



# Model specification for the purchase of structural bolting assemblies and holding down bolts

## 1 Introduction

### 1.1 General

This specification is for the purchase of structural bolting assemblies and holding down bolts for constructional steelwork and should be used in conjunction with the *National Structural Steelwork Specification for Buildings* (7<sup>th</sup> edition) and the *Steel Bridge Group: Model Project Specification for the Execution of Steelwork in Bridge Structures*.

Acceptance of structural bolts from a supplier is conditional on the supplier complying with the full requirements of this Model Specification.

This specification is presented here in its 14<sup>th</sup> edition, and comes into force on the 2<sup>nd</sup> October 2023, superseding all previous editions. The main changes compared to the previous issue 13.1 are as follows:

- Revised Table 4 for cup bolts and countersunk bolts.
- Expanded discussion for use of bolts at low service temperatures, see Section 7.
- Impact test in accordance with Clause 9.14 of BS EN ISO 898-1:2013 required.

### 1.2 Definitions

**Purchaser** The company purchasing the structural bolting assemblies and holding down bolts. Generally, this is a steelwork contractor that executes the structural steelwork, undertaking the role of constructor defined in BS EN 1090-2.

**Supplier** The company supplying the structural bolting assemblies and holding down bolts.

*Note: It is assumed that the natural or legal persons to the transaction are companies.*

**Manufacturer** Any natural or legal person who manufactures a construction product or who has such a product designed or manufactured and markets that product under his name or trademark. Original producers of structural bolting assemblies and holding down bolts are manufacturers.

Distributor Any natural or legal person in the supply chain, other than the manufacturer or the importer, who makes a construction product available on the market.

*Note: The terms “agent” and “trader” are also common usage in the steel supply chain, but these terms are not formally recognised under this specification.*

Inspection document Document issued by the manufacturer in which the manufacturer declares the products supplied are in compliance with the requirements of the order and/or relevant standard, and in which the manufacturer supplies supporting test results.

### 1.3 Referenced documents

The following documents and standards are referred to in this Model Specification.

- BS 3643-1:2007, *ISO metric screw threads — Part 1: Principles and basic data*, which gives a compilation of principles and basic data for single-start, parallel screw threads having the ISO basic profile for triangular screw threads.
- BS 3643-2:2007, *ISO metric screw threads — Part 2: Specification for selected limits of size*, which specifies the fundamental deviations, tolerances and limits of size for the tolerance classes 4H, 5H, 6H and 7H for internal threads (nuts) and 4h, 6g and 8g for external threads (bolts) for coarse pitch 1 mm to 68 mm diameter, fine pitch 1 mm to 33 mm diameter and constant pitch 8 mm to 300 mm diameter.
- BS 4320:1968, *Specification for metal washers for general engineering purposes — Metric series*, which relates to bright metal and black metal washers for use with ISO metric bolts, screws and nuts.
- BS 4933:2010, *Specification for ISO metric black cup and countersunk head bolts and screws with hexagon nuts*, which gives general dimensions and tolerances for cup head and countersunk head bolts and screws.
- BS 7371-1:2011, *Coatings on metal fasteners. Specification for general requirements and selection guidelines*, which gives requirements that are common to all other parts of BS 7371, including: preparation before coating, avoidance of hydrogen embrittlement, sampling, thickness testing, areas of parallel threaded fasteners, and selection of coatings.
- BS 7371-8:2011, *Coatings on metal fasteners. Specification for sherardized coatings*, which gives requirements for sherardized coatings on metal fasteners and accessories applied by thermal diffusion of zinc powder onto the component surface. It also specifies requirements for the local coating thickness for six grades of coating, possible types of post treatment, and assessment of corrosion resistance of unused coated parts when subjected to neutral salt spray testing.
- BS 7419:2012, *Specification for holding down bolts*, which gives general dimensions, tolerances (product grade C), materials and mechanical properties for use in connecting steel structures to their foundations and similar applications.
- BS EN 1090-2:2018, *Execution of steel structures and aluminium structures — Part 2: Technical requirements for steel structures*, which sets all the technical requirements that should be taken into account for the execution of structural steelwork.

- BS EN 14399-1:2015, *High-strength structural bolting assemblies for preloading — Part 1: General requirements*, which specifies the general requirements for the components of bolt/nut/washer(s) assemblies for high strength structural bolting, which are suitable for preloading, and for the assemblies themselves.
- BS EN 14399-2:2015, *High-strength structural bolting assemblies for preloading — Part 2: Suitability for preloading*, which details technical requirements for high-strength structural bolting assemblies, to ensure suitability for preloading. The standard test involves tightening the bolting assemblies and measuring the bolt force, relative rotation between the nut and bolt, the torque and bolt elongation.
- BS EN 14399-3:2015, *High-strength structural bolting assemblies for preloading — Part 3: System HR — Hexagon bolt and nut assemblies*, which looks at functional characteristics, designation and requirements for high-strength structural nut and bolt assemblies for preloaded joints with large widths across flats, thread sizes M12 to M36 and property classes 8.8/8 or 8.8/10, and 10.9/10.
- BS EN 14399-5:2015, *High-strength structural bolting assemblies for preloading — Part 5: Plain washers*, which specifies hardened and tempered plain washers intended for assembly with large series hexagon high-strength structural bolts and nuts with threads from M12 to M36 inclusive. Washers according to this standard can be applied under the nut only.
- BS EN 14399-6:2015, *High-strength structural bolting assemblies for preloading — Part 6: Plain chamfered washers*, which specifies requirements for hardened and tempered plain washers with chamfer intended for assembly with large series hexagon high-strength structural bolts and nuts with thread sizes from M12 to M36 inclusive. It also covers designation and marking requirements as well as providing details of reference standards.
- BS EN 14399-7:2018, *High-strength structural bolting assemblies for preloading — Part 7: System HR — Countersunk head bolt and nut assemblies*, which details functional characteristics, performance and suitability tests for high-strength structural countersunk bolts and nuts and associated washers of system HR suitable for preloaded joints with thread sizes M12 to M36 and property classes 8.8/8 or 8.8/10, and 10.9/10.
- BS EN 14399-9:2018, *High strength structural bolting assemblies for preloading — Part 9: System HR or HV — Direct tension indicators for bolt and nut assemblies*, which gives the requirements for assemblies of high-strength structural bolts and nuts, specifically those with large width across flats, of system HR or HV. It includes requirements for the general dimensions, tolerances, materials and performance for two grades, H8 and H10, of compressible washer-type direct tension indicators, nut face washers and bolt face washers suitable for preloaded joints.
- BS EN 14399-10:2018, *High-strength structural bolting assemblies for preloading — Part 10: System HRC — Bolt and nut assemblies with calibrated preload*, which gives the requirements for assemblies of high-strength structural bolts and nuts of system HRC suitable for preloaded joints, with hexagon head (large widths across flats) or cup head, thread sizes M12 to M36 and property class 10.9/10.
- BS EN 15048-1:2016, *Non-preloaded structural bolting assemblies — Part 1: General requirements*, which details general requirements for the components of bolt/nut/washer assemblies for non-preloaded structural bolting and for the assemblies themselves. The standard is applicable to carbon steel, alloy steel and stainless steel. It does not apply to separate bolts or nuts.

