (HV) -M20 -10Z HDG+MoS2	M20	100	7500
EN 14399-4 (HV) -M22 -10Z HDG+MoS2	M22	50	5100
EN 14399-4 (HV) -M24 -10Z HDG+MoS2	M24	50	3750
EN 14399-4 (HV) -M27 -10Z HDG+MoS2	M27	50	2550
EN 14399-4 (HV) -M30 -10Z HDG+MoS2	M30	50	2550
EN 14399-4 (HV) -M36 -10Z HDG+MoS2	M36	25	1275

Washers			
Index	Size	Box (pcs)	Pallet (pcs)
EN 14399-6 (HV)-300HV HDG -M12	13	200	44800
EN 14399-6 (HV)-300HV HDG -M16	17	200	44800
EN 14399-6 (HV)-300HV HDG -M20	21	200	20000
EN 14399-6 (HV)-300HV HDG -M22	23	200	20000
EN 14399-6 (HV)-300HV HDG -M24	25	200	20000
EN 14399-6 (HV)-300HV HDG -M27	28	100	7500
EN 14399-6 (HV)-300HV HDG -M30	31	100	7500
EN 14399-6 (HV)-300HV HDG -M36	37	50	6250

PRODUCT TRACEABILITY - HIGH STRENGTH HV SET

The ERP system adapted to our needs allows for 100% product traceability.

The product receives a unique ID Number and the Batch Number. In addition, the "Labeling" field is used for HV bolts, where the batch number placed on the head of the bolt is recorded.

We can also easily identify the steel grade and the heat number used for production. This is an important information, because under the heat number there are exact values of the chemical composition, which allows to flawlessly perform the heat treatment process - one of the most important processes for mechanical properties in the entire production of HV high strength bolts.

The ERP system for a given production batch contains the information about individual operations, state, as well as their start and end dates. Thanks to this, the production is monitored on an ongoing basis.

The components included in the HV set also have an original batch number, which ensures full traceability of production and easy access to detailed test results.

MANUFACTURER'S TECHNICAL SUPPORT

The manufacturer provides technical support. Consultations and advice by e-mail available 24 hours.

Contact details:

support.klfs@rawlplug.com

In case of any doubts concerning the quality of the set and the connection itself, the manufacturer guarantees full support and availability of laboratories, including tests to determine assembly parameters, strength, hardness and corrosion resistance.



HV3 **BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS**

BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

3.1 GENERAL INFORMATION

a) High strength bolt sets for preloading of the HV system should comply with the requirements of EN 14399-1:2015, EN 14399-2:2015, EN 14399-4:2015, EN 1090-2:2018. Compliance confirmation tests are performed according to the guidelines of the aforementioned standards.

b) The entire bolt set should be supplied by one manufacturer.

c) All bolt sets should have the CE mark, which should be placed on the labels.

d) The manufacturer of HV bolt sets should have and present the copy of the certificate for compliance with the standards in question, as well as the confirmation that the factory production control was approved by the third party's audit.

e) The components of the bolt set should be fully traceable.

f) Documents confirming the quality of the set should be kept by the manufacturer, and delivered on the recipient's request within two business days.

g) For the bolt class -K2, the characterizing parameters should be determined in the suitability test of preloading according to the standard 14399-2:2015 and compliant with the values according to the standard EN 14399-4:2015.

h) Stainless steel bolts are not used in preloading, unless specified otherwise. The bolts are then treated as special fasteners.

3.2 BOLT LENGTH SELECTION

The bolt length is selected according to the clamp length Σt of the parts to be connected.

The design engineer should select the bolt length taking into account the use of two washers (2x*h*) (see Tab. 3) and the total thickness of all connected supporting plates and supports (t_{s2}). Knowing what bolt range we need and knowing the value of the parameter Σt, using Tab. 4, we determine the HV bolt length.

$$\Sigma t = t_{s2} + (2xh) \qquad (1)$$

Example:

We use the M20 bolt, and the thickness of the three components to be connected is: 32, 32, 30 [mm]. Looking at Table 3, we know that both washers are 8 [mm] thick. Using the formula, we get:

$$\Sigma t = (32+32+30)+8 = 102\ [mm] \qquad (2)$$

For size M20 with a total clamp length **Σt equal to 102[mm]** use **the bolt with a length of 125 [mm] (M20 x125).**

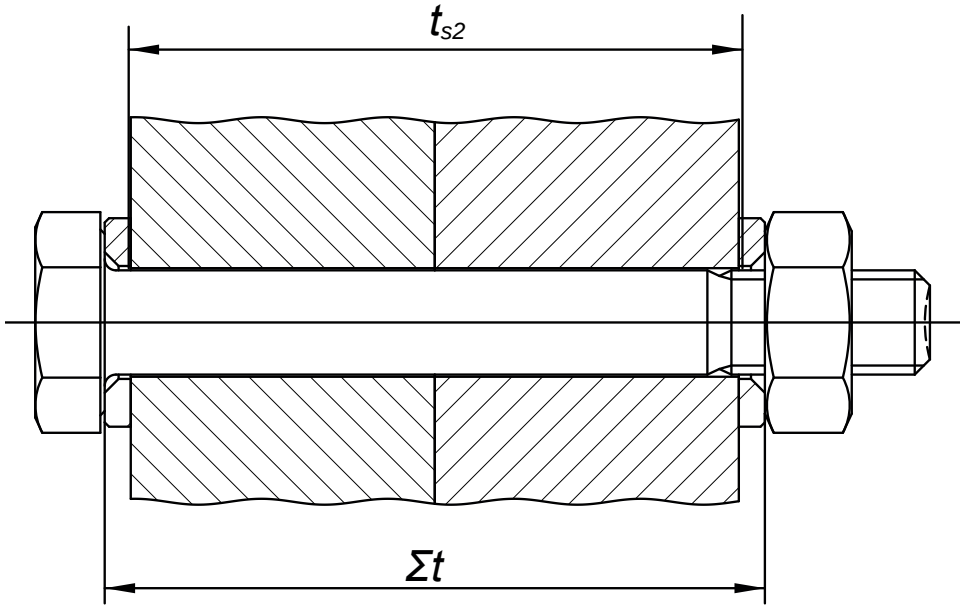


Fig. 1 Clamp length Σt of parts to be connected.

Tab. 3. Nominal thickness [mm] of two washers for a given assortment

Assortment	M12	M16	M20	M22	M24	M27	M30	M36
Thickness (2x*h*)	6	8	8	8	8	10	10	12

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HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

Tab. 4. Clamping length range Σt.

Bolt length [mm]	Clamping length range Σt [mm]							
	M12	M16	M20	M22	M24	M27	M30	M36
30	11 - 16							
35	16 - 21	12 - 17						
40	21 - 26	17 - 22	13 - 18					
45	26 - 31	22 - 27	18 - 23					
50	31 - 36	27 - 32	23 - 28	22 - 27	19 - 24			
55	36 - 41	32 - 37	28 - 33	27 - 32	24 -29			
60	41 - 46	37 - 42	33 - 38	32 - 37	29 - 34	26 - 31		
65	46 - 51	42 - 47	38 - 43	37 - 42	34 - 39	31 - 36		
70	51 - 56	47 - 52	43- 48	42- 47	39 - 44	36 - 41	34 - 39	
75	56 - 61	52 - 57	48- 53	47 - 52	44 - 49	41 - 46	39 - 44	
80	61 - 66	57 - 62	53 - 58	52 - 57	49 - 54	46 - 51	44 - 49	
85	66 - 71	62 - 67	58 - 63	57 - 62	54 - 59	51 - 56	49 - 54	43 - 48
90	71 - 76	67 - 72	63 - 68	62 - 67	59 - 64	56 - 61	54 - 59	48 - 53
95	76 - 81	72 - 77	68 - 73	67 - 72	64 - 69	61 - 66	59 - 64	53 - 58
100	81 - 86	77 - 82	73 - 78	72 - 77	69 - 74	66 - 71	64 - 69	58 - 63
105	86 - 91	82 - 87	78 - 83	77 - 82	74 - 79	71 - 76	69 - 74	63 - 68
110	91 - 96	87- 92	83 - 88	82 - 87	79 - 84	76 - 81	74 - 79	68 - 73
115	96 - 101	92 - 97	88 - 93	87 - 92	84 - 89	81 - 86	79 - 84	73 - 78
120	101 - 106	97 - 102	93 - 98	92 - 97	89 - 94	86 - 91	84 - 89	78 - 83
125	106 - 111	102 - 107	98 - 103	97 - 102	94 - 99	91 - 96	89 - 94	83 - 88
130	111 - 116	107 - 112	103 - 108	102 - 107	99 - 104	96 - 101	94 - 99	88 - 93
135	116 - 121	112 - 117	108 - 113	107 - 112	104 - 109	101 - 106	99 - 104	93 - 98
140	121 - 126	117 - 122	113 - 118	112 - 117	109 - 114	106 – 111	104 - 109	98 - 103
145	126 - 131	122 - 127	118 - 123	117 - 122	114 - 119	111 - 116	109 - 114	103 - 108
150	131 - 136	127 - 132	123 - 128	122 - 127	119 - 124	116 - 121	114 - 119	108 - 113
155	136 - 141	132 - 137	128 - 133	127 - 132	124 - 129	121 - 126	119 - 124	113 - 118
160	141 - 146	137 - 142	133 - 138	132 - 137	129 - 134	126 - 131	124 - 129	118 - 123
165	146 - 151	142 - 147	138 - 143	137 - 142	134 - 139	131 - 136	129 - 134	123 - 128
170	151 - 156	147 - 152	143 - 148	142 - 147	139 - 144	136 - 141	134 - 139	128 - 133
175	156 - 161	152 - 157	148 - 153	147 - 152	144 - 149	141 - 146	139 - 144	133 - 138
180	161 - 166	157 - 162	153 - 158	152 - 157	149 - 154	146 - 151	144 - 149	138 - 143
185	166 - 171	162 - 167	158 - 163	157 - 162	154 - 159	151 - 156	149 - 154	143 - 148
190	171 - 176	167 - 172	163 - 168	162 - 167	159 - 164	156 - 161	154 - 159	148 - 153
195	176 - 181	172- 177	168 - 173	167 - 172	164 - 169	161 - 166	159 - 164	153 - 158
200	181 - 186	177 - 182	173 - 178	172 - 177	169 - 174	166 - 171	164 - 169	158 - 163
210		187 - 192	183 - 188	182 - 187	179 - 184	176 - 181	174 - 179	
220		197 - 202	193 - 198	192 - 197	189 - 194	186 - 191	184 - 189	
230			203 - 208	202 - 207	199 - 204	196 - 201	194 - 199	
240			213 - 218	212 - 217	209 - 214	206 - 211	204 - 209	
250			223 - 228					
260			233 - 238					

Legend: Produced at the customer's request | Within EN 14399-4:2015

HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

3.3 REQUIREMENTS FOR BOLTS WITH INCREASED STRENGTH IN CLASS 10.9 (ACCORDING TO EN 14399-4:2015)

3.3.1 GENERAL REQUIREMENTS

Tab. 5. Requirements for bolts and standards referenced by EN 14399-4:2015.

Material		Steel
General requirements		EN 14399-1 and EN 14399-2
Thread	Tolerance class	6g [a]
	International Standards	ISO 261, ISO 965-2
Mechanical properties	Property class	10.9
	European Standard	EN ISO 898-1
Impact strength	Value	$K_{v,\,min}$ = 27 J at - 20°C
	Sample for testing[b]	ISO 148
	Test	EN 10045-1
Tolerances	Product grade	C except: *c* and *r* dimensions. Length tolerance ≥ 155 mm: $^{+\,IT\,17}_{-\frac{1}{2}\,IT\,17}$
	European Standard	EN ISO 4759-1
Surface finish[c]	Uncoated	According to the process [d]
	Hot-dip galvanized	EN ISO 10684
	Others	To be agreed [e]
Surface integrity		Limit for surface discontinuities as specified in EN 26157-1
Acceptability		Acceptance procedure, see EN ISO 3269.

[a] Specified tolerance class applies to dimensions prior to galvanization using the hot-dip galvanization method. Hot-dip galvanized bolts are intended for the set with an oversized threaded nut.

[b] Location of the Charpy V-notch in the sample for bolt testing should be as specified in EN ISO 898-1.

[c] Attention is drawn to the need to take into account the risk of hydrogen embrittlement for bolts of mechanical properties class 10.9 when selecting the appropriate surface treatment process (e.g. cleaning and coating), see appropriate coating standards.

[d] "According to the process" means normal finish performed by the manufacturer and light oil coverage.

[e] The recipient and the manufacturer may agree on other coatings, if they do not affect the reduction of mechanical properties or performance characteristics.

3.3.2 MATERIAL

Tab. 6. Chemical composition of steel used for the manufacture of bolts according to ISO 898-1:2013.

Property class	Material and heat treatment	Chemical composition limit (cast analysis, %)[a]					Tempering temperature
		C		P	S	B[b]	°C
		Min.	Max.	Max.	Max.	Max.	min.
10.9 [d]	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,20[c]	0,55	0,015	0,015	0,003	425
	or Carbon steel quenched and tempered	0,25	0,55	0,015	0,015		
	or Alloy steel quenched and temperede[e]	0,20	0,55	0,015	0,015		

[a] In case of dispute, the product analysis applies.

[b] Boron content can reach 0,005%, provided non-effective boron is controlled by the addition of titanium and/or aluminium.

[c] In case of plain carbon boron steel with a carbon content below 0,25% (cast analysis), the minimum manganese content shall be 0,6% for property class 8.8 and 0,7% for property classes 9.8 and 10.9.

[d] Fort he materials of these property classes, there shall be a sufficient hardenability to ensure a structure consisting of approximately 90% martensite in the core oft he threaded sections fort he fasteners in the „as-hardened" condition before tempering.

[e] This alloy steel shall contain at least one oft he following elements in the minimum quantity given: chromium 0,30%, nickel 0,30%, molybdenum 0,20%, vanadium 0,10%. Where elements are specified in combinations oft wo, three or four and have alloy contents less than those given above, the limit value tob e applied for steel class determination is 70% oft he sum oft he individual limit values specified above for the two, three or four elements concerned.

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HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

3.3.3 MECHANICAL AND PHYSICAL PROPERTIES

HV bolts should meet the requirements of EN 14339-4:2015.

Tab. 7. Mechanical and physical properties of bolts according to EN ISO 898-1:2013.

No.	Physical or mechanical property		Value
1	Tensile strength, R_m, MPa	nom.[a]	1000
		min.	1040
2	Lower yield point, R_{eL} [b], MPa	nom.[a]	—
		min.	—
3	Stress at 0,2% disproportionate elongation, $R_{p0,2}$, MPa	nom.[a]	900
		min.	940
4	Stress at disproportionate elongation of 0,0048 *d* for full-size fasteners, R_{pf}, MPa	nom.[a]	-
		min.	
5	Stress under test load, S_p [c], MPa	nom.	830
	Strength ratio	$S_{p,nom}/R_{eL\ min}$ oder $S_{p,nom}/R_{p0,2\ min}$ oder $S_{p,nom}/R_{pf\ min}$	0,88
6	Percent elongation after cracking for processed samples for testing, *A, %*	min.	9
7	Percent reduction in the surface after cracking for processed samples for testing, *Z, %*	min.	48
8	Elongation after cracking for full-size fasteners, A_f (see also Appendix C in ISO 898-1:2012)	min.	—
9	Head solidity		No cracks
10	Vickers hardness, HV $F \geq 98$ N	min.	320
		max.	380
11	Brinell hardness, HBW $F = 30\ D^2$	min.	316
		max.	375
12	Rockwell hardness, HRB	min.	—
		max.	—
	Rockwell hardness, HRC	min.	32
		max.	39
13	Surface hardness, HV 0,3	max.	390
14	Non-carburization, HV 0,3	max.	d
15	Height of non-decarburized thread zone, *E*, mm	min.	$\frac{2}{3}\ H_1$
	Depth of complete decarburization in the thread, *G*, mm	max.	0,015
16	Hardness reduction after re-tempering, HV	max.	20
17	Destructive torque, M_B, N.m	min.	According to ISO 898-7
18	Impact strength, K_V [e, f], J	min.	27
19	Surface integrity according to		ISO 6157-1 / ISO 6157-3[g]

[a] Rated values are specified only for the purposes of the marking system for the property classes. See, Section 5 of ISO 898-1:2013.

