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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

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Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 16224

Fasteners — Calculation methods for bolt/nut assemblies — Nut design

*Fixations — Méthodes de calcul pour les assemblages vis/écrou
— Conception des écrous*

ICS: 21.060.20

ISO/TC 2/SC 12

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This document is circulated as received from the committee secretariat.

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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*.

This document cancels and replaces the first edition (ISO/TR 16224:2012), which has been technically revised.

The main changes are as follows:

- the type of ISO document has been changed from Technical Report to International Standard;
- the title has been changed to “Fasteners — Calculation methods for bolt/nut assemblies — Nut design”;
- explanations for the loadability of bolt/nut assembly including the influencing factors have been moved to [Annex A](#);
- some editorial corrections have been made on the [Formulae \(1\), \(6\), \(7\) and \(11\)](#);
- the deviations assumed for D_2 and D_1 have been amended (see [Table 1](#));
- [Figure 2](#) was amended to include the nuts with chamfers on both sides;
- the symbol θ was introduced to consider countersunk (chamfer) angles other than 90° (e.g., 110° to 120° for thin nuts);
- for the conversion from the nut material strength R_{mn} to Vicker's hardness and vice versa in the range of 130 HV to 303 HV, the regression Formula was introduced, which gives similar values to the original Alexander's calculation^[7];
- the values of minimum hardness HV_{min} and corresponding stress under proof load S_p were recalculated and amended considering the above changes (see [Tables 2 and 3](#));
- all the technical backgrounds for the specifications in ISO 898-2: 2022 have been explained for traceability of the specified values of minimum hardness and the proof loads (see [Annex B](#));

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- calculations for nuts with sizes $M1,6 \leq D < M5$ and $39 \text{ mm} < D \leq 64 \text{ mm}$ (not included in ISO 898-2) were added in order to standardize the new nut heights corresponding to style 1 and style 2 as specified in ISO 898-2 (see [Annex C](#)).

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.

Fasteners — Calculation methods for bolt/nut assemblies — Nut design

1 Scope

This document specifies calculation methods for nuts designed to be mated with bolts, screws and studs in accordance with ISO 898-1, for use in bolted joints under tensile loading and for tightening with tension and torsion taking into account the three possible failure modes: bolt breaking, bolt thread stripping and nut thread stripping (see [clause 5](#)).

The terms “bolt” and “nut” are used as the general terms in this document for externally threaded fasteners (i.e. bolts, screws and studs) and internally threaded fasteners (i.e. tapped holes), respectively.

This document is primarily applicable to steel hexagon nuts:

- with ISO metric thread (coarse pitch and fine pitch, see ISO 68-1),
- with diameter/pitch combinations according to ISO 261 and ISO 262,
- with thread tolerances according to ISO 965-1 and ISO 965-2,
- with nominal thread diameters $5 \text{ mm} \leq D \leq 39 \text{ mm}$, and additionally with $D < 5 \text{ mm}$ and $D > 39 \text{ mm}$ (see [Annex C](#)),
- with a hexagon shape and width across flats $s \geq 1,4 D$.

The calculation methods are also applicable to non-standard nuts or internally threaded parts with ISO metric threads. However, dimensional factors affecting the rigidity of nuts such as the width across flats, outer diameter of cylindrical nuts or other features (e.g. shape of flange) as well as thread tolerances can affect the loadability of the individual bolt/nut assemblies, see (informative) [Annex A](#) for influencing factors.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 68-1, *ISO general purpose screw threads — Basic and design profiles — Part 1: Metric screw threads*

ISO 261, *ISO general purpose metric screw threads — General plan*

ISO 262, *ISO general purpose metric screw threads — Selected sizes for bolts, screws, studs and nuts*

ISO 724, *ISO general purpose metric screw threads — Basic dimensions*

ISO 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

ISO 898-2, *Fasteners — Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes*

ISO 965-1, *ISO general purpose metric screw threads — Tolerances — Part 1: Principles and basic data*

ISO 965-2, *ISO general purpose metric screw threads — Tolerances — Part 2: Limits of sizes for internal and external threads (tolerance classes 6 H and 6 g for M1,6 to M100 and 5H and 6h for M1 to M1,4)*

ISO 965-5, *ISO general purpose metric screw threads — Tolerances — Part 5: Limits of sizes for internal threads to mate with hot-dip galvanized external threads with maximum size of tolerance position h before galvanizing*

ISO 16047, *Fasteners — Torque/clamp force testing*

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Symbols

For the purposes of this document, the following symbols apply.

A_s	stress area of the bolt taking into account the thread tolerance, in mm ²
$A_{s, \text{nom}}$	nominal stress area of the bolt specified in ISO 898-1, in mm ²
A_{Sb}	shear area of the bolt thread, in mm ²
A_{Sn}	shear area of the nut thread, in mm ²
C_1	nut dilation factor
C_2	thread bending factor for bolts
C_3	thread bending factor for nuts
d	nominal thread diameter of the bolt, in mm
d_1	basic minor diameter according to ISO 724, in mm
d_2	basic pitch diameter of the bolt thread according to ISO 724, in mm
d_3	minor (root) diameter of the bolt thread, in mm
d_a	countersunk diameter of the nut, in mm
d_A	equivalent diameter of the stress area A_s , in mm
D	nominal thread diameter of the nut, in mm
D_1	minor diameter of the nut, in mm
D_2	pitch diameter of the nut, in mm
D_m	mean diameter of bell mouthed section of formed nut in the effective nut height or the length of thread engagement m_{eff} in mm
F	tensile load, (general), in N
F_{Bb}	bolt breaking load, in N
F_m	ultimate tensile load, in N
F_p	proof load, in N

F_S	stripping load of bolt/ nut assembly, in N
F_{Sb}	bolt thread stripping load, in N
F_{Sn}	nut thread stripping load, in N
F_u	ultimate clamp force, in N specified in ISO 16047
F_y	yield clamp force, in N specified in ISO 16047
h_c	height of chamfer per nut face, in mm
H	height of the fundamental triangle of the thread according to ISO 68-1, in mm
m	height of a nut, in mm
m_c	critical nut height giving same probabilities of stripping and breaking failure modes, in mm
m_{eff}	effective nut height, in mm
$m_{eff, c}$	critical effective nut height giving same probabilities of stripping and breaking failure modes, in mm
m_{mc}	critical nut height giving same probabilities of stripping and breaking failure modes taking into account the deviations in a manufacturing lot, in mm
P	thread pitch, in mm
R_{eL}	lower yield stress according to ISO 898-1, in MPa
R_m	tensile strength of the bolt material according to ISO 898-1, in MPa
R_{mn}	tensile strength of the nut material, in MPa
$R_{p0,2}$	stress at 0,2 % non-proportional elongation according to ISO 898-1, in MPa
R_s	strength ratio denoted by $(R_{mn} \cdot A_{sn})/(R_m \cdot A_{sb})$
s	width across flats of the nut, in mm
S_p	stress under proof load, in MPa
x	shear strength/tensile strength ratio
μ_{th}	coefficient of friction between threads
θ	countersunk angle of the nut, in degrees
τ_{Bb}	shear strength of the bolt material, in MPa
τ_{Bn}	shear strength of the nut material, in MPa

5 Calculation of the fracture loads in bolt/nut assemblies

5.1 General

When static tensile overload is applied to bolt/nut assemblies, three possible failure modes (i.e. bolt breaking, bolt thread stripping and nut thread stripping) characterized by three different fracture loads can occur:

- bolt breaking load (F_{Bb});
- bolt thread stripping load (F_{Sb});