- BS EN 15048-2:2016, *Non-preloaded structural bolting assemblies — Part 2: Fitness for purpose*, which describes suitability tests for tensile resistance of bolt/nut/washer assemblies used in non-preloaded structural bolting.
- BS EN ISO 898-1:2013, *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*, which gives physical and mechanical properties for carbon steel and alloy steel bolts, screws and studs. It applies to triangular ISO metric screw thread, coarse pitch thread M1,6 to M39 and fine pitch thread M8×1 to M39×3.
- BS EN ISO 898-2:2022, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes — coarse thread and fine pitch thread*, which gives mechanical and physical properties of nuts with coarse thread and fine pitch thread made of carbon steel and alloy steel.
- BS EN ISO 4014:2022, *Hexagon head bolts — Product grades A and B*, which specifies the characteristics of hexagon head bolts with threads from M1,6 up to and including M64 of product grade A for threads M1,6 to M24 and nominal lengths up to and including 10*d* or 150 mm, and product grade B for threads over M24 or nominal lengths over 10*d* or 150 mm.
- BS EN ISO 4017:2022, *Fasteners — Hexagon head screws — Product grades A and B*, which specifies the characteristics of hexagon head screws with threads from M1,6 up to and including M64, of product grade A for threads M1,6 to M24 and nominal lengths up to and including 10*d* or 150 mm, whichever is the shorter, and product grade B for threads over M24 or nominal lengths over 10*d* or 150 mm, whichever is the shorter.
- BS EN ISO 4018:2022, *Hexagon head screws — Product grade C*, which specifies the characteristics of hexagon head screws with threads from M5 up to and including M64, of product grade C. This type of product is the same as that covered by BS EN ISO 4016 with the exception of threading up to head.
- BS EN ISO 4032:2023, *Hexagon regular nuts (style 1) — Product grades A and B*, which specifies the characteristics of hexagon regular nuts (style 1), with threads from M1,6 up to and including M64, with product grade A for threads  $D \leq M16$  and product grade B for threads  $D > M16$ .
- BS EN ISO 4033:2023, *Hexagon high nuts (style 2) — Product grades A and B*, which specifies the characteristics of hexagon high nuts (style 2), with threads from M5 up to and including M36, with product grade A for threads  $D \leq M16$  and product grade B for threads  $D > M16$ .
- BS EN ISO 4034:2012, *Hexagon regular nuts (style 1) — Product grade C*, which gives the characteristics and dimensions for threads from M5 up to and including M64 and product grade C.
- BS EN ISO 4759-1:2001, *Tolerances for fasteners — Part 1: Bolts, screws, studs and nuts — Product grades A, B and C*, which specifies a selection of tolerances for bolts, screws, studs and nuts with ISO metric threads and with product grades A, B and C and for tapping screws with product grade A. Note that the product grades refer to the size of the tolerances where grade A is the most precise and grade C is the least precise.
- BS EN ISO 7091:2000, *Plain washers — Normal series — Product grade C*, which specifies the characteristics of normal-series, product-grade-C plain washers in the 100 HV hardness class and of nominal sizes (nominal thread diameters) ranging from 1,6 mm to 64 mm inclusive.

- BS EN ISO 9001:2015, *Quality management systems — Requirements*, which specifies requirements for a quality management system when an organization (i) needs to demonstrate its ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements, and (ii) aims to enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements.
- BS EN ISO 10642:2019, *Fasteners — Hexagon socket countersunk head screws with reduced loadability*, which specifies the characteristics of hexagon socket countersunk head screws with reduced loadability due to head design, in steel and stainless steel, with metric coarse pitch threads M2 to M20.
- BS EN ISO 10684:2004, *Fasteners — Hot dip galvanized coatings*, which specifies material, process, dimensional and some performance requirements for hot dip spun galvanized coatings applied to coarse threaded steel fasteners from M8 up to and including M64 and for property classes up to and including 10.9 for bolts, screws and studs and 12 for nuts.
- BS ISO 965-5:1998, *ISO general purpose metric screw threads — Tolerances — Part 5: Limits of sizes for internal screw threads to mate with hot-dip galvanized external screw threads with maximum size of tolerance position h before galvanizing*, which specifies deviations and limits of sizes for pitch and crest diameters.
- BS EN ISO/IEC 17025:2017, *General requirements for the competence of testing and calibration laboratories*, which specifies the general requirements for the competence, impartiality, and consistent operation of laboratories.
- DIN 7991:1986, *Hexagon socket countersunk head cap screws*, which specifies hexagon socket countersunk head cap screws with ISO metric screw thread from size M3 up to and including M24.
- National Highways Sector Scheme for Quality Management in Highway Works 3, Stocking and distribution activities for mechanical fasteners, Sector Scheme Advisory Committee for Mechanical Fasteners (SSACMF), UKAS, 2020.
- National Structural Steelwork Specification for Buildings (7<sup>th</sup> edition), British Constructional Steelwork Association Ltd., 2020.
- Steel Bridge Group: Model project specification for the execution of steelwork in bridge structures, Steel Construction Institute, SCI Publication P382, 2012.

