INTERNATIONAL STANDARD

ISO 8641

Second edition
2008-09-01

Aerospace — Self-locking nuts with maximum operating temperature greater than 425 °C — Procurement specification

Aéronautique et espace — Écrous à freinage interne dont la température maximale d'utilisation est supérieure à 425 °C — Spécification d'approvisionnement

Reference number
ISO 8641:2008(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 8641 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 4, *Aerospace fastener systems*.

This second edition cancels and replaces the first edition (ISO 8641:1987) which has been technically revised.

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Aerospace — Self-locking nuts with maximum operating temperature greater than 425 °C — Procurement specification

1 Scope

This International Standard specifies the required characteristics for metric self-locking nuts, with MJ thread, for use in aerospace construction at a maximum temperature greater than 425 °C.

It is applicable to nuts as defined above, provided that reference is made to this International Standard in the relevant definition document.

2 Normative references

The following referenced documents are indispensable for the application 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 691, *Assembly tools for screws and nuts — Wrench and socket openings — Tolerances for general use*

ISO 1463, *Metallic and oxide coatings — Measurement of coating thickness — Microscopical method*

ISO 2859-1:1999, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptable quality level (AQL) for lot-by-lot inspection*

ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*

ISO 5855-2, *Aerospace — MJ threads — Part 2: Limit dimensions for bolts and nuts*

ISO 7403, *Aerospace — Spline drives — Wrenching configuration — Metric series*

ISO 7870-1, *Control charts — General guidelines*

ISO 7966, *Acceptance control charts*

ISO 8258, *Shewhart control charts*

ISO 8642, *Aerospace — Self-locking nuts with maximum operating temperature greater than 425 °C — Test methods*

ISO 8788, *Aerospace — Nuts, metric — Tolerances of form and position*

ISO 9199, *Aerospace — Nuts, bihexagonal, self-locking, MJ threads, classifications: 1 100 MPa (at ambient temperature)/425 °C, 1 100 MPa (at ambient temperature)/650 °C, 1 210 MPa (at ambient temperature)/425 °C, 1 210 MPa (at ambient temperature)/730 °C, 1 550 MPa (at ambient temperature)/235 °C, 1 550 MPa (at ambient temperature)/425 °C and 1 550 MPa (at ambient temperature)/600 °C — Dimensions*

ISO/TR 13425, *Guidelines for the selection of statistical methods in standardization and specification*

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3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
definition document
document specifying all the requirements for nuts, i.e.:

— metallurgical;

— geometrical and dimensional;

— functional (strength and temperature classes)

NOTE The definition document can be an International Standard, a national standard, an in-house standard or a drawing.

3.2
finished nut
nut ready for use, inclusive of any possible treatments and/or surface coatings, as specified in the definition document

3.3
batch
definite quantity of some commodity manufactured or produced under conditions which are presumed to be uniform

NOTE For the purposes of this International Standard, a batch is a quantity of finished nuts, of the same type and same diameter, produced from a material obtained from the same melt, manufactured in the course of the same production cycle, following the same manufacturing route and having undergone all the relevant heat treatments and surface treatments.

3.4
crack
rupture in the material which may extend in any direction and which may be intercrystalline or transcrystalline in character

3.5
seam
open surface defect resulting from extension of the metal

3.6
lap
folding over of unwelded metal that can arise when the material is formed (drawing) or in the finished product (pressing or forging)

3.7
inclusions
non-metallic particles originating from the material manufacturing process

NOTE These particles can be isolated or arranged in strings.

3.8
critical defect
defect that, according to judgement and experience, is likely to result in hazardous or unsafe conditions for individuals using, maintaining or depending upon the considered product, or that is likely to prevent performance of the function of a major end item

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3.9
major defect
defect other than critical, that is likely to result in a failure or to reduce materially the usability of the considered product for its intended purpose

3.10
minor defect
defect that is not likely to reduce materially the usability of the considered product for its intended purpose, or that is a departure from established specifications having little bearing on the effective use or operation of this product

3.11
sampling plan
plan according to which one or more samples are taken in order to obtain information and possibly reach a decision

NOTE For the purposes of this International Standard, each sampling plan specifies the number of nuts to be inspected as a function of the size of the batch and the acceptance number [number of defective items acceptable (Ac)][1)].

3.12
simple random sampling
sampling of n items from a population of N items in such a way that all possible combinations of n items have the same probability of being chosen

3.13
acceptance quality limit
AQL
maximum percent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average

NOTE Variant: quality limit which in a sampling plan corresponds to a specified but relatively high probability of acceptance.

