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**Fasteners — Mechanical properties  
of fasteners made of carbon steel and  
alloy steel —**

**Part 2:  
Nuts with specified property classes**

*Fixations — Caractéristiques mécaniques des fixations en acier au  
carbone et en acier allié —*

*Partie 2: Écrous de classes de qualité spécifiées*





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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 2, *Fasteners*, Subcommittee SC 12, *Fasteners with metric internal thread*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 185, *Fasteners*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 898-2:2012) which has been technically revised.

The main changes are as follows:

- property class 9 has been deleted completely, and nuts with fine pitch thread and property class 5 have been deleted (see Introduction);
- nuts with fine pitch thread in style 2 and property class 12 have been added for diameters 18 mm to 39 mm (see [Tables 4, 6](#) and [10](#));
- styles have been more precisely specified for standard hexagon nuts according to their minimum height, and styles have been specified for other nuts according to their minimum design thread height (see [5.1](#));
- additional statements for thin nuts and jam nuts have been added (see [Clause 6](#));
- additional statements for hot dip galvanized nuts have been added by referencing ISO 10684;
- in relation to material, heat treatment and steel microstructure (see [Clause 7](#)):
  - the minimum carbon content has been added (see [Tables 3](#) and [4](#)),
  - the minimum manganese content has been specified to 0,25 % for all Non-Quenched and Tempered nuts (NQT) and has been raised to 0,45 % for all Quenched and Tempered nuts (QT) (see [Tables 3](#) and [4](#)),
  - the table footnote for free cutting steel has been reworked (see [Tables 3](#) and [4](#)),

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- the minimum tempering temperature has been added for QT nuts (see [Tables 3](#) and [4](#)), and a reference retempering test has been added (see [10.4](#)),
- for nuts that may optionally be quenched and tempered at the manufacturer's discretion, detailed specifications have been added (see [7.2](#)),
- specifications for steel microstructure have been added for NQT and QT nuts (see [7.4.1](#), [7.4.2](#) and [10.3](#));
- in relation to proof load:
  - the proof load values for nuts with coarse pitch thread and property classes 6 and 8 have been raised for sizes M27 to M39 (see Introduction, [Table 5](#), and [Annex C](#)),
  - the maximum hole diameter for the grip has been corrected for diameters 5 mm and 6 mm (see [Table 11](#)), and reference to additional proof load specifications has been added for prevailing torque nuts (see [10.1](#));
- in relation to hardness:
  - the reference Vickers hardness values have been recalculated, and conversion into Brinell and Rockwell hardness has been adjusted (see Introduction and [8.3](#)),
  - hardness determined on the bearing surface (see [10.2.4 a](#)) and hardness determined in the transverse section at mid-height of the nut (see [10.2.4 b](#)) have been added for routine inspection,
  - the test method for hardness determined in the thread has been improved and the test force has been specified according to the pitch dimension (see [10.2.5](#)),
  - for QT nuts, the test methods for hardness in the core (see [10.2.6](#)) and uniformity of hardness (see [10.2.7](#)) have been added,
  - requirements for hardness have been clarified (see [10.2.8](#) and [10.2.9](#));
- inspection documents have been referenced in accordance with ISO 16228 for fasteners (see [9.4](#));
- marking and labelling have been revised, and all nuts conforming to this document are to be marked whatever their shape (see [Clause 11](#));
- [Annex B](#), *Design principles for nuts*, has been improved;
- [Annex C](#), *Nominal stress under proof load*, has been added.

A list of all parts in the ISO 898 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

ISO 898, the basic standard for fasteners with ISO metric thread made of carbon steel and alloy steel, was developed in several parts, and includes diameters 5 mm to 39 mm only for nuts. Property classes are specified in the ISO 898 series in relation to materials and mechanical properties, so that nuts in accordance with ISO 898-2 are matching with bolts, screws and studs specified in ISO 898-1 and with flat washers specified in ISO 898-3, as necessary, in order to design suitable assemblies for a given application.

More parts are under development for bolts, screws, studs and nuts with sizes above 39 mm.

The nuts specified in this document result from the adequate combination of nut heights (regular, style 1 – high, style 2 – thin, style 0), diameter ranges, coarse or fine pitch thread, and property classes in relation to heat treatment (Non-Quenched and Tempered = NQT, or Quenched and Tempered = QT). These combinations are based on bolt/nut compatibility, manufacturing processes and market needs. If other combinations are needed, e.g. for nuts designed for particular applications, see ISO/TR 16224.

In order to assure the necessary material strength in relation to property classes:

- Quenched and Tempered nuts (QT) are specified with a minimum carbon content and a minimum tempering temperature, and are characterized by a homogeneous martensitic structure;
- Non-Quenched and Tempered nuts (NQT) are also specified with a minimum carbon content but are characterized by a non-quenched microstructure.

Some property classes (in relation to nut style, diameter and coarse or fine pitch thread) specified as NQT may be optionally quenched and tempered as specified in [7.2](#), and in this case all requirements for QT nuts apply.

For fully loadable non-standard nuts which are to meet the requirements of this document, the relevant style 1 or style 2 is assigned in relation to their minimum design thread height.

Nut loadability is primarily checked by proof load. For nuts with coarse pitch thread and property classes 6 and 8, proof load values have been raised for sizes M27 to M39 due to the latest calculations of Masaya Hagiwara<sup>[20]</sup> in accordance with the Alexander's theory<sup>[21]</sup>, see ISO/TR 16224. For those nuts it was necessary to develop full strength in relation to the mating bolts, screws and studs specified in ISO 898-1, the difference between the proof loads of ISO 898-2:2012 and the recalculated values being more than 5 % (see [Annex C](#)).

The Vickers hardness values specified for each individual group (consisting of property class, style, diameter range and pitch) have been chosen according to the same latest calculations, but adjusted to conventional figures taken over from the former versions of Parts 2 and 6 which were merged in 2012.

ISO 18265 presents no hardness to tensile strength correlation for steel in work hardened condition, which is typical for cold forged high volume NQT nuts: therefore, minimum hardness is just informative for NQT nuts and does not constitute a criterion in case of dispute. The maximum hardness of 334 HV is specified in order to prevent unexpected manufacturing processes which can lead to brittle behaviour of the NQT nuts: this limit is therefore mandatory and valid in case of dispute. However, it should be noted that work hardening is usually not severe enough to reach 302 HV when typical material and forging processes are used; nevertheless, inappropriate hardness testing or scattering due to just local properties is also covered by this specified limit of 334 HV.

Due to missing or decreasing market needs, nuts of property class 5 with fine pitch thread in style 1 and nuts of property class 9 were deleted (property class 5 or 9 can be substituted by property class 6 or 10 respectively).





# Fasteners — Mechanical properties of fasteners made of carbon steel and alloy steel —

## Part 2: Nuts with specified property classes

### 1 Scope

This document specifies the mechanical and physical properties of nuts made of non-alloy steel or alloy steel, when tested at the ambient temperature range of 10 °C to 35 °C.

This document applies to nuts:

- with ISO metric thread (see ISO 68-1),
- with diameter/pitch combinations according to ISO 261 and ISO 262,
- with coarse pitch thread M5 to M39, and fine pitch thread M8×1 to M39×3,
- with thread tolerances according to ISO 965-1, ISO 965-2 or ISO 965-5,
- with specified property classes 04, 05, 5, 6, 8, 10 and 12 including proof load,
- of three different nut styles (see 5.1): regular nuts (style 1), high nuts (style 2) and thin nuts (style 0),
- with a minimum outside diameter or width across flats  $s \geq 1,45D$ ,
- able to mate with bolts, screws and studs with property classes in accordance with ISO 898-1 (see Annex B), and
- intended to be used in applications ranging from -50 °C to +150 °C, or up to +300 °C.

**WARNING — Nuts conforming to the requirements of this document are tested at the ambient temperature range of 10 °C to 35 °C and are used in applications ranging from -50 °C to +150 °C; however, these nuts are also used outside this range and up to +300 °C for specific applications. It is possible that they do not retain the specified mechanical and physical properties at lower and/or elevated temperatures. Therefore, it is the responsibility of the user to determine the appropriate choices based on the service environment conditions of the assembly (see also 7.1).**

For additional specifications applicable to hot dip galvanized nuts, see ISO 10684.

For nuts designed for particular applications, see ISO/TR 16224.

This document does not specify requirements for functional properties such as:

- prevailing torque properties (see ISO 2320),
- torque/clamp force properties (see ISO 16047 for test method),
- weldability, or
- corrosion resistance.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1891-4, *Fasteners — Vocabulary — Part 4: Control, inspection, delivery, acceptance and quality*

ISO 2320, *Fasteners — Prevailing torque steel nuts — Functional properties*

ISO 6157-2, *Fasteners — Surface discontinuities — Part 2: Nuts*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 10684, *Fasteners — Hot dip galvanized coatings*

ISO 16228, *Fasteners — Types of inspection documents*

## 3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

## 4 Symbols

$D$	nominal thread diameter of the nut (basic major diameter of the internal thread), mm
$d_h$	hole diameter of the grip, mm
$F$	force, N
$F_p$	proof load, N
$h$	thickness of the grip, mm
$m$	height of the nut, mm
$m_{th,design}$	design thread height of the nut, mm
$P$	pitch of the thread, mm
$s$	width across flats, mm
$S_p$	stress under proof load, MPa

## 5 Designation systems

### 5.1 Nut styles

This document specifies three styles for nuts.

