BRITISH STANDARD

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3302:2007

Aerospace series — Bolts in heat resisting steel FE-PM1708 (FV535) — Classification: 1 000 MPa/550 °C — Technical specification

ICS 49.030.20

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 3302:2007.

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Luft- und Raumfahrt - Schrauben aus hochwarmfestem Stahl FE-PM1708 (FV535) - Klasse: 1 000 MPa/550 °C - Technische Lieferbedingungen

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Foreword

This document (EN 3302:2007) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2008, and conflicting national standards shall be withdrawn at the latest by June 2008.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This standard specifies the technical, qualification and quality assurance requirements for bolts in material FE-PM1708 (FV535) of tensile strength class 1 000 MPa at room temperature, maximum test temperature of material 550 °C.

Primarily for aerospace applications it is applicable to such bolts when referenced on the product standard or drawing.

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 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*.

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

ISO 3534:1977, *Statistics — Vocabulary and symbols.*

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

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T).*

ISO 9000, *Quality management systems — Fundamentals and vocabulary.*

EN 2493 [1)], *Heat resisting steel FE-PM38 — 1 000 MPa ≤ R_m ≤ 1 140 MPa — Bars — Aerospace series.* [2)]

EN 4244, *Aerospace series — Heat resisting alloy FE-PM1708 — Vacuum arc remelted — Hardened and tempered — Bar — a or D ≤ 200 mm — 1 000 MPa ≤ R_m ≤ 1 140 MPa.* [3)]

EN 4245, *Aerospace series — Heat resisting alloy FE-PM1708 — Vacuum arc remelted — As forged — Forging stock — D_e ≤ 300 mm.* [3)]

EN 9100, *Aerospace series — Quality management systems — Requirements (based on ISO 9001:2000) and Quality systems — Model for quality assurance in design, development, production, installation and servicing (based on ISO 9001:1994).*

EN 9133, *Aerospace series — Quality management systems — Qualification procedure for aerospace standard parts.*

TR 3040-1, *Aerospace series — Quality Assurance — EN aerospace products — Part 1: List of approved manufacturers.* [4)]

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1) Inactive for new designation, see EN 4244 and EN 4245.

2) Published as ASD Standard at the date of publication of this standard.

3) Published as ASD Prestandard at the date of publication of this standard.

4) Published as ASD Technical Report at the date of publication of this standard.

3 Terms and definitions

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

3.1
production batch
quantity of finished parts fabricated by the same process from a single material cast (single heat of alloy), having the same basic part number and diameter, heat treated together to the same specified condition and produced as one continuous run

3.2
inspection lot
quantity of parts from a single production batch of the same part number which completely defines the part

3.3 Surface discontinuities

3.3.1
crack
rupture in the material which may extend in any direction and which may be intercrystalline or transcrystallyne in character

3.3.2
seam
longitudinal surface defect in the form of an unwelded open fold in the material

3.3.3
lap
surface defect caused by folding over metal fins or sharp corners and then rolling or forging them into the surface

3.3.4
inclusion
non-metallic particles originating from the material making process. They may exist as discrete particles or strings of particles extending longitudinally

3.4
test temperature
ambient temperature, unless otherwise specified

3.5
simple random sampling
the taking 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

[ISO 3534, see definition]

3.6
critical defect
a 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

[ISO 3534, see definition]

3.7
major defect
a 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

[ISO 3534, see definition]

3.8
minor defect
a 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 specification having little bearing on the effective use or operation of this product

[ISO 3534, see definition]

3.9
sampling plan
a plan according to which one or more samples are taken in order to obtain information and possibly to reach a decision

[ISO 3534, see definition]

3.10
limiting quality (LQ_{10})
in a sampling plan, a quality limit which corresponds to a specified and relatively low probability of acceptance in this case 10 % probability of acceptance. It is the limiting lot quality characteristic that a lot of this quality would occur.

When expressed as a per cent defective, it may be referred to as a lot tolerance per cent defective.

[ISO 3534, see definition]

3.11
acceptance quality limit (AQL)
a quality limit which in a sampling plan corresponds to a specified but relatively high probability of acceptance

It is the maximum per cent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average.

[ISO 3534, see definition]

3.12
finished bolt
a bolt ready for use, inclusive of any possible treatments and/or surface coatings, as specified in the dimensional standard or definition document

3.13
definition document
document specifying all the requirements for bolts i.e.

— metallurgical;

— geometrical and dimensional;

— functional (strength and temperature classes).

4 Certification and quality assurance

4.1 Qualification

4.1.1 Purpose

The purpose of qualification tests is to ensure that the bolt design and bolt manufacturing conditions allow the bolt to comply with the requirements of this standard.

4.1.2 Conditions

The qualification tests summarized in Table 3 shall be performed on each type and diameter of bolt. Proposed changes in manufacturing source or procedure shall be subject to the requirements of EN 9133.

25 bolts selected from a single inspection lot by simple random sampling shall be subjected to the qualification tests.

The number of bolts to be subjected to each test as well as the method(s) to be used is specified in Table 1.

The tests to be applied to each bolt are shown in Table 4.

The test programme may possibly be reduced, this decision will be based on the comparison of results obtained from parts of similar design, size and manufacturing conditions.

All or part of these tests may also be performed for production acceptance, when a reinforced inspection seems to be necessary, or to survey bolts that have not proved satisfactory in use.

In that case, the sample to be subjected to these tests is the same as that used for production acceptance tests.

4.1.3 Qualification test requirements and procedures

The qualification test requirements and procedures shall be to the requirements of EN 9133.

4.1.4 Qualified manufacturers

A list of qualified manufacturers for specific standard parts is listed in TR 3040-1.