3.14
limiting quality
LQ
⟨sampling plan⟩ quality level that corresponds to a specified and relatively low probability of acceptance

NOTE 1 It is the limiting lot quality characteristic that the consumer is willing to accept with a low probability that a lot of this quality would occur.

NOTE 2 For the purposes of this International Standard, the limiting quality given in Table 11 corresponds to a consumer's risk of 10 %.

3.15
self-locking torque
torque to be applied to the nut or bolt to maintain its movement of rotation in relation to the associated part, the assembly being under no axial load and the nut-locking system being completely engaged with the bolt (two pitches minimum protrusion including the end chamfer)

3.16
seating torque
tightening torque to be applied to the nut or bolt to introduce or to increase the axial load in the assembly

3.17
unseating torque
untightening torque to be applied to the nut or bolt to reduce or remove the axial load in the assembly

1) Ac = acceptance number (supplementary information taken from ISO 2859-1).

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3.18
breakaway torque
torque required to start unscrewing the nut or bolt with respect to the associated part, with the nut-locking device still fully engaged on the bolt, but after the axial load in the assembly has been removed by unscrewing half a turn followed by a half in rotational movement

3.19
wrench torque
tightening and untightening torques which the driving feature of the nut shall withstand repeatedly, without any permanent deformation which would prevent the appropriate wrench from being used and preclude re-use of the nut

4 Quality assurance

4.1 General

The manufacturer shall be capable of continuous production of bolts complying with the quality requirements specified in this International Standard. It is recommended that the manufacturer be certified to a recognized quality management system. The certification authority may be the prime contractor.

The purpose of qualification inspections of nuts is to check that the design and manufacturing conditions of a bolt allow it to satisfy the requirements of this International Standard.

Qualification of the bolts shall be granted by the Certification Authorities in the purchaser's country, or their appointed representative, who may be the prime contractor.

The purpose of production acceptance inspection of a nut is to check, as simply as possible, using a method which is inexpensive but the most representative of the actual conditions of use, with the uncertainty inherent in statistical sampling, that the bolts satisfy the requirements of this International Standard.

Production acceptance inspections and tests shall be carried out by the manufacturer, or under his responsibility.

4.2 Qualification inspection and test conditions

Qualification inspections and tests (requirements, methods, numbers of nuts) are specified in Table 1. They shall be carried out on:

— each type and diameter of nut;

— 100 nuts selected from a single batch by simple random sampling.

The test programme may possibly be reduced, or qualification of a nut granted, without inspection or testing; any such decision shall be based on the results obtained on similar types and diameters of nuts provided that the design and manufacturing conditions are identical.

The inspections and tests shall be repeated on any nut if the supplier or the manufacturing conditions have changed. Qualification inspections and tests are summarized in Table 2.

4.3 Production acceptance inspection and test conditions

Production acceptance inspections and tests (requirements, methods, numbers of nuts) are specified in Table 1. They shall be carried out on each batch. Nuts from the batch to be tested shall be selected by simple random sampling.

Each nut may be submitted to several inspections or tests.

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The nuts to be subjected to destructive inspections or tests may be those on which non-destructive inspection or testing has been carried out.

If a more stringent inspection is deemed necessary, all or part of the qualification inspections and tests may be performed during the production acceptance inspections and testing. In this case, the number of nuts submitted is the same as that submitted for qualification inspections and tests.

Batches declared unacceptable after the production acceptance inspections and tests shall be submitted for re-inspection or testing only after all the defective units have been removed and/or defects have been corrected. In this case, the attribute(s) which caused the rejection shall be verified using a sample of twice the normal size with the same number of defective items acceptable. Production acceptance inspections and tests are summarized in Table 2.

4.4 Use of “statistical process control (SPC)”

Where a characteristic is obtained by a controlled statistical process, the manufacturer has the possibility, in order to declare conformity of the characteristic, of refraining from the final systematic sampling provided for in this International Standard, if he is capable of **formally justifying** this choice by using ISO/TR 13425 and the standards quoted in it as a basis.

This justification will include the following phases:

— analysis of the product's key characteristics;

— analysis of the risks for each implemented process;

— determination of the parameters and/or characteristics to be respected under SPC;

— determination of the capabilities of each process;

— drawing up an inspection plan and integration in the manufacturing process;

— drawing up of routes and control charts (ISO 7966, ISO 7870-1, ISO 8258);

— use of control charts for data consolidation;

— determination of the audits to be run and the control to be carried out to ensure reliability of the device.

To be usable in production, this process should have been validated beforehand by the qualifying body, either during the qualification phase, or *a posteriori* according to the case, by analysing the justificatory file and the results of the qualification inspections such as provided for in Clause 5.

5 Technical requirements

The technical requirements of this International Standard are given in Table 1.

They complement the requirements of all other standards or specifications referenced in the definition document of the nut.