For standard hexagon nuts without flange and without prevailing torque feature, the following limits apply:

- style 1: regular nut with minimum height  $0,80D \leq m_{\min} < 0,89D$ , see [Table B.1](#);
- style 2: high nut with minimum height  $m_{\min} \geq 0,89D$ , see [Table B.1](#);
- style 0: thin nut with minimum height  $0,45D \leq m_{\min} < 0,80D$ .

For other standard nuts (e.g. nuts with flange, prevailing torque nuts, non-hexagon nuts, etc.), the style shall be addressed in the product standard together with the mechanical properties.

For nuts per drawing, the style shall be addressed in accordance with the minimum design thread height,  $m_{\text{th,design}}$ , together with the mechanical properties.  $m_{\text{th,design}}$  is specified in [Figure 1](#) and [Table 1](#).  $m_{\text{th,design}}$  is the distance between the intersections of the nut chamfer(s) if any or the nut face(s), with the theoretical cylinder representing the nominal thread diameter  $D$ .

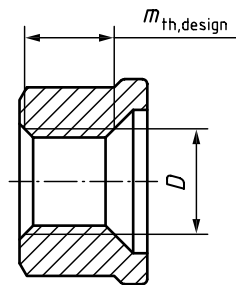


Figure 1 — Design thread height,  $m_{\text{th,design}}$

Table 1 — Design thread height for nuts per drawing

Regular nuts (style 1)	High nuts (style 2)	Thin nuts (style 0)
$0,73D \leq m_{\text{th,design,min}} < 0,83D$	$m_{\text{th,design,min}} \geq 0,83D$	$0,40D \leq m_{\text{th,design,min}} < 0,73D$
NOTE 1 Limits for $m_{\text{th,design,min}}$ are calculated by taking into account the most critical dimensions for the nuts, i.e. minimum height $m_{\min}$ , maximum diameter of the countersink $d_{a,\max}$ , minimum countersink angle for the chamfer ( $90^\circ$ for regular and high nuts, $110^\circ$ for thin nuts) and two chamfers (one on each bearing face).		
NOTE 2 The resulting minimum ratios for standard hexagon nuts with diameters 12 mm to 39 mm are the basis for the figures specified in this Table.		

### 5.2 Property classes

#### 5.2.1 Regular nuts (style 1) and high nuts (style 2)

The property classes of regular nuts (style 1) and high nuts (style 2) consist of a number. This number corresponds to the left number of the appropriate highest property class of bolts, screws and studs with which they can be mated, which is 1/100 of the nominal tensile strength of the mating bolt in megapascals.

EXAMPLE Nut with property class 10 is a regular or high nut to be mated with a bolt of property class up to 10.9 included.

### 5.2.2 Thin nuts (style 0)

The property classes of thin nuts (style 0) consist of two digits, specified in the following way:

- a) the first digit "zero" indicates the reduced loadability of thin nuts, in order to warn that these nuts are not designed to prevent thread stripping failure mode in case of overloading;
- b) the second digit corresponds to approximately 1/100 of the nominal stress under proof load,  $S_p$ , in megapascals (MPa).

EXAMPLE Nut with property class 05 is a thin nut with a nominal stress under proof load of 500 MPa.

## 6 Design of bolt and nut assemblies

Explanations of basic design principles of nuts and loadability of bolted assemblies are given in [Annex B](#). Information for nominal stress under proof load  $S_p$  is given in [Annex C](#).

Regular nuts (style 1) and high nuts (style 2) shall be mated with externally threaded fasteners in accordance with [Table 2](#). However, nuts of a higher property class may replace nuts of a lower property class, except for prevailing torque nuts where only nuts and externally threaded fasteners with corresponding property classes shall be combined.

**Table 2 — Combination of regular nuts (style 1) and high nuts (style 2) with bolt, screw, stud property classes**

Nut property class	Highest property class of mating bolt, screw and stud
5	5.8
6	6.8
8	8.8
10	10.9
12	12.9/ <u>12.9</u>

Thin nuts (style 0) have a reduced loadability compared to regular nuts or high nuts and are not designed to prevent thread stripping failure mode in case of overloading.

Thin nuts used as jam nuts shall be assembled together with a regular nut or a high nut (thin nuts of property class 04 with regular or high nuts up to and including property class 8, thin nuts of property class 05 with regular or high nuts of property class up to and including 12).

## 7 Material, heat treatment, chemical composition and steel microstructure

### 7.1 General

When tested at ambient temperature by the methods specified in [Clause 10](#), nuts with specified property class shall meet the requirements specified in [Clause 7](#), regardless of which tests are performed during manufacture or final inspection.

When nuts are intended to be used in applications outside the range of  $-50\text{ °C}$  to  $+150\text{ °C}$ , several factors need to be taken into account, e.g. steel composition, duration of exposure at low or elevated temperature, the effect of the temperature on the fastener mechanical properties and clamped parts.

NOTE Information for the selection and application of steels for use at lower and elevated temperatures is given for instance in EN 10269, ASTM A320/A320M and ASTM A194/A194M.

The chemical composition limits of steels, the heat treatment condition (including minimum tempering temperature for quenched and tempered nuts only) and microstructure for the specified combinations

of property classes, heights (styles) and thread diameters shall be in accordance with [Table 3](#) for nuts with coarse pitch thread, and with [Table 4](#) for nuts with fine pitch thread.

## 7.2 Heat treatment

Nuts shall be manufactured in accordance with the requirements specified in [Tables 3](#) and [4](#) for the following heat treatment conditions:

- Not Quenched and Tempered (NQT),
- Quenched and Tempered (QT).

Only the following nuts are allowed to be manufactured in one or the other condition (NQT or QT) at the manufacturer's discretion, and in both cases these nuts shall meet all applicable requirements for the relevant heat treatment condition:

- a) For nuts with coarse pitch thread and in accordance with [Table 3](#):
  - regular nuts (style 1) of property class 8 with  $D \leq M16$ ,
  - high nuts (style 2) of property class 8;
- b) For nuts with fine pitch thread and in accordance with [Table 4](#):
  - regular nuts (style 1) of property class 6 with  $D \leq 16$  mm,
  - high nuts (style 2) of property class 8 with  $D \leq 16$  mm.

## 7.3 Chemical composition

The chemical composition shall be assessed in accordance with the relevant International Standards. In case of dispute, the product analysis shall meet the limits specified in [Table 3](#) or [4](#).

For nuts that are to be hot dip galvanized, the additional requirements specified in ISO 10684 shall apply.

**Table 3 — Chemical composition limits of steels for nuts with coarse pitch thread**

Heat treatment	Property class	Nut height	Thread <i>D</i>	Cast analysis <sup>a,b</sup>					Tempering temperature °C min.
				C %		Mn	P	S	
				min.	max.	min.	max.	max.	
Not Quenched and Tempered (NQT) <sup>c</sup>	04 <sup>d</sup>	Style 0	M5 ≤ <i>D</i> ≤ M39	0,06	0,58	0,25	0,060	0,150	—
	5 <sup>d</sup>	Style 1	M5 ≤ <i>D</i> ≤ M39						
	6 <sup>d</sup>	Style 1	M5 ≤ <i>D</i> ≤ M39						
	8	Style 1	M5 ≤ <i>D</i> ≤ M16 <sup>e</sup>						
Style 2		M5 ≤ <i>D</i> ≤ M39 <sup>e</sup>							
Quenched and Tempered (QT) <sup>f</sup>	05	Style 0	M5 ≤ <i>D</i> ≤ M39	0,15	0,58	0,45	0,048	0,058	380
	8	Style 1	M5 ≤ <i>D</i> ≤ M39						
		Style 2	M5 ≤ <i>D</i> ≤ M39						
	10	Style 1	M5 ≤ <i>D</i> ≤ M39						
		Style 2	M5 ≤ <i>D</i> ≤ M39						
	12	Style 1	M5 ≤ <i>D</i> ≤ M16	0,18					410
Style 2		M5 ≤ <i>D</i> ≤ M39	0,15					380	

<sup>a</sup> In case of dispute, product analysis shall apply.

<sup>b</sup> Alloying elements may be added, provided the mechanical and physical properties required in [Clause 8](#) are met.

<sup>c</sup> The steel structure of NQT nuts shall not consist of quenched microstructure, in accordance with [7.4.1](#).

<sup>d</sup> These nuts may be manufactured from free cutting steel containing sulfur, phosphorus and lead, with the following contents: S ≤ 0,350 %; P ≤ 0,110 %; Pb ≤ 0,350 %.

<sup>e</sup> These nuts may be quenched and tempered at the manufacturer's discretion, and in this case all requirements for QT nuts shall apply.

<sup>f</sup> The microstructure of QT nuts shall show approximately 90 % martensite in accordance with [7.4.2](#).

