INTERNATIONAL STANDARD

ISO 9152

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Aerospace — Bolts, with MJ threads, in titanium alloys, strength class 1 100 MPa — Procurement specification

Aéronautique et espace — Vis à filetage MJ, en alliages de titane, classe de résistance 1 100 MPa — Spécification d'approvisionnement

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Contents

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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 3.

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.

International Standard ISO 9152 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 4, *Aerospace fastener systems*.

Annexes A and B of this International Standard are for information only.

Aerospace — Bolts, with MJ threads, in titanium alloys, strength class 1 100 MPa — Procurement specification

1 Scope

This International Standard specifies the characteristics and quality assurance requirements for MJ threads bolts made in titanium alloy, of strength class 1 100 MPa, for aerospace construction.

It is applicable whenever it is referenced in a definition document.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 2859-1:1989, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection.*

ISO 3452:1984, *Non-destructive testing — Penetrant inspection — General principles.*

ISO 4288:1996, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture.*

ISO 5855-2:1988, *Aerospace — MJ threads — Part 2: Limit dimensions for bolts and nuts.*

ISO 6892:1998, *Metallic materials — Tensile testing at ambient temperature.*

ISO 7870:1993, *Control charts — General guide and introduction.*

ISO 7961:1994, *Aerospace — Bolts — Test methods.*

ISO 7966:1993, *Acceptance control charts.*

ISO 8258:1991, *Shewhart control charts.*

ISO 9002:1994, *Quality systems — Model for quality assurance in production, installation and servicing.*

ISO/TR 13425:1995, *Guide for the selection of statistical methods in standardization and specification.*

3 Terms and definitions

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

3.1
production batch
quantity of finished bolts, manufactured using the same process, from a single material cast (single heat of alloy), having the same number of definition document, same thread and diameter code, heat treated together to the same specified conditions and produced as one continuous run

3.2
inspection lot
quantity of bolts from a single production batch having the same number of definition document

3.3
definition document
document specifying directly or indirectly all the requirements for bolts

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

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

3.6
lap
surface defect caused by folding over metal fins or sharp corners and then rolling or forging them into the surface

3.7
crevice
hollow area at thread crest

3.8
inclusions
non-metallic particles originating from the material manufacturing process

NOTE These particles may be isolated or arranged in strings.

3.9
microstructural shearing
shear banding
V- or U-shaped rippled grain structure immediately below the thread root, or chevron-shaped rippled grain structure within the thread crest

3.10
sampling plan
plan according to which one or more samples are taken in order to obtain information and to reach a decision, if possible

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

3.11
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

3.12
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 (bolt), or that is likely to prevent performance of the function of a major end item

3.13
major defect
defect, other than critical, that is likely to result in a failure or to reduce materially the usability of the considered product (bolt) for its intended purpose

3.14
minor defect
defect that is not likely to reduce materially the usability of the considered product (bolt) for its intended purpose, or that represents a departure from established specification having little bearing on the effective use or operation of this product

3.15
limiting quality
LQ
⟨sampling plan⟩ quality level which 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 quoted in Table 8 corresponds to a probability of acceptance of 10 %.

3.16
acceptable quality level
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 level which in a sampling plan corresponds to a specified but relatively high probability of acceptance.

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1) Supplementary information taken from ISO 2859-1.

4 Quality assurance

4.1 General

4.1.1 Approval of manufacturers

The manufacturer shall conform to the quality assurance and approval procedures defined by ISO 9002. The purpose of these procedures is to ensure that a manufacturer has a quality system and the capability for continuous production of bolts complying with the specified quality requirements.

Quality documentation, as specified in ISO 9002, for parts produced in accordance with this International Standard, shall be maintained for a minimum period of 10 years.

The approval of the manufacturer shall be granted by the Certification Authorities, or their appointed representative, who may be the prime contractor.

4.1.2 Qualification of bolts

The purpose of inspections[2)] is to verify that the design and manufacturing conditions of a bolt enable it to satisfy the requirements of this International Standard.

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

4.1.3 Acceptance of bolts

The purpose of inspections is to verify, as simply as possible, using a method which is inexpensive, with the uncertainty inherent in statistical sampling, that the bolts satisfy the requirements of this International Standard.

They shall be carried out by the manufacturer, or under his responsibility.

The manufacturer is responsible for the quality of the bolts manufactured.

4.2 Qualification inspection conditions

Unless otherwise specified, the inspection shall be carried out on:

— each type and diameter of bolt;

— 25 bolts selected from a single inspection lot by simple random sampling.

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

The inspections shall be repeated on any bolt if the manufacturing conditions have modified.