NOTE The attention of the users of this International Standard is drawn to the fact that if there is no International Standard specifying the method to be used, a prior agreement is necessary between the user and the manufacturer with respect to the following inspections and tests:

— spectrographic analysis or spectroscopic analysis of the material (see 5.1.1);

— micrographic inspection of the structure of the material (see 5.1.2);

— fluoroscopic inspection of surface discontinuities (see 5.1.3);

— inspection by chemical reagent to determine type of surface coating (see 5.2.2);

— tactile inspection or inspection using a profilometer of the surface roughness (see 5.3.2).

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Table 1 — Technical requirements and test methods

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
5.1		Material				
	5.1.1	Type	The material shall be as specified in the definition document.	Spectrographic analysis or spectroscopic analysis (method to be agreed upon between the user and manufacturer).	Qualification	3
					Production acceptance	Table 12 column B
	5.1.2	Microstructure	Nuts shall be free from cracks. The inclusions shall not exceed the values in the material standard, when specified therein. Nuts shall display no sign of overheating (nuts comprising ground parts) or of oxidation greater than 0,01 mm deep on machined areas and bearing surfaces and no deeper than 0,1 mm on non-machined areas. Grain size, measured approximately at the geometrical centre of the half-section of the nut, shall be in accordance with the requirements of the material standard.	Micrographic inspection of a transverse section (method to be agreed upon between the user and manufacturer).	Qualification [a]	5
					Production acceptance	Table 12 column B
	5.1.3	Surface discontinuities [b]	The types of permissible surface discontinuity are given in Annex A. The maximum depth allowed for these discontinuities is given in Table 13.	Fluoroscopic inspection (method to be agreed upon between the user and manufacturer).	Qualification [a]	5
					Production acceptance	Table 12 column B
			Cracks are not permitted.	In the event of any doubt arising as to the nature of the defects detected, inspect defective nuts at a magnification of × 10 after sectioning.		
	5.1.4	Hardness	The hardness of the finished nuts shall be within the limits specified in the definition document for the nut or in the material standard.	See ISO 8642.	Qualification	5
					Production acceptance	Table 12 column B

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Table 1 (*continued*)

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
5.2		Surface coating				
	5.2.1	Presence	Surface coating shall be applied at the locations specified in the definition document.	Visual examination	Qualification	100
					Production acceptance	Tables 10 and 11
	5.2.2	Type	Surface coating shall be as specified in the definition document.	Visual examination or inspection by chemical reagent in case of doubt (method to be agreed upon between the user and manufacturer).	Qualification[a]	3
					Production acceptance	Table 12 column A
	5.2.3	Thickness	The thickness of the surface coating shall be within the limits specified in the definition document.	Device for measuring the thickness of surface coatings. In case of doubt, micrographic inspection in accordance with ISO 1463 [c]	Qualification[a]	5
					Production acceptance	Table 12 column A
	5.2.4	Adhesion			Qualification[a]	5
		a) of molybdenum disulfide (MoS_2)	There shall be no sign of flaking, cracking or softening after test.	Heat the nuts to a temperature of 260 °C for 3 h, then cool the nuts slowly to ambient temperature.	Production acceptance	Table 12 column B
		b) of silver	There shall be no sign of blisters or exfoliation after test.	Heat the nuts to a temperature of 550 °C for 4 h, then rapidly cool the nuts with compressed air [at a pressure of (0,3 to 0,4) MPa] by means of a nozzle with a diameter of 1,5 mm held close to the surface of the nuts.		
5.3		Surface condition				
	5.3.1	Appearance	Finished nuts shall be free from burrs and bumps.	Visual examination In the event of any doubt arising as to the nature of the defects detected, inspect defective nuts at a magnification of × 10 after sectioning.	Qualification[a]	100
					Production acceptance	Tables 10 and 11
	5.3.2	Surface Roughness [b]	The surface roughness of the nuts shall be as specified in the definition document.	See ISO 4288.	Qualification[a]	5
				Visual examination		
5.4		Marking	The nuts shall be marked as specified in the definition document.	Visual examination	Qualification[a]	100
					Production acceptance	Tables 10 and 11

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Table 1 (*continued*)