Table 4 — Chemical composition limits of steels for nuts with fine pitch thread

Heat treatment	Property class	Nut height	Thread $D$	Cast analysis <sup>a,b</sup> %					Tempering temperature °C min.
				C min.	C max.	Mn min.	P max.	S max.	
Not Quenched and Tempered (NQT) <sup>c</sup>	04 <sup>d</sup>	Style 0	$8 \text{ mm} \leq D \leq 39 \text{ mm}$	0,06	0,58	0,25	0,060	0,150	—
	6 <sup>d</sup>	Style 1	$8 \text{ mm} \leq D \leq 16 \text{ mm}$ <sup>e</sup>						
	8	Style 2	$8 \text{ mm} \leq D \leq 16 \text{ mm}$ <sup>e</sup>						
Quenched and Tempered (QT) <sup>f</sup>	05	Style 0	$8 \text{ mm} \leq D \leq 39 \text{ mm}$	0,15	0,58	0,45	0,048	0,058	380
	6	Style 1	$8 \text{ mm} \leq D \leq 39 \text{ mm}$						
	8	Style 1	$8 \text{ mm} \leq D \leq 16 \text{ mm}$	0,18					410
		Style 1	$16 \text{ mm} < D \leq 39 \text{ mm}$						
	10	Style 1	$8 \text{ mm} \leq D \leq 16 \text{ mm}$	0,15					380
		Style 2	$8 \text{ mm} \leq D \leq 39 \text{ mm}$						
	12	Style 2	$8 \text{ mm} \leq D \leq 39 \text{ mm}$	0,18					410
<p><sup>a</sup> In case of dispute, product analysis applies.</p> <p><sup>b</sup> Alloying elements may be added, provided the mechanical and physical properties required in <a href="#">Clause 8</a> are met.</p> <p><sup>c</sup> The steel structure of NQT nuts shall not consist of quenched microstructure, in accordance with <a href="#">7.4.1</a>.</p> <p><sup>d</sup> These nuts may be manufactured from free cutting steel containing sulfur, phosphorus and lead, with the following contents: S <math>\leq 0,350</math> %; P <math>\leq 0,110</math> %; Pb <math>\leq 0,350</math> %.</p> <p><sup>e</sup> These nuts may be quenched and tempered at the manufacturer's discretion, and in this case all requirements for QT nuts shall apply.</p> <p><sup>f</sup> The microstructure of QT nuts shall show approximately 90 % martensite in accordance with <a href="#">7.4.2</a>.</p>									

## 7.4 Steel microstructure

### 7.4.1 Non-quenched and tempered nuts

Nuts that are non-quenched and tempered (NQT) shall be supplied in the as forged or machined condition. The steel structure shall not consist of quenched microstructure.

### 7.4.2 Quenched and tempered nuts

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.

## 8 Mechanical and physical properties

### 8.1 General

When tested at ambient temperature by the methods specified in [Clause 10](#), nuts with specified property class shall meet the mechanical and physical requirements specified in [Clause 8](#), regardless of which tests are performed during manufacture or final inspection.

## 8.2 Proof load

When tested in accordance with [10.1](#), nuts with specified property class shall meet the requirements for the proof load specified in [Table 5](#) or [6](#).

**Table 5 — Proof loads for nuts with coarse pitch thread**

Thread <i>D</i>	Pitch <i>P</i>	Proof load, $F_p$ (N)						
		Property class						
		04 <sup>a</sup>	05 <sup>a</sup>	5	6	8	10	12
<b>M5</b>	0,8	5 400	7 100	8 250	9 500	12 140	14 800	16 300
<b>M6</b>	1	7 640	10 000	11 700	13 500	17 200	20 900	23 100
<b>M7</b>	1	11 000	14 500	16 800	19 400	24 700	30 100	33 200
<b>M8<sup>b</sup></b>	1,25	13 900	18 300	21 600	24 900	31 800	38 100	42 500
<b>M10<sup>b</sup></b>	1,5	22 000	29 000	34 200	39 400	50 500	60 300	67 300
<b>M12</b>	1,75	32 000	42 200	51 400	59 000	74 200	88 500	100 300
<b>M14</b>	2	43 700	57 500	70 200	80 500	101 200	120 800	136 900
<b>M16</b>	2	59 700	78 500	95 800	109 900	138 200	164 900	186 800
<b>M18</b>	2,5	73 000	96 000	121 000	138 200	176 600	203 500	230 400
<b>M20</b>	2,5	93 100	122 500	154 400	176 400	225 400	259 700	294 000
<b>M22</b>	2,5	115 100	151 500	190 900	218 200	278 800	321 200	363 600
<b>M24</b>	3	134 100	176 500	222 400	254 200	324 800	374 200	423 600
<b>M27</b>	3	174 400	229 500	289 200	348 800	452 100	486 500	550 800
<b>M30</b>	3,5	213 200	280 500	353 400	426 400	552 600	594 700	673 200
<b>M33</b>	3,5	263 700	347 000	437 200	527 400	683 600	735 600	832 800
<b>M36</b>	4	310 500	408 500	514 700	620 900	804 700	866 000	980 400
<b>M39</b>	4	370 900	488 000	614 900	741 800	961 400	1 035 000	1 171 000

<sup>a</sup> When thin nuts are used, the application shall take into account the stripping load which is lower than the proof load of a nut with full loadability (see [Annex B](#)).

<sup>b</sup> Hot dip galvanized nuts with thread tolerance class 6H shall meet the requirements of this Table. For hot dip galvanized nuts with thread tolerance classes 6AX and 6AZ in accordance with ISO 965-5, the lower proof loads specified in ISO 10684 for M8 and M10 shall apply.



Table 6 — Proof loads for nuts with fine pitch thread

Thread <i>D</i> × <i>P</i>	Proof load, $F_p$ (N)					
	Property class					
	04 <sup>a</sup>	05 <sup>a</sup>	6	8	10	12
<b>M8×1</b>	14 900	19 600	30 200	37 400	43 100	47 000
<b>M10×1,25</b>	23 300	30 600	47 100	58 400	67 300	73 400
<b>M10×1</b>	24 500	32 200	49 700	61 600	71 000	77 400
<b>M12×1,5</b>	33 500	44 000	68 700	84 100	97 800	105 700
<b>M12×1,25</b>	35 000	46 000	71 800	88 000	102 200	110 500
<b>M14×1,5</b>	47 500	62 500	97 500	119 400	138 800	150 000
<b>M16×1,5</b>	63 500	83 500	130 300	159 500	185 400	200 400
<b>M18×2</b>	77 500	102 000	177 500	210 100	220 300	248 100
<b>M18×1,5</b>	81 700	107 500	187 000	221 500	232 200	262 800
<b>M20×2</b>	98 000	129 000	224 500	265 700	278 600	313 500
<b>M20×1,5</b>	103 400	136 000	236 600	280 200	293 800	329 900
<b>M22×2</b>	120 800	159 000	276 700	327 500	343 400	386 500
<b>M22×1,5</b>	126 500	166 500	289 700	343 000	359 600	404 700
<b>M24×2</b>	145 900	192 000	334 100	395 500	414 700	467 100
<b>M27×2</b>	188 500	248 000	431 500	510 900	535 700	609 800
<b>M30×2</b>	236 000	310 500	540 300	639 600	670 700	764 100
<b>M33×2</b>	289 200	380 500	662 100	783 800	821 900	935 800
<b>M36×3</b>	328 700	432 500	804 400	942 800	934 200	1 063 900
<b>M39×3</b>	391 400	515 000	957 900	1 123 000	1 112 000	1 265 000

<sup>a</sup> When thin nuts are used, the application shall take into account the stripping load which is lower than the proof load of a nut with full loadability (see [Annex B](#)).

### 8.3 Hardness

When tested in accordance with [10.2](#), nuts with specified property class shall meet the requirements for the hardness, as follows:

- for NQT nuts the minimum hardness is given for information only but the maximum hardness requirement of [Table 7](#) or [9](#) shall apply;
- for QT nuts the minimum hardness and the maximum hardness requirements of [Table 8](#) or [10](#) shall apply; the difference in hardness determined in the core and in the thread in accordance with [10.2.7](#) shall not be greater than 30 HV.

**Table 7 — Hardness for non-quenched and tempered nuts (NQT) with coarse pitch thread**

Property class	Style	Thread <i>D</i>	Vickers hardness HV		Converted Brinell hardness <sup>a</sup> HB or HBW		Converted Rockwell hardness <sup>a</sup>	
			min.	max.	min.	max.	min.	max.
<b>04</b>	Style 0	$M5 \leq D \leq M39$	188	334	179	318	88,8 HRB	33,9 HRC
<b>5</b>	Style 1	$M5 \leq D \leq M16$	130		124		71,2 HRB	
		$M16 < D \leq M39$	146		139		77,9 HRB	
<b>6</b>	Style 1	$M5 \leq D \leq M16$	150		143		78,7 HRB	
		$M16 < D \leq M39$	170		162		85,0 HRB	
<b>8</b>	Style 1	$M5 \leq D \leq M16$ <sup>b</sup>	200		190		91,5 HRB	
	Style 2	$M5 \leq D \leq M39$ <sup>b</sup>						

<sup>a</sup> Brinell and Rockwell hardness are converted from HV values according to ISO 18265 (unalloyed and low alloy steel conditions).

<sup>b</sup> These nuts may be quenched and tempered at manufacturer's discretion: in this case, [Table 8](#) shall apply.