Table 2 indicates the allocation of bolt sample for the inspections.

4.3 Acceptance inspection conditions

Inspections shall be carried out on each production batch or inspection lot. Bolts from the batch or lot to be inspected shall be selected by simple random sampling.

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2) In order to simplify the text the term "inspections" used in this International Standard also refers to "inspections and tests".

Each bolt may be submitted to several inspections, provided that none of its characteristics has been altered during any of these inspections.

The bolts to be subjected to destructive inspections may be those on which non-destructive inspections have been carried out.

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

Production batches or inspection lots declared unacceptable after the production acceptance inspections shall be submitted for re-inspection 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.

4.4 Use of "Statistical process control (SPC)"

When 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, 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. **Such an SPC process is not applicable to destructive tests** apart from the measurement of the hydrogen content.

5 Requirements

The requirements of this International Standard are given in Table 1 and, unless otherwise specified, they apply to bolts ready for use. The test temperature, unless otherwise specified, shall be the ambient temperature. These requirements complement the requirements of all other standards or specifications referenced in the definition document.

Table 1 — Requirements and test methods

Clause	Characteristic	Requirement	Inspection and test method	Designation [a]	Sample size
5.1	**Material**	In accordance with the definition document	See material standard		As required by semi-finished product
5.2	**Dimensions**	In accordance with the definition document	Standard gauging	Q	20
				A	Tables 3 and 4
5.3	**Manufacturing**				
5.3.1	**Forging**	The heads of the bolts shall be formed by a hot forging process before heat treatment. The equipment shall ensure an adequate and uniform temperature throughout the production batch.	According to the route of manufacture The equipment used shall be approved.	Q	
5.3.2	**Heat treatment**	The forged blanks shall be heat-treated to produce the properties required by the definition document. Blanks shall not be heat-treated more than twice.	According to the process route The equipment used shall be approved.	Q	
5.3.3	**Removal of surface contamination** (bearing face and shank)	If machining is required, it is necessary to respect the requirements of 5.5.1.			
5.3.4	**Fillet between head and shank**	The fillet radius shall be cold rolled after heat treatment and machining so as to remove all visual signs of machining and to create superficial cold working. The deformation shall not exceed the values in Figure 1. The requirements apply to bolts except for the following: a) threaded to head bolts; b) bolts with a nominal diameter < 5 mm.	Visual examination at a suitable magnification of × 10 to × 20 and dimensional check	Q	5
				A	Tables 3 and 4
5.3.5	**Threads**	Formed by a single rolling process after full heat treatment	According to the manufacturing route	Q	
5.3.6	**Surface roughness**	In accordance with the definition document	ISO 4288 Visual examination	Q	5
				A	Tables 3 and 4
5.3.7	**Surface coating**	In accordance with the definition document	See surface coating standard.	Q	5
				A	Tables 3 and 4

Table 1 *(continued)*

Clause	Characteristic	Requirement	Inspection and test method	Designation [a]	Sample size
5.4	**Mechanical properties**				
5.4.1	**Tensile strength**	See Table 5. The requirements apply on bolts except on the following: a) protruding head bolts of grip length < twice the nominal shank diameter; b) countersunk head bolts of grip length < two and a half times the nominal shank diameter; c) threaded to head bolts of overall length < three times the nominal shank diameter or bolts having an overall length < 18 mm; d) bolts with a thread length < one and a half times the thread nominal diameter; e) bolts with a nominal diameter < 4 mm. If the stress durability test is necessary, see 5.5.6, then this tensile test shall not be carried out.	On bolts: ISO 7961 On test specimen: ISO 6892 The test specimens to be produced from the same material batch as the bolts and treated with them.	Q A	5 Table 6 or Table 7
5.4.2	**Double shear strength**	See Table 5. The requirements apply on bolts except on the following: a) protruding head bolts of grip length < twice the nominal shank diameter; b) countersunk head bolts of grip length < two and a half times the nominal shank diameter; c) bolts with a nominal diameter < 4 mm; d) threaded to head bolts.	ISO 7961	Q A	5 Table 6 or Table 7

