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**Aerospace — Alloy steel bolts with strength
classification 1 100 MPa and MJ threads —
Procurement specification**

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

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7689 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Aerospace — Alloy steel bolts with strength classification 1 100 MPa and MJ threads — Procurement specification

1 Scope and field of application

This International Standard specifies the characteristics and quality assurance requirements for bolts with normal heads, made of alloy steel, having a tensile strength classification of 1 100 MPa and MJ threads, and intended for use in aerospace construction.

This International Standard applies to bolts as defined above, provided that reference is made to this International Standard in the product standard or definition document.

2 References

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

ISO 3534, *Statistics — Vocabulary and symbols.*

ISO 5855-2, *Aerospace construction — MJ threads — Part 2 : Dimensions for bolts and nuts.*

ISO 6506, *Metallic materials — Hardness test — Brinell test.*

ISO 6507-1, *Metallic materials — Hardness test — Vickers test — Part 1 : HV 5 to HV 100.*

ISO 6508, *Metallic materials — Hardness test — Rockwell test (scales A — B — C — D — E — F — G — H — K).*

ISO 7961, *Aerospace — Bolts — Test methods.*²⁾

3 Definitions

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 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 bolts from a single production batch with the same part number which completely defines the bolts.

3.3 Discontinuities

3.3.1 crack : Rupture in the material which may extend in any direction and which may be intercrystalline or transcrystalline in character.

3.3.2 seam : Open surface defect resulting from extension of 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 inclusions : Non-metallic particles originating from the material manufacturing process. These particles may be isolated or arranged in strings.

3.4 single 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.³⁾

3.5 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.³⁾

3.6 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.³⁾

3.7 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.³⁾

3.8 sampling plan : A plan according to which one or more samples are taken in order to obtain information and possibly to reach a decision.³⁾

3.9 limiting quality (LQ) : In a sampling plan, a quality level which corresponds to a specified and relatively low probability of acceptance : for the purposes of this International Standard, a 10 % probability of acceptance (LQ₁₀). 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.³⁾

3.10 acceptable quality level (AQL) : A quality level which in a sampling plan corresponds to a specified but relatively high probability of acceptance.

1) At present at the stage of draft. (Revision, in part, of ISO 2859 : 1974.)

2) At present at the stage of draft.

3) Definition taken from ISO 3534 : 1977. (ISO 3534 is currently being revised by ISO/TC 69, *Applications of statistical methods.*)

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.¹⁾

4 Quality assurance

4.1 General

4.1.1 Approval of manufacturers

The manufacturer shall conform to the quality assurance and approval procedures in effect in the purchaser's country : 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.

The granting of an approval of the manufacturer is a function of the Certification Authorities, or their appointed representative, who may be the prime contractor.

4.1.2 Qualification of bolts

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

The granting of qualification of a bolt is a function of 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 acceptance inspections and tests of bolts is to check, as simply as possible, using a method which is inexpensive and representative of actual conditions of use, with the uncertainty inherent in statistical sampling, that the bolts satisfy the requirements of this International Standard.

Acceptance inspections and tests 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 and test conditions

Qualification inspections and tests (requirements, methods, numbers of bolts) are specified in table 1. They 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 of a bolt be granted, without inspection or testing : 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 and tests shall be repeated on any bolt if the manufacturing conditions have changed.

Table 2 indicates the allocation of bolt specimens for the inspections and tests.

Qualification inspections and tests are summarized in table 3.

4.3 Acceptance inspection and test conditions

Acceptance inspections and tests (requirements, methods, numbers of bolts) are specified in table 1; they shall be carried out on each production batch or inspection lot. Bolts from the batch or lot to be tested shall be selected by simple random sampling.

Each bolt may be submitted to several inspections or tests.

The bolts to be subjected to destructive inspections or tests may be those on which non-destructive inspections or tests have 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 acceptance inspection and testing. In this case, the number of bolts submitted to these inspections and tests is the same as that submitted for qualification inspections and tests.

Production batches or inspection lots declared unacceptable after the acceptance inspections and tests shall be submitted for re-inspection or re-testing only after all defective units have been removed and/or defects have been corrected.

Twice the normal sample size shall be used for re-inspecting or re-testing the attributes causing initial rejection; the same acceptance level shall be used.

Acceptance inspections and tests are summarized in table 3.