[b] In cases where the lower yield point ReLnie can be determined, it is allowed to measure the stress at 0.2% disproportionate elongation of Rp0.2.

[c] Test loads are specified in Tables 5 and 7 of ISO 898-1:2013.

[d] The surface hardness should not be higher than 30 Vickers points above the measured hardness of the core of the fastener, when the determination of both surface hardness and core hardness is performed with HV 0.3.

[e] Values are determined at a test temperature of -20°C (see 9.14 ISO 898-1:2013).

[f] Applies to d ≥ 16 mm.

[g] Instead of ISO 6157-1, ISO 6157-3 may apply, on the basis of the agreement between the manufacturer and the buyer.

HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

Tab. 8. Loads - standard metric thread, EN ISO 898-1:2013.

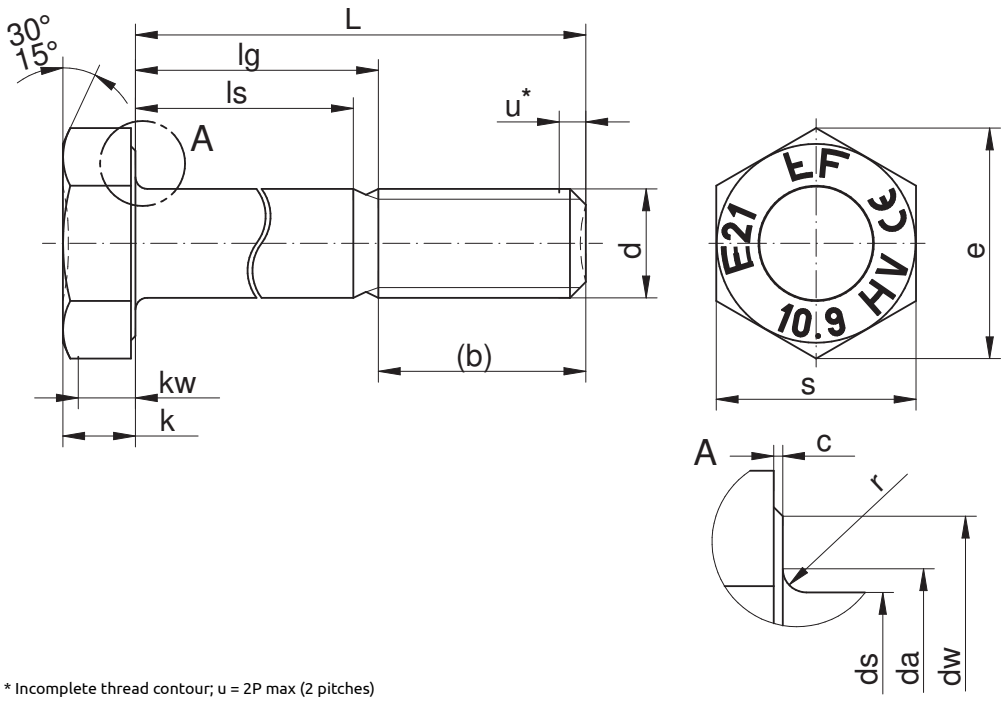
Thread[a]	d		M12	M16	M20	M22	M24	M27	M30	M33	M36
Nominal cross-sectional area	$A_{s,nom}$ [b]	mm^2	84,3	157	245	303	353	459	561	694	817
			Minimum final tensile load, $F_{m\,min}$ ($A_{s,nom\,x}$ $R_{m,\,min}$), N								
			87 700	163 000	255 000	315 000	367 000	477 000	583 000	722 000	850 000
			Proof load, F_p ($A_{s,nom}$ x $S_{p,\,nom}$), N								
			70 000	130 000	203 000	252 000	293 000	381 000	466 000	576 000	678 000

[a] In those cases where no thread pitch is indicated in the thread designation, the normal pitch is specified.

[b] To calculate $A_{s,\,nom}$, see 9.1.6.1 ISO 898-1:2013

3.3.4 BOLT DIMENSIONS

Bolt geometry in accordance with EN 14399-4:2015



* Incomplete thread contour; u = 2P max (2 pitches)

Fig. 2. Bolt according to EN 14399-4:2015.

Tab. 9. Bolt dimensions according to EN 14399-4:2015.

Thread (d)		M12	M16	M20	M22	M24	M27	M30	M36
Pitch		1,75	2,0	2,5	2,5	3,0	3,0	3,5	4,0
b (ref.)		23	28	33	34	39	41	44	52
c	min	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
	max	0,6	0,6	0,8	0,8	0,8	0,8	0,8	0,8
da max		15,2	19,2	24,0	26,0	28,0	32,0	35,0	41,0
ds	nom.	12	16	20	22	24	27	30	36
	min	11,30	15,30	19,16	21,16	23,16	26,16	29,16	35,00
	max	12,70	16,70	20,84	22,84	24,84	27,84	30,84	37,00
dw min		20,1	24,9	29,5	33,3	38,0	42,8	46,6	55,9
e min		23,91	29,56	35,03	39,55	45,20	50,85	55,37	66,44
k	nom.	8	10	13	14	15	17	19	23
	min	7,55	9,25	12,10	13,10	14,10	16,10	17,95	21,95
	max	8,45	10,75	13,90	14,90	15,90	17,90	20,05	24,05
kw min		5,28	6,47	8,47	9,17	9,87	11,27	12,56	15,36
r min		1,2	1,2	1,5	1,5	1,5	2,0	2,0	2,0
s	max = nom.	22	27	32	36	41	46	50	60
	min	21,16	26,16	31,00	35,00	40,00	45,00	49,00	58,80

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HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

Tab. 10. Ls min. and lg max. dimensions in the bolt according to EN 14399-4:2015.

L		ls & lg															
Lnom	Tol. L	M12		M16		M20		M22		M24		M27		M30		M36	
		ls min	lg max	ls min	lg max	ls min	lg max	ls min	lg max	ls min	lg max	ls min	lg max	ls min	lg max	ls min	lg max
30	±1,25	2,5	7														
35	±1,25	6,75	12	2,5	7												
40	±1,25	11,75	17	6	12	2,5	7										
45	±1,25	16,75	22	11	17	4,5	12	3,5	11								
50	±1,25	21,75	27	16	22	9,5	17	8,5	16	2,5	11						
55	±1,5	26,75	32	21	27	14,5	22	13,5	21	7	16						
60	±1,5	31,75	37	26	32	19,5	27	18,5	26	12	21	10	19				
65	±1,5	36,75	42	31	37	24,5	32	23,5	31	17	26	15	24				
70	±1,5	41,75	47	36	42	29,5	37	28,5	36	22	31	20	29	15,5	26		
75	±1,5	46,75	52	41	47	34,5	42	33,5	41	27	36	25	34	20,5	31		
80	±1,5	51,75	57	46	52	39,5	47	38,5	46	32	41	30	39	25,5	36		
85	±1,75	56,75	62	51	57	44,5	52	43,5	51	37	46	35	44	30,5	41	21	33
90	±1,75	61,75	67	56	62	49,5	57	48,5	56	42	51	40	49	35,5	46	26	38
95	±1,75	66,75	72	61	67	54,5	62	53,5	61	47	56	45	54	40,5	51	31	43
100	±1,75	71,75	77	66	72	59,5	67	58,5	66	52	61	50	59	45,5	56	36	48
105	±1,75	76,75	82	71	77	64,5	72	63,5	71	57	66	55	64	50,5	61	41	53
110	±1,75	81,75	87	76	82	69,5	77	68,5	76	62	71	60	69	55,5	66	46	58
115	±1,75	86,75	92	81	87	74,5	82	73,5	81	67	76	65	74	60,5	71	51	63
120	±1,75	91,75	97	86	92	79,5	87	78,5	86	72	81	70	79	65,5	76	56	68
125	±2,0	96,75	102	91	97	84,5	92	83,5	91	77	86	75	84	70,5	81	61	73
130	±2,0	101,75	107	96	102	89,5	97	88,5	96	82	91	80	89	75,5	86	66	78
135	±2,0	106,75	112	101	107	94,5	102	93,5	101	87	96	85	94	80,5	91	71	83
140	±2,0	111,75	117	106	112	99,5	107	98,5	106	92	101	90	99	85,5	96	76	88
145	±2,0	116,75	122	111	117	104,5	112	103,5	111	97	106	95	104	90,5	101	81	93
150	±2,0	121,75	127	116	122	109,5	117	108,5	116	102	111	100	109	95,5	106	86	98
155	+4,0/-2,0	126,75	132	121	127	114,5	122	113,5	121	107	116	105	114	100,5	111	91	103
160	+4,0/-2,0	131,75	137	126	132	119,5	127	118,5	126	112	121	110	119	105,5	116	96	108
165	+4,0/-2,0	136,75	142	131	137	124,5	132	123,5	131	117	126	115	124	110,5	121	101	113
170	+4,0/-2,0	141,75	147	136	142	129,5	137	128,5	136	122	131	120	129	115,5	126	106	118
175	+4,0/-2,0	146,75	152	141	147	134,5	142	133,5	141	127	136	125	134	120,5	131	111	123
180	+4,0/-2,0	151,75	157	146	152	139,5	147	138,5	146	132	141	130	139	125,5	136	116	128
185	+4,6/-2,3	156,75	162	151	157	144,5	152	143,5	151	137	146	135	144	130,5	141	121	133
190	+4,6/-2,3	161,75	167	156	162	149,5	157	148,5	156	142	151	140	149	135,5	146	126	138
195	+4,6/-2,3	166,75	172	161	167	154,5	162	153,5	161	147	156	145	154	140,5	151	131	143
200	+4,6/-2,3	171,75	177	166	172	159,5	167	158,5	166	152	161	150	159	147,5	156	136	148
210	+4,6/-2,3			171	177	164,5	172	163,5	171	157	166	160	169	161,5	166		
220	+5,2/-2,9			176	182	169,5	177	168,5	176	162	171	170	179	175,5	176		
230	+5,2/-2,9					174,5	182	173,5	181	167	176	180	189	189,5	186		
240	+5,2/-2,9					179,5	187	178,5	186	172	181	190	199	203,5	196		
250	+5,8/-3,4					184,5	192										
260	+5,8/-3,4					189,5	197										

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Tab. 11. Bolt weight according to EN 14399-4:2015.

Assortment / Length	Bolt weight [g/pc]							
	M12	M16	M20	M22	M24	M27	M30	M36
30	47,72							
35	52,15	95,28						
40	56,58	103,15	171,71					
45	61,01	111,03	184,02	237,80				
50	65,44	118,90	196,32	252,69	319,53			
55	69,87	126,78	208,62	267,58	337,24			
60	74,30	134,65	220,93	282,47	354,96	478,73		
65	78,73	142,53	233,23	297,36	372,68	501,15		
70	83,15	150,40	245,54	312,24	390,40	523,58	650,77	
75	87,58	158,28	257,84	327,13	408,12	546,00	690,64	
80	92,01	166,15	270,14	342,02	425,83	568,42	718,32	
85	96,44	174,03	282,45	356,91	443,55	590,85	746,01	1164,05
90	100,87	181,90	294,75	371,80	461,27	613,27	773,69	1203,92
95	105,30	189,78	307,06	386,68	478,99	635,70	801,37	1243,78
100	109,73	197,65	319,36	401,57	496,71	658,12	829,06	1283,65
105	114,16	205,53	331,66	416,46	514,42	680,54	856,74	1323,51
110	118,59	213,40	343,97	431,35	532,14	702,97	884,43	1363,38
115	123,02	221,28	356,27	446,24	549,86	725,39	912,11	1403,24
120	127,44	229,15	368,58	461,12	567,58	747,82	939,79	1443,11
125	131,87	237,03	380,88	476,01	585,30	770,24	967,48	1482,97
130	136,30	244,90	393,18	490,90	603,01	792,66	995,16	1522,84
135	140,73	252,78	405,49	505,79	620,73	815,09	1022,85	1562,70
140	145,16	260,65	417,79	520,68	638,45	837,51	1050,53	1602,57
145	149,59	268,53	430,10	535,56	656,17	859,94	1078,21	1642,43
150	154,02	276,40	442,40	550,45	673,89	882,36	1105,90	1682,30
155	158,45	284,28	454,70	565,34	691,60	904,78	1133,58	1722,16
160	162,88	292,15	467,01	580,23	709,32	927,21	1161,27	1762,03
165	167,31	300,03	479,31	595,12	727,04	949,63	1188,95	1801,89
170	171,73	307,90	491,61	610,00	744,76	972,06	1216,63	1841,76
175	176,16	315,78	503,92	624,89	762,48	994,48	1244,32	1881,62
180	180,59	323,65	516,22	639,78	780,19	1016,90	1272,00	1921,49
185	185,02	331,53	528,53	654,67	797,91	1039,33	1299,69	1961,35
190	189,45	339,40	540,83	669,56	815,63	1061,75	1327,37	2001,22
195	193,88	347,28	553,13	684,44	833,35	1084,18	1355,05	2041,08
200	198,31	355,15	565,44	699,33	851,07	1106,60	1382,74	2080,95
210		370,90	590,05	729,11	886,50	1151,45	1438,11	
220		386,65	614,65	758,88	921,94	1196,30	1493,47	
230			639,26	788,66	957,37	1241,14	1548,84	
240			663,87	818,44	992,81	1285,99	1604,21	
250			688,48					
260			713,09					

Thread tolerance should be compliant with the 6g test before the hot-dip galvanization process. After the coating process, the bolts should be controlled using the nut in the 6AZ tolerance.

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3.3.4.1 HOT-DIP GALVANIZATION PROCESS

The process should be conducted according to ISO 10684 with additional requirements and guidelines according to DASt 022 and DSV GAV, the guide for the manufacture of galvanized bolts ("Herstellung feuerverzinkter Schrauben").

Additional process requirements must be implemented due to the risk of hydrogen embrittlement and bolt cracking under stress. If hydrochloric acid used as the pickling medium before the process, use inhibitors and limit the residence time to a maximum of 15 minutes. High temperature coating 530-560 °C is only allowed up to a maximum diameter of M24.

Before the coating is applied, randomly check several pieces for cracks. Tests for the phenomenon of sensitization of bolts to hydrogen embrittlement should be performed in relation to the process according to ISO 15330.

Hot-dip galvanization provides efficient and durable anti-corrosion protection even in an aggressive atmosphere. Depending on the severity of adverse conditions, the zinc coating with a thickness from 50 to 70 µm, permanently bonded to the base material, guarantees full functionality of the bolt connection for many years.