For dated references of Standards, only the edition cited applies, e.g. Clause x of BS EN 1090-2:2018. For undated references, the latest edition of the referred standard, including any amendments, applies, e.g. BS EN 1090-2.

## 2 General requirements

### 2.1 Colour coded system

All bolts that comply with the requirements in Tables 1 and 2 below shall be supplied with a colour coded system. The colour coding system shall identify the diameter of the bolt and the type of protective treatment used. Example colour coding systems for the bolt diameter shown on the bag

or drum and protective treatment shown on a label are given below. Manufacturers/suppliers may use alternative colour coding systems provided the system is agreed with the purchaser in advance; especially if bolts above M30 diameter are supplied. Other forms of packaging are allowed if agreed between parties.

<b>Bolt diameter</b>	<b>Type of protective treatment</b>
M12 = RED	Electroplating = BLUE
M16 = BLUE	Galvanized = ORANGE
M20 = YELLOW	Sherardized = PINK
M24 = GREEN	
M30 = BLACK	

## 2.2 Thread lengths

Thread lengths should be provided in accordance with the product specifications unless longer or non-standard thread lengths are agreed between the purchaser and the supplier at the time of order.

## 3 Technical specification

Bolts shall be supplied in accordance with the following tables or in the case of proprietary bolts in accordance with Sections 4 and 5.

Bolts complying with Tables 1 to 6 shall not be welded.

Bolts outside the scope of BS EN ISO 898-1 (e.g.  $d > 39$  mm) may also be supplied in accordance with this specification provided the requirements in Tables 2 and 3 of BS EN ISO 898-1:2013 are complied with. In such circumstances it is recommended that the requirements are discussed and agreed between the purchaser and supplier of the bolts prior to order.

Higher property class bolts must not be substituted for lower grade ones without the prior approval of the designer and the purchaser. The substitution of higher property class nuts is permitted.

*Note 1: Bolts supplied in accordance with Tables 3, 4, 5 and 6 are not in the scope of BS EN 15048-1:2016 and cannot be UK/CE marked. These bolts may still be used in steelwork executed to BS EN 1090-2 and the NSSS.*

**Table 1** Matching ordinary (non-preloaded) assemblies

Property Class	Bolt	Nut <sup>(1)</sup>	Washer
<b>Incorporating fully threaded length bolts</b>			
4.6	BS EN ISO 4018	BS EN ISO 4034 (Property Class 5) <sup>(3)</sup>	BS EN ISO 7091 (100 HV)
8.8	BS EN ISO 4017 <sup>(2)</sup>	BS EN ISO 4032 <sup>(2)</sup> (Property Class 8) <sup>(3)</sup>	BS EN ISO 7091 (100 HV)
10.9	BS EN ISO 4017 <sup>(2)</sup>	BS EN ISO 4032 <sup>(2)</sup> (Property Class 10) <sup>(3) (4)</sup>	BS EN ISO 7091 (100 HV)
<b>Incorporating part threaded length bolts</b>			
4.6	BS EN ISO 4016	BS EN ISO 4034 (Property Class 5) <sup>(3)</sup>	BS EN ISO 7091 (100 HV)
8.8	BS EN ISO 4014 <sup>(2)</sup>	BS EN ISO 4032 <sup>(2)</sup> (Property Class 8) <sup>(3)</sup>	BS EN ISO 7091 (100 HV)
10.9	BS EN ISO 4014 <sup>(2)</sup>	BS EN ISO 4032 <sup>(2)</sup> (Property Class 10) <sup>(3) (4)</sup>	BS EN ISO 7091 (100 HV)
<p>1. Nuts of a higher property class may also be used.</p> <p>2. Bolts of property classes 8.8 and 10.9 to BS EN ISO 4014 or BS EN ISO 4017 (dimensions and tolerances of BS EN ISO 4016 or BS EN ISO 4018) may also be used, with matching nuts of the same property classes to BS EN ISO 4032 (dimensions and tolerances of BS EN ISO 4034).</p> <p>3. Nuts for galvanized or sherardized bolts shall be tapped over-size to tolerance 6AZ to accommodate the thickness of galvanizing/sherardizing. This over-tapping reduces the strength of the nut and therefore a nut that has a proof load higher than the minimum ultimate tensile load of the assembly must be used. Nuts for galvanized or sherardized 4.6 bolts shall be property class 8; nuts for galvanized or sherardized 8.8 bolts shall be property class 10 and nuts for galvanized or sherardized 10.9 bolts shall be property class 12 to BS EN ISO 4033.</p> <p>4. The BS EN ISO 4033 nut standard does not include sizes M22, M27, M33 or sizes greater than M36; it is therefore not possible to supply assemblies in these diameters which comply with this Model Specification for property class 10.9 in the hot dip galvanized or sherardized condition.</p>			