4.2 Acceptance

4.2.1 Purpose

The purpose of acceptance tests is to check, as simply as possible, by a method representative of actual use conditions, with the uncertainty inherent to statistical sampling, that the bolts constituting the batch satisfy the requirements of this standard.

4.2.2 Conditions

Acceptance tests are summarized in Table 3. They shall be performed on each batch. Table 1 specifies, the test method and sampling plan to be used for each test. Bolts from the batch to be tested shall be selected by simple random sampling.

Each bolt may be submitted to several tests.

The bolts to be subjected to destructive tests may be those on which non-destructive tests have been performed.

4.3 Quality system certification

4.3.1 Purpose

The purpose of quality system certification is to ensure that the manufacturer has demonstrated the acceptability of his quality system and his ability for continuing production of parts to this standard, to the required limit of quality.

4.3.2 Requirements and procedure

The requirements and procedures for quality system certification shall be to the requirements of ISO 9000 and EN 9100.

4.4 Responsibility for inspection and tests

The manufacturer is responsible for the performance of all inspection and test requirements as specified herein. Each manufacturer will use their own or exceptionally, any other facilities approved in accordance with 4.1 and 4.2 for the implementation of these inspection and test requirements.

4.5 Inspection and test report

A test report showing actual numerical values shall be provided at the purchaser's option as part of the terms of the purchase order.

5 Technical requirements and test methods

Table 1 — Technical requirements and test methods

Clause	Characteristic	Requirement	Inspection and test method	Q/A [a]	Sample size
5.1	**Material**	Material FE-PM1708 to specification EN 2493 supplied by an approved source: shall be used for the manufacture of bolts to this standard.	As stated in the material specification.		
5.2	**Dimensions, tolerances of form and position, threads and quality**			Q	25
				A	Tables 6 and 7
5.2.1	**Dimensions**	The dimensions of the finished bolts shall conform to the product standard or definition document.	All dimensions shall be controlled by an approved system of gauging.		
5.2.2	**Tolerances of form and position**	Tolerances of form and position shall conform to the product standard or definition document.	Tolerances of form and position shall be controlled by an approved system of gauging.		
5.2.3	**Threads**	Threads shall conform to the product standard or definition document.	Threads shall be gauged by an approved system of gauging.		
5.3	**Manufacturing**				
5.3.1	**Forging**	The heads of the bolts shall be formed by hot or cold forging. If hot forged the forging temperature shall not exceed 1 170 °C. The heating equipment for forging shall be of a type which ensures a consistent temperature throughout the batch.	The method of forging shall be approved.		

continued

Table 1 *(continued)*

Clause	Characteristic	Requirement	Inspection and test method	Q/A [a]	Sample size
5.3.2	**Heat treatment**	The heat treatment medium or atmosphere shall not cause any surface contamination except as permitted by 5.5.6. Any scale which will not be removed by subsequent machining shall be removed by abrasive blasting.	The heat treatment equipment shall be approved. The equipment for abrasive blasting shall be approved.		
5.3.2.1	**Harden and temper heat treatment**	The headed blanks shall be pre-heated to 650 °C/700 °C, then heated to (1 170 ± 10) °C, followed by oil or fast gas quench. The headed and hardened blanks shall then be tempered at (610 ± 5) °C for 2 hours to 5 hours and air cooled, followed by 620 °C/ 650 °C for 2 hours to 5 hours and air cooled.			
5.3.3	**Removal of surface contamination**	After all heat treatment the headed blanks shall have all the shank and bearing surface of the head ground: a) For the removal of all surface contamination and oxide penetration; b) To obtain a clean smooth surface. The amount of material removed from the shank diameter and underneath the head shall be as little as practicable but shall not exceed the limits of Table 2.			
5.3.4	**Head to shank fillet**	After completion of hardening, double tempering and machining. The underhead radius shall be cold rolled sufficiently to remove all evidence of machining. Cold rolling the head to shank fillet radius may cause distortion of the fillet area. Any such distortion shall be in accordance with the requirements of Figure 2 unless otherwise specified on the bolt standard or definition document.	Dimensional check (see 5.5.2) and visual examination.	Q A	25 Tables 6 and 7

continued

Table 1 *(continued)*

Clause	Characteristic	Requirement	Inspection and test method	Q/A [a]	Sample size
5.3.4 *(continued)*		For parts with compound radii between head and shank, cold work only the radius that blends with the head, however it is acceptable for cold work to extend over the compound radius. The fillet shall not show evidence of seams or inclusions.	See 5.5.7.1.		
5.3.5	**Threads**	Threads shall be formed on the hardened, double tempered and machined blanks by a single rolling operation.			
5.3.6	**Surface roughness**	The surface roughness shall be as specified on the bolt standard or definition document prior to protective treatment.	The surface roughness of the thread shall be determined by visual comparator method, see ISO 4288.	Q A	3 Tables 6 and 7
5.3.7	**Surface coating**	Where applicable, all surfaces shall be coated as specified on the bolt standard or definition document.	See applicable coating specification.	Q 	3 Tables 6 and 7
5.4	**Mechanical properties**	A test sample shall be selected from each diameter of bar/coil drawn from each cast, and shall be heat treated together with a production batch of bolts.	The sample selected shall be sufficient to provide tensile test pieces. The test pieces shall meet the mechanical properties required by the material specification.		
5.4.1	**Tensile strength**	The finished bolts shall meet the tensile load requirements specified in Table 5. Standard externally wrenched bolts shall not fail in the head to shank area when subjected to the tensile test. The maximum value of Table 5 may be exceeded by up to 10 % provided parts are retested with acceptable results, after reducing the cross sectional area below the thread minor diameter.	Tensile tests are not applicable to the following: a) Protruding head bolts of grip length less than 2 D; b) Countersunk head bolts of overall length less than 3 D or bolts having an overall length less than 18 mm. In such cases acceptability shall be based on the results from test bars of the same material heat treated within the same process cycle.	Q A	4 Table 8 column B or Table 10
5.4.2	**Hardness**	The hardness of the finished bolts shall be uniform and within the range 318 HV – 366 HV, but hardness of the threaded section and of the head to shank fillet area may be higher as a result of the cold working operations.	For hardness testing, see ISO 6508-1.	Q A	4 Table 8 column A

