INTERNATIONAL STANDARD

ISO 898-2

Fourth edition
2022-09

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).

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).

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.

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),

  - 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.

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[20] in accordance with the Alexander's theory[21], 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, $m_{th,design}$, together with the mechanical properties. $m_{th,design}$ is specified in Figure 1 and Table 1. $m_{th,design}$ 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.

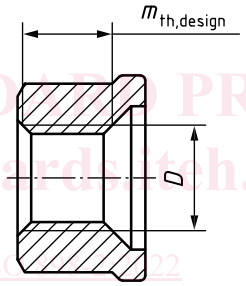

Figure 1 — Design thread height, $m_{th,design}$

Table 1 — Design thread height for nuts per drawing

Regular nuts (style 1)	**High nuts** (style 2)	**Thin nuts** (style 0)
$0{,}73D \leq m_{th,design,min} < 0{,}83D$	$m_{th,design,min} \geq 0{,}83D$	$0{,}40D \leq m_{th,design,min} < 0{,}73D$
NOTE 1 Limits for $m_{th,design,min}$ 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° for regular and high nuts, 110° 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	12.9/12.9

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 °C to +150 °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.