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
5.5		Dimensions				
	5.5.1	General dimensions	The dimensions and any deviations in form and position, measured at ambient temperature, shall be within the limits specified in the definition document.	Suitable limit gauges or measuring instruments.	Qualification [a]	20
					Production acceptance	Tables 10 and 11
	5.5.2	Thread	The thread shall be in conformity with the definition document.		Qualification [a]	20
					Production acceptance	Tables 10 and 11
			The threaded GO gauge shall be capable of being freely screwed for at least one turn.	Threaded GO/NO GO gauges		
			As regards nuts with molybdenum disulphide dry-lubrication, a bolt with standard threads shall be capable of being freely screwed for at least one turn.	Bolt with standard threads in accordance with ISO 5855-2.		
	5.5.3	Wrench engagement [d]	The deformation necessary to achieve internal locking shall not prevent a wrench from being used. A female gauge, of identical form to the driving feature of the nut to be inspected, shall be capable of being freely installed over a length equal to the wrenching height specified in the definition document.	Female gauge satisfying the following dimensional requirements: a) Hexagonal and bihexagonal drive Minimum tolerances specified in ISO 691; b) Spline drive Maximum material condition of female wrenching device in accordance with ISO 7403.	Qualification [a]	20
					Production acceptance	Tables 10 and 11
	5.5.4	Squareness of the bearing surface	Any out-of-squareness of the bearing surface, relative to the thread, shall be within the limits specified in ISO 8788.	See ISO 8642.	Qualification[a]	20
					Production acceptance	Tables 10 and 11

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Table 1 (*continued*)

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
5.6		Performance				
	5.6.1	Axial load	The finished nuts shall withstand the axial load specified for their tensile strength class, as laid down in the definition document.	See ISO 8642. The load to be applied is specified in Table 3.		
		a) at ambient temperature	After test, the nuts shall not display: — any cracks; — any permanent set, and the locking torque shall not be less than the values specified in Table 8, column 4.		Qualification [a] Production acceptance	4 Table 12 column B
		b) at ambient temperature after maximum operating temperature baking	After test, the nuts shall not display: – any cracks; – any fracture. Permanent set and resultant effects (reduction or disappearance of the locking torque) are permissible.		Qualification [a]	4
	5.6.2	Wrenching feature [d]	Finished nuts shall withstand the torque specified for the tensile strength class, as laid down in the definition document, and shall not display any permanent deformation of the wrenching feature.	See ISO 8642. The torque shall be as specified in Table 4 and shall be applied × 15 by alternately tightening and untightening the nut.	Qualification [a]	3
	5.6.3	Torque-out [e]	The retention device in the body of the nut shall be capable of withstanding the torque arising during screwing, tightening, unscrewing and untightening, and the body of the nut shall not become detached from the plate, cage or gang channel. No crack or deformation shall be present which is likely to prevent the nut from being re-used.	See ISO 8642. The torque specified in Table 6 shall be applied in both directions.	Qualification [a]	5

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Table 1 (*continued*)

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
	5.6.4	No rotation of the captive washer	During application of the seating torque, the washer shall not rotate on the bearing plate. The test is not applicable to nuts with a diameter < 4 mm. The test shall be carried out on one cycle only.	See ISO 8642. The squeeze torque applied shall be equal to $0{,}5 \times$ the value specified in Table 5. The seating torque to be applied is the torque specified in Table 5.	Qualification[a]	5
	5.6.5	Push-out [f]	Finished nuts shall be capable of withstanding the axial load which may arise during screwing, without any cracks appearing. Any deformation at the thread axis shall be less than 0,8 mm and shall not prevent a standard bolt being installed over at least one turn.	See ISO 8642. The load specified in Table 7 shall be applied.	Qualification[a]	5
	5.6.6	Locking	The locking device shall enable: — the nuts to be re-used after several removal operations; — correct tensioning of the bolts when a normal tightening torque is applied and there shall be no risk of causing the bolts to fall under tension. After the test has been completed, the thread of the bolts and nuts shall not display any signs of stripping, permanent deformation or seams likely to reduce the effectiveness of the threads. Furthermore, the bolt thread shall enable a new nut to be screwed up to the point where the locking device is engaged.			
	5.6.6.1	Presence of locking element		Visual examination	Qualification[a]	100
					Production acceptable	Tables 10 and 11
	5.6.6.2	Inspection of locking torque at ambient temperature				

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Table 1 (*continued*)

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
	5.6.6.2.1	— test over 15 cycles	The self-locking torque shall lie within the maximum and minimum values specified in Table 8, columns 2 and 4.	See ISO 8642. The tightening torque to be applied is specified in Table 5.	Qualification [a]	10
	5.6.6.2.2	— test over three cycles	The self-locking torque shall lie within the maximum and minimum values specified in Table 8, columns 2 and 5 for the first cycle and columns 3 and 6 for the second and third cycles.	See ISO 8642. The tightening torque to be applied is specified in Table 5.	Production acceptance	Table 12 column B
	5.6.6.3	Inspection of locking torques at ambient temperature, after exposure to the maximum operating temperature	After the maximum operating load of the associated bolt has being applied and after the nut has been exposed five times for 6 h ± 15 min to the maximum operating temperature as specified in the definition document of the nut, to within ± 8 °C, the locking torques, measured after each cycle, the nut being cooled down slowly to ambient temperature, shall be within the values specified in Table 8, columns 3 and 4.	See ISO 8642.	Qualification[a]	10
	5.6.6.4	Permanent set	The locking torques of finished nuts, measured at ambient temperature on a maximum threaded mandrel followed by a minimum threaded mandrel, shall lie within the maximum and minimum values specified in Table 8, columns 2 and 4.	See ISO 8642.	Qualification[a]	3