**Table 8 — Hardness for quenched and tempered nuts (QT) with coarse pitch thread**

Property class	Style	Thread <i>D</i>	Vickers hardness HV		Converted Brinell hardness <sup>a</sup> HB or HBW		Converted Rockwell hardness <sup>a</sup>	
			min.	max.	min.	max.	min.	max.
<b>05</b>	Style 0	$M5 \leq D \leq M39$	272	353	268	349	26,5 HRC	36,9 HRC
<b>8</b>	Style 1	$M5 \leq D \leq M16$	200	334	195 <sup>b</sup>	330	92,7 HRB <sup>b</sup>	34,8 HRC
		$M16 < D \leq M39$	233		228		98,9 HRB	
	Style 2	$M5 \leq D \leq M39$	200		195 <sup>b</sup>		92,7 HRB <sup>b</sup>	
<b>10</b>	Style 1	$M5 \leq D \leq M39$	272	353	268	349	26,5 HRC	36,9 HRC
	Style 2	$M5 \leq D \leq M39$	233		228		98,9 HRB	
<b>12</b>	Style 1	$M5 \leq D \leq M16$	308	368	304	363	31,6 HRC	38,5 HRC
	Style 2	$M5 \leq D \leq M39$	272	353	268	349	26,5 HRC	36,9 HRC

<sup>a</sup> Brinell and Rockwell hardness are converted from HV values according to ISO 18265 (quenched and tempered condition).

<sup>b</sup> Extrapolated value (no conversion available in ISO 18265 for values less than 210 HV).

**Table 9 — Hardness for non-quenched and tempered nuts (NQT) with fine pitch thread**

Property class	Style	Thread <i>D</i>	Vickers hardness HV		Converted Brinell hardness <sup>a</sup> HB or HBW		Converted Rockwell hardness <sup>a</sup>	
			min.	max.	min.	max.	min.	max.
<b>04</b>	Style 0	$8 \text{ mm} \leq D \leq 39 \text{ mm}$	188	334	179	318	88,8 HRB	33,9 HRC
<b>6</b>	Style 1	$8 \text{ mm} \leq D \leq 16 \text{ mm}$ <sup>b</sup>	200		190		91,5 HRB	
<b>8</b>	Style 2	$8 \text{ mm} \leq D \leq 16 \text{ mm}$ <sup>b</sup>	223		212		95,4 HRB	

<sup>a</sup> Brinell and Rockwell hardness are converted from HV values according to ISO 18265 (unalloyed and low alloy steel conditions).

<sup>b</sup> These nuts may be quenched and tempered at manufacturer's discretion: in this case, [Table 10](#) shall apply.

**Table 10 — Hardness for quenched and tempered nuts (QT) with fine pitch thread**

Property class	Style	Thread $D$	Vickers hardness HV		Converted Brinell hardness <sup>a</sup> HB or HBW		Converted Rockwell hardness <sup>a</sup>	
			min.	max.	min.	max.	min.	max.
<b>05</b>	Style 0	$8 \text{ mm} \leq D \leq 39 \text{ mm}$	272	353	268	349	26,5 HRC	36,9 HRC
<b>6</b>	Style 1	$8 \text{ mm} \leq D \leq 16 \text{ mm}$	200	334	195 <sup>b</sup>	330	92,7 HRB <sup>b</sup>	34,8 HRC
		$16 \text{ mm} < D \leq 39 \text{ mm}$	233	334	228	330	98,9 HRB	34,8 HRC
<b>8</b>	Style 1	$8 \text{ mm} \leq D \leq 16 \text{ mm}$	262	334	258	330	24,9 HRC	34,8 HRC
		$16 \text{ mm} < D \leq 39 \text{ mm}$	295	353	291	349	29,8 HRC	36,9 HRC
	Style 2	$8 \text{ mm} \leq D \leq 16 \text{ mm}$	223	334	218	330	97,2 HRB	34,8 HRC
		$16 \text{ mm} < D \leq 39 \text{ mm}$	244	334	239	330	21,9 HRC	34,8 HRC
<b>10</b>	Style 1	$8 \text{ mm} \leq D \leq 16 \text{ mm}$	320	380	316	375	33,1 HRC	39,6 HRC
	Style 2	$8 \text{ mm} \leq D \leq 39 \text{ mm}$	272	353	268	349	26,5 HRC	36,9 HRC
<b>12</b>	Style 2	$8 \text{ mm} \leq D \leq 39 \text{ mm}$	308	368	304	363	31,6 HRC	38,5 HRC

<sup>a</sup> Brinell and Rockwell hardness are converted from HV values according to ISO 18265 (quenched and tempered condition).

<sup>b</sup> Extrapolated value (no conversion available in ISO 18265 for values less than 210 HV).

## 8.4 Surface integrity

Surface integrity shall be in accordance with ISO 6157-2.

## 9 Inspection

### 9.1 Manufacturer's inspection

This document does not mandate which of the tests the manufacturer shall perform on each manufacturing lot. It is the responsibility of the manufacturer to apply suitable methods of their choice, such as in-process control or final inspection, to ensure that the manufactured lot does conform to all specified requirements. For additional information, see ISO 16426.

In case of dispute, all applicable test methods in accordance with [Clause 10](#) (except hardness routine tests given in [10.2.4](#)) shall apply.

### 9.2 Supplier's inspection

The supplier may test the nuts which they provide using methods of their choice (periodic evaluation of the manufacturer, checking of test results from the manufacturer, tests on the nuts themselves, etc.), provided all specified requirements are met.

In case of dispute, all applicable test methods in accordance with [Clause 10](#) (except hardness routine tests of [10.2.4](#)) shall apply.

### 9.3 Purchaser's inspection

The purchaser may test the delivered nuts using the test methods specified in [Clause 10](#).

In case of dispute, all applicable test methods in accordance with [Clause 10](#) (except hardness routine tests given in [10.2.4](#)) shall apply.

## 9.4 Delivery of test results

If the purchaser requires test results from the supplier, the type of test report shall be agreed upon at the time of the order. It shall be established in accordance with ISO 16228, unless otherwise agreed. Any additional or specific test shall also be specified by the purchaser and agreed upon before the order.

For nuts which are optionally quenched and tempered in accordance with [7.2](#), the heat treatment option (QT or NQT) shall be included in the test report.

## 10 Test methods

### 10.1 Proof load test

#### 10.1.1 General

The proof load test consists of two main operations, namely:

- a) application of a specified proof load by means of a test mandrel (see [Figure 2](#)), and
- b) checking of the damage to the nut thread caused by the proof load, if any.

For proof load testing of prevailing torque nuts, the additional test procedure and requirements specified in ISO 2320 shall apply.

#### 10.1.2 Applicability

This test applies to nuts of all sizes and for all property classes.

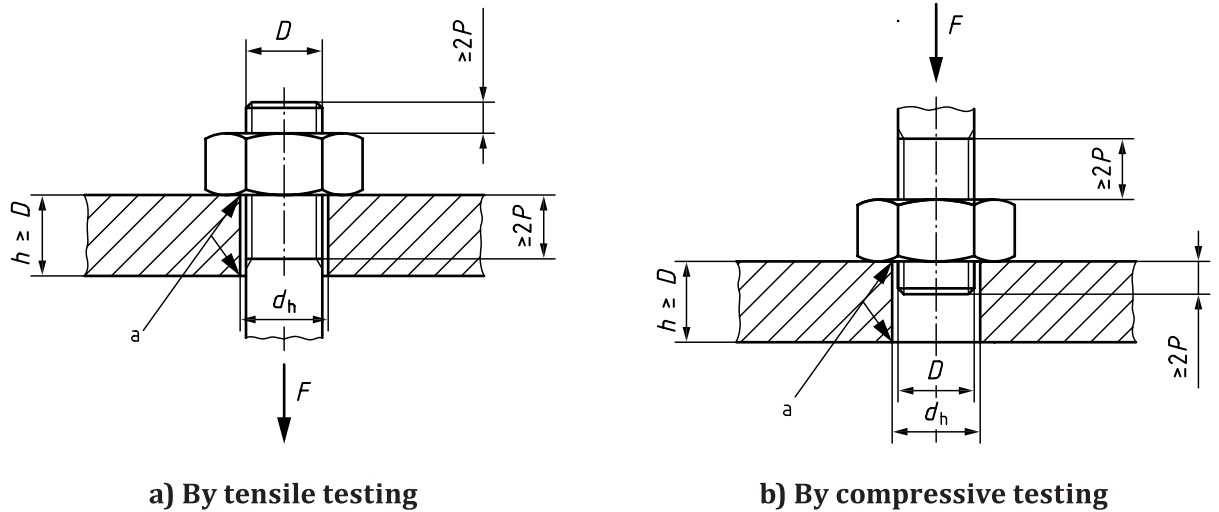
#### 10.1.3 Apparatus

The tensile testing machine shall be in accordance with ISO 7500-1, class 1 or better. Side thrust on the nut shall be avoided, e.g. by self-aligning grips.

#### 10.1.4 Testing device

The grip and test mandrel shall fulfil the following requirements:

- hardness of the grip: 45 HRC minimum,
- thickness of the grip,  $h$ :  $1D$  minimum,
- hole diameter of the grip,  $d_h$ : in accordance with [Table 11](#),
- mandrel hardened and tempered: hardness 45 HRC to 50 HRC,
- thread tolerance class of the test mandrel: 5h6g, and additionally the tolerance of the major diameter shall be the lowest quarter of the 6g range; thread dimensions for the test mandrel shall be as specified in [Annex A](#).



<sup>a</sup> No sharp edge.