continued

Table 1 *(continued)*

Clause	Characteristic	Requirement	Inspection and test method	Q/A [a]	Sample size
5.5	**Metallurgical properties**		NOTE The same test sample may be utilized for more than one test provided that none of the characteristics of the samples are altered during the examination procedure (see Table 3).		
5.5.1	**Head to shank grain flow**	A section of the heads shall show no detrimental defects. Flow lines in the fillet area immediately below the surface shall closely conform to the fillet contour. Slight cutting in the flow lines shall not extend beyond the *A* dimension as shown in Figure 1 and tabulated in Table 2.	Head structure and grain flow shall be determined by macroscopic examination at a suitable magnification 10×/20×. Specimens shall be taken from the finished bolt as shown in Figure 7. The specimen shall be etched in a suitable solution.	Q	4
				A	Table 8 column B
5.5.2	**Microstructure**	Bolts shall have a microstructure of tempered martensite.	Microstructure shall be determined by microscopic examination at 100×. Specimens shall be taken from the finished bolts as shown in Figure 7. The specimens shall be etched in a suitable solution.	Q	4
				A	Table 8 column B
5.5.3	**Thread grain flow and work effect**	The grain flow in the threads shall be continuous and shall follow the general thread contour with the maximum density at the bottom of the root radius as shown in Figure 3.	Macroscopic examination (see 5.5.1). Thread discontinuities are also to be looked for during the examination of bolt sections (see 5.5.6.2).	Q	4
				A	Table 8 column B
5.5.4	**Surface hardening**	Bolts shall have no change in hardness from core to surface except as produced during cold working of the head to shank fillet radius and during rolling of threads.	Microscopic examination (see 5.5.2). In case of dispute over the results of the microscopic examination, microhardness testing shall be used as a referee method; a Vickers hardness reading within 0,08 mm of an unrolled surface which exceeds the reading in the core by more than 30 points shall be evidence of non-conformance to this requirement.	Q	4
				A	Table 8 column B
5.5.5	**Surface contamination**	The bearing surface of the head, the head to shank fillet, shank diameter and threads must be free from surface oxide. Depth of oxide penetration on the unmachined surfaces of the head shall not be greater than 0,025 mm.	Microscopic examination (see 5.5.2).	Q	4
				A	Table 8 column B

continued

Table 1 *(continued)*

Clause	Characteristic	Requirement	Inspection and test method	Q/A [a]	Sample size
5.5.6	**Discontinuities**	Finished bolts having discontinuities exceeding the limitations specified herein shall be rejected. Care must be exercised to avoid confusing cracks with other discontinuities. Cracked bolts and those having discontinuities transverse to axis (i.e. at an angle more than 10° to the longitudinal axis) shall be rejected and be destroyed.	The finished bolts shall be subjected to penetrant flaw detection in accordance with ISO 3452. Bolts showing indications which are considered significant will be subjected to microexamination at a suitable magnification (×100).	Q A	25 Penetrant Tables 6 and 7 micro Table 8 column B
5.5.6.1	**Head and shank discontinuities**	The bolt head shall not possess seams or inclusions along the top or sides exceeding 0,2 mm in depth. Close tolerance shank bolts shall have no discontinuities in the shank or head to shank fillet. Bolts with non-close tolerance shanks having longitudinal defects in the shank of depth and width greater than 0,05 mm and/or length exceeding 5 mm shall be rejected. Discontinuities shall not be permitted in the head to shank fillet. There shall be no evidence of surface or subsurface inclusions in the head to shank fillet.	See 5.5.6.		See 5.5.6. See 5.5.6.
5.5.6.2	**Thread discontinuities**	Threads shall have no multiple or single laps at the root or on the flanks below the pitch diameter (see Figure 4). The root shall not contain seams, notches, slivers, folds, roughness or oxide scale. Faults with depth less than 20 % of the basic thread height (see Table 9) are permissible on the thread crest and on that part of the non-loaded flank which is situated above the pitch diameter. Slight deviation from the thread contour is permissible at the crest of the threads (see Figures 4 to 6) NOTE As the major diameter of the thread approaches maximum size, values for crest lap imperfections listed in Table 8 may be increased by half the difference between the minimum major diameter and the actual major diameter as measured on the part (see Figure 6).	See 5.5.6.		See 5.5.6.

continued

Table 1 *(concluded)*

Clause	Characteristic	Requirement	Inspection and test method	Q/A [a]	Sample size
5.5.7	**Material identification**	Each finished bolt shall be subjected to a non-destructive physical test to verify the type of material. The test equipment shall be standardized by samples of known chemical composition of the same type and form and in the same heat treatment condition as the parts to be tested.	The test equipment shall be approved.	Q	25
				A	100 %
5.6	**Product identification**	Each finished bolt shall, unless package marking is stipulated, be marked at the location and by the method as specified on the bolt standard or definition document. Bolts to be package marked shall be packed and identified in accordance with 5.7.1 and 5.7.2.	Visual examination.	Q	25
				A	Tables 6 and 7.
5.7	**Delivery**		Visual examination.	A	100 %
5.7.1	**Packaging**	The finished bolts shall be packed in such a way as to prevent any damage or corrosion occurring in the course of handling, transportation and storage. Each primary package shall only contain bolts of one part number and of the same inspection lot number.			See 5.7.
5.7.2	**Labelling**	Each primary package shall bear a label upon which is legibly recorded the designation as specified in the product standard; quantity; production batch number and manufacturers name or trade mark.			See 5.7.