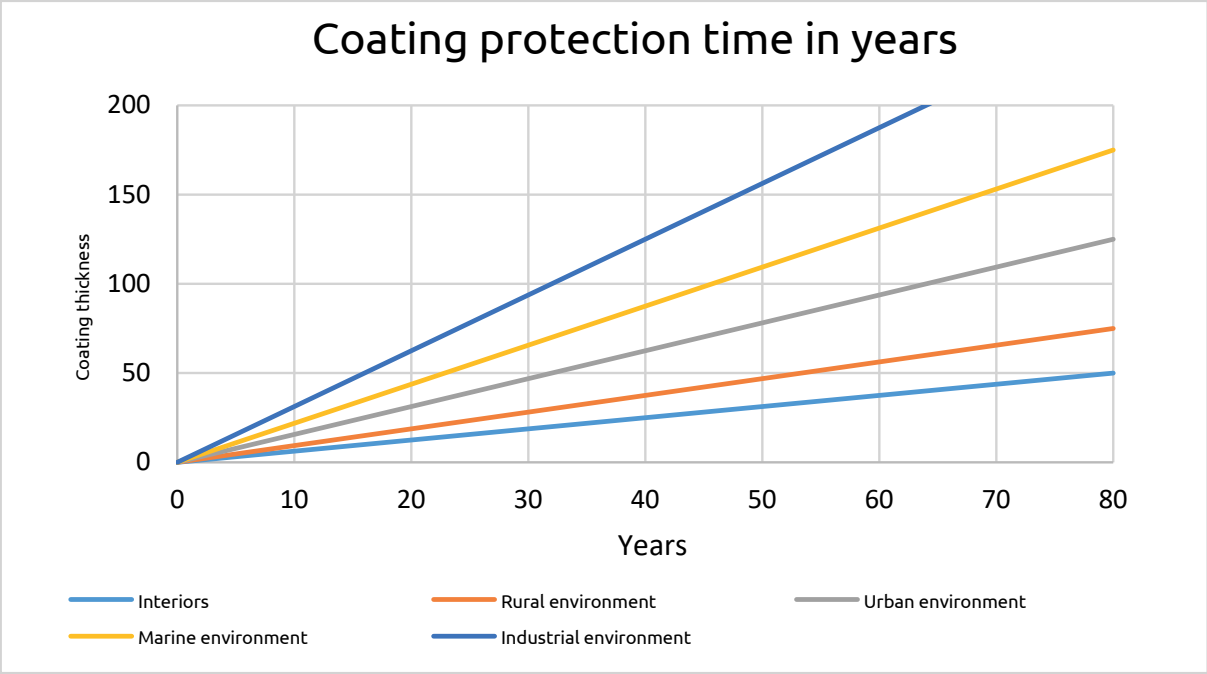


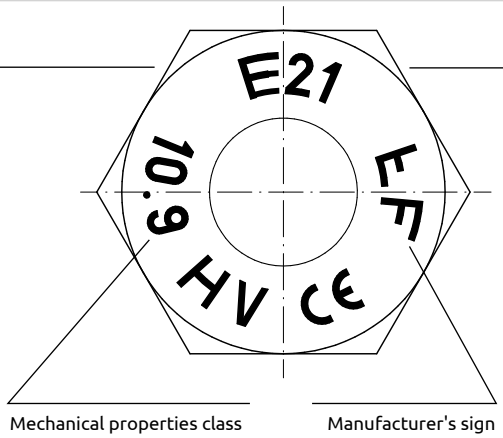
Fig. 3. Protection time of the zinc coating in years.

3.3.5 LABELING

The bolts should be labeled in accordance with EN 14399-4:2015 and EN 1090-2:2018 for full identification also after assembly. The bolt labeling presented in Fig. 4 consists of the mechanical property class, manufacturer identification mark, HV mark and batch identification number (e.g. month and year of production). Labeling must be placed on the upper surface of the head; concave or convex labeling is allowed.

Month of production

Mark	Miesiąc/Month
C	Styczeń / January
D	Luty / February
E	Marzec / March
F	Kwiecień / April
H	Maj / May
I	Czerwiec / June
J	Lipiec / July
K	Sierpień / August
L	Wrzesień / September
M	Październik / October
N	Listopad / November
O	Grudzień / December



Year of production

Mark	Miesiąc/Month
17	2017
18	2018
19	2019
20	2020
21	2021
22	2022
23	2023
24	2024
25	2025
26	2026
27	2027
28	2028

Fig. 4. Bolt labeling according to EN 14399-4:2015, allowing full batch identification.

HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

3.4 REQUIREMENTS FOR NUTS (EN 14399-4:2015)

3.4.1 GENERAL REQUIREMENTS

Tab. 12. Requirements for nuts and standards referenced by EN 14399-4:2005.

Material		Steel
General requirements		EN 14399-1 and EN 14399-2
Thread	Tolerance	6AZ
	International Standards	ISO 261, ISO 965-2, ISO 965-5
Mechanical properties	Mechanical property class	10
	European Standard	EN ISO 898-2
Tolerances	Accuracy class	B
	European Standard	EN ISO 4759-1
Finish - Coating	Uncoated	As processed [a]
	Hot-dip galvanized	EN ISO 10684
	Other	To be agreed [b]
Surface integrity		Limit for surface discontinuities as specified in EN 26157-1.
Acceptance		Acceptance procedure, see EN ISO 3269.

[a] „According to the process" means normal finish performed by the manufacturer and light oil coverage.

[b] The recipient and the manufacturer may agree on other coatings, if they do not affect the reduction of mechanical properties or performance characteristics. Cadmium or cadmium alloy coatings are not allowed.

3.4.2 MATERIAL

Chemical composition of the material used must be in accordance with ISO 898-2.

Tab. 13. Chemical composition of steel used for the manufacture of nuts according to ISO 898-2:2022.

Strength class	Material and heat treatment of nuts	Chemical composition (% mas.) [a, b]					Tempering temperature
		C		Mn	P	S	°C
		min.	max.	min.	max.	max.	min.
10	Carbon steel, QT[c]	0,15	0,58	0,45	0,048	0,058	380

QT = Hardened and tempered nuts.

[a] In case of dispute, product analysis shall apply.

[b] Alloying elements may be added, provided the mechanical and physical properties required in Clause 8 acc. ISO 898-2:2022 are met.

[c] For materials of nuts to be quenched and tempered (QT), there shall be a sufficient hardenability to ensure a homogenous microstructure consisting of approximately 90 % martensite throughout the nuts. The manufacturer shall ensure that the austenite transformation temperature has been exceeded and sufficient duration allowed to achieve adequate transformation to martensite throughout the nut during quenching to ensure uniform mechanical properties.

3.4.3 MECHANICAL AND PHYSICAL PROPERTIES

The nut should comply with EN 14399-4:2015 and ISO 898-2:2022 for class 10.

Tab. 14. Hardness properties of standard threaded nuts, ISO 898-2:2022.

	Strength class 10					
Thread	Vickers hardness, HV		Brinell hardness, HB		Rockwell hardness, HRC	
D	min	max	min	max	min	max
M5 ≤ D ≤ M39	272	353	268	349	26,5	36,9

Tab. 15. Test load values for nuts with the standard thread.

		Load [a], kN								
Thread	D	M12	M16	M20	M22	M24	M27	M30	M33	M36
Thread pitch	P	1,75	2	2,5	2,5	3	3	3,5	3,5	4
Strength class	10	88 500	164 900	259 700	321 200	374 200	486 500	594 700	735 600	866 000

[a] When using flat nuts, one should take into account that the shear force is less than the full-load nut test force (see Attachment B in ISO 898-2:2022).

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HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

3.4.4 NUT DIMENSIONS

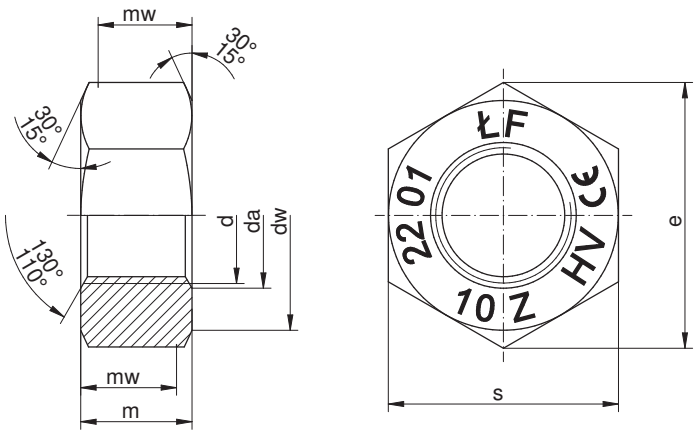


Fig. 5. Nut according to EN 14399-4:2015.

Tab. 16. Nut dimensions according to EN 14399-4:2015.

Thread (d)		M12	M16	M20	M22	M24	M27	M30	M36
Hub		1,75	2,0	2,5	2,5	3,0	3,0	3,5	4,0
da	max	13,0	17,3	21,6	23,7	25,9	29,1	32,4	38,9
	min	12	16	20	22	24	27	30	36
dw min		20,1	24,9	29,5	33,3	38,0	42,8	46,6	55,9
e min		23,91	29,56	35,03	39,55	45,20	50,85	55,37	66,44
m	nom. = max	10	13	16	18	20	22	24	29
	min	9,64	12,30	14,90	16,90	18,70	20,70	22,70	27,70
mw min		7,71	9,84	11,92	13,52	14,96	16,56	18,16	22,16
s	nom. = max	22	27	32	36	41	46	50	60
	min	21,16	26,16	31,00	35,00	40,00	45,00	49,00	58,80

Tab. 17. Nut weight according to EN 14399-4:2015.

Weight – Nuts (g/pc)								
Assortment	M12	M16	M20	M22	M24	M27	M30	M36
Weight [g]	24,76	45,45	75,4	109,12	164,04	225,14	286,01	497,63

3.4.5 NUT MARKING

The nuts should be marked in accordance with EN 14399-4:2015 and EN 1090-2:2018 for full identification also after assembly. The nut marking presented in Fig. 6 consists of the mechanical property class, set manufacturer identification mark, HV mark and batch number (e.g. month and year). Marking must be placed on the upper surface of the head; concave or convex marking is allowed.

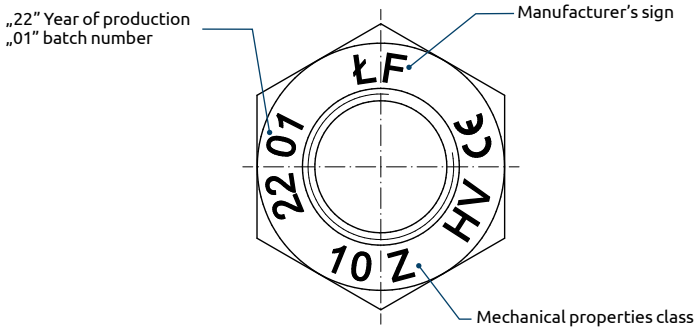


FIg. 6. Nut marking in accordance with EN 13499-4:2015, allowing full batch identification.

HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

3.5 REQUIREMENTS FOR WASHERS (EN 14399-6:2015)

3.5.1 GENERAL REQUIREMENTS

Tab. 18. Requirements and standards referenced by EN 13499-6:2015.

Material		Steel
General requirements		EN 14399-1 and EN 14399-2
Mechanical properties	Hardness range	300 HV to 370 HV
Tolerances	Accuracy class	A
	International standard	EN ISO 4759-3
Finish - Coating[a]	Uncoated	According to the process [b]
	Hot dip galvanized	EN ISO 10684
	Other	To be agreed [c]
Workmanship		Parts shall be uniform and free of irregularities or detrimental defects. No protruding burrs shall appear on the washer
Acceptability		For acceptance procedure, see EN ISO 3269

[a] Attention is drawn to the need to take into account the risk of hydrogen embrittlement when selecting the appropriate surface treatment process (e.g. cleaning and coating), see relevant coating application standards.

[b] "According to the process" means normal finish performed by the manufacturer and light oil coverage.

[c] The recipient and the manufacturer may agree on other coatings, if they do not affect the reduction of mechanical properties or performance characteristics. Cadmium or cadmium alloy coatings are not allowed.

3.5.2 MATERIAL

Chemical composition of the washer should be in accordance with ISO 898-3:2018.

Tab.19. Chemical composition of steel used for the production of washers according to ISO 898-3:2018.

Property class	Material and process		Chemical composition (% mas.)[a,b,c]					Minimum tempering temperature [b, c] °C
	Materiał	Proces	C		P	S	B[d]	
			min.	max.	max.	max.	max.	
300HV[e]	Alloys steel [f]	Hardening and tempering	0,17	0,80	0,035	0,035	0,003	425
	Alloys steel [g]		0,14	1,30	0,035	0,035	0,003	425

[a] In disputable matters, the product analysis applies.

[b] In the case of lock washers, see ISO 10644 or ISO 10673. Chemical composition and minimum tempering temperature should be agreed between the buyer and the supplier when placing the order.

[c] In the case of special applications (e.g. hot-dip galvanization washers), chemical composition and minimum tempering temperature should be agreed between the buyer and the supper when placing the order.

[d] The boron content should be a maximum of 0.003%, but may be up to 0.005%, provided that the boron concentration is supplemented by titanium and/or aluminum.

[f] There must be sufficient hardenability to provide the structure consisting of approximately 90% of martensite in the core area in the "post-hardening" state before tempering.

[g] Carbon steel may contain additives, e.g. chromium, manganese, nickel, etc.

[h] Alloy steel contains at least one of the following elements in the minimum amounts: 0.30% chromium, 0.20% manganese, 0.30% nickel, 0.10% vanadium, 0.08% molybdenum and 0.0008% boron. If the elements are specified in connections, the permissible value to be used to determine the steel class is 70% of the sum of the individual minimum values specified above for the given elements.

3.5.3 MECHANICAL AND PHYSICAL PROPERTIES

Mechanical properties of the washer should be in accordance with EN 14399-6:2015 and ISO 898-3:2018.

Tab. 20. Combination of property classes of flat washers (e.g. plain washers) with property classes of bolts, screws, studs and nuts.

Threaded connections according to ISO 898-1 and ISO 898-2		Property classes for flat washers
Property class		300HV[a]
Bolts, screws and studs	Regular and high nuts	
9.8, 10.9	10	RC

RC = recommended connection

[a] Only the 200 HV or 300 HV property classes are standardized for lock washers in bolts in accordance with ISO 10644 or ISO 10674.

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HV3 BOLT SETS FOR PRELOADING - GENERAL REQUIREMENTS

3.5.4 WASHER DIMENSIONS

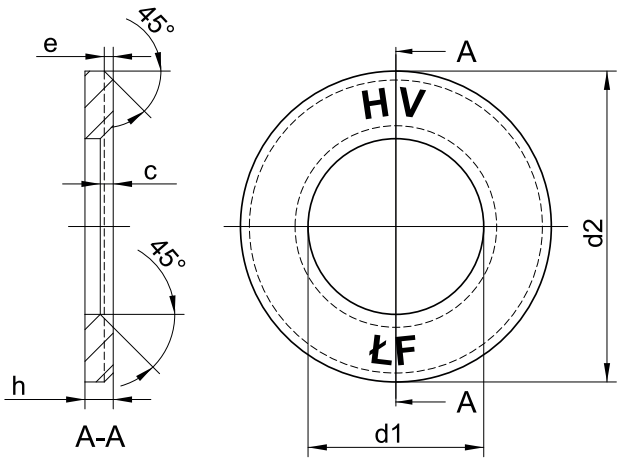


Fig. 7. Washer according to EN 14399-6:2015.

Tab. 21. Washer dimensions according to EN 13499-6:2015.

Nominal diameter of the thread of the connected bolts		12	16	20	22	24	27	30	36
d1	min	13	17	21	23	25	28	31	37
	max	13,27	17,27	21,33	23,33	25,33	28,52	31,62	37,62
d2	min	23,48	29,48	36,38	38,38	43,38	49,00	54,80	64,80
	max	24	30	37	39	44	50	56	66
h	nom.	3	4	4	4	4	5	5	6
	min	2,7	3,7	3,7	3,7	3,7	4,4	4,4	5,4
	max	3,3	4,3	4,3	4,3	4,3	5,6	5,6	6,6
e	nom. = min	0,5	0,75	0,75	0,75	0,75	1,00	1,00	1,25
	max	1,00	1,50	1,50	1,50	1,50	2,00	2,00	2,50
c	min	1,6	1,6	2,0	2,0	2,0	2,5	2,5	2,5
	max	1,9	1,9	2,5	2,5	2,5	3,0	3,0	3,0

Nut geometry should be in accordance with EN 14399-6:2015, i.e. have the cut on one side.

Tab. 22. Washer weight according to EN 14399-6:2015.

Chamfered washers								
Assortment	M12	M16	M20	M22	M24	M27	M30	M36
Weight [g]	6,79	13,9	20,82	22,29	29,95	48,2	61,72	102,92

3.5.5 MANUFACTURING PROCESS REQUIREMENTS

Manufacturing process should ensure that the ISO 898-3 requirements for washers are met.

3.5.6 WASHER MARKING

Washers should be marked in accordance with EN 14399-6:2015. The washer marking presented in Fig. 8 consists of the set manufacturer identification mark and HV mark. The marking should be placed on the side without cut.