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Table 1 (*continued*)

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
	5.6.7	Vibration [g]	The finished nuts shall be capable of absorbing, without failure, the energy imparted by vibrations, tremors, shocks, etc., that are likely to be experienced in operation without suffering any structural damage (cracks, fracture of the insert, expulsion of the locking elements, fracture of threads, etc.) or any loss of their locking characteristics.	See ISO 8642. The tightening torque specified in Table 9 shall be applied × 5. Half of the nuts to be tested (five) shall be exposed to the maximum operating temperature specified in the definition document before the tightening torque is applied for the first time. The test shall be performed for a period of time equivalent to 30 000 cycles of vibration at 30 Hz. Rotation of the nut, relative to the bolt, less than or equal to 360° is permissible. Failure of the bolt shall not be considered as grounds for rejecting the nut.	Qualification[a]	10
	5.6.8	Swaging [h]	The shank of finished clinch nuts shall be capable of being flared using a 60° conical tool to 1,2 × its original diameter for A286 and Inconel 718 nuts and to 1,15 × its original diameter for Waspaloy nuts without cracking or fracturing.	See ISO 8642.	Qualification[a]	5
					Production acceptance	Table 12 column B
5.7		Delivery				
	5.7.1	Packaging	The nuts shall be packed so as to prevent damage and corrosion during handling, transportation and storage. Each primary package shall only contain nuts with the same part number and the same production lot number.	Visual examination	Qualification[a]	100 %
					Production acceptance	

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Table 1 (*continued*)

Subclause		Characteristic	Technical requirement	Inspection and test method	Test category	Sample size
	5.7.2	Labelling	Each individual package shall have the manufacturer's name or trade mark, the complete part number, the quantity, the production lot number and the date of manufacture clearly shown on a label.	Visual examination	Qualification[a]	100 %
					Production acceptance	

[a] See Clause 4 for applicability conditions.

[b] Inspection to be carried out before coating of the surface or after removal of the surface coating.

[c] This inspection may be performed on nuts that have been subjected to the inspection of microstructure (see 5.1.2).

[d] Test applicable only to wrench nuts.

[e] Test applicable only to floating anchor nuts, gang channel nuts and fixed anchor nuts, produced in several parts and assembled by brazing or clinching.

[f] Test applicable only to gang channel and anchor nuts, with the exception of corner nuts (see ISO 8642) and of reduced series single-lug nuts.

[g] Test applicable only to nuts of diameters of 5 mm, 6 mm, 7 mm, 8 mm, 10 mm and 12 mm (see ISO 8642).

[h] Test applicable only to clinch nuts.

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Table 2 — Summary of qualification and production acceptance inspections and tests

Characteristic	Qualification [a]	Production acceptance
	Subclause	
Material		
Type	5.1.1	5.1.1
Microstructure	5.1.2	5.1.2
Surface discontinuities	5.1.3	5.1.3
Hardness	5.1.4	5.1.4
Surface coating		
Presence	5.2.1	5.2.1
Type	5.2.2	5.2.2
Thickness	5.2.3	5.2.3
Adhesion	5.2.4	5.2.4
Surface condition		
Appearance	5.3.1	5.3.1
Roughness	5.3.2	
Marking	5.4	5.4
Dimensions		
General dimensions	5.5.1	5.5.1
Thread	5.5.2	5.5.2
Wrench engagement	5.5.3	5.5.3
Squareness of the bearing surface	5.5.4	5.5.4
Performance		
Axial load	5.6.1	5.6.1
Wrenching feature	5.6.2	
Torque-out	5.6.3	
No rotation of the captive washer	5.6.4	
Push-out	5.6.5	
Presence of the locking element	5.6.6.1	5.6.6.1
Inspection of locking torque at ambient temperature		
— test over 15 cycles	5.6.6.2.1	
— test over 3 cycles		5.6.6.2.2
— after exposure to the maximum operating temperature	5.6.6.3	
Permanent set	5.6.6.4	
Vibration	5.6.7	
Swaging	5.6.8	5.6.8
Delivery		
Packaging	5.7.1	5.7.1
Labelling	5.7.2	5.7.2

[a] See 4 for applicability conditions.