Figure 2 — Proof load test

Table 11 — Hole diameter for the grip

Dimensions in millimeters

Thread <i>D</i>	Hole diameter <i>d<sub>h</sub></i> <sup>a</sup>		Thread <i>D</i>	Hole diameter <i>d<sub>h</sub></i> <sup>a</sup>		Thread <i>D</i>	Hole diameter <i>d<sub>h</sub></i> <sup>a</sup>	
	min.	max.		min.	max.		min.	max.
5	5,030	5,105	14	14,050	14,160	27	27,065	27,195
6	6,030	6,105	16	16,050	16,160	30	30,065	30,195
7	7,040	7,130	18	18,050	18,160	33	33,080	33,240
8	8,040	8,130	20	20,065	20,195	36	36,080	36,240
10	10,040	10,130	22	22,065	22,195	39	39,080	39,240
12	12,050	12,160	24	24,065	24,195	—	—	—

<sup>a</sup>  $d_h = D$  with tolerance class D11 (see ISO 286-2).

### 10.1.5 Test procedure

The nut shall be tested as received.

The thread of the test mandrel shall be checked before and after each test. If the thread of the test mandrel is damaged during the test, the test result shall be discarded and a new test shall be carried out with a conforming mandrel.

The nut shall be assembled on the test mandrel in accordance with [Figure 2](#).

The axial tensile test or axial compressive test shall be carried out in accordance with ISO 6892-1. The speed of testing, as determined with a free-running cross-head, shall not exceed 10 mm/min up to 50 % of the proof load  $F_p$  and 3 mm/min beyond.

The proof load specified in [Table 5](#) for nuts with coarse pitch thread and in [Table 6](#) for nuts with fine pitch thread shall be applied, however exceeding the proof load value shall be minimized. The proof load shall be maintained for 15 seconds, and then released.

The nut shall be removed using the fingers from the test mandrel. It can be necessary to use a manual wrench to start the nut in motion, but the use of such a wrench is permissible only to a half turn.

### 10.1.6 Test results and requirements

The nut shall resist the proof load specified in [Table 5](#) or [6](#) without failing, i.e. without significant plastic deformation, thread stripping, cracking or fracture.

Nuts without prevailing torque feature shall be removable using the fingers after the release of the proof load (and, if necessary, after a half turn maximum with a wrench).

Failure mode and the use of a wrench shall be documented in the test result.

In case of dispute, the tensile proof load test in accordance with [Figure 2](#) a) shall be the reference test method for acceptance.

## 10.2 Hardness tests

### 10.2.1 General

Hardness test procedures are specified in [10.2.4](#) to [10.2.7](#).

Optional routine inspection described in [10.2.4](#) may be carried out to monitor the nut manufacturing process.

In case of dispute, only the hardness test procedures specified in [10.2.5](#) to [10.2.7](#) shall apply. Hardness requirements for acceptance of nuts are specified in [10.2.8](#) for non-quenched and tempered nuts (NQT), and in [10.2.9](#) for quenched and tempered nuts (QT). [Table 12](#) summarizes hardness requirements for nuts.

**Table 12 — Summary of hardness requirements**

Subclause	Characteristic	Requirement for NQT nuts ( <a href="#">10.2.8</a> )	Requirement for QT nuts ( <a href="#">10.2.9</a> )
<a href="#">10.2.4</a>	Routine tests for hardness	Not valid in case of dispute	
<a href="#">10.2.5</a>	Hardness in the thread	Maximum hardness in accordance with <a href="#">Table 7</a> or <a href="#">9</a>	Minimum and maximum hardness in accordance with <a href="#">Table 8</a> or <a href="#">10</a>
<a href="#">10.2.6</a>	Hardness in the core	Maximum hardness in accordance with <a href="#">Table 7</a> or <a href="#">9</a>	Minimum and maximum hardness in accordance with <a href="#">Table 8</a> or <a href="#">10</a>
<a href="#">10.2.7</a>	Uniformity of hardness	No requirement	Difference in hardness in the core and hardness in the thread $\leq 30$ HV

### 10.2.2 Applicability

Hardness tests apply to nuts of all sizes and for all property classes.

### 10.2.3 Test methods

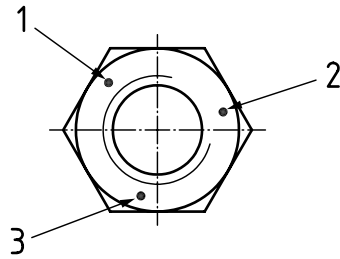
Hardness shall be determined using the Vickers hardness test in accordance with ISO 6507-1, the Brinell hardness test in accordance with ISO 6506-1, or the Rockwell hardness test in accordance with ISO 6508-1.

### 10.2.4 Test procedures for routine inspection

These test procedures may be used for routine inspection only.

#### a) Hardness determined on the bearing surface

The hardness may be determined on one bearing surface of the nut, after removal of any coating and after suitable preparation of the nut. Any appropriate hardness test method can be used. The hardness readings should be located about 120° apart (see [Figure 3](#)).

**Key**

1, 2, 3 position of the hardness readings

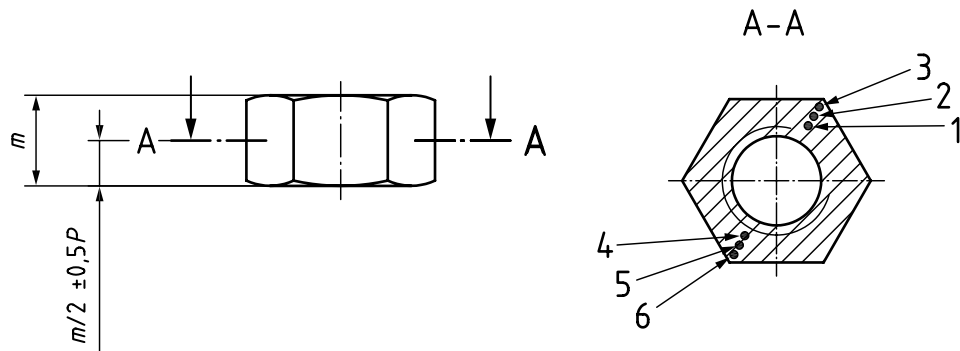
**Figure 3 — Example of hardness determination on the bearing surface**

Following test forces/scales may be used:

- Vickers hardness test: 98 N minimum (HV 10);
- Brinell hardness test: HBW 2,5/187,5;
- Rockwell hardness test: HRB or HRC.

**b) Hardness determined on the transverse section**

Hardness may be determined on the transverse section through the mid-thread height of the nut. This section should be made with a suitable process where hardness is not altered by excessive heating or work hardening, and the surface should be suitably prepared. Any appropriate hardness test method can be used. Two sets of three readings should be taken along the width across corners and located about 180° apart (see [Figure 4](#)).

**Key**

- 1, 4 position of the hardness readings (next to the thread)
- 2, 5 position of the hardness readings (core)
- 3, 6 position of the hardness readings (next to the corner)

**Figure 4 — Hardness determination on the transverse section**

Following test forces/scales may be used:

- Vickers hardness test: 98 N minimum (HV 10);
- Brinell hardness test: HBW 2,5/187,5;
- Rockwell hardness test: HRB or HRC.

**c) Alternative test methods used for production control**

Hardness test procedures specified in [10.2.5](#) and [10.2.6](#) may also be used for production control, with any of the test methods (Vickers, Brinell or Rockwell) specified in [10.2.3](#). Care shall be taken that the minimum distance to any edge is in accordance with the relevant hardness standard.

**10.2.5 Hardness determined in the thread**

Nuts shall be tested as received.

A longitudinal section shall be made through the axis and width across corners, with a suitable process where hardness is not altered by excessive heating or work hardening, and the surface shall be suitably prepared. Vickers hardness with test force in accordance with [Table 13](#) shall be used.

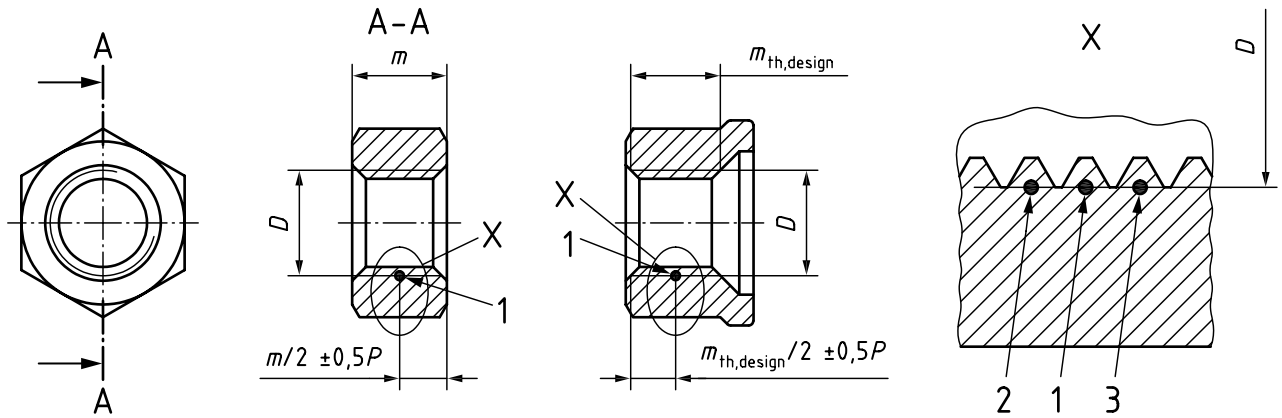
**Table 13 — Selection of appropriate test force for Vickers hardness test**

Pitch of the nut thread mm	Hardness test symbol
0,8 to 1,75	HV 1
2 to 4	HV 5
NOTE Vickers test force selection is based on the dimensions of the basic profile of ISO metric thread and on the minimum hardness requirement for nuts.	