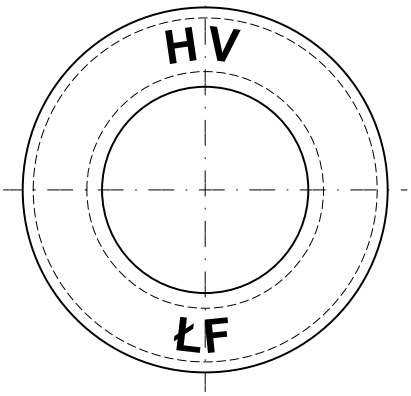


Fig. 8 Washer marking according to EN 14399-6:2015, allowing full batch identification.

HV4 GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

4.1 BOLT SETS

a) For assembly, use bolts, nuts and washers from one manufacturer.

b) HV sets for K-class K2 should only be used together with tested nuts.

c) For class 10.9 bolts, washers under the head and under the nut are required.

NOTE - The bolt set, which was tightened to the minimum tightening level and then unbolted - is not suitable for further use and should be scrapped!

d) Tightening is performed by turning the nut, unless access is insufficient, then tightening by turning the bolt requires consultation with the supplier and preparation of special sets.

NOTE - Additional lubrication of the set components is not allowed! It causes changes in the K coefficient value.

e) Tighten subsequent bolts in the first and last cycle from the most to the least rigid contact zone, as shown in Fig. 9. More than one tightening cycle may be needed to achieve even tightening.

f) Install the nuts so that their marking is visible after assembly.

g) In preloading, the protruding part of the thread, measured from the face of the nut to the end of the spindle, should have the length not less than one thread pitch.

h) Washers according to EN 14399-6 should be installed with the cut to the bolt head.

i) When using the torque control method, tightening cannot be applied after a few days (current guidelines of EN 1090-2:2018)

j) In the case of thick coatings, possible measures to compensate for the accidental drop in the tightening force should be determined in the specification.

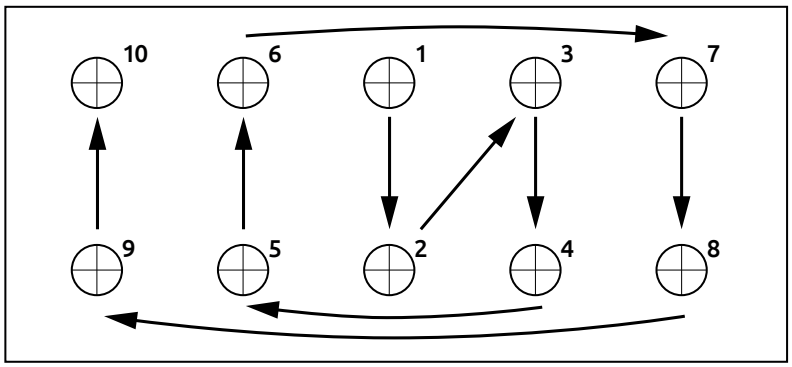


Fig. 9 Sample order of tightening bolts in the connection.

k) In the case of connections with double-sided covers (Fig. 10), the value of D should not exceed 1 [mm]. If steel seal plates are provided, ensuring non-exceedance of the aforementioned limit, their thickness should not be less than 1 [mm].

In the conditions of crevice corrosion danger, tighter contact fitting is required.

The thickness of steel plates should be selected so that the number of spacers does not exceed three.

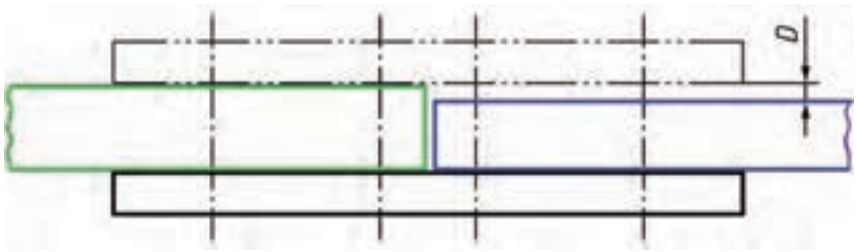


Fig. 10 Difference in the thickness of parts in the connection with double-sided covers.

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HV4 GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

4.2 CONTACT SURFACES

a) Contact surfaces should be free from impurities, such as oil, dirt or paint. Burrs that could prevent close adhesion of connected surfaces should be removed.

b) Uncoated surfaces should be free from rust and other loose materials. Be careful not to disturb rough contact surfaces.

c) To adjust the clamping length, one additional sheet metal washer (not thinner than 4 mm) or at most 3 standard washers with a maximum total thickness of 12 mm can be used.

In preloading, only one washer from the side of the tightened part (nut) can be used by means of the tightening torque control method (for class K2) and possibly an additional washer made of sheet metal or standard washers from the not-tightened part (bolt).

NOTE! The use of additional washers may cause the movement of the shear plane to the threaded part of the bolt. In such cases, it is necessary to check the carrying capacity.

4.3 TORQUE WRENCHES

a) To obtain a certain tightening force, use torque wrenches that give the possibility to accurately set the required tightening torque indicated on the label of bolts obtained for preloading.

b) Hand or power wrenches can be used. Impact wrenches can be used for the first bolt tightening step. The use of the impact wrench is not recommended due to the difficulty to meet the ±4% accuracy requirement.

c) Torque wrenches should ensure decoupling when achieving the set tightening torque or have a clear reading of the torque value. In both cases, the error tolerance of ± 0.1 Mv cannot be exceeded.

d) Torque wrenches used in all phases of the torque control method and for testing should be carefully calibrated and have the accuracy of ± 4 % according to EN ISO 6789. The wrenches are kept under control in accordance with EN ISO 6789, while pneumatic wrenches are checked whenever the length of the cable changes.

e) The wrenches should be checked after each incident that occurred during their use, i.e. significant impact, fall, overload, etc., or in the case of malfunction.

f) When the result of the control is the replacement of the bolt, check the accuracy of the torque wrench.

4.4 ASSEMBLY METHODS

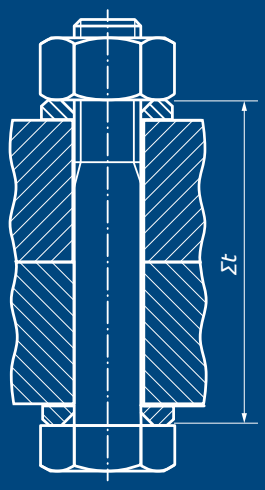
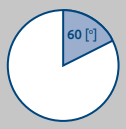
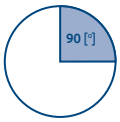
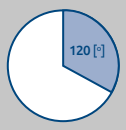
Tab. 23. Assembly methods and examples of calculations.

Tightening force $F_{p,C} = 0,7 * f_{ub} * A_s$									
		M12	**M16**	**M20**	**M22**	**M24**	**M27**	**M30**	**M36**
A_s	mm^2	84,3	157	245	303	353	459	561	817
$F_{p,C}$	kN	59	110	172	212	247	321	393	572

Combined method according to EN 1090-2									
$M_{r,1} = 0,125 * d * F_{p,C}$; $0,10 \leq k \leq 0,16$									
First tightening step									
		M12	**M16**	**M20**	**M22**	**M24**	**M27**	**M30**	**M36**
0,75 $M_{r,1}$	Nm	70	170	320	440	560	820	1100	2000

* Values were rounded to facilitate the setting of the torque wrench in construction conditions.

HV4 GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

Second tightening step				
The clamp length Σt of the parts to be connected (containing all washers); d - nominal diameter of the bolt		**Additional angle/part of rotation in the second tightening**		
	Σt < 2d	Kąt [°]	60	
		Part of rotation [-]	1/6	
	2d ≤ Σt ≤ 6d	Angle [°]	90	
		Part of rotation [-]	1/4	
	6d ≤ Σt ≤ 10d	Angle [°]	120	
		Part of rotation [-]	1/3	

Torque method according to EN 1090-2	
Data for this assembly method are determined individually for the delivery. The assembly steps and parameters can be found on our label.	
$M_{r,2} = k_m * d * F_{p,C}$; 0,10 ≤ km ≤ 0,23; Vk ≤ 0,06	
First tightening step	0,75 * $M_{r,2}$ [Nm]
Second tightening step	1,1 * $M_{r,2}$ [Nm]

Modified method of controlled torque according to DAST – Richtlinie 024 / DIN EN 1993-1-8/NA

$F_{p,C}* = 0,7 * f_{yb} * A_s$; 0,10 ≤ k ≤ 0,16

		M12	M16	M20	M22	M24	M27	M30	M36
$F_{p,C}*$	kN	50	100	160	190	220	290	350	510
First tightening step									
$0,75 * M_A$	Nm	75	190	340	490	600	940	1240	2100
Second tightening step									
M_A	Nm	100	250	450	650	800	1250	1650	2800

In category B, C and E joints, the limit state of which depends on the value of the preload force $F_{p,C} = 0,7 * f_{ub} * A_s$ it is recommended to tighten the k-class K1 bolts by the combined method according to EN 1090-2. In other cases, a reduced value of the preload force $F_{p,C}* = 0,7 * f_{yb} * A_s$ and a modified method of controlled tightening torque can be used.

Example of calculation	
Combined method	
Example of calculation of the combined method. For the M20 x 100 bolt with the value of the k coefficient of 0.12.	
First tightening step	Select from the first step table: **320 [Nm]**
Second tightening step	For the M20 x100 bolt, the value *Σt* is 73-78 [mm] from Tab. 4.
	73/20 = 3,65 i 78/20 = 3,9 hence 2d ≤ Σt ≤ 6d
	Additional angle in the second tightening step is **90 [°]**

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HV4 GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

CONTROLLER TORQUE METHOD	
In the method, the value k_m in the connection suitability test according to EN 14399:2015 should be determined. The result of k_m must be in the range 0,10 ≤ km ≤ 0,23 and the variation of the coefficient k_m must be less or equal to 0,06 (Vk ≤ 0,06). Then calculate the value $M_{r,2}$.	
Example of calculation of the torque control method. For the M20 x 100 bolt with the value of km 0,123 i Vk 0,048.	
	$M_{r,2}$= 0,123 * 20 * 172 = 422 [Nm]
First tightening step	0,75 * $M_{r,2}$ = 316 [Nm]
Second tightening step	1,1 * $M_{r,2}$ = 464 [Nm]

4.5 ASSEMBLY METHOD BY COMBINED METHOD

4.5.1 GENERAL ASSEMBLY GUIDELINES BY COMBINED METHOD

Before assembly, the following requirements must be met:

a) Observe the recommendations from section 4.1

b) Use the torque wrench with an appropriate operating range; the wrench can be hand or mechanical.

c) Assembly with the torque that is continuous and smooth. The bolt assembly cannot be interrupted until the set-point on the wrench is obtained.

d) Perform two tightening steps.

e) Take the torque value and the angle of rotation given on the label from the manufacturer.

4.5.2 CLASS K1 LABEL

Example of the label for class K1 presented in Fig. 11 contains the following information:

a) Set assortment (e.g. M12)

b) Class 1 requirements

c) Class K1 parameter values

d) Tightening step values

4.5.3 CLASS K1 PARAMETERS

F_v – Bolt tightening value [kN]

First tightening step

a) The wrench should be set to the torque value given in "Step 1" placed on the label (e.g. for example of the label from Fig. 11 it is 70 [Nm]).

b) The first tightening step should be performed for all bolts in one connection before starting the second tightening step.

Second tightening step

a) After the first tightening step, determine the position of the bolt thread. You can use chalk or paint for marking. This will allow to easily assess the rotation of the nut after the second step.

b) The wrench should be set to the value of the angle of rotation given in "Stage 2" placed on the label (e.g. for example of the label from Fig. 11 it is 90 [°]).

c) The second tightening step should be performed for all bolts in one connection.



Fig. 11 An example of the label characterizing the bolt for class K1.

HV4 GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

4.6 TORQUE CONTROL ASSEMBLY METHOD

4.6.1 GENERAL GUIDELINES FOR THE TORQUE CONTROL ASSEMBLY - CLASS K2

a) Observe the recommendations from section 4.1

b) Use the torque wrench with an appropriate operating range; the wrench can be hand or mechanical.

c) For the first step, it is recommended to use the impact wrench due to the ±4% accuracy requirement.

d) Assembly with the torque that is continuous and smooth. The bolt assembly cannot be interrupted until the set-point on the wrench is obtained.

e) Perform two tightening steps.

f) Take the torque value given on the label from the manufacturer.

4.6.2 CLASS K2 LABEL

Example of the label for class K2 presented in Fig. 12 contains the following information:

a) Set assortment (e.g. M16)

b) Class K2 requirements

c) Class K2 parameter values

d) Tightening step values

e) Note concerning the set

4.6.3 CLASS K2 PARAMETERS

F_v – Bolt tightening value [kN]

k_m – average value of the K coefficient

V_k – coefficient of variation of the K coefficient

First tightening step

a) The wrench should be set to the torque value given in "Step 1" placed on the label (e.g. for example of the label from Fig. 12 it is 165 [Nm]).

b) The first tightening step should be performed for all bolts in one connection before starting the second tightening step.

Second tightening step

a) The wrench should be set to the torque value given in "Step 2" placed on the label (e.g. for example of the label from Fig. 12 it is 245 [Nm]).

b) The second tightening step should be performed for all bolts in one connection.

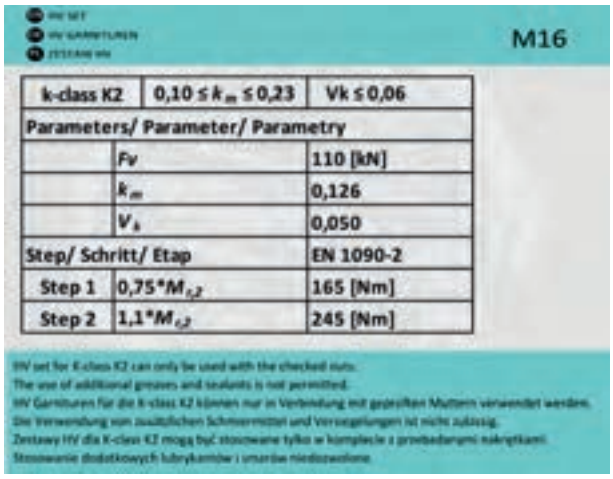


Fig. 12 An example of the additional label characterizing the bolt set for class K2.

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HV4 GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

4.7 CONTROL OF PRELOADED BOLT CONNECTIONS

4.7.1 FRICTION SURFACE CONTROL

a) All friction surfaces are checked visually, immediately prior to the assembly process.

b) The assessment criteria of the surface should be in accordance with section 4.1.

4.7.2 CONTROL BEFORE TIGHTENING

a) All preloading are checked visually before tightening, after initial tightening of bolts and local adjustment of the structure.

b) Acceptance criteria should be in accordance with section 4.1.

c) For EXC2, EXC3 and EXC4 class structures, check the tightening procedure.

d) Torque wrenches used to compress the connections should be verified for compliance with section 4.3 and have the calibration certificate

4.7.3 CONTROL DURING TIGHTENING AND AFTER TIGHTENING

4.7.3.1 GENERAL INFORMATION

In the case of EXC2, EXC3 and EXC4 class structures, the following control is performed during and after tightening:

a) Control locations are selected on a random sample basis, taking into account the following relevant variables: connection type, bolt group, number, type and dimensions of bolts, equipment used and its operator.

b) For control purposes, the bolt group is defined as bolt sets in similar connections, homogeneous in terms of dimension origin and class. Significant bolt groups can be divided into subgroups for control purposes;

c) The following numbers of bolt sets are controlled depending on the assembly method

- EXC2: 5% in the second step of the torque control method or combined method
- EXC3 and EXC4:
  - 5% in the first step; 10 % in the second step of the combined method,
  - 10% in the second step of the torque control method.

d) Unless the specification provides otherwise, the control is performed on a sufficient number of bolts using the sequential method **(section 4.7.3.2),** unless the acceptance or rejection criteria for the type of sequential test (or testing of all sets) are met. The following sequence types are used:

- EXC2 and EXC3: - A sequence;
- EXC4: - B sequence;

e) At this tightening step, the connection is visually checked in terms of tight contact adhesion;

f) The final tightening control of bolt sets shall be used to detect under-tightening or, if so specified in the specification, excessive tightening of the bolts;

g) The pre-tightening control is only performed in terms of loosening the bolts;

h) The criteria defining non-compliance and correction requirements are given below for each bolt tightening method;

i) If the control indicates non-compliance, all bolt sets in a given subgroup of bolts should be checked and corrected accordingly. When negative control results are obtained using A sequence, the control can be extended using B sequence;

j) After the correction is made, the re-control is performed.

k) If the fasteners were used in accordance with the established tightening method, the entire bolt group must be replaced and confirmed.