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Table 3 — Loads to be applied in the axial load test (see 5.6.1)

Thread	Load, F [a] kN		
	Tensile strength class, R_m, of the nut		
	$R_m = 1\,100$ MPa	$R_m = 1\,210$ MPa	$R_m = 1\,550$ MPa
MJ4 × 0,7	10,5	10,8	14,8
MJ5 × 0,8	16,8	17,4	23,7
MJ6 × 1	23,9	24,7	33,7
MJ7 × 1	34	35,3	47,9
MJ8 × 1	45,9	47,9	64,6
MJ10 × 1,25	71,6	74,8	101
MJ12 × 1,25	106,8	112	150,5
MJ14 × 1,5	144,7	152	203,9
MJ16 × 1,5	193,2	204	272,2
MJ18 × 1,5	248,5	263	350,2
MJ20 × 1,5	310,8	330	438
MJ22 × 1,5	380	405	535,5
MJ24 × 2	441,8	468	622,6

[a] See Annex B (informative).

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Table 4 — Torques to be applied for testing the wrenching feature (see 5.6.2)

Nominal thread diameter	Torque					
	Tensile strength class of the nut					
	1 100 MPa [a]		1 210 MPa		1 550 MPa [e]	
	MoS_2	Silver plated or uncoated	Across flats	Torque	MoS_2	Silver plated
mm	N·m	N·m	mm	N·m	N·m	N·m
5	11,4	13,8	7 [b]	19 [a]	32	32
			8 [c]	23 [d]		
6	19,5	24	8 [b]	32 [a]	41	41
			9 [c]	39 [d]		
7	32	40	9 [b]	53 [a]	60	60
			10 [c]	64 [d]		
8	48	60	10 [b]	82 [a]	90	90
			12 [c]	98 [d]		
10	94	115	12 [b]	158 [a]	160	165
			14 [c]	190 [d]		
12	166	200	14 [b]	280 [a]	290	295
			17 [c]	336 [d]		
14	262	330	17 [b]	445 [a]	480	480
			19 [c]	534 [d]		
16	397	500	19 [b]	675 [a]	557	705
			22 [c]	810 [d]		
18	571	720	22 [b]	975 [a]	800	1 020
			24 [c]	1 170 [d]		
20	790	1 000	24 [b]	1 350 [a]	1 110	1 410
			27 [c]	1 620 [d]		
22	1 060	1 350	27 [b]	1 830 [a]	1 490	1 890
			30 [c]	2 200 [d]		
24	1 350	1 700	30 [b]	2 230 [a]	1 890	2 400
			—	—		

[a] Value = 2,5 × tightening torque to be applied for measuring locking torques.

[b] Double reduced: thread nominal diameter and across flats associations in accordance with ISO 9199.

[c] Single reduced: thread nominal diameter and across flats associations incremented of one step of across flats with regard to ISO 9199.

[d] Value = 3 × tightening torque to be applied for measuring locking torques.

[e] Value included between 1,5 × tightening torque to be applied for measuring locking torques and 80 % of endurance integrity torque agreed by the driver.

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Table 5 — Tightening torques to be applied for measuring locking torques
(see 5.6.6.2.1, 5.6.6.2.2 and 5.6.6.3)

Nominal thread diameter	Torque [a]				
	Tensile strength class of the nut				
	1 100 MPa		1 210 MPa	1 550 MPa	
	MoS_2	Silver plated or uncoated		MoS_2	Silver plated
mm	N·m	N·m	N·m	N·m	N·m
4	3	2,8	3,9	6,1	7,4
5	5,7	5,5	7,7	11,8	14,5
6	9,6	9,6	13	20	24,5
7	15	16	21,4	32,5	40
8	23	24	32,6	48,5	60
10	43	46	63,8	93	116
12	75	80	112	164	204
14	117	132	178	258	322
16	177	200	270	390	488
18	253	288	390	559	703
20	344	400	541	768	970
22	460	540	733	1 027	1 300
24	582	685	929	1 304	1 645

[a] Values = torque required to induce 75 % of 2 % proof stress in companion bolt.