Table 1 *(continued)*

Clause	Characteristic	Requirement	Inspection and test method	Designation [a]	Sample size
5.4.3	**Tension fatigue strength**	Lifetime: — mean value: 65 000 cycles min. — individual value: 45 000 cycles min. 130 000 cycles max. Frequency: 140 Hz max. Loads: see Table 8. The requirements apply on bolts except on the following: a) protruding head bolts of grip length < twice the nominal shank diameter; b) countersunk head bolts of grip length < two and a half times the nominal shank diameter; c) bolts with a nominal diameter < 5 mm; d) drilled shank bolts; e) threaded to head bolts.	ISO 7961	Q A	5 Table 6
5.4.4	**Recess removal torque**	The recess of the finished bolt shall, unless otherwise specified in the product standard or definition document, withstand the torque values specified in Table 9. During the test, the driving feature shall show no camout and the recess no excessive distortion.	With the bolt fixed in rotation, submit the driving feature to an end load of (45 ± 2,5) N with the application of the required removal torque at the same time.	Q	5
5.5	**Metallurgical properties**				
5.5.1	**Head to shank grain flow**	Flow lines shall closely conform to the contour indicated by Figure 2. Breaks in flow lines, see Figure 2. If there is doubt about the acceptability, it shall be decided by the results of the acceptance tension fatigue test, see 5.4.3. This test shall thus be carried out on exempted bolt types.	Macroscopic examination × 10 to × 20 (see Figure 3), after appropriate etching	Q A	5 Table 6

Table 1 *(continued)*

Clause	Characteristic	Requirement	Inspection and test method	Designation [a]	Sample size
5.5.2	**Thread grain flow**	Shall be continuous and shall follow the general thread contour with the maximum density at the bottom of the root radius (see Figure 4).	Macroscopic examination × 10 to × 20 (see Figure 3), after appropriate etching	Q	5
				A	Table 6
5.5.3	**Microstructure, overheating and surface contamination**	Shall not have: — microporosity or major segregation; — indication that the bolt has been heated to a temperature > the transition temperature of the beta range without subsequently receiving adequate working within the alpha/beta temperature range. Overheating of the head, except for the bearing surface, is permitted provided that its maximum depth, measured normal to the surface of the head, does not exceed: 1,5 mm for diameters ≤ 16 mm; 2,8 mm for diameters > 16 mm. A WIDMANSTATTEN or equi-axed grain structure of beta origin without primary alpha is regarded as overheating. Surface contamination on the non-bearing surfaces of the head shall not exceed 0,08 mm for all diameters. It is not permitted on other surfaces.	Microscopic examination at a magnification of × 100 (see Figure 3), after appropriate etching	Q	5
				A	Table 6
5.5.4	**Hydrogen content**	≤ 0,012 5 % on material removed from the head	The equipment shall be approved.	Q	3
				A	1 per inspection lot
5.5.5	**Discontinuities**	See Table 10.	Fluorescent penetrant inspection according to ISO 3452 In case of doubt, submit suspect bolts to a microscopic examination at a magnification of × 100 (see Figure 3) after appropriate etching.	Q	5
				A	Penetrant Tables 3 and 4 Microscopic examination Table 6

Table 1 *(concluded)*

Clause	Characteristic	Requirement	Inspection and test method	Designation [a]	Sample size
5.5.6	**Microstructural shearing of threads**	Not permissible	Microscopic examination at a magnification of × 100 (see Figure 3), after appropriate etching Bolts from the suspect batch to be submitted to a stress durability test in accordance with ISO 7961: — loads: Table 5; — duration: 5 h min. Reject production batch if one or more bolts are cracked when microscopically examined at a magnification of × 100.	Q	Microscopic examination 5 Stress durability 5
				A	Microscopic examination Table 6 Stress durability Table 6
5.6	**Marking**	In accordance with the definition document	Visual inspection	Q	25
				A	Tables 3 and 4
5.7	**Delivery**				
5.7.1	**Packaging**	To prevent all damage or corrosion occurring in the course of handling, transportation and storage. Each basic package shall only contain bolts from the same inspection lot number.	Visual inspection	A	100 %
5.7.2	**Labelling**	Each basic package shall carry a label which legibly indicates: — the designation as specified by the definition document; — the quantity; — the inspection lot number; — the inspector's stamp.	Visual inspection	A	100 %
5.7.3	**Certificate of conformity**	At the demand of the customer each delivery shall be accompanied by a certificate of conformity certifying that, without exception or dispensation, the bolts satisfy the requirements of this International Standard.	Visual examination	A	100 %

[a] Q = Qualification, A = Acceptance

Table 2 — Summary of inspections for qualification and allocation of bolt samples