Tab. 24. Inspection of tightening by the torque method according to EN 1090-2:2018.

Execution class	At the start of tightening	After tightening
EXC2	Identification of assembly bolt lot locations	Inspection of the second tightening step
EXC3 and EXC4	Identification of assembly bolt lot locations Checking the bolt tightening procedure for each bolt group	Inspection of the second tightening step

HV4 GENERAL PROVISIONS FOR THE ASSEMBLY OF BOLT SETS

4.7.3.2 SEQUENTIAL METHOD OF CONNECTOR CONTROL

The control of connectors using the sequential method is performed in accordance with the principles given in ISO 2859-5. The standard contains the rules referring to the progressive analysis of successively obtained control test results. The graphical method is used to control the connectors.

Two control cases are described in Fig. 13 and individual objects included in the envelope are explained:

Key:	Example:	
X - number of controlled connectors	**Dashed line:** 2, 6 and 12 connectors are defective. The control curve, crossing the envelopes in the 12th sample (R point) is in the rejection zone.	**Dotted line:** 4 and 8 connectors are defective. The control was continued until the control curve was crossed with the vertical envelope section in the 16th sample I (A point) and reached the acceptance zone.
Y - number of defective connectors		
1 - rejection zone		
2 - continuation one (no conclusions)		
3 - acceptance zone		

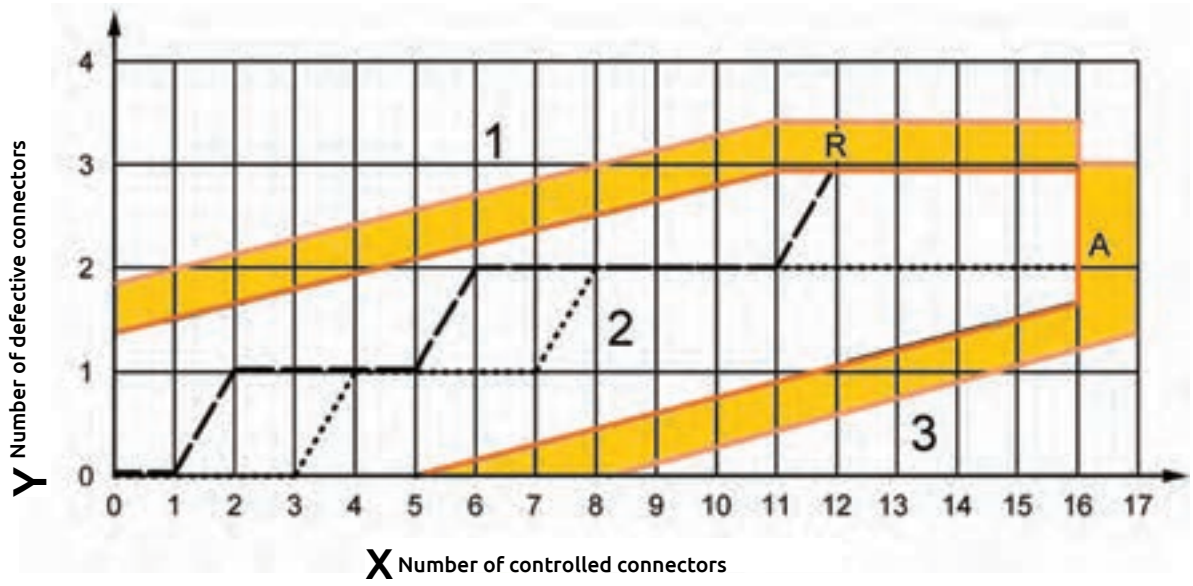


Fig. 13. Example of sequential inspection diagram according to EN 1090-2:2018.

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4.7.3.3 TORQUE CONTROL METHOD

The bolt sets are controlled according to Tab. 23 by rotating the nut by means of the calibrated torque wrench (or the bolt head, if so determined). The purpose of the control is to check whether the torque value necessary to initiate the rotation is at least $1.05M_{ri}$. The rotation should closely correspond to the minimum value. The following conditions apply:

a) The torque wrench used for control should be carefully calibrated and have an accuracy of ±4 %,

b) The control should be performed between 12h and 72h after completing the final tightening of the bolts in a given sub-group,

NOTE: When the bolt sets with different batch and control torque value are to be controlled, the location of each batch should be determined.

NOTE: When the contact surfaces have protective coatings, especially paint coatings, this may cause the decrease in the tightening force value, which makes it impossible to meet the design criteria. In such cases, it may be necessary to apply special control procedures, such as continuation of the tightening control.

c) When the result of the control is the replacement of the bolt, check the accuracy of the torque wrench.

d) The bolt set in which the nut turned more than 15° after the application of the torque is considered to be non-tightened (< 100%) and should be tightened to 100% of the required torque.

e) If checking the set in terms of exceeding the assembly torque is specified, the requirements must be determined and met.

NOTE: If during the control the tightening torques were exceeded, the sets should be replaced with new ones and the old sets should be scrapped.

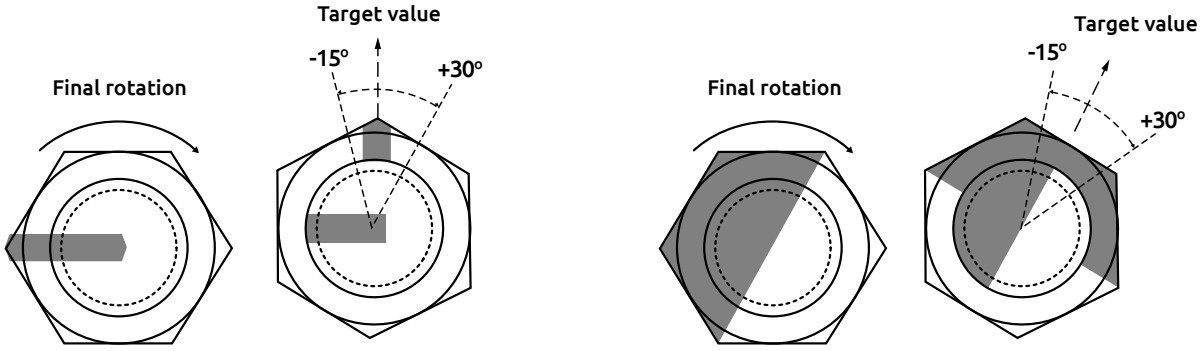


Fig. 14. Bolt marking methods before the second tightening step.

4.7.3.4 COMBINED METHOD

In the case of EXC3 and EXC4 class structures, the first step of connection control is performed before marking the sets. In this case, the same torque as in the first tightening step (Step 1) is used. The bolts that rotate more than 15[°] after applying the control torque, are considered insufficiently tight and must be properly tightened.

If there is no close adhesion of the parts, the calibration of torque wrenches should be checked taking into account sample loads. If necessary, repeat the first tightening step already with the adjusted torque values.

Before starting the second step, the marking on all nuts and threads is checked visually. Missing marking must be completed.

After the second step, the sets labeled should be checked in terms of the following requirements:

a) Correct if the angle obtained is smaller by more than 15[°] from the required value,

b) The bolt set is replaced with the new one when:

- The angle of rotation obtained is larger than 30[°] from the required value,
- The bolt or nut was damaged.

HV5 CATEGORIES OF BOLTED CONNECTIONS – EN 1993-1-8

Tab. 25. Categories of bolted connections according to EN 1993-1-8.

Categories of bolted connections				
Shear connections			Tension connections	
A (Bearing type)	**B** (Slip-resistant at serviceability)	**C** (Slip-resistant at ultimate)	**D** (Non-preloaded)	**E** (Preloaded)
$F_{v,Ed} \le F_{v,Rd}$ $F_{v,Ed} \le F_{b,Rd}$	$F_{v,Ed,ser} \le F_{s,Rd,ser}$ $F_{v,Ed} \le F_{v,Rd}$ $F_{v,Ed} \le F_{b,Rd}$	$F_{v,Ed} \le F_{s,Rd}$ $F_{v,Ed} \le F_{b,Rd}$ $F_{v,Ed} \le N_{net,Rd}$	$F_{t,Ed} \le F_{t,Rd}$ $F_{t,Ed} \le B_{p,Rd}$	$F_{t,Ed} \le F_{t,Rd}$ $F_{t,Ed} \le B_{p,Rd}$
No preloading required. Bolt classes from 4.6 to 10.9 may be used	Preloaded 8.8 or 10.9 bolts should be used. Slip resistance in the serviceability limit state	Preloaded 8.8 or 10.9 bolts should be used. Slip resistance in the ultimate limit state	No preloading required. Bolt classes from 4.6 to 10.9 may be used.	Preloaded 8.8 or 10.9 bolts should be used

Legend:

$F_{V,Ed}$ – is the design shear force per bolt for the ultimate limit state

$F_{V,Rd}$ – is the design shear resistance per bolt

$F_{b,Rd}$ – is the design bearing resistance per bolt

$F_{V,Ed,ser}$ – is the design shear force per bolt for the serviceability limit state

$F_{S,Rd,ser}$ – is the design slip resistance per bolt at the serviceability limit state

$F_{S,Rd}$ – is the design slip resistance per bolt at the ultimate limit state

$N_{net,Rd}$ – is the design plastic resistance of the net cross-section at bolt holes

$F_{t,Ed}$ – is the design tensile force per bolt for the ultimate limit state

$F_{t,Rd}$ – is the design tension resistance per bolt

$B_{p,Rd}$ – is the design punching shear resistance of the bolt head and the nut

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SB SET ACCORDING TO EN 15048

FEATURES AND BENEFITS

- Perfect selection of the thread fit enables manual assembly
- Provision of the assembly procedure of SB bolts produced by the manufacturer, increasing the self-locking of the thread
- Provision of the SB bolt assembly procedure according to the requirements of DASt - Richtlinie 024 / DIN EN 1993-1-8 / NA
- Possibility to test bolts during assembly, testing the friction coefficient and the clamping force of the connection
- Each batch of nuts is tested in a set in accordance with EN 15048
- The ERP system enables full product identification and access to test results
- Special requirements for nuts - dimensional and coating stability
- Clear product label informing about the basic parameters of the set and the values required for assembly
- SB quality endurance confirmed by the CQI-9 certificate
- Even hot-dip galvanized coating ensuring corrosion resistance
- Customer support backed by a team of laboratories, assistance in the selection of assembly methods
- Customer support backed by a team of laboratories, assistance in the selection of assembly methods



CATEGORIES OF BOLTED CONNECTIONS

Shear connections:
Category A: Bearing Type connections

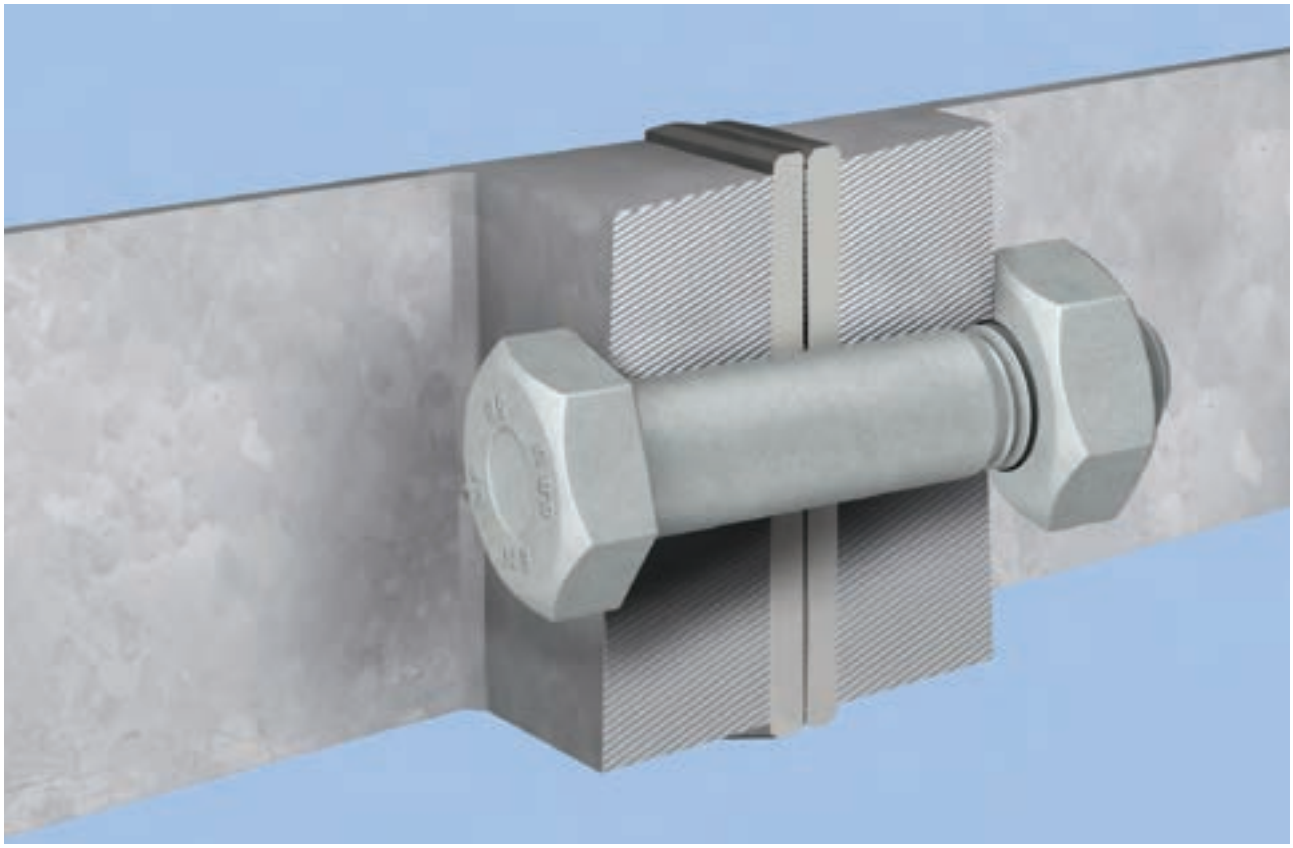
Tension connections:
Category D: Non-preloaded

APPROVALS AND REPORTS

- DoP Number 2018/05/02-CPR/8.8
- Certificate no 0045-CPR-1145/1
- Certificate of Conformity EN 1090-2
- Certificate of Conformity EN 15048
- Certificate of Conformity IATF 16949
- Certificate of Conformity ISO 9001
- Certificate of Conformity ISO 14001
- Certificate of Conformity AD 2000

CE 0045

User's guide



APPLICATIONS

- Halls
- Bridges
- Trading centres
- Roof constructions
- Internal building skeletons with large lateral spread
- Multi-level parkings
- Wind turbines
- Industrial installations











SB SB-SETS

6.1 AVAILABILITY OF SB SETS ACCORDING TO EN 15048

SB sets are available for sale from the warehouse in the M10 – M30 range, in accordance with the following table. Confirmation of product availability when is required. Possibility to manufacture other sizes for verification after request for proposal

Standard	4014	4017	4014	4017	4014	4017	4014	4017	4014	4017	4014	4017
l / d	M10		M12		M16		M20		M24		M30	
20												
25												
30												
35												
40												
45												
50												
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185												
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195												
200												
205												
210												
215												
220												
225												
230												
235												
240												
245												
250												
255												
260												