Table 6 — Torques to be applied in the torque out test (see 5.6.3)

Nominal thread diameter	Torque
mm	N·m
4	5
5	10
6	16
7	22
8	33
10	63

Table 7 — Loads to be applied in the push out test (see 5.6.5)

Nominal thread diameter	Torque
mm	N·m
4	850
5	900
6	950
7	1 050
8	1 100
10	

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Table 8 — Locking torques (see 5.6.6)

Nominal thread diameter	Locking torque N·m				
mm	max. [a]	max. [b]	min. [c]	min. [d]	min. [e]
4	1,6	3,2	0,15	0,3	0,18
5	2	4	0,25	0,5	0,3
6	3,2	6,4	0,35	0,7	0,42
7	4,6	9,2	0,5	1	0,6
8	6	12	0,7	1,4	0,84
10	9,5	19	1,2	2,4	1,44
12	15	30	1,8	3,6	2,16
14	22	44	2,6	5,2	3,12
16	33	66	3,7	7,4	4,44
18	44	88	4,9	9,8	5,88
20	50	100	6,3	12,6	7,56
22	65	130	7,5	15	9
24	75	150	9,3	18,6	11,2

[a] Maximum values for test at ambient temperature:
- over 15 cycles (see 5.6.6.2.1);
- over 3 cycles (see 5.6.6.2.2);
- for permanent set (see 5.6.6.4).

[b] Maximum values for the test at ambient temperature after exposure to the maximum operating temperature (see 5.6.6.3).

[c] Minimum values for the test at ambient temperature:
- over 15 cycles (see 5.6.6.2.1);
- after exposure to the maximum operating temperature (see 5.6.6.3);
- for permanent set (see 5.6.6.4).

[d] Minimum values for first cycle of test over three cycles (see 5.6.6.2.2).

[e] Minimum values for second and third cycles of test over three cycles (see 5.6.6.2.2).

Table 9 — Tightening torques to be applied in the vibration test (see 5.6.7)

Nominal thread diameter mm	Torque N·m
5	4
6	6,4
7	9,2
8	12
10	19
12	30

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Table 10 — Classification of visual and dimensional inspections

Category	Acceptable quality level [a] AQL	Characteristics
Critical	0,4 %	Presence of locking element Thread size
Major	1 %	Diameter and squareness of bearing surface Diameter and position of rivet holes Presence of surface coating
	2,5 %	Overall length Overall width Overall height Wrenching configuration Radial float of nut element Flange dimensions Dimensions and position of counterbore Appearance Marking
Minor	4 %	All other dimensions and deviations in tolerance of form or position

[a] The acceptance quality limit (AQL) specified in this table is used to select, from Table 11, the sampling plan to be applied according to the characteristics to be inspected and the batch size.

Table 11 — Sampling plans for visual and dimensional inspections

Batch size	Sample size	Acceptance number (Ac)[a] and limiting quality (LQ) in accordance with the acceptance quality limit (AQL)							
		AQL 0,4 %		AQL 1 %		AQL 2,5 %		AQL 4 %	
		Ac	LQ_{10} %	Ac	LQ_{10} %	Ac	LQ_{10} %	Ac	LQ_{10} %
2 to 8	2	↓	↓	↓	↓	↓	↓	↓	↓
9 to 15	3	↓	↓	↓	↓	↓	↓	0	53,6
16 to 25	5	↓	↓	↓	↓	0	36,9	↑	↑
26 to 50	8	↓	↓	↓	↓	↓	↑	↓	↓
51 to 90	13	↓	↓	0	16,2	↑	↓	1	26,8
91 to 150	20	↓	↓	↑	↑	1	18,1	2	24,5
151 to 280	32	0	6,94	↓	↓	2	15,8	3	19,7
281 to 500	50	↓	↓	1	7,56	3	12,9	5	17,8
501 to 1 200	80	↓	↓	2	6,52	5	11,3	7	14,3
1 201 to 3 200	125	1	3,08	3	5,27	7	9,24	10	12,1
3 201 to 10 000	200	2	2,64	5	4,59	10	7,60	14	9,81
10 001 to 35 000	315	3	2,11	7	3,71	14	6,33	21	8,84
35 001 to 150 000	500	5	1,85	10	3,06	21	5,60	↑	↑
150 001 to 500 000	800	7	1,47	14	2,51	↑	↑	↑	↑

↑ Use sampling plan above (sample size and Ac).

↓ Use sampling plan below (sample size and Ac).

The data given in this table are based on single sampling plans for a normal inspection, as specified in ISO 2859-1:1999, Tables 2-A and 6-A.

A 100 % inspection should be performed when the sample size is as large as or larger than the batch size.

Other sampling plans specified in ISO 2859-1 may be used (double or multiple sampling), but these shall be chosen in such a way as to ensure an equivalent quality limit.

As regards those manufacturers who carry out an inspection during the manufacturing process (inspection on a machine and/or inspection between operations), the sampling plan for the final inspection shall be compiled in such a way that the overall inspection plan will guarantee an equivalent quality limit.

[a] See 3.11.