Characteristic	Defined in	Bolt sample number																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		Prior to coating					Finished bolts																			
Non-destructive tests																										
Dimensions	5.2						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fillet between head and shank	5.3.4	X	X	X	X	X																				
Surface roughness	5.3.6	X	X	X	X	X																				
Surface coating	5.3.7						X	X	X	X	X															
Recess removal torque	5.4.4																					X	X	X	X	X
Discontinuities — Fluorescent	5.5.5	X	X	X	X	X																				
Marking	5.6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Destructive tests																										
Tensile strength	5.4.1						X	X	X	X	X															
Double shear strength	5.4.2																					X	X	X	X	X
Tension fatigue strength	5.4.3																X	X	X	X	X					
Head to shank grain flow	5.5.1											X	X	X	X	X										
Thread grain flow	5.5.2											X	X	X	X	X										
Microstructure, overheating and surface contamination	5.5.3											X	X	X	X	X										
Hydrogen content	5.5.4	X	X	X																						
Microstructural shearing of threads																										
— microscopic	5.5.6	X	X	X	X	X																				
— stress durability	5.5.6						X	X	X	X	X															

Table 3 — Classification of defects

Category of defects	Acceptable quality level (AQL)	Characteristics
Major	0,065 %	Discontinuities
	1 %	Thread size Shank diameter Grip length Fillet radius: Distortion and dimensions Drilled hole(s) missing when required Surface roughness Burrs and tool marks Surface coating Marking Depth of lightening hole Thread form Incomplete threads Head angle (countersunk head) Perpendicularity of head-bearing surface Straightness of shank
Minor	2,5 %	Overall length Head diameter Lightening hole diameter Drilled hole(s) position tolerance and diameter Wrenching configuration Run-out — Head external diameter to shank Run-out — Thread pitch diameter to shank Recess torque
	4 %	Chamfer of thread end Hexagon head: chamfer and washer face Collar height Head height

Table 4 — Sampling plans for visual inspections and dimensional characteristics

Production batch size	Sample size	Acceptance number (Ac) and limiting quality (LQ) in accordance with the acceptable quality level (AQL)							
		AQL 0,065 %		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	54
16 to 25	5	↓	↓	↓	↓	0	37	↑	↑
26 to 50	8	↓	↓	↓	↓	↓	↑	↓	↓
51 to 90	13	↓	↓	0	16	↑	↓	1	27
91 to 150	20	↓	↓	↑	↑	1	18	2	25
151 to 280	32	↓	↓	↓	↓	2	16	3	20
281 to 500	50	↓	↓	1	7,6	3	13	5	18
501 to 1 200	80	↓	↓	2	6,5	5	11	7	14
1 201 to 3 200	125	↓	↓	3	5,4	7	9,4	10	12
3 201 to 10 000	200	0	1,2	5	4,6	10	7,7	14	10
10 001 to 35 000	315	↑	↑	7	3,7	14	6,4	21	9
35 001 to 150 000	500	↓	↓	10	3,1	21	5,6	↑	↑
150 001 to 500 000	800	1	0,49	14	2,5	↑	↑	↑	↑

↑ 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 2859-1:1989, tables II-A and VI-A. A 100 % inspection shall be performed when the sample size is equal to or greater 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 level.

For 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 shall guarantee an equivalent quality level.

Table 5 — Minimum loads for tensile[a] and double shear tests[b]

Thread		Tensile strength test				Double shear strength test
		Protruding head	Countersunk head			
			normal head	reduced head		
				no recess	recessed	
Diameter	Pitch					
mm	mm	kN	kN	kN	kN	kN
4	0,7	10	8,4	5,2	4,7	16,6
5	0,8	17	13	8,4	7,6	26
6	1	24	19	12	11	37
7	1	34	27	17	14	51
8	1	46	37	23	18	66
10	1,25	72	57	36	29	104
12	1,25	107	85	53	43	149
14	1,5	145	116	72	58	203
16	1,5	193	155	97	62	265
18	1,5	249	199	124	80	336
20	1,5	311	249	155	99	415

[a] See annex A (informative) for areas and formulae.

[b] See annex B (informative) for areas and formulae.

Table 6 — Sampling plans for the inspection of mechanical and metallurgical characteristics

Production batch size	Sample size destructive testing	Acceptance number (Ac)
≤ 500	3	0
501 to 3 200	5	0
3 201 to 35 000	5	0
≥ 35 001	8	0

Table 7 — Variable sampling for tensile and shear tests

Production batch size	Sample number	Acceptable quality level approximately AQL 1 %				
		Sample size	Total	First sample		Combined sample
				K_a	K_r	K_t
≤ 150	First	4	4	2,42	1,35	—
	Second	8	12	—	—	1,72
151 to 280	First	5	5	2,21	0,89	—
	Second	10	15	—	—	1,74
281 to 500	First	6	6	2,22	0,94	—
	Second	12	18	—	—	1,7
501 to 1 200	First	7	7	2,32	1,1	—
	Second	14	21	—	—	1,78
1 201 to 3 200	First	8	8	2,48	0,99	—
	Second	16	24	—	—	1,81
≥ 3 201	First	10	10	2,34	1,31	—
	Second	20	30	—	—	1,8