Produced at the customer's request

Standard

SB SB-SETS

6.1.1 PACKING LIST

Tab. 26. SB set packing list - Bolt and Nut (ISO 4014 and ISO 4032)

Size	Box (pcs)	Pallet (pcs)
10x40	100	7500
10x45	100	7500
10x50	100	5100
10x55	100	5100
10x60	100	5100
10x65	100	5100
10x70	100	5100
10x75	100	5100
10x80	100	5100
10x85	100	5100
10x90	100	5100
10x95	100	5100
10x100	100	5100
10x105	50	3750
10x110	50	3750
10x115	50	3750
10x120	50	3750
10x125	50	3750
10x130	50	3750
10x135	50	3750
10x140	50	3750
10x145	50	3750
10x150	50	3750
10x155	50	3750
10x160	50	3750
12x50	100	5100
12x55	100	5100
12x60	100	5100
12x65	50	3750
12x70	50	3750
12x75	50	3750
12x80	50	3750
12x85	50	3750
12x90	50	3750
12x95	50	3750
12x100	50	3750
12x105	50	3750
12x110	50	3750
12x115	50	3750
12x120	50	3750
12x125	50	3750
12x130	50	3750
12x135	50	3750
12x140	50	3750
12x145	50	3750
12x150	50	3750
12x155	25	1875
12x160	25	1875
12x165	25	1875
12x170	25	1875
12x175	25	1875
12x180	25	1875
12x185	25	1875
12x190	25	1875
12x195	25	1875
12x200	25	1875
12x205	25	1875
12x210	25	1875
12x215	25	1875
12x220	25	1875
12x225	25	1875
12x230	25	1875
12x235	25	1875
12x240	25	1875
12x245	25	1875
12x250	25	1875
12x255	25	1875
12x260	25	1875
16x55	50	2550
16x60	50	2550
16x65	25	1875
16x70	25	1875
16x75	25	1875
16x80	25	1875
16x85	25	1875
16x90	25	1875
16x95	25	1875
16x100	25	1875
16x105	25	1875
16x110	25	1875
16x115	25	1875
16x120	25	1875
16x125	25	1875
16x130	25	1875
16x135	25	1875
16x140	25	1875
16x145	25	1875
16x150	25	1875
16x155	25	1875
16x160	25	1875
16x165	25	1875
16x170	25	1875
16x175	25	1875
16x180	25	1275
16x185	25	1275
16x190	25	1275
16x195	25	1275
16x200	25	1275
16x205	10	750
16x210	10	750
16x215	10	750
16x220	10	750
16x225	10	750
16x230	10	750
16x235	10	750
16x240	10	750
16x245	10	750
16x250	10	750
16x255	10	750
16x260	10	750
20x60	25	1270
20x65	25	1270
20x70	25	1270
20x75	25	1270
20x80	25	1270
20x85	25	1270
20x90	25	1270
20x95	25	1270
20x100	25	1270
20x105	25	1270
20x110	25	1270
20x115	25	1270
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20x125	25	1270
20x130	25	1270
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20x165	10	750
20x170	10	750
20x175	10	750
20x180	10	750
20x185	10	750
20x190	10	750
20x195	10	750
20x200	10	750
20x205	10	750
20x210	10	750
20x215	10	750
20x220	10	750
20x225	10	750
20x230	10	750
20x235	10	750
20x240	10	750
20x245	10	750
20x250	10	750
20x255	10	750
20x260	10	750
24x75	25	1875
24x80	25	1875
24x85	10	750
24x90	10	750
24x95	10	750
24x100	10	750
24x105	10	750
24x110	10	750
24x115	10	750
24x120	10	750
24x125	10	750
24x130	10	750
24x135	10	750
24x140	10	750
24x145	10	750
24x150	10	750
24x155	10	750
24x160	10	750
24x165	10	750
24x170	10	750
24x175	10	750
24x180	10	750
24x185	10	750
24x190	10	750
24x195	10	750
24x200	10	750
24x205	10	750
24x210	10	750
30x90	10	510
30x95	10	510
30x100	10	510
30x105	10	510
30x110	10	510
30x115	10	510
30x120	10	510
30x125	10	510
30x130	10	510
30x135	10	510
30x140	10	510
30x145	10	510
30x150	10	510
30x155	10	510
30x160	10	510
30x165	10	510
30x170	10	510
30x175	10	510
30x180	10	510
30x185	10	510
30x190	10	510
30x195	10	510
30x200	10	510
30x205	10	510
30x210	10	510
30x215	10	510
30x220	10	510
30x225	10	510
30x230	10	510
30x235	10	510
30x240	10	510

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SB SB-SETS

Tab. 27. SB set packing list - Bolt and Nut (ISO 4017 and ISO 4032)

Size	Box (pcs)	Pallet (pcs)	Size	Box (pcs)	Pallet (pcs)	Size	Box (pcs)	Pallet (pcs)	Size	Box (pcs)	Pallet (pcs)
10x20	200	15000	12x65	50	3750	16x90	25	1875	24x55	25	1275
10x25	200	15000	12x70	50	3750	16x95	25	1875	24x60	25	1275
10x30	200	15000	12x75	50	3750	16x100	25	1875	24x65	25	1275
10x35	100	7500	12x80	50	3750	16x105	25	1875	24x70	25	1275
10x40	100	7500	12x85	50	3750	16x110	25	1875	24x75	25	1275
10x45	100	7500	12x90	50	3750	16x115	25	1875	24x80	25	1275
10x50	100	5100	12x95	50	3750	16x120	25	1875	24x85	10	1275
10x55	100	5100	12x100	50	3750	20x40	25	1875	24x90	10	1275
10x60	100	5100	12x105	50	2550	20x45	25	1875	24x95	10	1275
10x65	100	5100	12x110	50	2550	20x50	25	1875	24x100	10	1275
10x70	100	5100	12x115	50	2550	20x55	25	1875	24x105	10	1275
10x75	100	5100	12x120	50	2550	20x60	25	1875	24x110	10	1275
10x80	100	5100	16x25	50	3750	20x65	25	1875	24x115	10	1275
10x85	100	5100	16x30	50	3750	20x70	25	1275	24x120	10	1275
10x90	100	5100	16x35	50	3750	20x75	25	1275	30x50	10	510
10x95	100	5100	16x40	50	3750	20x80	25	1275	30x55	10	510
10x100	100	5100	16x45	50	3750	20x85	25	1275	30x60	10	510
12x25	100	5100	16x50	50	3750	20x90	25	1275	30x65	10	510
12x30	100	5100	16x55	50	3750	20x95	25	1275	30x70	10	510
12x35	100	5100	16x60	50	3750	20x100	25	1275	30x75	10	510
12x40	100	5100	16x65	25	1875	20x105	25	1275	30x80	10	510
12x45	100	5100	16x70	25	1875	20x110	25	1275	30x85	10	510
12x50	100	5100	16x75	25	1875	20x115	25	1275	30x90	10	510
12x55	100	5100	16x80	25	1875	20x120	25	1275	30x95	10	510
12x60	100	5100	16x85	25	1875	24x50	25	1275	30x100	10	510

6.1.2 PRODUCT WEIGHT

Tab. 28. Bolts and nuts weight according to ISO 4014 and ISO 4032.

Size	Bolt (g/pc)	Set (g/pc)	Size	Bolt (g/pc)	Set (g/pc)	Size	Bolt (g/pc)	Set (g/pc)	Size	Bolt (g/pc)	Set (g/pc)
10x40	31.1	40.94	12x60	61.8	76.8	12x195	176.5	187	16x120	213	238.3
10x45	34.1	43.94	12x65	66.1	81.1	12x200	181	191.5	16x125	220	246.3
10x50	37.1	46.94	12x70	70.4	85.4	12x205	185.5	196	16x130	226	253.3
10x55	40	49.84	12x75	74.6	89.6	12x210	190	200.5	16x135	234	259.3
10x60	43	52.84	12x80	78.9	93.9	12x215	194.5	205	16x140	242	267.3
10x65	45.9	55.74	12x85	83.1	98.1	12x220	199	209.5	16x145	249.5	275.3
10x70	48.9	58.74	12x90	87.4	102.4	12x225	202.5	214	16x150	257	282.8
10x75	51.9	61.74	12x95	91.7	106.7	12x230	206	217.5	16x155	264.5	290.3
10x80	54.8	64.64	12x100	95.9	110.9	12x235	210.5	221	16x160	272	297.8
10x85	57.8	67.64	12x105	100.2	115.2	12x240	215	225.5	16x165	280	305.3
10x90	60.7	70.54	12x110	104.5	119.5	12x245	219.5	230	16x170	288	313.3
10x95	63.7	73.54	12x115	108.7	123.7	12x250	224	234.5	16x175	295.5	321.3
10x100	66.7	76.54	12x120	113	128	12x255	228.5	239	16x180	303	328.8
10x105	69.6	79.44	12x125	116.6	131.6	12x260	233	243.5	16x185	310.5	336.3
10x110	72.6	82.44	12x130	121	136	16x55	115	248	16x190	318	343.8
10x115	75.6	85.44	12x135	125.4	140.4	16x60	120.3	148.3	16x195	326	351.3
10x120	78.5	88.34	12x140	129.3	144.3	16x65	128	153.6	16x200	334	359.3
10x125	81.5	91.34	12x145	133.2	148.2	16x70	135.7	161.3	16x205	340	367.3
10x130	84.4	94.24	12x150	138	153	16x75	143.4	169	16x210	346	373.3
10x135	87.4	97.24	12x155	142	157	16x80	151	176.7	16x215	360	379.3
10x140	90.4	100.24	12x160	146	161	16x85	158.8	184.3	16x220	374	393.3
10x145	93.4	103.24	12x165	149.5	164.5	16x90	166.5	192.1	16x225	388	407.3
10x150	96.3	106.14	12x170	157	172	16x95	174.2	199.8	16x230	394	421.3
10x155	99.9	109.74	12x175	150.5	165.5	16x100	181.9	207.5	16x235	400	427.3
10x160	102.2	112.04	12x180	164	179	16x105	189.6	215.2	16x240	406	433.3
12x50	53.3	68.3	12x185	168	183	16x110	197.3	222.9	16x245	412	445.3
12x55	57.6	72.6	12x190	172	187	16x115	205	230.6	16x250	418	451.3

SB SB-SETS

Size	Bolt (g/pc)	Set (g/pc)
16x255	424	457.3
16x260	430	463.3
20x60	200	264.4
20x65	212	276.4
20x70	224	288.4
20x75	236	300.4
20x80	248	312.4
20x85	260	324.4
20x90	272	336.4
20x95	284	348.4
20x100	296	360.4
20x105	309	373.4
20x110	321	385.4
20x115	333	397.4
20x120	345	409.4
20x125	357	421.4
20x130	367	431.4
20x135	379	443.4
20x140	391	455.4
20x145	403	467.4
20x150	415	479.4
20x155	427	491.4
20x160	439	503.4
20x165	451	515.4
20x170	463	527.4
20x175	475.5	539.9
20x180	488	552.4
20x185	500	564.4
20x190	512	576.4
20x195	524	588.4
20x200	536	600.4
20x205	545.5	609.9
20x210	555	619.4
20x215	567	631.4
20x220	579	643.4
20x225	591	655.4
20x230	603	667.4
20x235	615	679.4
20x240	627	691.4
20x245	639	703.4
20x250	651	715.4
20x255	663	727.4
20x260	675	739.4
24x75	356	473
24x80	373	490
24x85	390	507
24x90	408	525
24x95	425	542
24x100	443	560
24x105	460	577
24x110	477	594
24x115	495	612
24x120	512	629
24x125	529	646
24x130	543	660
24x135	560.5	677.5
24x140	578	695
24x145	595.5	712.5
24x150	613	730
24x155	630.5	747.5
24x160	648	765
24x165	665.5	782.5
24x170	683	800
24x175	700.5	817.5
24x180	718	835
24x185	735	852
24x190	752	869
24x195	769.5	886.5
24x200	787	904
24x205	801	918
24x210	815	932
30x90	712.0	946.0
30x95	750.0	984.0
30x100	787.0	1021.0
30x105	805.0	1039.0
30x110	823.0	1057.0
30x115	852.0	1086.0
30x120	880.0	1114.0
30x125	908.0	1142.0
30x130	920.0	1154.0
30x135	948.0	1182.0
30x140	975.0	1209.0
30x145	1003.0	1237.0
30x150	1030.0	1264.0
30x155	1058.0	1292.0
30x160	1085.0	1319.0
30x165	1113.0	1347.0
30x170	1140.0	1374.0
30x175	1170.0	1404.0
30x180	1200.0	1434.0
30x185	1225.0	1459.0
30x190	1250.0	1484.0
30x195	1280.0	1514.0
30x200	1310.0	1544.0
30x205	1137.0	1371.0
30x210	1365.0	1599.0
30x215	1393.0	1627.0
30x220	1420.0	1654.0
30x225	1448.0	1682.0
30x230	1475.0	1709.0
30x235	1503.0	1737.0
30x240	1530.0	1764.0

Tab. 29. Bolts and nuts weight according to ISO 4017 and ISO 4032.

Size	Bolt (g/pc)	Set (g/pc)
10x20	20.2	30.04
10x25	22.7	32.54
10x30	25.2	35.04
10x35	27.6	37.44
10x40	30	39.84
10x45	32.5	42.34
10x50	35	44.84
10x55	37.4	47.24
10x60	39.9	49.74
10x65	42.3	52.14
10x70	44.8	54.64
10x75	47.2	57.04
10x80	49.7	59.54
10x85	52.1	61.94
10x90	54.6	64.44
10x95	57	66.84
10x100	59.5	69.34
12x25	33	48
12x30	36.6	51.6
12x35	40.1	55.1
12x40	43.7	58.7
12x45	47.2	62.2
12x50	50.7	65.7
12x55	54.3	69.3
12x60	57.8	72.8
12x65	61.4	76.4
12x70	64.9	79.9
12x75	68.5	83.5
12x80	72	87
12x85	75.5	90.5
12x90	79	94
12x95	82.6	97.6
12x100	86.2	101.2
12x105	89.75	104.75
12x110	93.3	108.3
12x115	96.85	111.85
12x120	100.4	115.4
16x25	70.6	103.9
16x30	77.2	110.5
16x35	83.7	117
16x40	90.3	123.6
16x45	96.8	130.1
16x50	103	136.3
16x55	110	143.3
16x60	116	149.3
16x65	123	156.3
16x70	130	163.3
16x75	136	169.3
16x80	143	176.3
16x85	149	182.3
16x90	156	189.3
16x95	162	195.3
16x100	169	202.3
16x105	175.5	208.8
16x110	182	215.3
16x115	188.5	221.8
16x120	195	228.3
20x40	155	219.4
20x45	165	229.4
20x50	176	240.4
20x55	186	250.4
20x60	196	260.4
20x65	207	271.4
20x70	217	281.4
20x75	227	291.4
20x80	237	301.4
20x85	247	312.4
20x90	257	323.4
20x95	268	335.4
20x100	278	346.4
20x105	288.5	352.9
20x110	299	363.4
20x115	309	373.4
20x120	319	383.4
24x50	274	391
24x55	289	406
24x60	304	421
24x65	319	436
24x70	334	451
24x75	348	465
24x80	363	480
24x85	378	495
24x90	393	510
24x95	408	525
24x100	423	540
24x105	438	555
24x110	453	570
24x115	468	585
24x120	483	600
30x50	496.0	730.0
30x55	519.0	753.0
30x60	543.0	777.0
30x65	566.0	800.0
30x70	590.0	824.0
30x75	613.0	847.0
30x80	637.0	871.0
30x85	660.0	894.0
30x90	685.0	919.0
30x95	708.0	942.0
30x100	732.0	966.0

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6.2 TECHNICAL REQUIREMENTS FOR SB SETS

6.2.1 REQUIREMENTS FOR BOLTS WITH INCREASED STRENGTH IN CLASS 8.8U (ACC. TO EN 15048-1 AND EN 15048-2)

6.2.1.1 GENERAL REQUIREMENTS

Tab. 30. Requirements for bolts and standards referenced by EN 15048-1:2007.