**Table 2** Matching preloaded assemblies <sup>(1)(2)</sup>

	System HR		System HRC
	Hexagon bolt	Countersunk bolt	HRC bolt <sup>(3)</sup>
<b>Bolt/nut assembly</b>	BS EN 14399-3	BS EN 14399-7	BS EN 14399-10
Bolt marking	HR	HR	HRC
Nut marking	HR	HR	HR or HRD
Property class	8.8/8;8.8/10 or 10.9/10	8.8/8; 8.8/10 or 10.9/10	10.9/10
<b>Washers</b>	BS EN 14399-5 or BS EN 14399-6		
Washer marking	H		
DTI <sup>(4)</sup> , nut and bolt face washers	BS EN 14399-9		At user's discretion
DTI <sup>(4)</sup> marking	H8 or H10		
Nut face washer marking	HN		
Bolt face washer marking	HB	Not applicable	
<p>1. In terms of suitability for preloading, bolts shall meet the test requirements of BS EN 14399-2 and any additional testing specified in the product standard.</p> <p>2. Bolt lengths shall be selected to ensure that a minimum number of four full threads (in addition to the thread run-out) remain clear between the bearing surface of the nut and the unthreaded part of the shank.</p> <p>3. Commonly known as a “tension control bolt”. BS EN 14399-10 system HRC assemblies with calibrated preload depend on accurate control of the torque-tension characteristics to achieve the specified axial tensile loads as with other torque methods.</p> <p>4. DTI – direct tension indicator.</p>			



**Table 3** Holding down assemblies

<b>Property class</b>	<b>Bolt</b>	<b>Nut <sup>(1)</sup></b>	<b>Washer <sup>(4)</sup></b>
4.6	BS 7419	BS EN ISO 4032 <sup>(2)</sup> (Property Class 5) <sup>(3)</sup>	BS EN ISO 7091 (100 HV)
8.8	BS 7419	BS EN ISO 4032 <sup>(2)</sup> (Property Class 8) <sup>(3)</sup>	BS EN ISO 7091 (100 HV)

1. Nuts of a higher property class may also be used.
2. Nuts of property classes to BS EN ISO 4032 with dimensions and tolerances of BS EN ISO 4034 may also be used.
3. Nuts for galvanized or sherardized bolts shall be tapped over-size to tolerance 6AZ to accommodate the thickness of galvanizing/sherardizing. This over-tapping reduces the strength of the nut and therefore a nut that has a proof load higher than the minimum ultimate tensile load of the assembly must be used. Nuts for galvanized or sherardized 4.6 bolts shall be property class 8 and nuts for galvanized or sherardized 8.8 bolts shall be property class 10.
4. As an alternative, BS 4320 form G may be used.

**Table 4** Cup bolts and countersunk bolts in non-preloaded assemblies <sup>(1)</sup>

<b>Assemblies designed to transmit forces through tension, or combined shear and tension</b>			
<b>Property class</b>	<b>Bolt</b>	<b>Nut <sup>(2)</sup></b>	<b>Washer</b>
4.6 <sup>(5)</sup>	BS 4933	BS EN ISO 4032 <sup>(3)</sup> (Property Class 5) <sup>(4)</sup>	BS EN ISO 7091 (100 HV)
8.8 <sup>(5)</sup>	BS 4933	BS EN ISO 4032 <sup>(3)</sup> (Property Class 8) <sup>(4)</sup>	BS EN ISO 7091 (100 HV)
10.9	BS 4933	BS EN ISO 4032 <sup>(3)</sup> (Property Class 10) <sup>(4)</sup>	BS EN ISO 7091 (100 HV)
<b>Assemblies designed to transmit forces through shear only</b>			
<b>Property class</b>	<b>Bolt</b>	<b>Nut <sup>(2)</sup></b>	<b>Washer</b>
4.6 <sup>(5)</sup>	BS 4933 BS EN ISO 10642 DIN 7991	BS EN ISO 4032 <sup>(3)</sup> (Property Class 5) <sup>(4)</sup>	BS EN ISO 7091 (100 HV)
8.8 <sup>(5)</sup>	BS 4933 BS EN ISO 10642 DIN 7991	BS EN ISO 4032 <sup>(3)</sup> (Property Class 8) <sup>(4)</sup>	BS EN ISO 7091 (100 HV)
10.9	BS 4933 BS EN ISO 10642 DIN 7991	BS EN ISO 4032 <sup>(3)</sup> (Property Class 10) <sup>(4)</sup>	BS EN ISO 7091 (100 HV)
<ol style="list-style-type: none"> <li>1. Countersunk bolts subject to tensile loads, e.g., direct tension or prying, should only be supplied with a screwdriver slot head unless the alternative can be demonstrated to not adversely affect the bolt loadability to BS EN ISO 898-1 or BS EN 15048- 2, see also 8.2.</li> <li>2. Nuts of a higher property class may also be used.</li> <li>3. Nuts of property classes to BS EN ISO 4032 with dimensions and tolerances of BS EN ISO 4034 may also be used.</li> <li>4. Nuts for galvanized or sherardized bolts shall be tapped over-size to tolerance 6 AZ to accommodate the thickness of galvanizing/sherardizing. This over-tapping reduces the strength of the nut and therefore a nut that has a proof load higher than the minimum ultimate tensile load of the assembly must be used. Nuts for galvanized or sherardized 4.6 bolts shall be property class 8 and nuts for galvanized or sherardized 8.8 bolts shall be property class 10.</li> <li>5. The availability of countersunk bolts property class 4.6 and 8.8 is limited and therefore the use of property class 10.9 should be considered prior to specification.</li> </ol>			