[a] Q: Qualification, A: Acceptance.

Table 2 — Material removal and cutting of flow lines (see 5.5.1 and Figure 1)

Nominal thread diameter mm	Maximum amount of material to be removed *e* mm	Maximum cutting of flow lines *A* mm
5	0,2	0,5
6	0,25	0,7
7	0,25	0,7
8	0,25	0,7
10	0,25	0,8
12	0,33	0,9
14	0,38	1,1
16	0,38	1,1
18	0,38	1,3
20	0,38	1,3
22	0,38	1,5
24	0,38	1,5

Table 3 — Qualification testing requirements for bolt samples

Type of test	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
		Uncoated			Finished bolts																					
Non-destructive																										
Dimensions, tolerances of form and position, threads and quality	5.2	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
Surface roughness	5.3.6	X	X	X																						
Surface coating	5.3.7				X	X	X																			
Hardness	5.4.2							X	X	X	X															
Head and shank discontinuities	5.5.6.1	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
Thread discontinuities	5.5.6.2	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
Material identification	5.5.7	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
Product identification	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																										
Tensile strength	5.4.1					X	X	X	X																	
Head to shank grain flow	5.5.1	X	X	X	X																					
Microstructure	5.5.2	X	X	X	X																					
Thread grain flow and work effect	5.5.3	X	X	X	X																					
Surface hardening	5.5.4	X	X	X	X																					
Surface contamination	5.5.5	X	X	X	X																					

Table 4 — Summary of tests – Qualification and acceptance

Type of test	Qualification		Acceptance	
	Clause	Sample size	Clause	Sample size
Dimensions, tolerances of form and position, threads and quality	5.2	25	5.2	Tables 6 and 7
Head to shank fillet	5.3.4	25	5.3.4	Tables 6 and 7
Surface roughness	5.3.6	3	5.3.6	Tables 6 and 7
Surface coating	5.3.7	3	5.3.7	Tables 6 and 7
Tensile strength	5.4.1	4	5.4.1	Table 8 column B or Table 10
Hardness	5.4.2	4	5.4.2	Table 8 column A
Head to shank grain flow	5.5.1	4	5.5.1	Table 8 column B
Microstructure	5.5.2	4	5.5.2	Table 8 column B
Thread grain flow and work effect	5.5.3	4	5.5.3	Table 8 column B
Surface hardening	5.5.4	4	5.5.4	Table 8 column B
Surface contamination	5.5.5	4	5.5.5	Table 8 column B
Discontinuities Head and shank discontinuities Thread discontinuities	5.5.6 5.5.6.1 5.5.6.2	25	5.5.6	Penetrant Tables 6 and 7 micro Table column B
Material identification	5.5.7	25	5.5.7	100 %
Product identification	5.6	25	5.6	Tables 6 and 7
Delivery Packaging Labelling			5.7 5.7.1 5.7.2	100 %

Table 5 — Tensile loads

Thread		Tensile		
Diameter	Pitch	Stress area	Ambient temperature load kN	
mm	mm	mm^2	min.	max.
5	0,8	15,296	15,3	17,44
6	1,0	21,753	21,75	24,8
7	1,0	30,93	30,93	35,26
8	1,0	41,682	41,68	47,52
10	1,25	65,136	65,14	74,26
12	1,25	97,128	97,13	111
14	1,5	131,562	132	150
16	1,5	175,613	176	200
18	1,5	225,949	226	258
20	1,5	282,571	283	322
22	1,5	345,478	345	394
24	2	401,68	402	458

Table 6 — Classification of defects

Category No.	AQL	Characteristics
Major A		
101	0,065 %	Surface discontinuities revealed by fluorescent penetrant inspection
Major B		
201	1,0 %	Thread size
202		Shank diameter
203		Grip length
204		Fillet radius - distortion and dimensions
205		Drilled holes missing when required
206		Surface texture (visual)
207		Burrs and tool marks
208		Overall length
209		Head diameter
210		Depth of lightening hole in head when required
211		Thread form
212		Incomplete threads
213		Perpendicularity - head bearing surface to shank
214		Straightness of shank
Minor A		
301	2,5 %	Surface coating when required
302		Product identification
303		Lightening hole diameter when required
304		Drilled hole location and diameter when required
305		Wrenching configuration
306		Runout - head outside diameter to shank
307		Runout - thread pitch diameter to shank
Minor B		
401	4,0 %	Chamfer on thread end
402		Head flange thickness
403		Head height
404		Other dimensional characteristics not listed

Table 7 — Sampling plans for visual inspections and dimensional characteristics

Batch size	Sample size	Acceptance number (Ac) and limiting quality (LQ_{10}) in accordance with the acceptance quality limit (AQL)							
		AQL 0,065 %		AQL 1,0 %		AQL 2,5 %		AQL 4,0 %	
		Ac	LQ_{10} %	Ac	LQ_{10} %	Ac	LQ_{10} %	Ac	LQ_{10} %
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	0,5	14	2,5	↑	↑	↑	↑

↑ Use sampling plan above.

↓ Use sampling plan below.

The data given in this table are based on single sampling plans for a standard inspection, as specified in ISO 2859-1, 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 in such a way that the overall inspection plan shall guarantee an equivalent quality limit.