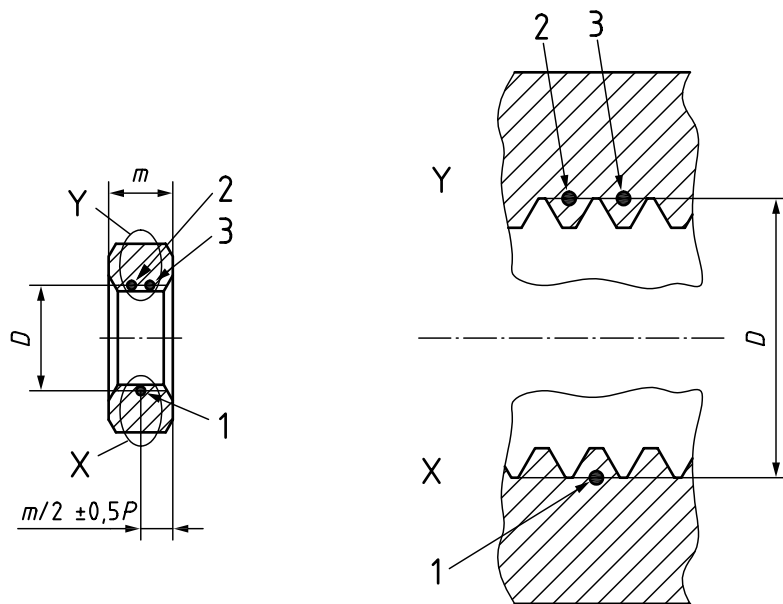
The hardness shall be determined by taking three readings at three pitches, located at the major diameter of the nut thread  $D$  and at mid-thread height of the nut (see points 1, 2 and 3 in [Figure 5](#)).

The hardness value in the thread shall be the average of these three readings.





a) Regular or high nut (style 1 or 2)



b) Thin nut (style 0)

**Key**

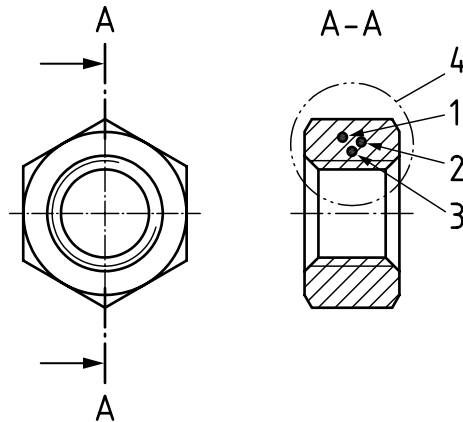
- 1, 2, 3 hardness readings
- D major thread diameter

**Figure 5 — Hardness determination in the thread**

**10.2.6 Hardness determined in the core**

Nuts shall be tested as received.

Hardness in the core shall be determined on a longitudinal section through the axis and width across corners in accordance with [Figure 6](#). This section shall be made with a suitable process where hardness is not altered by excessive heating or work hardening, and the surface shall be suitably prepared. Hardness test shall be performed using HV 10.



**Key**

- 1, 2, 3 position of the hardness readings for hardness determination in the core
- 4 area for microstructure evaluation in accordance with [10.3](#)

**Figure 6 — Hardness determination in the core**

Three readings in the middle of the core shall be taken (see points 1, 2 and 3 in [Figure 6](#)). The hardness value in the core shall be the average of these three readings.

**10.2.7 Uniformity of hardness for quenched and tempered nuts (QT)**

Nuts shall be tested as received.

Uniformity of hardness for quenched and tempered nuts shall be determined by comparing hardness in the thread as determined in [10.2.5](#) and hardness in the core as determined in [10.2.6](#).

For the proper comparison of hardness in the core with hardness in the thread, hardness test forces for both tests shall be in accordance with [Table 13](#).

**10.2.8 Requirements for non-quenched and tempered nuts (NQT)**

Not achieving the minimum hardness shall not be cause of rejection provided the proof load requirements in accordance with [10.1.6](#) are met.

The maximum hardness in the thread determined in accordance with [10.2.5](#) shall meet the requirements specified in [Table 7](#) or [9](#).

The maximum hardness in the core determined in accordance with [10.2.6](#) shall meet the requirements specified in [Table 7](#) or [9](#).

**10.2.9 Requirements for quenched and tempered nuts (QT)**

The hardness in the thread determined in accordance with [10.2.5](#) shall meet the requirements specified in [Table 8](#) or [10](#).

The hardness in the core determined in accordance with [10.2.6](#) shall meet the requirements specified in [Table 8](#) or [10](#).

The difference in hardness in the core and in the thread, determined in accordance with [10.2.7](#), shall not be greater than 30 HV, as specified in [8.3](#).

## 10.3 Steel microstructure

### 10.3.1 General

The purpose of the control of the steel microstructure is to ensure that:

- non-quenched and tempered nuts (NQT) have a non-quenched microstructure as specified in [7.4.1](#),
- quenched and tempered nuts (QT) have a uniform martensitic microstructure as specified in [7.4.2](#).

### 10.3.2 Applicability

This test applies to nuts of all sizes and for all property classes.

### 10.3.3 Test method

The nut shall be tested as received. Before sample preparation, removal of any coating is recommended.

The microstructure shall be evaluated by an optical microscope on the entire nut section through the width across corners, in accordance with [10.2.6](#) and [Figure 6](#) (Key 4).

### 10.3.4 Test results and requirements

For non-quenched and tempered nuts (NQT), the requirement for the microstructure specified in [7.4.1](#) shall be met.

For quenched and tempered nuts (QT), the requirement of approximately 90 % martensite specified in [7.4.2](#) shall be met.

## 10.4 Retempering test

### 10.4.1 General

The purpose of this test is to check that the minimum tempering temperature has been achieved.

This test applies to nuts having the following specifications:

- all sizes,
- all quenched and tempered nuts (whether they are mandatorily or optionally quenched and tempered).

This test shall be applied only in case of dispute.

### 10.4.2 Test procedure

The nut shall be tested as received.

A longitudinal section shall be made through the nut axis, with a suitable process where hardness is not altered by excessive heating or work hardening, and the surface shall be suitably prepared. The Vickers hardness shall be determined in the thread in accordance with [10.2.5](#) (see [Figure 5](#)).

The other half-nut shall be retempered by holding it for 30 minutes at a part temperature of 10 °C less than the minimum tempering temperature specified in [Table 3](#) or [4](#). After retempering and back to the ambient temperature, the Vickers hardness shall be determined in the thread in accordance with [10.2.5](#) (see [Figure 5](#)).

### 10.4.3 Test results and requirements

The average of the three hardness readings taken before and after retempering shall be compared. The reduction of hardness after retempering, if any, shall be less than 20 HV.

### 10.5 Surface discontinuity inspection

The surface discontinuity inspection shall be performed in accordance with ISO 6157-2.

## 11 Marking and labelling

### 11.1 General requirements

Marking of nuts shall be included during the manufacturing process. They shall be marked preferably on the top of the nut (i.e. at the opposite side of the bearing face) by indenting or embossing. The height of embossed marking shall not be included in the nut height dimension.

Nuts may also be marked:

- on the flange for flanged nuts,
- on the side by indenting,
- on the chamfer, and in this case embossed marking shall not protrude beyond the bearing surface of the nut,
- on one bearing face by indenting, and in this case it shall not impair functional properties.

Marking of the nuts consists of:

- the property class symbol, as specified in [11.2](#) or [11.3](#),

and

- the manufacturer's identification mark, as specified in [11.4](#).

Nuts manufactured in accordance with the requirements of this document shall be designated in accordance with the designation system specified in [Clause 5](#) and shall be marked in accordance with this [Clause 11](#).

The designation system specified in [Clause 5](#) shall only be used and marking shall only be affixed in accordance with this [Clause 11](#) when all applicable requirements of this document:

- material, heat treatment, chemical composition and steel microstructure as specified in [Clause 7](#),

and

- mechanical and physical properties as specified in [Clause 8](#),

are met, when tested in accordance with [Clause 10](#).

For hot dip galvanized nuts with thread tolerance classes 6AX and 6AZ in accordance with ISO 965-5, additional marking is specified in ISO 10684.

### 11.2 Property class marking symbols for nuts with full loadability

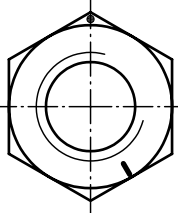
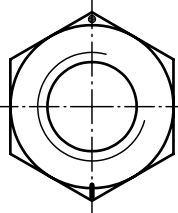
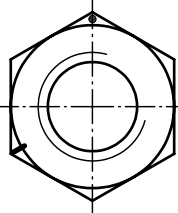
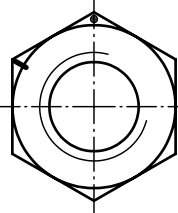
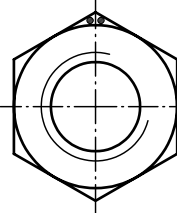
The property class marking symbols shall be as specified in the second row of [Table 14](#) for nuts with full loadability:

- regular hexagon nuts (style 1) and high hexagon nuts (style 2), and

- other standardized or non-standardized nuts in accordance with this document (nuts with flange, prevailing torque nuts, nuts per drawing, etc.) and with design thread height  $m_{th,design,min} \geq 0,73D$  (see [Table 1](#)).