5 Requirements

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

1) Definition taken from ISO 3534 : 1977. (ISO 3534 is currently being revised by ISO/TC 69, *Applications of statistical methods.*)

Table 1 — Technical requirements and test methods

| Clause No. | Characteristic | Technical requirement | Inspection and test method | Q/A ¹⁾ | Sample size |
|------------|-----------------------|---|--|-------------------|-------------------------------------|
| 5.1 | Materials | In accordance with the product standard or definition document. | As stated in the material specification. | | |
| 5.2 | Dimensions | In accordance with the requirements of the product standard or definition product. | Standard gauging. | Q A | 22 Tables 8 and 9 |
| 5.3 | Manufacturing | | | | |
| 5.3.1 | Forging | The heads of the bolts shall be formed by a hot or cold forging process before heat treatment. In the case of hot forging, the equipment shall be such that an adequate temperature is guaranteed throughout the production batch. | The equipment used shall be approved. | | |
| 5.3.2 | Heat treatment | The forged blanks shall be heat treated to produce the properties required by the product standard or definition document. Blanks shall not be hardened more than twice. | | | |
| 5.3.3 | Machining | The amount of material removed from the bearing surface of the head and the shank of the heat-treated blanks shall be as little as practicable consistent with the removal of surface contamination, production of a smooth surface and maintenance of optimum grain flow around the under-head fillet radius as shown in figure 1. | See 5.5.1. | | |
| 5.3.4 | Cold rolling | 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; this may cause distortion which shall not exceed the values shown in figure 2; this requirement is not applicable to fully threaded screws or bolts with a nominal diameter less than MJ5. | See 5.5.1. | | |
| 5.3.5 | Threads | To be formed by a single rolling process after all heat treatment (e.g. after hardening, tempering, etc.). | | | |
| 5.3.6 | Surface roughness | In accordance with the product standard or definition document. | Visual comparison method or thumbnail comparison method. | Q A | 3 Tables 8 and 9 |
| 5.3.7 | Surface coating | In accordance with the product standard or definition document. | See applicable coating specification. | Q A | 3 Tables 8 and 9 |
| 5.4 | Mechanical properties | | | | |
| 5.4.1 | Tensile strength | In accordance with the minimum tensile loads specified in table 5. Tensile tests are not applicable to the following : a) protruding head bolts of grip length less than $2D$; b) countersunk head bolts of grip length less than $2,5D$; c) threaded-to-head bolts of overall length less than $3D$ or bolts having an overall length less than 18 mm. In such cases, this test shall be replaced by a hardness test. | See ISO 7961. | Q A | 5 Table 10, column B or table 11 |

1) Q = qualification inspection and test conditions (see 4.2)

A = acceptance inspection and test conditions (see 4.3)

Table 1 — Technical requirements and test methods (continued)

| Clause No. | Characteristic | Technical requirement | Inspection and test method | Q/A | Sample size |
|------------|---|--|---|--------|---|
| 5.4.2 | Double shear strength | In accordance with the values specified in table 5. The grip length shall not be shorter than twice the nominal shank diameter for protruding head bolts or shorter than 2,5 times the nominal shank diameter for countersunk heads. | See ISO 7961. | Q A | 5 Table 10, column B or table 11 |
| 5.4.3 | Hardness | Before surface coating is applied, the hardness at the end of the thread shall be : Brinell : 327/370 HBS or Rockwell : 36/40 HRC or Vickers : 344/390 HV 30 | See ISO 6506, ISO 6507-1 and ISO 6508. | Q A | 4 Table 10, column A |
| 5.4.4 | Tension fatigue strength | Life : — mean value 65 000 cycles min. — individual value 45 000 cycles min. 130 000 cycles max. Frequency : 140 Hz Loads : see table 6 Unbroken bolts shall be rendered unusable. Unless otherwise specified, fatigue tests shall not be carried out on the following : a) bolts with drilled shanks; b) bolts of thread size smaller than 5 mm; c) bolts having a grip length of less than twice the diameter. | See ISO 7961. | Q A | 10 Table 10, column B |
| 5.5 | Metallurgical properties | | | | |
| 5.5.1 | Head-to-shank grain flow and fillet work effect | Flow lines in the fillet area immediately below the surface shall closely conform to the fillet contour (see figure 1). See figure 1 for breaks in flow lines. If there is doubt about the acceptability of the grain flow or fillet work effect, the acceptability shall be decided by the results of the acceptance fatigue test. | Specimens shall be taken from the finished bolt (see figure 6). The sections to be examined shall be subjected to a macroscopic etchant. Macroscopic examination of a longitudinal section at a suitable magnification (X10 to X20). | Q A | 4 Table 10, column B |
| 5.5.2 | Thread grain flow and work effect | The 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 3). | Macroscopic examination. | Q A | 4 Table 10, column B |
| 5.5.3 | Microstructure | The finished bolts shall show no signs of overheating, carburization, nitrogenization or intergranular oxidation in excess of the limits specified in table 4. | Specimens shall be taken from the finished bolt (see figure 6). The sections to be examined shall be subjected to an appropriate microscopic etchant. Microscopic examination at a magnification of X100. In cases of doubt, micro-hardness testing of the shank shall be carried out using a load of 50 g. Bolts are acceptable if the difference in Vickers micro-hardness, when measured in a zone between 0,075 and 1,5 mm from the surface, is within 45 points. | Q A | 4 Table 10, column B |
| 5.5.4 | Discontinuities | The bolts shall not show any discontinuity equal to or greater than the limitations specified in this International Standard (see table 4). Care shall be exercised to avoid confusing cracks with other discontinuities. Cracked bolts and those having discontinuities transverse to the axis (i.e. at an angle of more than 10° to the longitudinal axis) shall be rejected and destroyed. | Magnetic inspection by both longitudinal and circular methods. The combined method is permissible. In cases of doubt, microscopic examination at a magnification of X100 shall be carried out. | Q A | 25 Magnetic : tables 8 and 9 Microscopic examination : table 10, column B |