Evaluate each sample by tensile or shear tests as follows:

First sample: accept if $\overline{X}_1 - K_a S_1 \geq M$ Reject if $\overline{X}_1 - K_r S_1 < M$

Take a second sample if batch is doubtful; evaluate as follows:

Second sample: accept if $\overline{X}_t - K_t S_t \geq M$ Reject if $\overline{X}_t - K_t S_t < M$

Definition of symbols:

$\overline{X}_1$ is the average of X_1 individual values in the first sample;

K_a, K_r and K_t are coefficients of S, which is the best estimate of the standard deviation and which are used to determine acceptance or rejection of the batch represented by the sample;

M is the minimum tensile or the minimum shear value in accordance with Table 5;

$\overline{X}_t$ is the average of X_t individual values in the combined samples;

$$S_1 = \sqrt{\frac{N_1 \sum X_1^2 - \left(\sum X_1\right)^2}{N_1 (N_1 - 1)}}$$

where

N_1 is the sample size of the first sample;

ΣX_1^2 is the sum of squares of X_1 values;

$(\Sigma X_1)^2$ is the square of the sum of X_1 values;

$$S_t = \sqrt{\frac{N_t \sum X_t^2 - \left(\sum X_t\right)^2}{N_t (N_t - 1)}}$$

where

N_t is the sample size of the combined sample;

ΣX_t^2 is the sum of squares of X_t values;

$(\Sigma X_t)^2$ is the square of the sum of X_t values.

Table 8 — Tension fatigue test loads [a]

Thread		Protruding head		Countersunk head					
				normal head		reduced head			
						no recess		recessed	
Diameter	Pitch	high load	low load	high load	low load	high load	low load	high load	low load
		± 2 %	± 2 %	± 2 %	± 2 %	± 2 %	± 2 %	± 2 %	± 2 %
mm	mm	kN	kN	kN	kN	kN	kN	kN	kN
5	0,8	7	0,7	4,3	0,4	3,4	0,3	3	0,3
6	1	10	1	6,3	0,6	4,8	0,5	4,3	0,4
7	1	14	1,4	11	1,1	6,8	0,7	5,4	0,5
8	1	18	1,8	15	1,5	9,2	0,9	7,3	0,7
10	1,25	29	2,9	23	2,3	14	1,4	11	1,1
12	1,25	43	4,3	34	3,4	21	2,1	17	1,7
14	1,5	58	5,8	46	4,6	29	2,9	23	2,3
16	1,5	77	7,7	62	6	39	3,9	25	2,5
18	1,5	100	10	80	8	50	5	32	3,2
20	1,5	124	12	99	10	62	6	40	4

[a] See annex A (informative) for cross sectional areas and formulae.

Table 9 — Recess wrenching torque

Recess dash number	Torque Nm
2	1,3
3	2,7
4	3,6
4J	5,6
5	
6	14,1
7	28,2
8	42,2
9	73,4
10	112,9
11	158,1
12	214,6

Table 10 — Discontinuities

Type	Location	Maximum depth (mm), normal to surface		
		Bolts threaded to head (all diameters) and other bolts $D < 5$ mm	Bolts 5 mm $\leqslant D \leqslant$ 16 mm	Bolts $D >$ 16 mm
Cracks	All zones	0	0	0
Laps, seams, inclusions	Head to shank fillet	0	0	0
	Root of thread [a]			
	Non-bearing surface of head	0,15	0,25	0,3
Laps and seams, forming an angle of more than 10° with the longitudinal axis	Shank	0,1	0	0
Laps	Unload flank of threads	See Table 11 and Figures 5 and 6.		
Laps and/or crevices	Crest of thread [b]	See Table 11 and Figures 6 and 8. NOTE Values increased by half the difference between the actual measured diameter and the minimum external diameter (see ISO 5855-2).		

[a] See Figure 5.