In case where the shape of the nut does not allow that marking, the alternative clock-face marking symbols specified in the third row of [Table 14](#) shall be used.

**Table 14 — Property class marking symbols for nuts with full loadability (e.g. regular and high nuts)**

<b>Property class</b>	<b>5</b>	<b>6</b>	<b>8</b>	<b>10</b>	<b>12</b>
<b>Marking symbol</b>	5	6	8	10	12
<b>Alternative clock face marking symbol<sup>a</sup></b>					

<sup>a</sup> The reference twelve o'clock position shall be marked either by the identification mark of the manufacturer or by a dot.

### 11.3 Property class marking symbols for nuts with reduced loadability

The property class marking symbols (including the preceding digit “0”) shall be as specified in [Table 15](#) for nuts with reduced loadability:

- thin nuts (style 0), and
- other standardized or non-standardized nuts in accordance with this document and with design thread height  $0,40D \leq m_{th,design,min} < 0,73D$  (see [Table 1](#)).

**Table 15 — Property class marking symbols for nuts with reduced loadability (e.g. thin nuts)**

<b>Property class</b>	<b>04</b>	<b>05</b>
<b>Marking symbol</b>	04	05

The alternative clock-face marking of [Table 14](#) is specified for full loadability only, it shall not be used for nuts with reduced loadability.

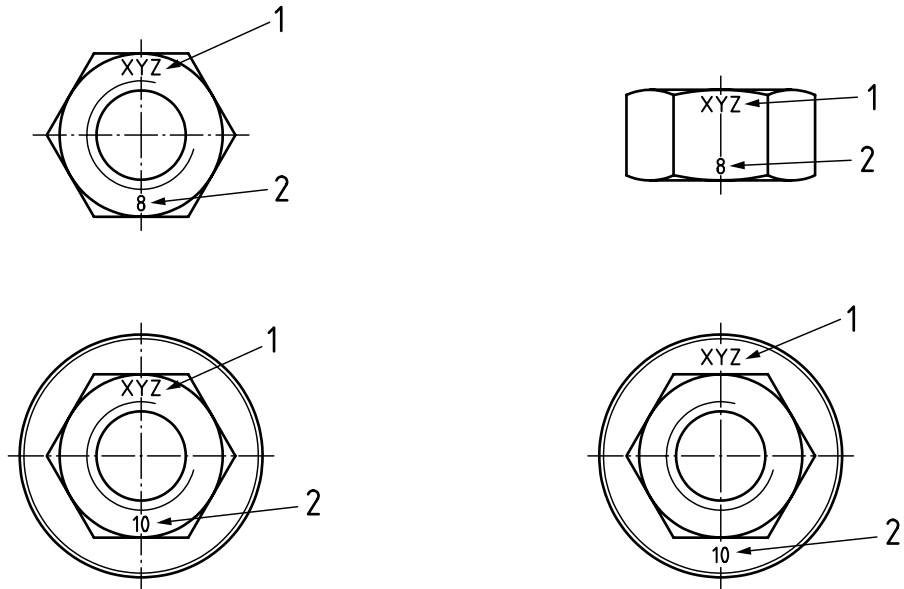
### 11.4 Manufacturer’s identification mark

The manufacturer’s identification mark shall be included during the manufacturing process on all nuts which shall be marked with the property class symbol.

A distributor who distributes nuts that are marked with its own identification mark shall be considered to be the manufacturer.

### 11.5 Nut marking

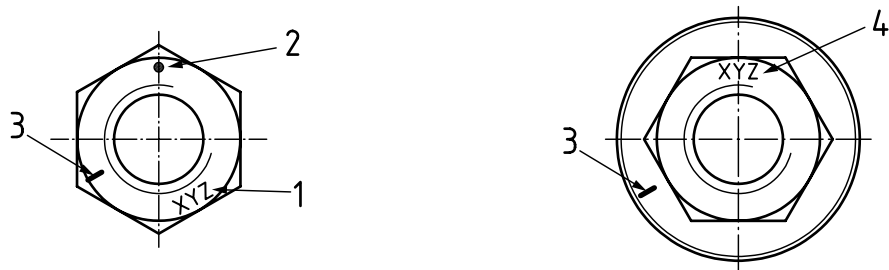
All nuts in accordance with this document shall be marked with the property class marking symbol in accordance with either [11.2](#) or [11.3](#), and with the manufacturer's identification mark in accordance with [11.4](#). Nuts shall be marked preferably on the top of the nut (i.e. at the opposite side of the bearing face). Examples are shown in [Figures 7 to 9](#).



**Key**

- 1 manufacturer's identification mark
- 2 property class symbol (full loadability)

**Figure 7 — Examples of marking for hexagon nuts with full loadability**

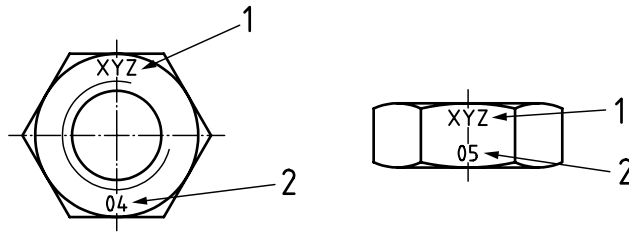


**Key**

- 1 manufacturer's identification mark
- 2 reference twelve o'clock position marked by a dot
- 3 property class symbol (full loadability)
- 4 reference twelve o'clock position marked by the manufacturer's identification mark (replacing the dot)

**Figure 8 — Examples of marking with clock-face system for hexagon nuts with full loadability**

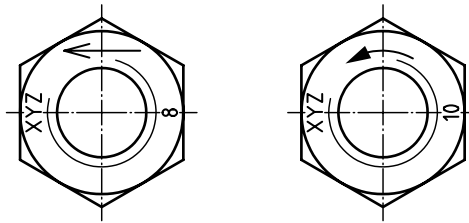
For nuts with reduced loadability, the property class symbol specified in [Table 15](#) shall be used (see [Figure 9](#)).

**Key**

- 1 manufacturer's identification mark
- 2 property class symbol (reduced loadability)

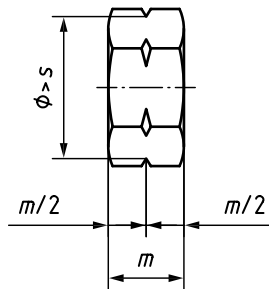
**Figure 9 — Examples of marking for hexagon nuts with reduced loadability**

Nuts with left-hand thread in accordance with this document shall additionally be marked with a left pointing arrow, see [Figure 10](#). It shall be located at the same face as the property class marking and preferably on the top of the nut.



**Figure 10 — Examples of marking for left-hand thread**

Alternative groove marking for left-hand thread as specified in [Figure 11](#) may also be used for hexagon nuts.



- $s$  width across flats
- $m$  nut height

**Figure 11 — Alternative groove marking for left-hand thread**

## 11.6 Marking of the packages (labelling)

All packages for all types of nuts of all sizes and for all property classes in accordance with this document shall be marked through labelling. The labelling shall include at least:

- the manufacturer's and/or distributor's identification and/or name, and
- the property class symbol in accordance with [11.2](#) for nuts with full loadability, or the property class symbol in accordance with [11.3](#) for nuts with reduced loadability, and

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— the manufacturing lot number, as specified in ISO 1891-4.

For hot dip galvanized nuts with thread tolerance classes 6AX and 6AZ, additional information is needed for labelling and designation, as specified in ISO 10684.



## Annex A (normative)

### Thread dimensions of the test mandrel

**Table A.1 — Thread dimensions of the proof load test mandrel —  
Coarse pitch thread**

Dimensions in millimetres

Nut thread <i>D</i>	External thread diameter of the mandrel (lowest quarter of tolerance 6g)		Pitch diameter of the mandrel (tolerance 5h)	
	max.	min.	max.	min.
<b>M5</b>	4,864	4,826	4,480	4,405
<b>M6</b>	5,839	5,794	5,350	5,260
<b>M7</b>	6,839	6,794	6,350	6,260
<b>M8</b>	7,813	7,760	7,188	7,093
<b>M10</b>	9,791	9,732	9,026	8,920
<b>M12</b>	11,767	11,701	10,863	10,745
<b>M14</b>	13,752	13,682	12,701	12,576
<b>M16</b>	15,752	15,682	14,701	14,576
<b>M18</b>	17,707	17,623	16,376	16,244
<b>M20</b>	19,707	19,623	18,376	18,244
<b>M22</b>	21,707	21,623	20,376	20,244
<b>M24</b>	23,671	23,577	22,051	21,891
<b>M27</b>	26,671	26,577	25,051	24,891
<b>M30</b>	29,628	29,522	27,727	27,557
<b>M33</b>	32,628	32,522	30,727	30,557
<b>M36</b>	35,584	35,465	33,402	33,222
<b>M39</b>	38,584	38,465	36,402	36,222