Table 8 — Sampling plans for the inspection of mechanical and metallurgical characteristics

Batch size	Sample size		Acceptance number
	Non-destructive tests A	Destructive tests B	(Ac)
up to 500	8	3	0
501 to 3 200	13	5	0
3 201 to 35 000	20	5	0
above 35 000	32	8	0

Table 9 — Thread discontinuities – Maximum depth or permissible faults (see 5.5.6.2)

Dimensions in millimetres

Thread pitch	Depth [a]
0,5	0,06
0,7	0,08
0,8	0,09
1,0	0,12
1,25	0,15
1,5	0,18
2,0	0,24

[a] These values correspond to 20 % of basic thread depth.

Table 10 — Variable sampling for tensile test

Batch size	Sample number	Acceptance quality limit (AQL) approximately 1,0 %				
		Sample size	Total	First sample		Combined sample
				K_a	K_r	K_t
under 151	First Second	4 8	4 12	2,42 —	1,35 —	— 1,72
151 to 300	First Second	5 10	5 15	2,21 —	0,89 —	— 1,74
301 to 500	First Second	6 12	6 18	2,22 —	0,94 —	— 1,70
501 to 1 300	First Second	7 14	7 21	2,32 —	1,10 —	— 1,78
1 301 to 3 200	First Second	8 16	8 24	2,48 —	0,99 —	— 1,81
above of 3 200	First Second	10 20	10 30	2,34 —	1,31 —	— 1,80

Evaluate each sample by tensile strength 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 second sample if batch is rejected.

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

where

$\overline{X}_1$ 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 standard deviation and which are used to determine acceptance or rejection of the batch represented by the sample;

M is the minimum tensile or minimum shear value according to 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 number of parts in the first sample;

$\sum X_1^2$ is the sum of squares of X_1 values;

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

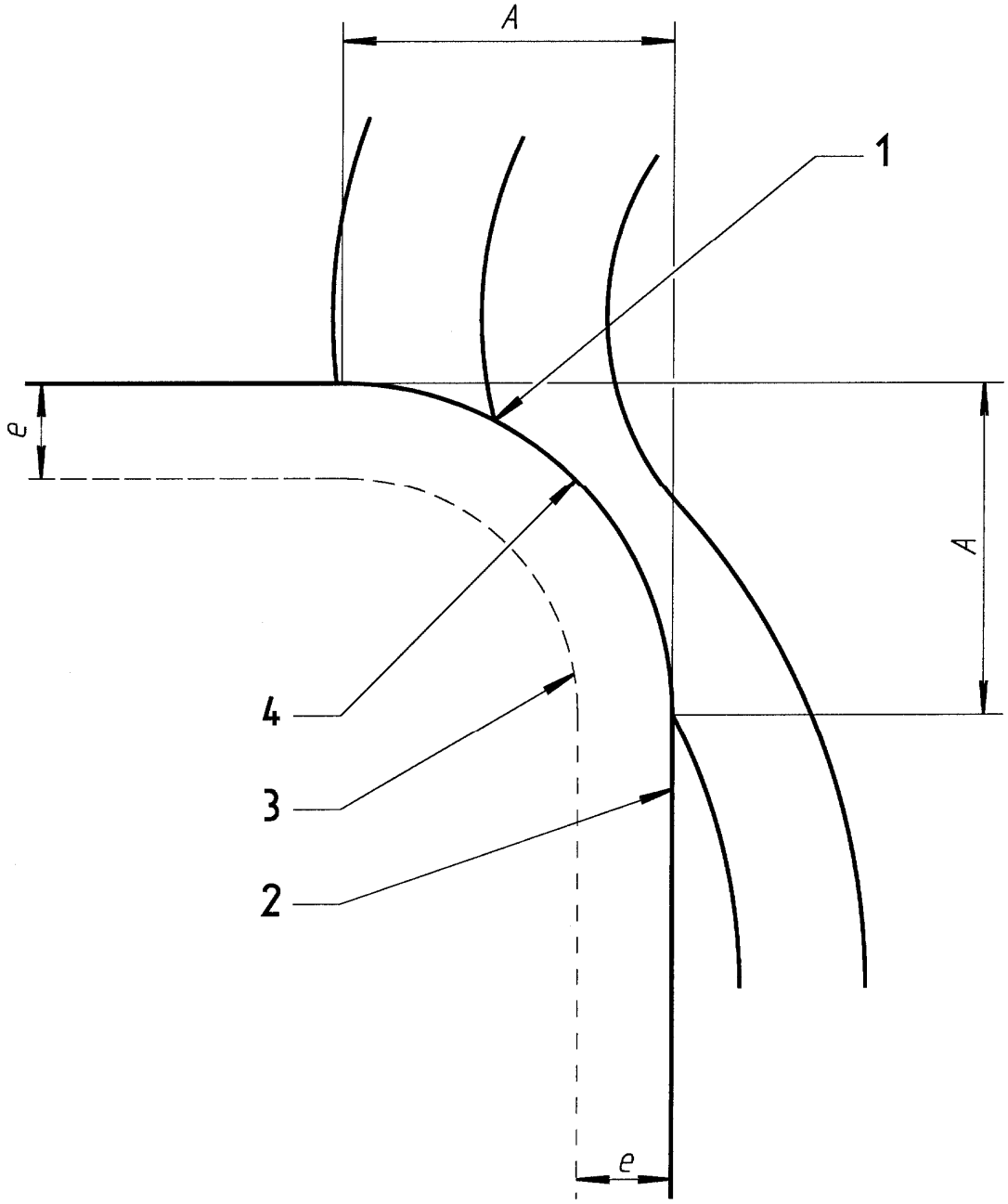
$$S_t = \sqrt{\frac{N_t \sum X_t^2 - \left(\sum X_t\right)^2}{N_t (N_t - 1)}}$$

where

N_t is the number of parts in the combined sample;