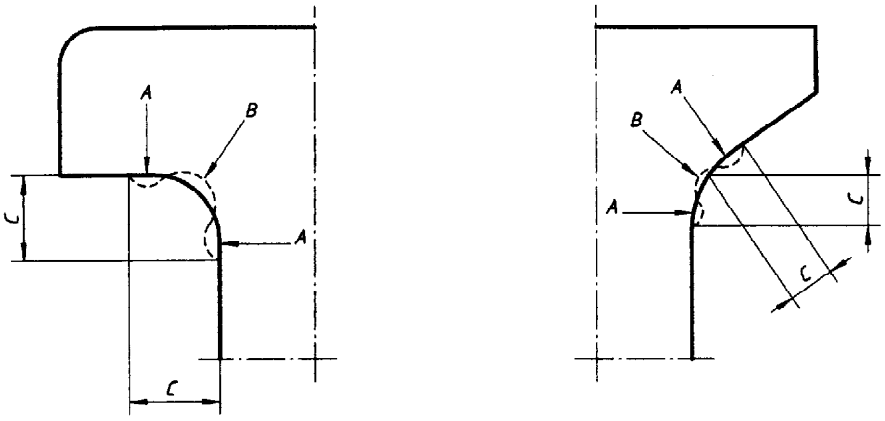
[b] See Figure 7.

Table 11 — Thread discontinuities [a]

Dimensions in millimetres

Thread pitch	Depth max.
0,7	0,08
0,8	0,09
1	0,12
1,25	0,15
1,5	0,18

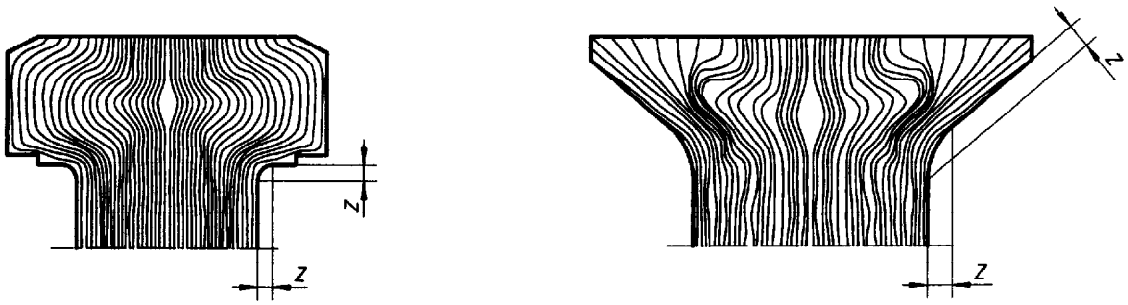
[a] Nature and position, see Table 10.



Dimensions in millimetres

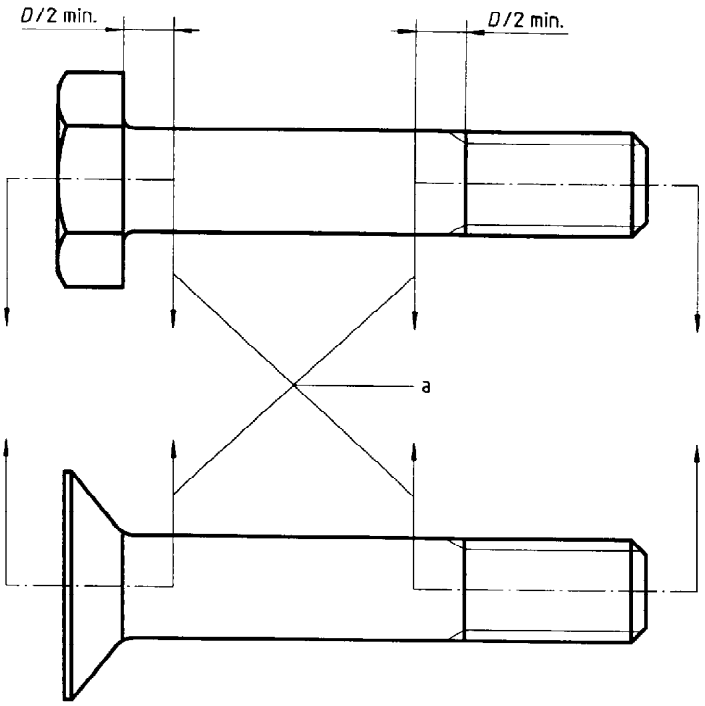
Bolt nominal diameter	*A* max.	*B* max.	*C* max.
5	0,03	0,025	1,5
6			
7			
8			2,5
10			
12			3,5
14			
16			
18			4,5
20			

Figure 1 — Distortion in head to shank fillet area (see 5.3.4)



NOTE Cut grain acceptable in the zone defined by *Z* dimensions [*Z* max. = *R* max. (where *R* max. is the maximum fillet radius specified in the definition document)]

Figure 2 — Head to shank grain flow (see 5.5.1)



[a] Cut here for test pieces to be subjected to micro- or macroscopic examination.