**Table 5** Ordinary tie bar assemblies <sup>(1)</sup>

Element / Parameter		Conformance criteria
Thread	Tolerance Class	6g or 8g <sup>(2)</sup>
	Standards	BS 3643-1 and BS 3643-2
Mechanical properties	Property Classes	$d \leq 39\text{mm}$ : 4.6, 8.8, 10.9
	Standard	BS EN ISO 898-1
Tolerance	Product grade	C <sup>(3)</sup>
	Standard	BS EN ISO 4759-1
Associated nuts	Standards	BS EN ISO 4032, BS EN ISO 4034 and BS EN ISO 4033 <sup>(4)</sup>
	Property Classes	5, 8, 10, 12 <sup>(4)</sup>
	Standard	BS EN ISO 898-2
	Thread Tolerance	6H, 7H or 6AZ
	Standards	BS 3643-2 or BS ISO 965-5
Associated washers (if required)	Standards	BS EN ISO 7091
	<i>Others</i>	<i>To be agreed</i> <sup>(5)</sup>
Suitability test	Standard	BS EN 15048-2
<p>1. These ordinary tie-bar assemblies are threaded bars supplied with nuts and, if required, washers and are suitable for non-preloaded applications.</p> <p>2. The tolerance class is at the option of the manufacturer, dependant on the manufacturing method, and applies before hot dip galvanizing or coating with any thick protective coating.</p> <p>3. Other product grades may be supplied by agreement between the purchaser and the supplier.</p> <p>4. Recommended bolt and nut combinations are shown in Table 6.</p> <p>5. Other washers may be supplied by agreement between the purchaser and the supplier.</p>		

**Table 6** Matching ordinary tie bar assemblies

Property Class Tie Bar	Nut <sup>(1)</sup>	Washer (if required)
4.6	BS EN ISO 4032 <sup>(2)</sup> (Property Class 5) <sup>(3)</sup>	BS EN ISO 7091 <sup>(5)</sup> (100 HV)
8.8	BS EN ISO 4032 <sup>(2)</sup> (Property Class 8) <sup>(3)</sup>	BS EN ISO 7091 <sup>(5)</sup> (100 HV)
10.9	BS EN ISO 4032 <sup>(2)</sup> (Property Class 10) <sup>(3) (4)</sup>	BS EN ISO 7091 <sup>(5)</sup> (100 HV)

1. Nuts of a higher property class may also be used.

2. Nuts of property classes to BS EN ISO 4032 with the dimensions and tolerances of BS EN ISO 4034 may also be used.

3. Nuts for galvanized or sherardized tie bars shall be tapped over-size to tolerance 6AZ to accommodate the thickness of galvanizing/sherardizing. This over-tapping reduces the strength of the nut and therefore a nut that has a proof load higher than the minimum ultimate tensile load of the assembly must be used. Nuts for galvanized or sherardized 4.6 tie bars shall be property class 8; nuts for galvanized or sherardized 8.8 tie bars shall be property class 10 and nuts for galvanized or sherardized 10.9 tie bars shall be property class 12 to BS EN ISO 4033.

4. The BS EN ISO 4033 nut standard does not include sizes M22, M27, M33 or sizes greater than M36; it is therefore not possible to supply assemblies in these diameters which comply with this Model Specification for property class 10.9 in the hot dip galvanized or sherardized condition.

5. Other washers may be supplied by agreement between the purchaser and supplier.

Where required, bolts shall be provided with protective coatings, complying with the appropriate standards from Table 7.

**Table 7** Protective coatings

Galvanizing	BS EN ISO 10684
Zinc Electroplating	BS EN ISO 4042
Sherardizing	BS 7371-8

*Note 2: Attention is drawn to the risk of hydrogen embrittlement during electroplating or hot dip galvanizing of 10.9 bolts. Further guidance is given in Section 9 of this Model Specification.*

## 4 Proprietary products

All proprietary items shall be used in accordance with the manufacturer's recommendations and instructions if relevant.

## 5 UK/CE marking

All bolt assemblies manufactured to designated/harmonised BS EN standards shall be supplied complete with UK/CE marking as follows and a UK Declaration of Conformity (DoC)/Declaration of Performance (DoP) shall be available (the UK DoC/DoP can be available on a website). The relevant designated/harmonised standards are:

- Ordinary (non-preloaded) assemblies to BS EN 15048-1:2007.
- Preloaded assemblies to BS EN 14399-1:2015.

*Note 1: Only bolt assemblies consisting of (i) bolts and nuts as stipulated in BS EN 15048-1, and (ii) bolts, nuts and washers as required by BS EN 14399-1 may be UK/CE marked to these designated/harmonised standards and hence are supplied from one manufacturer as sets.*

*Note 2: BS EN 15048-1:2007 is the current designated/harmonised standard as the 2016 edition is yet to be cited in the consolidated list for designated standards for construction products: <https://www.gov.uk/government/publications/designated-standards-construction-products> and the Official Journal of the European Union.*

Bolts supplied as proprietary items shall be UK/CE marked as being in accordance with a European Technical Approval — or UK equivalent — or be treated as special bolts to BS EN 1090-2. Special bolts shall only be used if the manufacturer publishes suitable product information in the form of a component specification and provides a declaration of conformity that the bolts have been supplied in accordance with the component specification.

*Note 3: A common example of a special bolt to BS EN 1090-2 would be “shoulder-bolts” used in expansion joints. Bolts manufactured from structural steel intended to be welded would also be an example of a special bolt to BS EN 1090-2. Washer plates are steelwork complying to the requirements of BS EN 1090-2 and not covered by this Model Specification.*

## 6 Inspection documents

All bolts shall be supplied with an inspection certificate 3.1 “type 3.1” from the manufacturer/supplier to BS EN 10204 verifying compliance with this Model Specification. The coating or surface finish shall be included in the inspection certificate 3.1.

The manufacturer’s inspection certificate, and the supplier’s inspection certificate — which is traceable to the manufacturer’s inspection certificate — must be retained by the supplier for a period of not less than 10 years and shall be made available on request.