$\sum X_t^2$ is the sum of squares of X_t values;

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

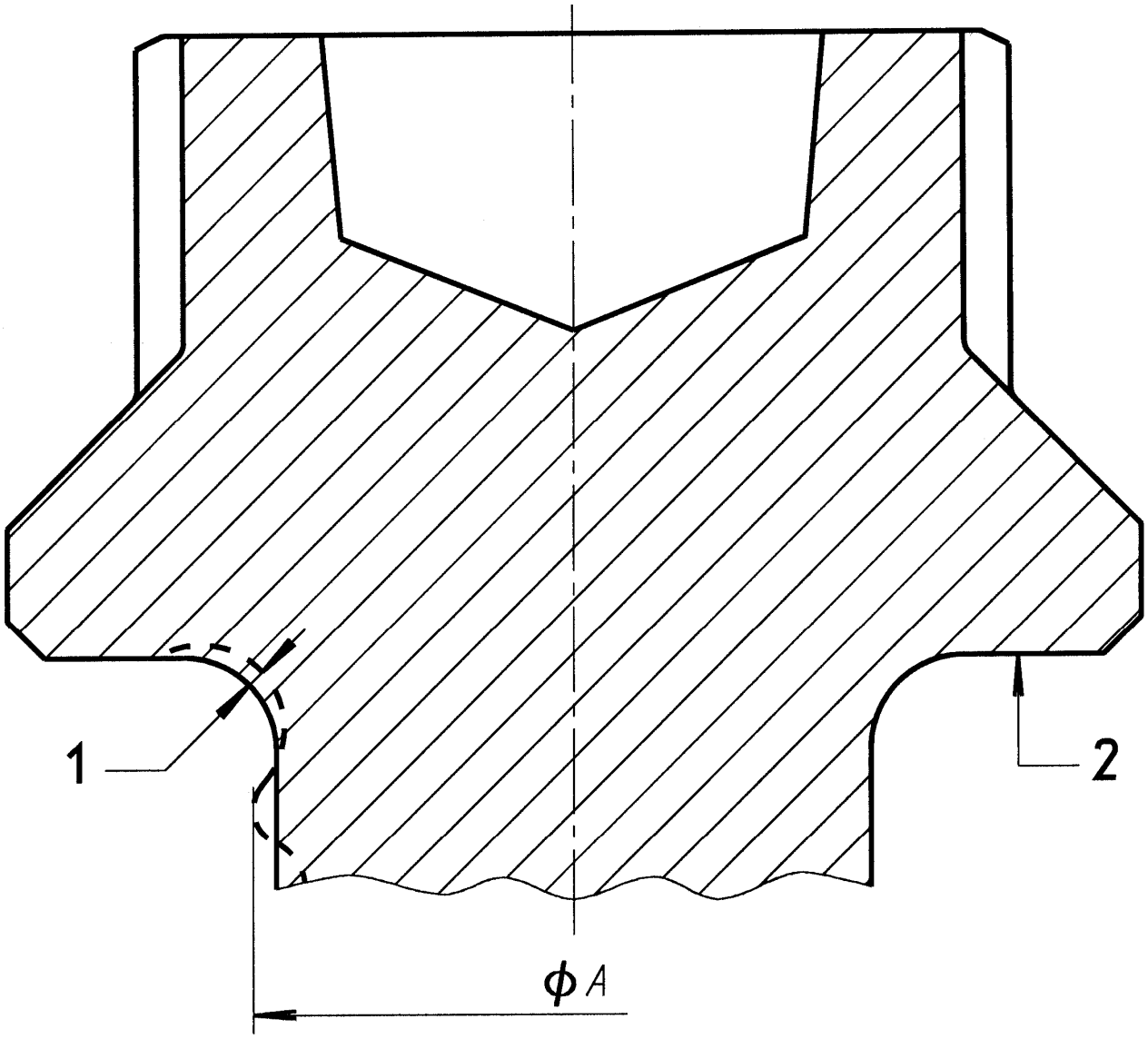


Key

1 Cut flow line
2 Profile of finished part
3 Profile of rough forging
4 Underhead radius

See Table 2 for values of A and e.

Figure 1 — Cutting of flow lines in the underhead radius



Key

1 0,025 mm max.

2 No excrescence permissible on the head bearing face

NOTE Diameter at this position, inclusive of distortion shall A:

- On full shank "close" tolerance bolts, not exceed maximum shank diameter;
- On full shank "open" tolerance bolts, not exceed the actual shank diameter, prior to distortion by more than 0,06 mm;
- On pitch diameter bolts, not exceed the actual pitch diameter, prior to distortion by more than 0,06 mm.

Figure 2 — Distortion in fillet area (see 5.3.4)