Figure 3 — Metallurgical test pieces (see 5.5.1 to 5.5.6)

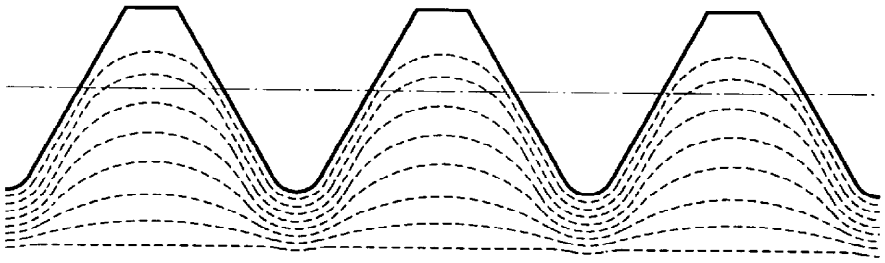
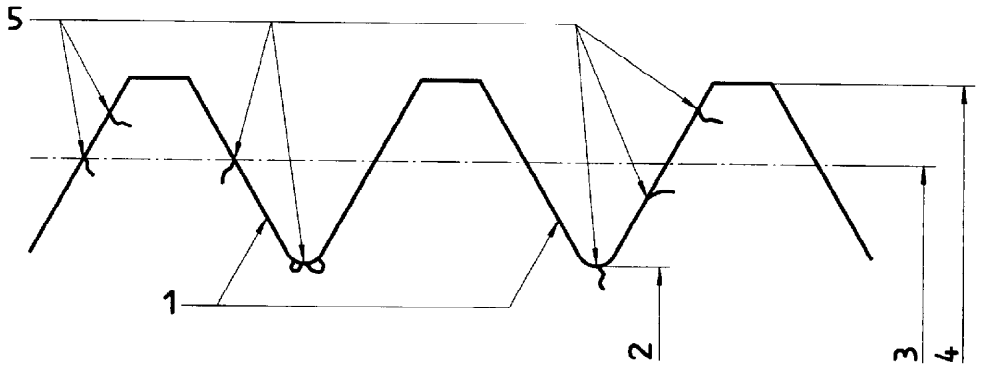


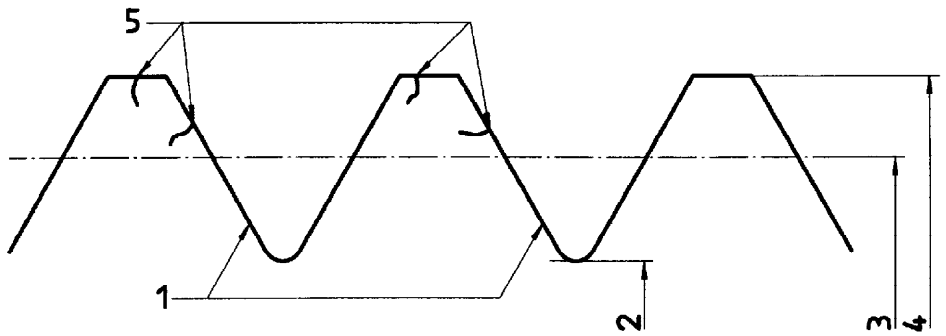
Figure 4 — Grain flow in threads (see 5.5.2)



Key

1 Non-loaded flanks
2 Minor diameter
3 Pitch diameter
4 Major diameter
5 Laps and seams not permissible

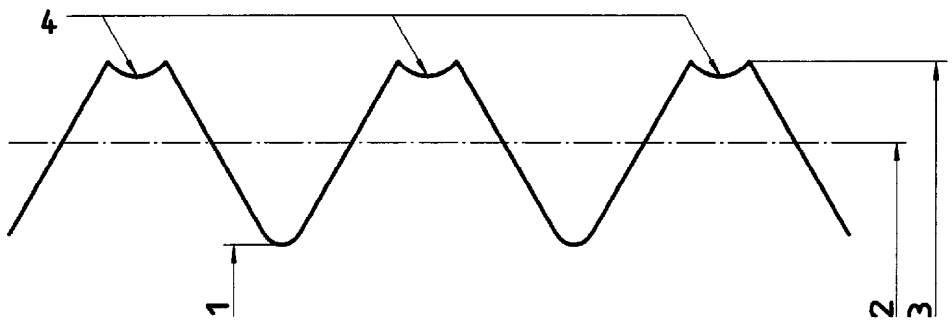
Figure 5 — Not permissible laps, seams and surface irregularities in threads (see 5.5.5)