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Table 12 — Sampling plans for the inspection of mechanical and metallurgical characteristics

Batch size	Sample size		Acceptance number [a] (Ac)
	Non-destructive tests A	Destructive tests B	
⩽ 500	8	3	0
501 to 3 200	13	5	0
3 201 to 35 000	20	5	0
⩾ 35 001	32	8	0

[a] See 3.11.

Table 13 — Maximum depth of permissible surface discontinuities (see 5.1.3)

Dimensions in millimetres

Nominal thread diameter	Depth [a]
3	0,1
3,5	0,12
4	
5	
6	0,13
7	
8	0,15
10	
12	0,2
14	0,22
16	0,25
18	
20	
22	
24	0,3
27	
30	
33	
36	
39	

[a] These values do not apply to unmachined surfaces of semi-products for machined nuts for which 0,04 mm per 1,6 mm of diameter or across flats of semi-product is permissible.

EXAMPLE For a hexagonal nut manufactured from bars with an across flat dimension of 8 mm, the maximum depth of permissible surface discontinuities in millimetres should be:

$$0{,}04 \times \frac{8}{1{,}6} = 0{,}2.$$

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Annex A
(normative)

Type of permissible surface discontinuities (see 5.1.3)

The following surface discontinuities are permissible:

a) laps or seams produced in the drawing process and seams produced in the machining process;

b) laps produced in the stamping process;

c) marks caused by the forming tool used to achieve internal locking.

The location and appearance of these discontinuities are illustrated in Figure A.1.

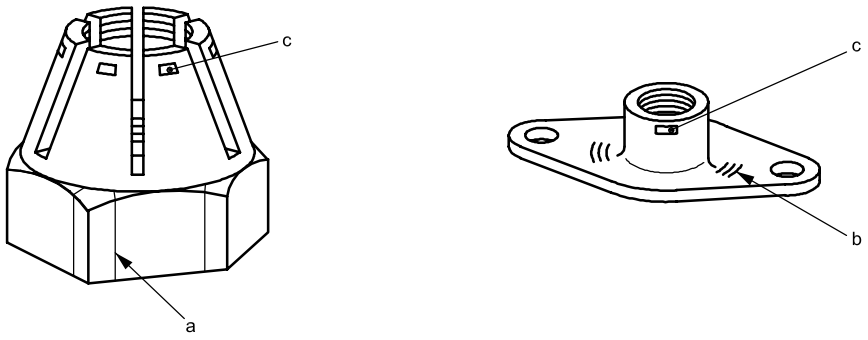

Figure A.1

These discontinuities shall not:

— result in any abrupt change in area;

— be located within the self-locking zone [apart from c)];

— be deeper than those values specified in Table 13.

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Annex B
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Cross-sectional area and formulae for axial loads (see Table 3)

B.1 Cross-sectional area

B.1.1 General

The cross-sectional area taken into consideration to calculate the axial load to be applied to a nut is the same as that of the bolt with an identical diameter and pitch manufactured in the same material.

The formula for this cross-sectional area is different according to whether the bolt thread is rolled after heat treatment (case of bolts in A286 or Inconel 718) or before heat treatment (case of bolts in Waspaloy).

B.1.2 Formulae

B.1.2.1 A286 or Inconel 718 material

$$A = \frac{\pi}{4}(d_3)^2 \left[2 - \left(\frac{d_3}{d_2} \right)^2 \right] \quad \text{(B.1)}$$

where

A is the cross-sectional area, in square millimetres;

d_2 is the maximum thread flank diameter of the bolt according to ISO 5855-2, in millimetres;

d_3 is the maximum root diameter of the bolt according to ISO 5855-2, in millimetres.

B.1.2.2 Waspaloy material

$$A = \frac{\pi}{4} \left(\frac{d_2 + d_3}{2} \right)^2 \quad \text{(B.2)}$$

B.1.3 Values

See Table B.1.

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Table B.1

Thread	Cross-sectional area	
	Nuts in A286 or Inconel 718	Nuts in Waspaloy
mm	mm^2	mm^2
MJ4 × 0,7	12,566	8,912
MJ5 × 0,8	19,635	14,374
MJ6 × 1	28,274	20,408
MJ7 × 1	38,485	29,201
MJ8 × 1	50,265	39,564
MJ10 × 1,25	78,54	61,828
MJ12 × 1,25	113,1	92,843
MJ14 × 1,5	153,9	125,622
MJ16 × 1,5	201,1	168,495
MJ18 × 1,5	254,5	217,652
MJ20 × 1,5	314,2	273,091
MJ22 × 1,5	380,1	334,814
MJ24 × 2	452,4	386,936

B.2 Axial test load

$$L = \frac{A \times R_{\mathrm{m}}}{1\ 000}\ \mathrm{kN} \tag{B.3}$$

where R_{m} is the strength class of the nut in MPa.

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