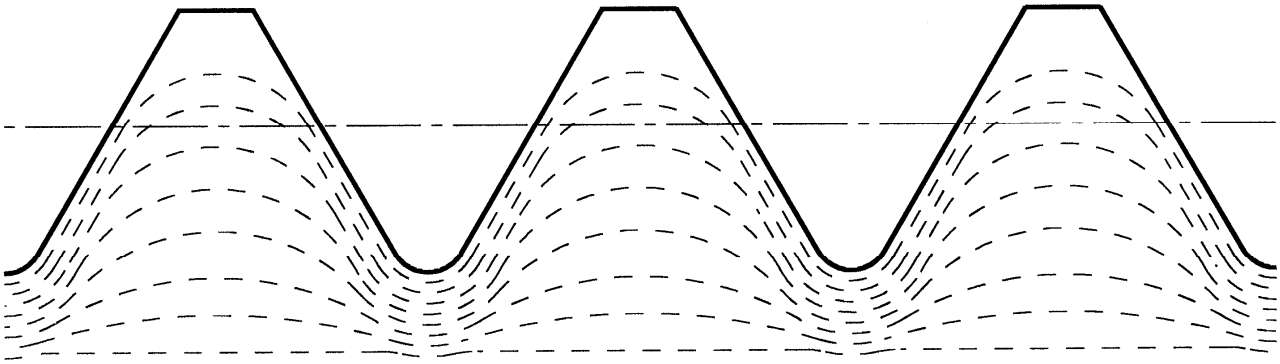
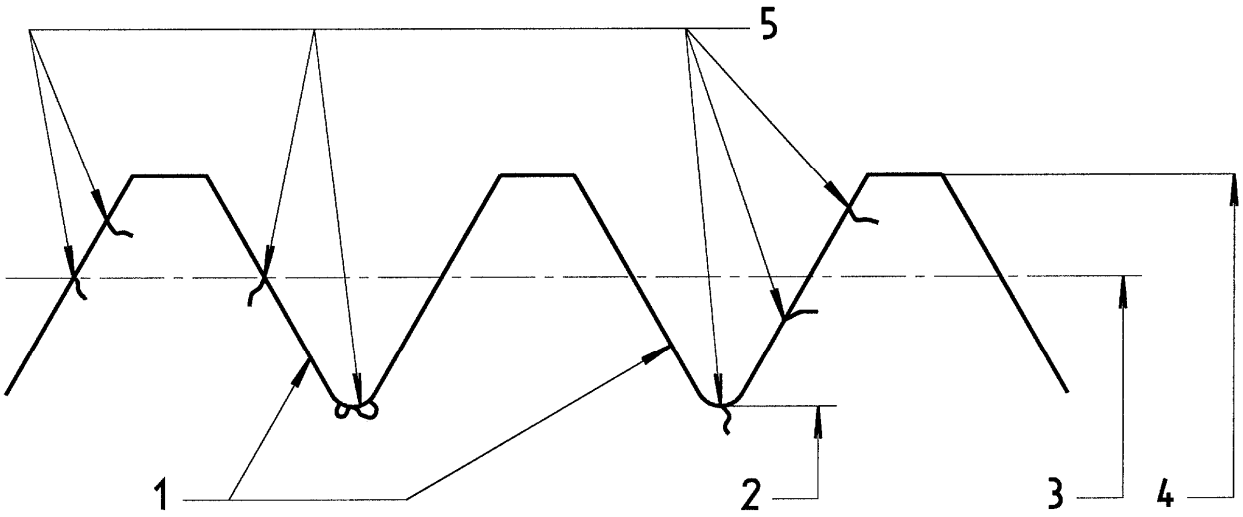


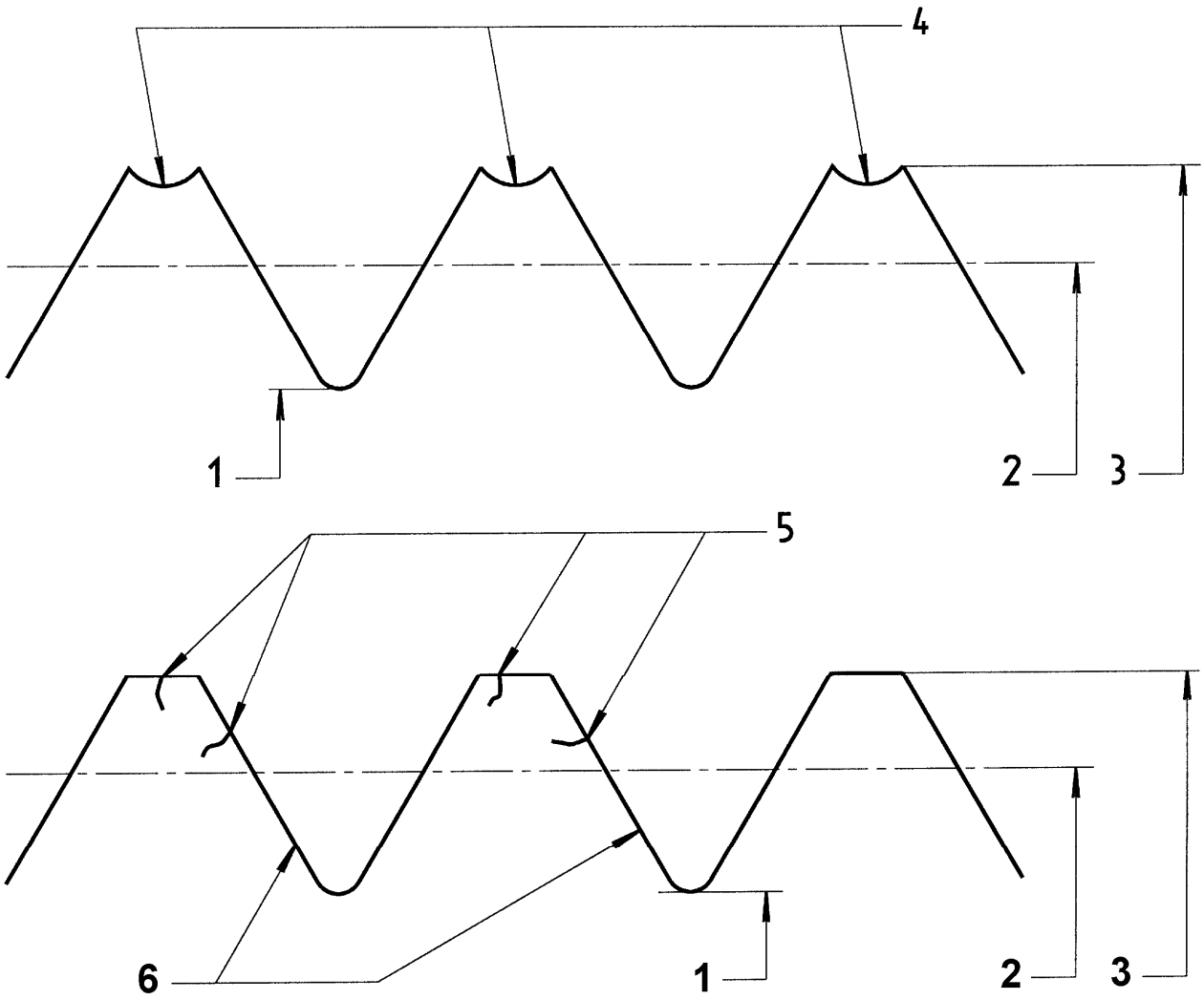
Figure 3 — Grain flow in thread (see 5.5.4)