Key

1 Non-loaded flanks
2 Minor diameter
3 Pitch diameter
4 Major diameter
5 Permissible seams and laps

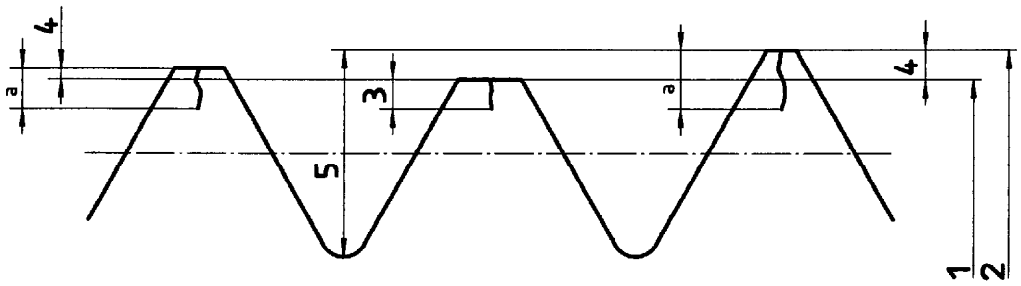
Figure 6 — Permissible laps and seams in threads (see 5.5.5)



Key

1 Minor diameter
2 Pitch diameter
3 Major diameter
4 Permissible surface irregularities (see Table 10)

Figure 7 — Permissible surface irregularities in threads (see 5.5.5)



Key

1 Minimum major diameter
2 Maximum major diameter
3 Maximum permissible discontinuity 20 % of basic thread depth (see Table 11)
4 Difference of actual major diameter and minimum major diameter
5 Basic thread depth

[a] See Tables 10 and 11.

Figure 8 — Thread discontinuities (see 5.5.5)

Annex A
(informative)

Cross sectional areas and formulae for tensile and tension fatigue loads

A.1 Cross sectional area values

See Table A.1.

Table A.1

Thread		Cross sectional area
Diameter mm	Pitch mm	mm²
4	0,7	9,517
5	0,8	15,296
6	1	21,753
7	1	30,93
8	1	41,682
10	1,25	65,136
12	1,25	97,128
14	1,5	131,562
16	1,5	175,613
18	1,5	225,949
20	1,5	282,571

A.2 Formulae

A.2.1 Cross sectional area

$$A_t = \frac{\pi}{4}(d_3)^2\left[2-\left(\frac{d_3}{d_2}\right)^2\right]$$

where

d_2 is the maximum pitch diameter (according to ISO 5855-2), in millimetres;

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

A.2.2 Tensile test load

$$\text{Load} = \frac{A_t k R_m}{1000} \text{ kN}$$

where

k for protruding head bolts = 1

k for normal countersunk head bolts = 0,8

k for reduced countersunk head bolts without drive recess in head = 0,5

k for reduced countersunk head bolts with drive recess in head:

for diameters $D \leqslant 6$ mm = 0,45

for diameters 7 mm $\leqslant D \leqslant$ 14 mm = 0,4

for diameters $D \geqslant 16$ mm = 0,32

R_m = 1 100 MPa for diameters $D \leqslant 20$ mm

R_m = 900 MPa for diameters $D \geqslant 22$ mm[3)]

A.2.3 Tension fatigue test loads

a) High load = 0,4 times tensile strength test load, except for normal countersunk head bolts with diameters 5 mm and 6 mm: 0,33 times tensile strength test load

b) Low load = 0,1 times high load

3) Included to indicate reduction in mechanical properties due to size effect.

Annex B
(informative)

Cross sectional areas and formulae for double shear loads

B.1 Cross sectional area values (single section)

See Table B.1.

Table B.1

Nominal shank diameter mm	Cross sectional area mm^2
4	12,566
5	19,635
6	28,274
7	38,485
8	50,265
10	78,54
12	113,1
14	153,9
16	201,1
18	254,5
20	314,2

B.2 Formulae

B.2.1 Shear strength cross sectional area (single section)

$$A_s = \frac{\pi}{4} d^2$$

where

d is the nominal shank diameter.

B.2.2 Double shear strength test load

$$\text{Load} = \frac{2 A_s R_c}{1\,000} \text{ kN}$$

where:

R_c = 660 MPa for diameters $D \leqslant 20$ mm;

R_c = 620 MPa for diameters $D \geqslant 22$ mm[4].

---

4) Included to indicate reduction in mechanical properties due to size effect.

ICS 49.030.20

Descriptors: aircraft industry, fasteners, MJ threads, titanium alloys, bolts, procurements, specifications, characteristics, mechanical properties, tests, mechanical tests, quality assurance, qualification.

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