Material		Steel
General requirements		EN 15048-1 and EN 15048-2
Geometry		ISO 4014 and ISO 4017
Thread	Tolerance class	6AZ
	International Standards	ISO 261, ISO 965-2
Mechanical properties	Property class	8.8U
	European Standard	EN ISO 898-1
Impact strength	Value	$K_{v,\,min}$ = 27 J at - 20°C
	Sample for testing [b]	ISO 148
	Test	EN 10045-1
Tolerances	Product grade	C except for: dimensions c and r. Length tolerance ≥ 155 mm + IT17 $-\frac{1}{2}$ IT 17
	European Standard	EN ISO 4759-1
Finish - Coating	Uncoated	As processed [a]
	Hot-dip galvanized	EN ISO 10684
	Others	To be agreed [b]
Surface integrity		Limit for surface discontinuities as specified in EN 26157-1
Acceptability		Acceptance procedure, see EN ISO 3269

[a] "As processed" means normal finish performed by the manufacturer and light oil coverage.

[b] The recipient and the manufacturer may agree on other coatings, if they do not affect the reduction of mechanical properties or performance characteristics. Cadmium or cadmium alloy coatings are not allowed.

6.2.1.2 MATERIAL

Tab. 31. Chemical composition of steel used for the manufacture of bolts according to ISO 898-1:2013.

Property class	Material and heat treatment	Chemical composition limit (cast analysis, %)[a]					Tempering temperature
		C		P	S	B[b]	°C
		min.	max.	max.	max.	max.	min.
8.8[d]	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,15[c]	0,40	0,015	0,015	0,003	425
	or Carbon steel quenched and tempered	0,25	0,55	0,015	0,015		
	or Alloy steel quenched and temperede	0,20	0,55	0,015	0,015		

[a] In case of dispute, the product analysis applies.

[b] Boron content can reach 0,005%, provided non-effective boron is controlled by the addition of titanium and/or aluminium.

[c] In case of plain carbon boron steel with a carbon content below 0,25% (cast analysis), the minimum manganese content shall be 0,6% for property class 8.8 and 0,7% for property classes 9.8 and 10.9.

[d] **Fort he materials of these property classes, there shall be a sufficient hardenability to ensure a structure consisting of approximately 90% martensite in the core oft he threaded sections fort he fasteners in the „as-hardened" condition before tempering.**

[e] This alloy steel shall contain at least one oft he following elements in the minimum quantity given: chromium 0,30%, nickel 0,30%, molybdenum 0,20%, vanadium 0,10%. Where elements are specified in combinations oft wo, three or four and have alloy contents less than those given above, the limit value tob e applied for steel class determination is 70% oft he sum oft he individual limit values specified above for the two, three or four elements concerned.

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6.2.1.3 MECHANICAL AND PHYSICAL PROPERTIES FOR BOLTS IN CLASS 8.8

Tab. 32. Mechanical and physical properties of bolts according to EN ISO 898-1:2013.

Nr	Physical or mechanical property		Value	
			d≤16 mm[a]	d>16 mm[b]
1	Tensile strength, R_m, MPa	nom.[c]	800	
		min.	800	830
2	Lower yield point, R_{eL} [d], MPa	nom.[c]	—	—
		min.	—	—
3	Stress at 0.2% disproportionate elongation, $R_{p0,2}$, MPa	nom.[c]	640	640
		min.	640	660
4	Stress at disproportionate elongation of 0.0048 d for full-size fasteners, R_{pf}, MPa	nom.[c]	—	—
		min.	—	—
5	Stress under test load, S_p [e], MPa	nom.	580	600
	Strength ratio	$S_{p,nom}/R_{eL\ min}$ or $S_{p,nom}/R_{p0,2\ min}$ or $S_{p,nom}/R_{pf\ min}$	0,91	0,91
6	Percent elongation after cracking for processed samples for testing, *A, %*	min.	12	12
7	Percent reduction in the surface after cracking for processed samples for testing, *Z, %*	min.	52	
8	Elongation after cracking for full-size fasteners, A_f (see also Appendix C in ISO 898-1:2013)	min.	—	—
9	Head solidity		No cracks	
10	Vickers hardness HV $F \geq 98$ N	min.	250	255
		max.	330	335
11	Brinell hardness, HBW $F = 30\ D^2$	min.	245	250
		max.	316	331
12	Rockwell hardness, HRB	min.	—	
		max.	—	
	Rockwell hardness, HRC	min.	22	23
		max.	32	34
13	Surface hardness, HV 0,3	max.	—	
14	Non-carburization, HV 0,3	max.	f	
15	Height of non-decarburized thread zone, *E*, mm	min.	½ H_1	
	Depth of complete decarburization in the thread, *G*, mm	max.	0,015	
16	Hardness reduction after re-tempering, HV	max.	20	
17	Destructive torque, M_B, N.m	min.	according to the ISO 898-7 standard	
18	Impact strength, K_v [g, h], J	min.	27	27
19	Surface integrity according to		ISO 6157-1[i]/ ISO 6157-3	

[a] Values do not apply to structural bolting

[b] For structural bolting ≥ M12

[c] Rated values are specified only for the purposes of the marking system for the property classes. See, Section 5 of ISO 898-1:2013

[d] In cases where the lower yield point ReLnie can be determined, it is allowed to measure the stress at 0.2% disproportionate elongation of Rp0.2

[e] Test loads are specified in Tables 5 and 7 of ISO 898-1:2013

[f] The surface hardness should not be higher than 30 Vickers points above the measured hardness of the core of the fastener, when the determination of both surface hardness and core hardness is performed with HV 0.3

[g] Values are determined at a test temperature of -20°C (see 9.14 ISO 898-1:2013)

[h] Applies to d ≥ 16 mm

[i] Instead of ISO 6157-1, ISO 6157-3 may apply, on the basis of the agreement between the manufacturer and the buyer

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6.2.1.4 BOLT DIMENSIONS ACCORDING TO ISO 4014

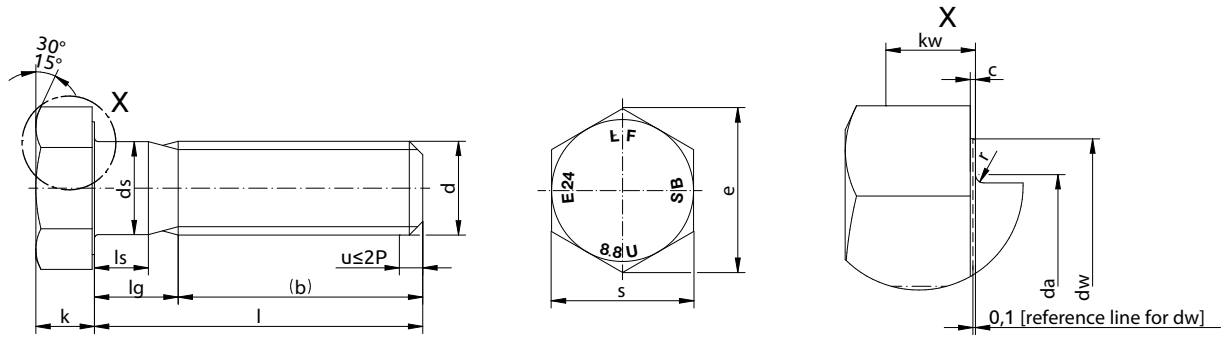


Fig. 15. Bolt according to ISO 4014.

Tab. 33. Bolt dimensions according to ISO 4014.

Thread (d)			M10	M12	M16	M20	M24	M30
P [a]			1,5	1,75	2	2,5	3	3,5
b		[b]	26	30	38	46	54	66
		[c]	32	36	44	52	60	72
		[d]	45	49	57	65	73	85
c		max	0,60	0,60	0,80	0,80	0,80	0,80
		min	0,15	0,15	0,20	0,20	0,20	0,20
da		max	11,2	13,7	17,7	22,4	26,4	33,4
ds	nom. = max		10,00	12,00	16,00	20,00	24,00	30,00
	Product class A		9,78	11,73	15,73	19,67	23,67	29,48
dw	Product class A	min	14,63	16,63	22,49	28,19	33,61	42,75
e	Product class A	min	17,77	20,03	26,75	33,53	39,98	50,85
k		nom	6,4	7,5	10	12,5	15	18,7
	Product class A	min	6,580	7,680	10,180	12,715	15,215	19,12
		min	6,220	7,320	9,820	12,285	14,785	18,28
kw[e]	Product class A	min	4,35	5,12	6,87	8,60	10,35	12,8
r		min	0,4	0,6	0,6	0,8	0,8	1
s	nom. = max		16	18	24	30	36	46
	Product class A	min	15,73	17,73	23,67	29,67	35,38	45

[a] P is the thread pitch
[b] Dla $l_{nom} \leq 125$ mm
[c] Dla 125 mm < $l_{nom} \leq 200$ mm
[d] Dla $l_{nom} > 200$ mm
[e] $k_{w,min} = 0,7\ k_{min}$

6.2.1.5 BOLT DIMENSIONS ACCORDING TO ISO 4017

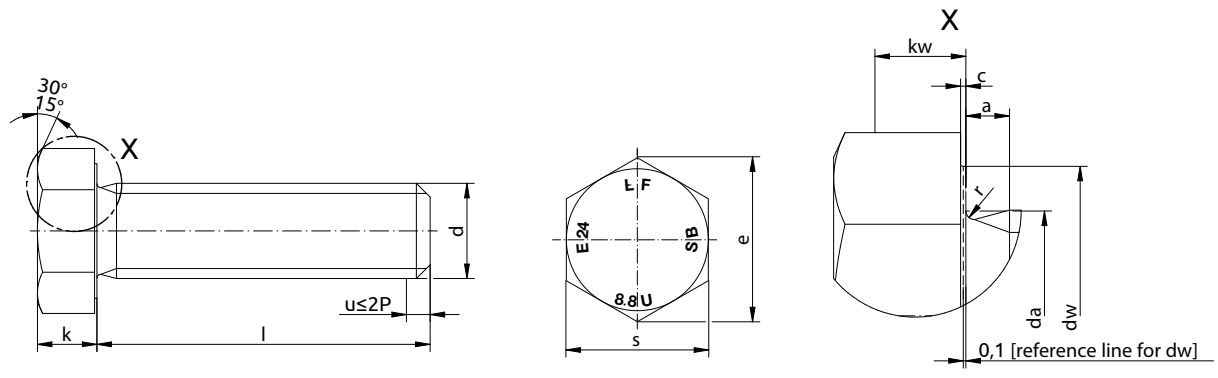


Fig. 16. Bolt according to ISO 4017.

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Tab. 34. Bolt dimensions according to ISO 4017.

Thread (d)			M10	M12	M16	M20	M24	M30
P [a]			1,5	1,75	2	2,5	3	3,5
a		max [b]	4,5	5,3	6	7,5	9	10,5
		min	1,5	1,75	2	2,5	3	3,5
c		max	0,60	0,60	0,80	0,80	0,80	0,80
		min	0,15	0,15	0,20	0,20	0,20	0,20
da		max	11,2	13,7	17,7	22,4	26,4	33,4
dw	Product class A	min	14,63	16,63	22,49	28,19	33,61	42,75
e	Product class A	min	17,77	20,03	26,75	33,53	39,98	50,85
k	nom.		6,4	7,5	10	12,5	15	18,7
	Product class A	max	6,58	7,68	10,18	12,715	15,215	19,12
		min	6,22	7,32	9,82	12,285	14,785	18,28
kw [c]		min	4,35	5,12	6,87	8,60	10,35	12,80
r		min	0,4	0,6	0,6	0,8	0,8	1
s	nom. = max		16	18	24	30	36	46
	Product class A	min	15,73	17,73	23,67	29,67	35,38	45,00

[a] *P* is the thread pitch

[b] Parameter values a_{max}, according to ISO 3508, normal series

[c] $k_{w,min} = 0,7\ k_{min}$

6.2.1.6 MARKING SB

The bolts should be marked according to EN 15048. The bolt and nut marking presented in Fig. 17 consists of the mechanical property class, manufacturer identification sign and SB mark. Stamping must be placed on the upper surface of the head; concave or convex marking is allowed.

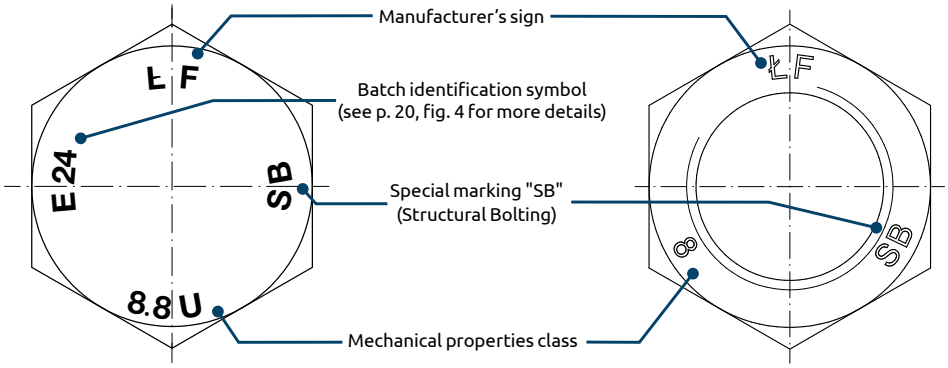


Fig. 17. Bolt and nut marking according to EN 15048.

6.2.2 REQUIREMENTS FOR NUTS ACCORDING TO EN 15048-1 AND EN 15048-2

6.2.2.1 GENERAL REQUIREMENTS

Tab. 35. Requirements for nuts and standards referenced by EN 15048-1 and EN 15048-2.

Material		Steel
General requirements		EN 15048-1 and EN 15048-2
Geometry		ISO 4032
Thread	Tolerance	6H
	International Standards	ISO 261, ISO 965-2, ISO 965-5
Mechanical properties	Property class	8
	European Standard	ISO 261, ISO 965-2, ISO 965-5
Tolerances	Accuracy class	B
	European Standard	EN ISO 4759-1
Finish - Coating	Uncoated	As processed [a]
	Hot-dip galvanized	EN ISO 10684
	Others	To be agreed [b]
Surface integrity		Limit for surface discontinuities as specified in EN ISO 6157-2
Acceptability		Acceptance procedure, see EN ISO 3269

[a] „As processed" means normal finish resulting from manufacturer with a light coating of oil.

[b] The recipient and the manufacturer may agree on other coatings, if they do not affect the reduction of mechanical properties or performance characteristics. Cadmium or cadmium alloy coatings are not allowed.

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6.2.2.2 MATERIAL

Chemical composition of the material used must be in accordance with ISO 898-2:2022.

Tab. 36. Chemical composition of steel used for the manufacture of nuts according to ISO 898-2:2022.

Strength class	Thread	Material and heat treatment of nuts	Chemical composition (%)[a, b]					Tempering temperature
			C		Mn	P	S	°C
			min	max	min	max	max	min.
8	Style 1 M5 ≤ D ≤ M16[c]	NQT[d]	0,06	0,58	0,25	0,060	0,150	-
8	Style 1 M5 ≤ D ≤ M39	QT[e]	0,15	0,58	0,45	0,048	0,058	380

QT = Quenched and tempered nuts.

NQT = Not Quenched and Tempered

[a] In case of dispute, product analysis shall apply.

[b] Alloying elements may be added, provided the mechanical and physical properties required in Clause 8 acc. ISO 898-2:2022 are met.

[c] These nuts may be quenched and tempered at the manufacturer's discretion, and in this case all requirements for QT nuts shall apply.

[d] The steel structure of NQT nuts shall not consist of quenched microstructure, in accordance with 7.4.1 ISO 898-2:2022.

[e] For materials of nuts to be quenched and tempered (QT), there shall be a sufficient hardenability to ensure a homogenous microstructure consisting of approximately 90 % martensite throughout the nuts. The manufacturer shall ensure that the austenite transformation temperature has been exceeded and sufficient duration allowed to achieve adequate transformation to martensite throughout the nut during quenching to ensure uniform mechanical properties.