Key

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

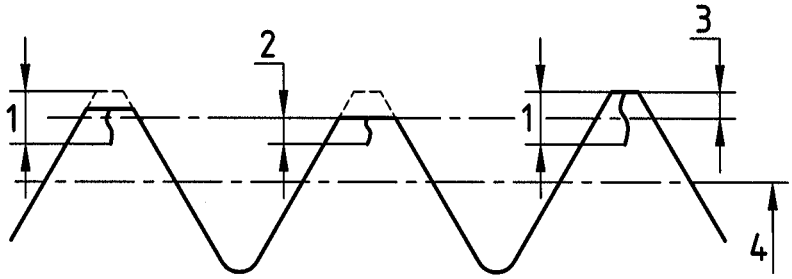
Figure 4 — Non-permissible laps, seams and surface irregularities (see 5.5.6.2)



Key

1 Minor diameter
2 Pitch diameter
3 Major diameter
4 Permissible surface irregularities
5 Permissible laps and seams
6 Non-loaded flank

Figure 5 — Permissible laps, seams and surface irregularities (see 5.5.6.2)

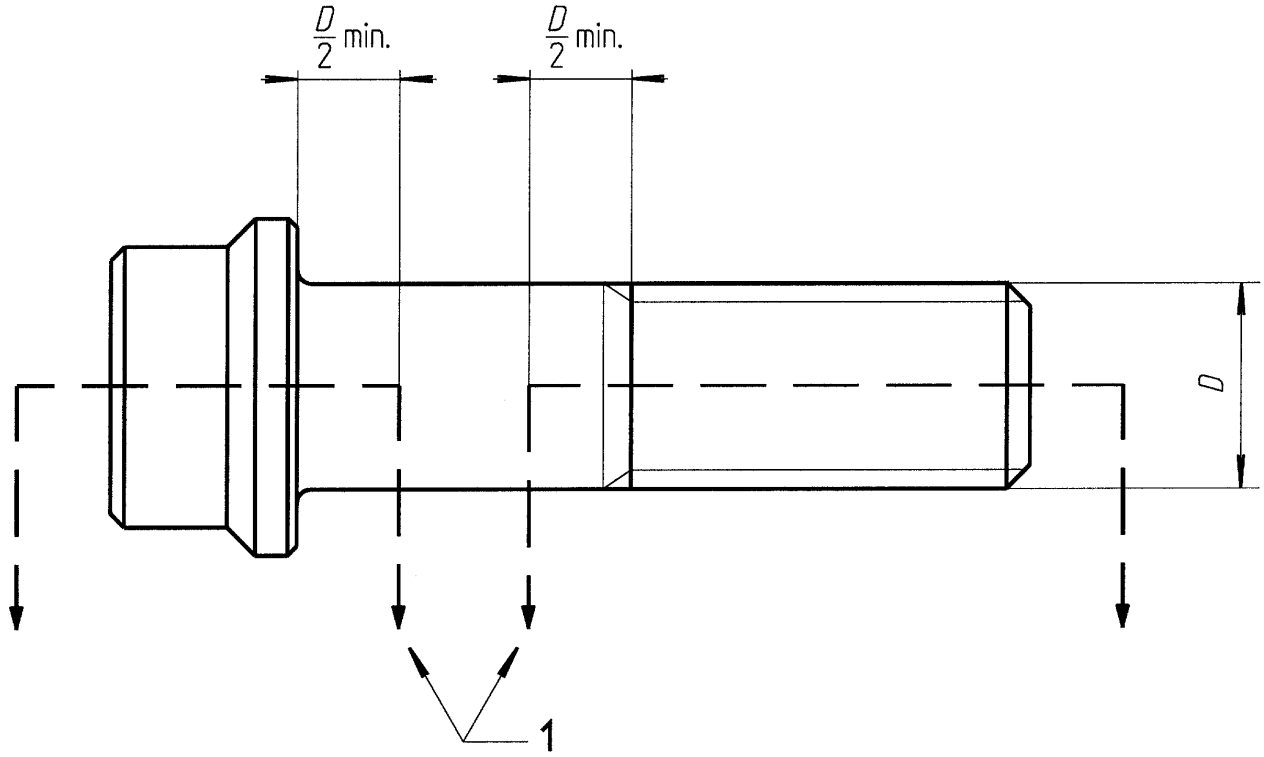


Key

1 See note.
2 Maximum permissible defect 20 % of basic thread depth
3 ½ tolerance on major diameter
4 Pitch diameter

NOTE Depth of defect equals 20 % of basic thread depth plus ½ the difference or actual major diameter and minimum major diameter.

Figure 6 — Crest lap imperfections (see 5.5.6.2)



Key

1 Cut here for specimens to be micro-examined or macro-examined

Figure 7 — Metallurgical specimens (see 5.5.1)

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