When agreed with the purchaser, the supplier may provide a certificate of conformity created by the supplier that references the original manufacturer’s conformity documents. The original manufacturer’s conformity documents shall be retained by the supplier and the supplier’s certificate of conformity shall be traceable to the manufacturer’s original conformity documents.

## 7 Service temperature

Bolts conforming to the requirements of BS EN ISO 898-1 are used in applications ranging from  $-50^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ . The purchaser shall consult an experienced bolt metallurgist for temperatures outside this range. The purchaser shall also consult an experienced bolt metallurgist for bolts with a diameter greater than M39 for use at low service temperatures.

If bolts are intended for use at a service temperature below  $-50^{\circ}\text{C}$ , the purchase order shall specify the temperature at or below which the bolts have a minimum impact strength of 27J according to BS EN ISO 898-1.

The impact test for machined test pieces to Clause 9.14 of BS EN ISO 898-1:2013 shall also be carried out per manufacturing lot.

## 8 Quality management

### 8.1 BS EN ISO 9001 and National Highways Sector Scheme 3 (NHSS3)

Manufacturers, importers, suppliers, and distributors of structural bolts shall be BS EN ISO 9001 certified by a certification body accredited by UKAS or equivalent European accreditation organisation which is party to a multi-lateral agreement (MLA) with UKAS. For projects in the UK, manufacturers, importers, suppliers, and distributors of structural bolts shall comply with National Highways Sector Scheme 3 (NHSS3), which applies to all structures, not just highway structures. For projects outside the UK, it is recommended that the NHSS3 is adopted by all suppliers and distributors of structural bolts.

The manufacturer, importer, supplier, or distributor shall have a system of receipt and despatch in place to ensure continued traceability from manufacture to despatch of the structural bolting assemblies and holding down bolts to the client.

### 8.2 Inspection, testing and product requirements

For all bolts supplied under this Model Specification, manufacturers' test reports must be provided for each manufacturing lot of bolts.

*Note: A manufacturing lot is described in BS EN ISO 1891-4 as a quantity of bolts of a single designation including product grade, property class, type and size, manufactured from bar, wire, rod or flat product from a single cast, processed through the same steps at the same time or over a continuous time period, including the same heat treatment cycle and/or surface treatment, if any.*

*“Same heat treatment cycle or surface treatment” means:*

- o for a continuous process, the same treatment cycle without any setting modification,*
- or*

- *for a discontinuous process, the same treatment cycle for identical consecutive loads (manufacturing batches).*

For bolts manufactured and tested outside of the UK/EU, each manufacturing lot of product shall be subjected to sample inspection and mechanical testing at the point of entry into the UK market place (or EU market place) and shall be organized by the manufacturer, importer, supplier, or distributor in accordance with Sections 8.2.1 or 8.2.2. These test reports shall include the actual results of the tests specified in these sections.

#### Non-preloaded and preloaded bolt assemblies

For all bolting assemblies the following tests shall be undertaken and the results given in the test report:

- Visual and dimensional inspection in accordance with the relevant product standard.
- Tensile test under wedge loading to determine the tensile strength  $R_m$  (property no. 1 in Table 3 of BS EN ISO 898-1:2013). This test also allows to determine the integrity of the transition section between the head and the unthreaded shank or the thread.
- Hardness test to determine the hardness of the bolt, which can be determined using the Vickers (HV), Brinell (HBW), or Rockwell (HR) tests (properties no. 10, 11, and 12 in Table 3 of BS EN ISO 898-1:2013, respectively).
- Carburisation test to determine the surface hardness (property no. 13 in Table 3 of BS EN ISO 898-1:2013). Carburisation is detected by (i) hardness test on a longitudinal section, or (ii) surface hardness test. Clause 9.11.1 of BS EN ISO 898-1:2013 stipulates that when the pitch of thread  $P$  is greater than or equal to 1.25 mm, the hardness test on a longitudinal section is the reference method. For threads rolled after heat treatment, carburisation tests should be carried out by a Vickers micro-hardness test on a transverse section through the shank, with readings taken close to the actual surface, see Fig. 1 and the note to Clause 9.11.1 of BS EN ISO 898-1:2013.
- Impact test in accordance with Clause 9.14 of BS EN ISO 898-1:2013.
- Suitability test in accordance with BS EN 14399-2 or BS EN 15048-2.

The retempering test and torsional test are only carried out as an alternative test for given properties when agreed between parties, see Clauses 9.12 and 9.13 of BS EN ISO 898-1:2013, respectively.

#### Cup bolts and countersunk bolts in non-preloaded assemblies

The test requirements given above also apply to cup bolts and countersunk bolts both supplied in accordance with Table 4. However, those bolts supplied with an internal head fastening detail, other than a screwdriver slot, (e.g. Allen Key socket) are unlikely to be capable of satisfying the tensile and suitability tests due to the reduced section at the head to shank location. These bolt types are not preferred and should only be specified for use in connections where they are subject to tension loads where they can be demonstrated to provide full loadability by satisfying the requirements of Tables 8-11 of BS EN ISO 898-1:2013 and BS EN 15048-2, as applicable.

Tension may arise from tensile or prying forces in the connection or as a result of bending at the head due to shear load applied to the shank. Where the designer deems the use of bolts without full loadability to be acceptable, this must be stated by the purchaser at the time of order. In this case, manufacturers' tests should be in accordance with Table 10 of BS EN ISO 898-1:2013 with

the exception of tensile tests which may be carried out on a machined test piece, produced from a finished bolt, and performed in accordance with Table 12 and Clause 9.7 of BS EN ISO 898-1:2013. All bolts >M39 must be fully loadable in tension to the requirements of Tables 8-11 of BS EN ISO 898-1:2013, as applicable.