**Table A.2 — Thread dimensions of the proof load test mandrel —  
Fine pitch thread**

Dimensions in millimetres

Nut thread <i>D</i> × <i>P</i>	External thread diameter of the mandrel (lowest quarter of tolerance 6g)		Pitch diameter of the mandrel (tolerance class 5h)	
	max.	min.	max.	min.
<b>M8×1</b>	7,839	7,794	7,350	7,260
<b>M10×1,25</b>	9,813	9,760	9,188	9,093
<b>M10×1</b>	9,839	9,794	9,350	9,260
<b>M12×1,5</b>	11,791	11,732	11,026	10,914
<b>M12×1,25</b>	11,813	11,760	11,188	11,082
<b>M14×1,5</b>	13,791	13,732	13,026	12,911
<b>M16×1,5</b>	15,791	15,732	15,026	14,914
<b>M18×2</b>	17,752	17,682	16,701	16,569
<b>M18×1,5</b>	17,791	17,732	17,026	16,914
<b>M20×2</b>	19,752	19,682	18,701	18,569
<b>M20×1,5</b>	19,791	19,732	19,026	18,914
<b>M22×2</b>	21,752	21,682	20,701	20,569
<b>M22×1,5</b>	21,791	21,732	21,026	20,914
<b>M24×2</b>	23,752	23,682	22,701	22,569
<b>M27×2</b>	26,752	26,682	25,701	25,569
<b>M30×2</b>	29,752	29,682	28,701	28,569
<b>M33×2</b>	32,752	32,682	31,701	31,569
<b>M36×3</b>	35,671	35,577	34,051	33,891
<b>M39×3</b>	38,671	38,577	37,051	36,891

## Annex B (informative)

### Design principles for nuts

#### B.1 Basic design principles for nuts

The design of the nuts specified in this document was basically made for hexagon regular nuts (style 1) and for hexagon high nuts (style 2) of product grades A and B, see [Table B.1](#). For detailed technical information on the design principle for nuts, see ISO/TR 16224.

A bolted joint basically consists of two or more work pieces, which are clamped together using an externally threaded fastener (bolt, screw or stud) on one side and an internally threaded part or a nut on the other side (for fully threaded studs, an additional nut is used instead of the head of the bolt or screw).

An externally threaded fastener with specified property class in accordance with ISO 898-1 assembled with a regular or high nut of the mating property class in accordance with [Table 2](#) of this document, is designed to be used up to the yield strength of the externally threaded fastener.

Under tensile load, the failure mode of bolt and nut assemblies corresponds to the lowest value of the following three loads:

- a) thread stripping load of the nut;
- b) ultimate tensile load of the bolt, screw or stud;
- c) thread stripping load of the bolt, screw or stud.

The bolt breaking in the free threaded length after elongation is the intended failure mode of bolt and nut assemblies in case of overloading.

These three loads mainly depend on:

- the hardness, height and effective thread height, diameter, pitch and thread tolerance class of the nut,
- the hardness, diameter, pitch and thread tolerance class of the externally threaded fastener,
- the effective length of engaged thread between the externally threaded fastener and the nut.

These three loads are linked to each other; their interdependence was the analytical basis for the calculation of the different stripping loads by Alexander<sup>[21]</sup>, and extensive experimental tests proved the Alexander's theory through practical results. In addition, recent FEM-based calculations<sup>[20]</sup> also confirmed Alexander's theory.

According to Alexander's theory, hexagon nuts were classified to style 1 (regular nuts) and style 2 (high nuts) in relation to their height, see [Table B.1](#).

Thin nuts (style 0) have a reduced loadability compared to regular nuts or high nuts and are not designed to prevent thread stripping failure mode in case of overloading.

**WARNING — Nuts on the market showing vertical bars on each side of the property class symbol (e.g. |8| ) do not fulfil the requirements of this document.**

NOTE The vertical bars in the warning above are from former DIN 267-4, which was withdrawn in 1994.

**Table B.1 — Minimum height of standard hexagon nuts  
(without flange and without prevailing torque feature)**

Dimensions in millimeters

Thread $D$	Width across flats $s_{\text{nom}}$	Minimum height of hexagon nuts			
		Regular nuts (style 1) $0,80D \leq m_{\text{min}} < 0,89D$		High nuts (style 2) $m_{\text{min}} \geq 0,89D$	
		$m_{\text{min}}$	$m_{\text{min}}/D$	$m_{\text{min}}$	$m_{\text{min}}/D$
5	8	4,40	0,88	4,80	0,96
6	10	4,90	0,82	5,40	0,90
7	11	6,14	0,88	6,84	0,98
8	13	6,44	0,81	7,14	0,90
10	16	8,04	0,80	8,94	0,89
12	18	10,37	0,86	11,57	0,96
14	21	12,10	0,86	13,40	0,96
16	24	14,10	0,88	15,70	0,98
18	27	15,10	0,84	16,90	0,94
20	30	16,90	0,85	19,00	0,95
22	34	18,10	0,82	20,50	0,93
24	36	20,20	0,84	22,60	0,94
27	41	22,50	0,83	25,40	0,94
30	46	24,30	0,81	27,30	0,91
33	50	27,40	0,83	30,90	0,94
36	55	29,40	0,82	33,10	0,92
39	60	31,80	0,82	35,90	0,92

## B.2 Nuts with diameters $D < 5$ mm and $D > 39$ mm

Mechanical properties for bolts and nuts have been specified using the Alexander theory<sup>[21]</sup> for fasteners with nominal diameters 5 mm to 39 mm only, on the basis of hexagon nut dimensions specified in ISO 4032 (regular nuts, style 1) and ISO 4033 (high nuts, style 2) with the specified width across flats and minimum heights shown in [Table B.1](#).

Nuts with  $D < 5$  mm and nuts with  $D > 39$  mm given in ISO 4032 have a minimum height  $m_{\text{min}}$  less than  $0,80D$ . These nuts heights originate from former DIN 934<sup>1)</sup>, and they have not been resized up to now: **this means that such nuts would need a higher hardness and/or a greater minimum height to match the Alexander theory and meet the requirements of this document.** However, increased hardness alone cannot always compensate for an insufficient height to avoid the thread stripping failure mode of the nut.

Therefore, mechanical properties for nuts with  $D < 5$  mm and for nuts with  $D > 39$  mm are not specified in this document, and property classes cannot be assigned in product standards. Consequently, the mechanical properties and related tests to be performed as well as the relevant marking and labelling should be specified by agreement between the purchaser and the supplier.

1) DIN 934 has been withdrawn in 1992 and replaced by ISO 4032.

## Annex C (informative)

### Stress under proof load, $S_p$

Stress under proof load  $S_p$  is related to proof load values  $F_p$  and to the nominal stress area of the bolt  $A_s$ , as given in [Formula \(C.1\)](#):

$$S_p = \frac{F_p}{A_{s,nom}} \quad (\text{C.1})$$

Stress under proof load is given in [Tables C.1](#) and [C.2](#) for information only.

$S_p$  values of [Tables C.1](#) and [C.2](#) are the result of the calculations provided in ISO/TR 16224. These calculation groupings are the basis for the revision of the hardness values and proof load values of this document. During this last revision, the proof load values from ISO 898-2:1992 were updated according to the recalculated values only if the difference between the stress under proof load 1992 and 2022 was above 5 %. There is therefore a non-consistency between the normative proof load values of this document and the corresponding calculated  $S_p$  given in [Tables C.1](#) and [C.2](#).

The proof load values specified in [Tables 5](#) and [6](#) of this document are to be met.

**Table C.1 — Stress under proof load,  $S_p$  — Coarse pitch thread**

Thread <i>D</i>	Stress under proof load, $S_p$ (MPa)						
	Property class						
	04	05	5	6	8	10	12
Nominal tensile strength $R_{m,nom}$ of the mating bolt (ISO 898-1)	—	—	500	600	800	1 000	1 200
M5 to M7	380	500	585	680	860	1 040	1 150
M8 to M10			605	705	885		1 180
M12 to M16			610	710	895	1 050	1 195
M18 to M24			640	740	965	1 070	1 205
M27 to M39			660	760	985	1 095	1 220

**Table C.2 — Stress under proof load,  $S_p$  — Fine pitch thread**

Thread <i>D</i> (mm)	Stress under proof load, $S_p$ (MPa)					
	Property class					
	04	05	6	8	10	12
Nominal tensile strength $R_{m,nom}$ of the mating bolt (ISO 898-1)	—	—	600	800	1 000	1 200
8 to 10	380	500	795	970	1 100	1 200
12 to 16			790		1 110	1 210
18 to 24			870	1 030	1 080	1 215
27 to 33			1 045	1 230		
36 to 39			930	1 090		

Proof load values not specified in [Table 5](#) or [6](#) should be calculated by using the exact data for  $A_s$  (see hereafter) and only at the end, the values should be rounded to the next upper 10 N up to 100 000 N, and to the next upper 100 N above.

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In accordance with ISO 898-1, the nominal stress area  $A_s$  is calculated as given in [Formula \(C.2\)](#) and [Formula \(C.3\)](#):

$$A_{s,\text{nom}} = \frac{\pi}{4} \left( \frac{d_2 + d_3}{2} \right)^2 \quad (\text{C.2})$$

where

$d_2$  is the basic pitch diameter of external thread in accordance with ISO 724

$d_3$  is the minor diameter of external thread

$$d_{3,\text{nom}} = d_1 - \frac{H}{6} \quad (\text{C.3})$$

where

$d_1$  is the basic minor diameter of external thread in accordance with ISO 724

$H$  is the height of the fundamental triangle of the thread in accordance with ISO 68-1

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- [5] 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*
- [6] ISO 898-3, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 3: Flat washers with specified property classes*
- [7] ISO 898-6,<sup>2)</sup> *Mechanical properties of fasteners — Part 6: Nuts with specified proof load values — Fine pitch thread*
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2) Withdrawn and replaced by ISO 898-2.