6.2.2.3 MECHANICAL AND PHYSICAL PROPERTIES FOR CLASS 8

Tab. 37. Hardness properties of standard threaded nuts, ISO 898-2:2022.

	Strength class 8					
Thread	Vickers hardness, HV		Converted Brinell hardness, HB		Converted Rockwell hardness	
D	min	max	min	max	min	max
Style 1 M5 ≤ D ≤ M16 (NQT)	200	334	190	318	91,5 HRB	33,9 HRC
Style 1 M16 < D ≤ M39 (QT)	233	353	228	330	98,9 HRB	34,8 HRC
Style 1 M5 ≤ D ≤ M16 (QT)	200	334	195	330	92,7 HRB	34,8 HRC

Tab. 38. Test load values for nuts with the standard thread, ISO 898-2:2022.

		Load[a], kN					
Thread	D	M10	M12	M16	M20	M24	M30
Thread pitch	P	1,5	1,75	2	2,5	3	3,5
Strength class	8	50 500	74 200	138 200	225 400	324 800	552 600

[a] When using flat nuts, one should take into account that the shear force is less than the full-load nut test force (see Attachment B in ISO 898-2:2022).

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6.2.2.4 NUT DIMENSIONS ACCORDING TO ISO 4032

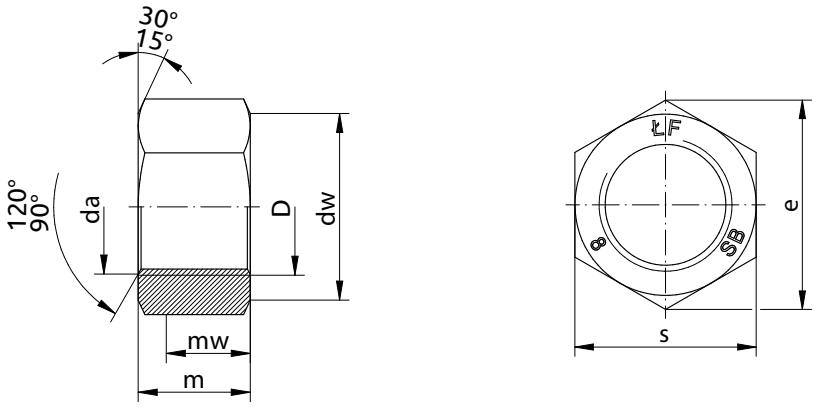


Fig. 18. Nut according to ISO 4032.

Tab. 39. Nut dimensions according to ISO 4032.

Thread (d)		M10	M12	M16	M20	M24	M30
P [a]		1,5	1,75	2	2,5	3	3,5
c	**max**	0,60	0,60	0,80	0,80	0,80	0,80
	min	0,15	0,15	0,20	0,20	0,20	0,20
da	**max**	10,8	13,0	17,3	21,6	25,9	32,40
	min	10,0	12,0	16,0	20,0	25,9	30,00
dw		14,6	16,6	22,5	27,7	33,3	42,80
e		17,77	20,03	26,75	32,95	39,55	50,85
m	**max**	8,40	10,80	14,80	18,00	21,50	25,60
	min	8,04	10,37	14,10	16,90	20,20	24,30
mw		6,4	8,3	11,3	13,5	16,2	19,40
s	**nom. = max**	16,00	18,00	24,00	30,00	36,00	46,00
	min	15,73	17,73	23,67	29,16	35,00	45,00
[a] *P* is the thread pitch							

6.2.3 TENSILE TEST OF BOLTING ASSEMBLIES ACCORDING TO EN 15048:2007

The tests are carried out in bolt sets consisting of ISO 4014 or ISO 4017 bolts and ISO 4032 nuts. The test is used to determine the elongation of the bolt and nut set under load to measure the force in the bolt set during the test. The examination is carried out on a materials testing machine. The tests should be carried out on a minimum of 5 SB sets. The bolt sets should be arranged in the tensile test of bolting assemblies as shown in Fig. 19, so that the clamp length is the maximum allowed range. The end of the bolt should not protrude more than one pitch beyond the free surface of the nut.

Tab. 40. Minimum tensile load requirements in accordance with EN 15048-1:2007.

Thread	Grade 8.8	
	Minimum breaking tensile loade ($A_{saz,\,nom}$ x $R_{m,\,min}$), w kN	Nominal tension area $A_{saz,\,nom}$ mm²
M10	42,9	53,6
M12	70	84
M14	95,5	115
M16	130	157
M18	159	192
M20	203	245
M22	252	303
M24	293	353
M27	381	459
M30	466	561
M33	576	694
M36	678	817

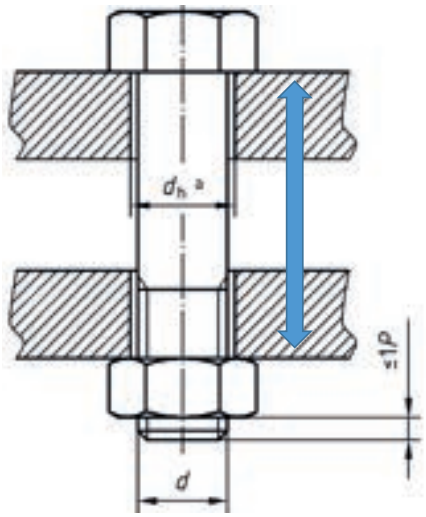


Fig. 19. Diagram of the tensile test of bolting assemblies.

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SB SB-SETS

6.3 THE LABEL OF AN SB SET, AS REQUIRED BY EN 15048:2007

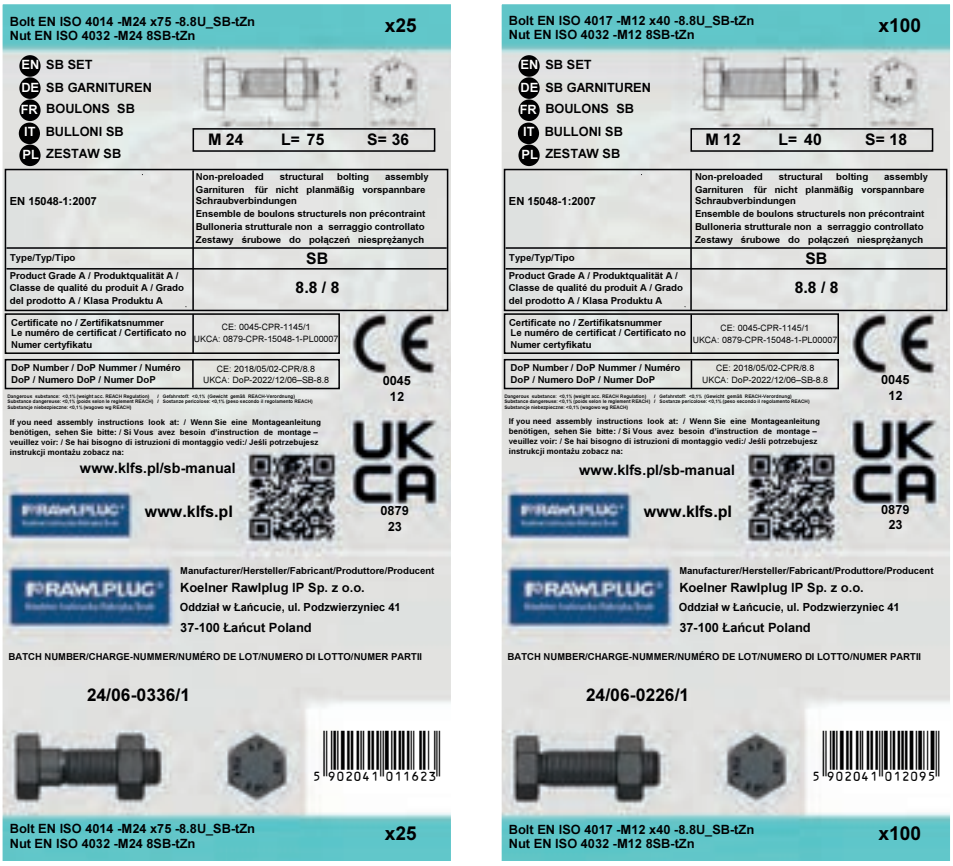


Fig. 20. The label of the SB set for ISO 4014 and ISO 4017 with nuts ISO 4032.

The SB set label must contain the following information:

- Set contents (e.g. M12)
- The harmonised standard number
- Type, grade marking and product class
- Identification number of the FPC and the last two digits of the year the certificate was issued
- DoP number and FPC certificate number
- The registered address of the manufacturer
- Production batch number
- Information on dangerous substances

SB SB-SETS

6.4 GENERAL PROVISIONS FOR THE INSTALLATION OF SB SETS IN GRADE 8.8

a. For both the first and last cycles, tighten the bolts in sequence from the most rigid to the least rigid contact area, as shown in Fig. 21. More than one tightening cycle may be required to achieve even compression.

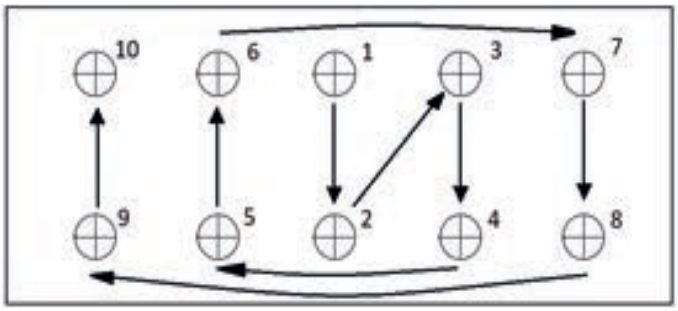


Fig. 21. Example of bolt tightening sequence in a connection.

b. This manual applies to SB sets supplied by Koelner Rawlplug IP.

c. SB sets should only be used in the provided set of bolts and nuts.

d. Before starting assembly, check the label of the SB set and the set properties certificate (EN 10204:2004) with the requirements of EN 15048:2007 and confirm its conformity.

e. The set properties certificate (EN 10204:2004) should include information on the tests of the set (refer to in point 3), the mechanical properties and the chemical composition of the bolt, including the steel melt and grade, the thickness of the zinc coating, and the test load of the nut.

f. The preparation of holes according to EN 1090-2 is recommended.

g. The tightening is done by turning the nut or bolt head in the opposite direction to HV bolts.

PLEASE NOTE: additional lubrication of set components can be applied after consulting the supplier. Additional lubrication changes the friction coefficient values and affects the assembly torque.

h. In SB connections, the thread projection measured from the nut head to the end of the mandrel should be no less than one thread pitch.

i. For connections using pads on both sides (Fig 22.), it is recommended that D should not exceed 1 [mm]. Where steel sealing plates are provided to ensure that the above limit is not exceeded, their thickness should be no less than 1 [mm]. In conditions of risk of crevice corrosion, a tighter contact fit is required. The thickness of steel plates must be chosen so that the number of spacers does not exceed three.

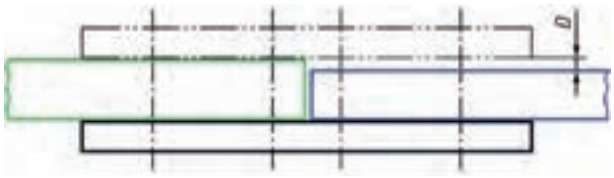


Fig. 22. The difference in part thickness in a connection with pads on both sides.

6.5 GENERAL GUIDELINES FOR CONTROLLED TORQUE ASSEMBLY

The following requirements must be met before assembly:

a. Follow the instructions in point 6.4.

b. Assemble using torque that is continuous and smooth. Do not interrupt installing a bolt until the set value on the wrench is reached.

c. Perform the two tightening steps.

d. Use the assembly torque values provided in Table 41.

Tab. 41. Values of the predicted tensioning from using torque in steps 1 and 2.

	M10	M12	M16	M20	M24	M30
Step 1 [Nm]	30	50	120	240	350	650
Step 2 [Nm]	55	100	240	470	700	1400
min. $F_{p,C}$ [kN]	28	40	75	118	145	230

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SB SB SETS

6.5.1 TIGHTENING – FIRST STEP

a. Set the wrench to the torque value provided in "Step 1" in Table 41. (e.g. for the M16 bolt it is 120 [Nm]).

b. Step one of tightening must be carried out for all bolts in one connection before moving onto step two of tightening. Tightening order – see point 6.4.

6.5.2 TIGHTENING – SECOND STEP

a. Set the wrench to the torque value provided in "Step 2" in Table 41 (e.g. for the M16 bolt it is 240 [Nm]).

b. Step one of tightening must be carried out for all bolts in one connection. Tightening order – see point 6.4.

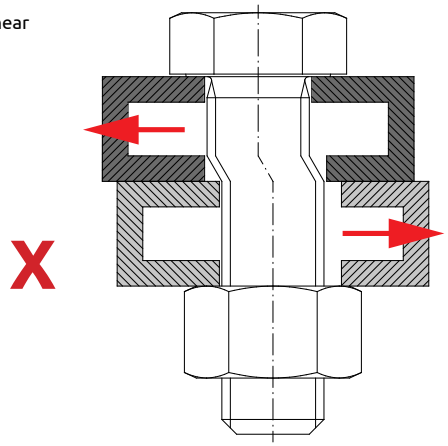
*If you are installing a single set, you can skip step one.

6.6 CONDITIONS TO ENSURE THREAD SELF-LOCKING

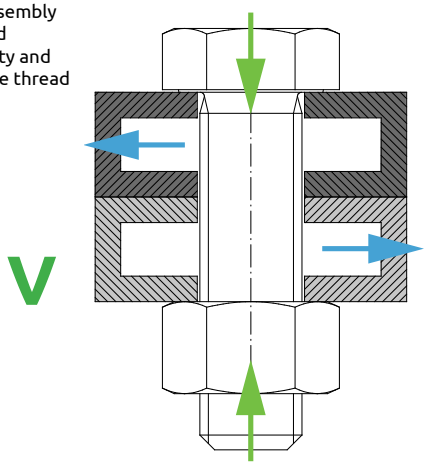
In threaded connections subjected to dynamic lateral force (e.g. as a result of wind), displacement of construction elements may occur. If the construction moves with every change in load, it means the friction between the connected elements is too low. In such a situation, the internal loosening torque causes the nut or bolt to turn with relation to each other, which leads to the connection getting loosened, and in the long term to the set coming apart. The internal loosening torque depends on the clamping force and the bolt pitch. The danger is most serious when assembling the connection took place in a chaotic manner without knowing what clamping force has already been created in the connection.

Conditions for ensuring the self-locking of the thread

Incorrectly selected assembly torque, shear stresses and risk of loosening the nut

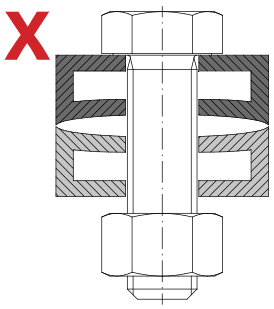


A well-chosen assembly moment, ensured connection rigidity and self-locking of the thread

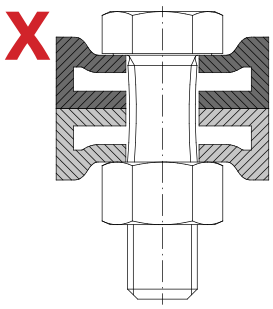


The solution to prevent this phenomenon is to create a higher pre-load in the connection, which will increase the friction resistance between the structural components and reduce the influence of the variable lateral force on the bolt.

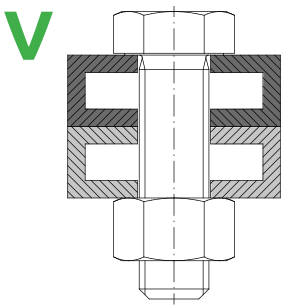
Torque too low.
No adhesion of the joined elements



Torque too high.
Deformation of the bolt and connected elements



The torque specified by the manufacturer.
Connection stability



The most simple and least costly solution is to install the bolts correctly using torque as per the manufacturer's recommendation, which will increase thread self-locking and friction between the components.

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