### **8.2.1 Bolts of property class 4.6 in all diameters, and property class 8.8 and 10.9 up to M39**

Sample inspection and testing shall be completed in accordance with Table 8. The organisation/laboratory conducting the inspection and testing must as a minimum be part of a BS EN ISO 9001 certified management system.

### **8.2.2 Bolts with a diameter greater than M39 of property class 8.8 and 10.9 only**

Bolts shall be produced from steel in accordance with Table 2 of BS EN ISO 898-1:2013 with the following restrictions:

- The as cast (mill certificate) percentage content of both phosphorous and sulphur shall be less than or equal to 0.015%.

Mechanical testing shall be completed by a BS EN ISO/IEC 17025 accredited laboratory within the UK/EU market in accordance with Table 9, all mechanical testing shall be conducted prior to any surface coating being applied. Visual and dimensional inspection need not be conducted at an BS EN ISO/IEC 17025 accredited laboratory.



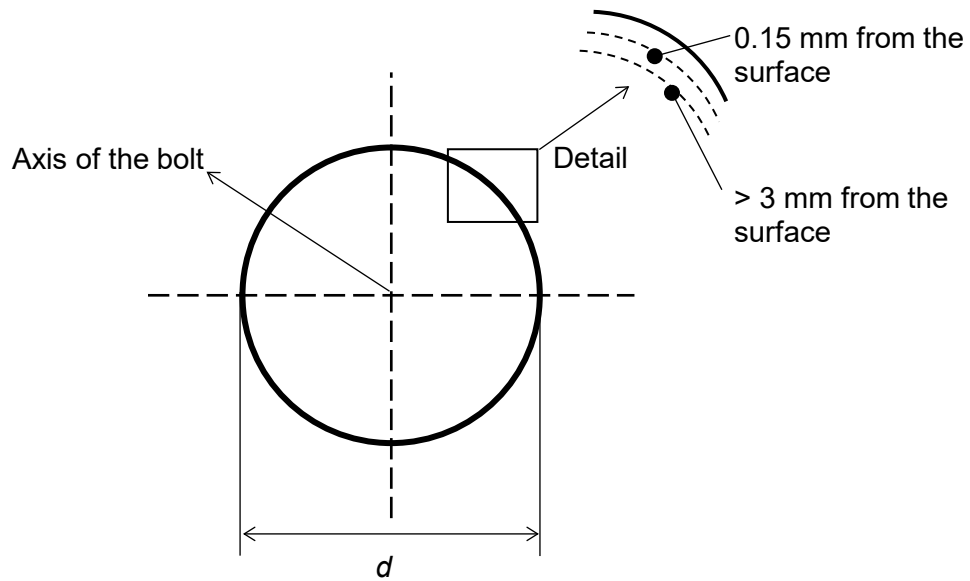
**Table 8** Inspection and testing requirements for bolts of property class 4.6 in all diameters and property class 8.8 and 10.9 up to M39

Property (see Table 3 of BS EN ISO 898-1:2013) No.		Test method	Reference	Sample size	
				≤ 8.8	10.9
—	—	Visual and dimensional inspection	BS EN 14399 or BS EN 15048	3	5
1	Tensile strength, $R_m$	Tensile test under wedge loading <sup>(1)</sup>	Clause 9.1 of BS EN ISO 898-1:2013	3	5
10 11 12	Core hardness	Hardness test <sup>(2)</sup>	Clause 9.9 of BS EN ISO 898-1:2013 <sup>(3)</sup>	3	5
13	Surface hardness (HV 0.3)	Carburisation test <sup>(2) (4)</sup>	Generally, Clause 9.11.2 of BS EN ISO 898-1:2013; For threads rolled after heat treatment, Vickers micro-hardness test on a transverse section through the shank with readings in accordance with Fig. 1	—	5
18	Impact strength, $K_v$	Impact test for machined test pieces	Clause 9.14 of BS EN ISO 898-1:2013	3	5
—	—	Suitability test <sup>(5)</sup>	BS EN 14399-2 or BS EN 15048-2	3	5
<p>1. Bolts not required to provide full loadability due to head fastening details, see 8.2, do not require these tests but alternatively should be subjected to tensile tests on a machined sample as described in 8.2 using the same sample quantities noted in the table above.</p> <p>2. Bolts which have a length of more than 390 mm shall be tested at both ends of the bolt.</p> <p>3. Test method a) <i>Vickers hardness test</i> in sub-clause 9.9.3 is the preferred method.</p> <p>4. If a reading is high (i.e., &gt;390 HV – hard spot) then 2 further readings may be taken, on the same test sample, adjacent to the first reading. If both additional readings meet the acceptance criteria, then the bolt may be accepted provided all other tests are within specification.</p> <p>5. Only conducted on assemblies.</p>					

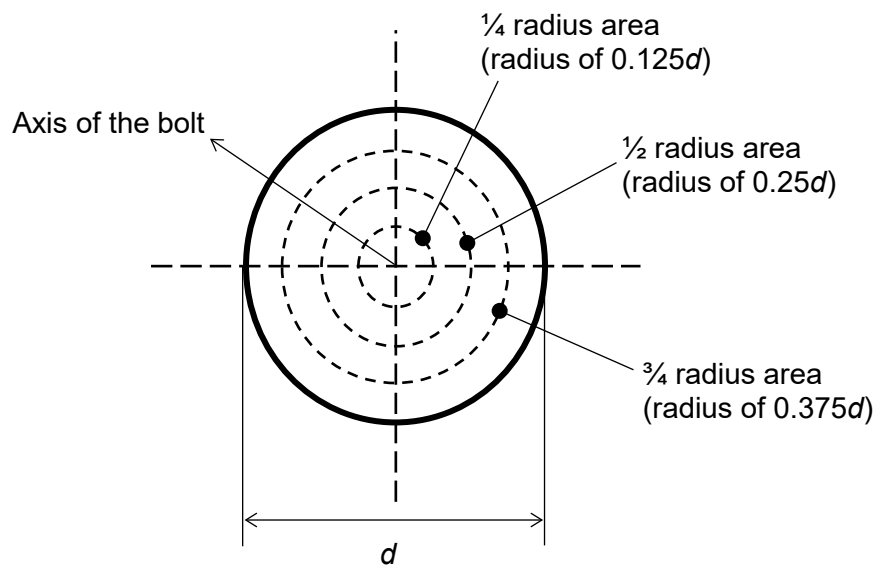
**Table 9** Inspection and testing requirements for bolts with a diameter greater than M39 of property class 8.8 and 10.9 only