Table 1 — Technical requirements and test methods (concluded)

| Clause No. | Characteristic | Technical requirement | Inspection and test method | Q/A | Sample size |
|------------|------------------------|---|----------------------------|--------|----------------------|
| 5.5.4.1 | Head and shank | See table 4 for the limits of acceptance. | | | |
| 5.5.4.2 | Thread | Acceptance limits (see figures 4 and 5) : — in the unloaded part of the fillet, above the pitch diameter, see table 7; — at the crest of the threads, see table 7 — values to be increased by half the difference between the actual measured diameter and the minimum external thread diameter (see ISO 5855-2); — a slight irregularity in the form of the crests in relation to the basic profile is acceptable (see figure 5). | | | |
| 5.6 | Product identification | Marking in accordance with the product 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 inspection. | Q A | 25 Tables 8 and 9 |
| 5.7 | Delivery | | | | |
| 5.7.1 | Packaging | The 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 basic package shall only contain bolts with the same part number and the same inspection lot number. | Visual inspection. | A | 100 % |
| 5.7.2 | Labelling | Each basic package shall carry a label on which the complete part number, quantity, production batch number and inspector's stamp have been legibly recorded. | Visual inspection. | A | 100 % |

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Table 2 — 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 | |
| | | Un-coated | | | Coated | | | | | | | | | | | | | | | | | | | | | | |
| Non-destructive | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dimensions | 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 |
| Surface roughness | 5.3.6 | X | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| Surface coating | 5.3.7 | | | | X | X | X | | | | | | | | | | | | | | | | | | | | |
| Discontinuities | 5.5.4 | 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 | 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 | X |
| Destructive | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Tensile strength | 5.4.1 | | | | X | X | X | X | X | | | | | | | | | | | | | | | | | | |
| Double shear strength | 5.4.2 | X | X | X | | | | | | | | X | X | | | | | | | | | | | | | | |
| Hardness | 5.4.3 | | | | | | | | | X | X | X | X | | | | | | | | | | | | | | |
| Tension fatigue strength | 5.4.4 | | | | | | | | | | | | | | | | X | X | X | X | X | X | X | X | X | X | |
| Head-to-shank grain flow and fillet work effect | 5.5.1 | | | | | | | | | X | X | X | X | | | | | | | | | | | | | | |
| Thread grain flow and work effect | 5.5.2 | | | | | | | | | X | X | X | X | | | | | | | | | | | | | | |
| Microstructure | 5.5.3 | | | | | | | | | X | X | X | X | | | | | | | | | | | | | | |

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Table 3 — Summary of qualification and acceptance tests

| Type of test | Defined in | Sample size for | |
|---|------------|-----------------------------------|---|
| | | qualification tests ¹⁾ | acceptance tests |
| Dimensions | 5.2 | 22 | Tables 8 and 9 |
| Surface roughness | 5.3.6 | 3 | Tables 8 and 9 |
| Surface coating | 5.3.7 | 3 | Tables 8 and 9 |
| Tensile strength | 5.4.1 | 5 | Table 10, column B or table 11 |
| Double shear strength | 5.4.2 | 5 | Table 10, column B or table 11 |
| Hardness | 5.4.3 | 4 | Table 10, column A |
| Tension fatigue strength | 5.4.4 | 10 | Table 10, column B |
| Head-to-shank grain flow and fillet work effect | 5.5.1 | 4 | Table 10, column B |
| Thread grain flow and work effect | 5.5.2 | 4 | Table 10, column B |
| Microstructure | 5.5.3 | 4 | Table 10, column B |
| Discontinuities | 5.5.4 | 25 | Magnetic : tables 8 and 9 Microscopic examination : table 10, column B |
| Product identification | 5.6 | 25 | Tables 8 and 9 |
| Packaging | 5.7.1 | — | 100 % |
| Labelling | 5.7.2 | — | 100 % |

1) The same test sample may be used for more than one test provided that none of the characteristics of the sample is altered during the test procedure.

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Table 4 — Surface discontinuities and contamination

Dimensions in millimetres

| Location | Permissible discontinuity | Maximum depth normal to surface for bolts having a nominal diameter | |
|--|---|---|-----------------|
| | | up to 16 mm | 18 mm and above |
| Head-to-shank fillet and root of thread | No discontinuities | | |
| | No surface contamination | | |
| Shank diameter and bearing surface of head | Seams not extending into head-to-shank fillet or root of thread | 0,12 | 0,15 |
| | No surface contamination | | |
| Non-bearing surface of head | Laps, seams and inclusions | 0,25 | 0,3 |
| | Decarburization | | |
| | — partial | 0,1 | 0,1 |
| | — total | 0 | 0 |
| Any other location | Decarburization | | |
| | — partial | 0,1 | 0,2 |
| | — total | 0 | 0 |