Property (see Table 3 of BS EN ISO 898-1:2013)		Test method	Reference	Sample size
No.				
—	—	Visual and dimensional inspection	BS EN 14399 or BS EN 15048	3
1	Tensile strength, $R_m$	Tensile test for machined test pieces	Clause 9.7 of BS EN ISO 898-1:2013	1
3	Stress at 0.2% non-proportional elongation $R_{p0.2}$			
6	Percentage elongation after fracture, $A$			
7	Percentage reduction of area after fracture, $Z$			
10	Core hardness (HV 98)	Hardness test <sup>(1)</sup>	Clause 9.9.4.2 of BS EN ISO 898-1:2013, but hardness readings shall be performed in the following areas (see Fig. 2): (i) between the axis and the ¼-radius position; (ii) between the axis and the ½-radius position; (iii) between the axis and the ¾-radius position.	1
13	Surface hardness (HV 0.3)	Carburisation test <sup>(1) (2)</sup>	Generally, Clause 9.11.2 of BS EN ISO 898-1:2013; For threads rolled after heat treatment, Vickers micro-hardness test on a transverse section through the shank with readings in accordance with Fig. 1	1
18	Impact strength, $K_v$	Impact test for machined test pieces	Clause 9.14 of BS EN ISO 898-1:2013	1
—	—	Suitability test <sup>(3)</sup>	BS EN 14399-2 or BS EN 15048-2 <sup>(4)</sup>	<i>If required</i>

1. Bolts which have a length of more than 390 mm shall be tested at both ends of the bolt.
2. If a reading is high (i.e., >390 HV – hard spot) then 2 further readings may be taken, on the same test sample, adjacent to the first reading. If both additional readings meet the acceptance criteria, then the bolt may be accepted provided all other tests are within specification.
3. Only conducted on assemblies.
4. These standards do not apply to bolts with a diameter greater than M39, and therefore the suitability test is not mandatory. Suitability tests on assemblies with bolts with a diameter greater than M39 are not easily carried out given the limited availability of test equipment. Therefore, this test will only be carried out if specified by the client.



**Fig. 1.** Vickers hardness positions for HV 0.3 on a cross section of the shank



**Fig. 2.** Areas for Vickers hardness determination, minimum test load of 98 N (HV 98 N)

## 9 Hydrogen embrittlement in structural bolts

### 9.1 General

Hydrogen embrittlement occurs when a process used in the production of structural bolts or from environmental corrosion generates nascent hydrogen that can be absorbed into the steel of the bolts. The effect of the absorbed hydrogen becomes more critical with the increasing tensile strength of the bolt steel; property class 8.8 is considered to be the highest strength level that does not require special precautions during surface coating treatments.

Methods such as low temperature “baking” can be used to reduce the possibility of hydrogen embrittlement with higher strength bolts such as property class 10.9. However, Annex B of BS 7371-1:2009 includes the following warning:

*Most electrolytic and acidic processes are liable to produce hydrogen and, though baking after coating will minimize the risk of failure, the process can never be guaranteed to be completely effective.*

There is no known test procedure which can satisfactorily guarantee that the heat treatment (baking) process has successfully eliminated all traces of hydrogen embrittlement from all parts of a processed batch. If the risk of failure is unacceptable, cleaning and coating specifications which do not involve electrolysis from aqueous solutions should be used.

Annex B of BS 7371-1:2009 — *Avoidance of hydrogen embrittlement* gives additional information.

## 9.2 Protective coatings

Neither the galvanizing process nor the process of applying a coating by the thermal diffusion of zinc powder e.g. sherardizing generates nascent hydrogen during the coating process.

However, if prior to coating the pre-cleaning method uses acid (such as pickling) or any other method that generates nascent hydrogen there is a risk of hydrogen embrittlement. With property class 10.9 bolts acid cleaning is not permitted and other cleaning methods shall be used, such as shot blasting.

Electroplated property class 10.9 bolts in preloaded assemblies shall not be used.

Cleaning of property class 10.9 bolts in preloaded assemblies prior to hot dip galvanising shall be by blast cleaning and not by pickling.

## 10 Documentation requirements

The supplier shall make the following data records available:

- Suitability test results for bolting assemblies, in accordance with BS EN 14399-2 or BS EN 15048-2;
- Test results for all properties in Tables 8 and 9, as appropriate, for bolts manufactured outside of the UK or EU.

## 11 References

The supplier and the purchaser shall have access to up-to-date copies of all the relevant standards referred to in this Model Specification.

## 12 Undertaking

I/we the undersigned agree to supply steel products in accordance with this specification and any variation from this agreement will be agrees in writing.

**On behalf of supplier:**

**On behalf of purchaser:**

Company: \_\_\_\_\_

Company: \_\_\_\_\_

Signed: \_\_\_\_\_

Signed: \_\_\_\_\_

Print: \_\_\_\_\_

Print: \_\_\_\_\_

Date:

Date: