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Space product assurance

Requirements for manufacturing and procurement of threaded fasteners

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Foreword

This Standard is one of the series of ECSS Standards intended to be applied together for the management, engineering and product assurance in space projects and applications. ECSS is a cooperative effort of the European Space Agency, national space agencies and European industry associations for the purpose of developing and maintaining common standards.

Requirements in this Standard are defined in terms of what shall be accomplished, rather than in terms of how to organize and perform the necessary work. This allows existing organizational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standards.

The formulation of this Standard takes into account the existing ISO 9000 family of documents.

This Standard has been prepared by editing ESA PSS-01-746, reviewed by the ECSS Product Assurance Panel and approved by the ECSS Steering Board.

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Contents

Figures

Tables

1

Scope

This Standard defines the minimum requirements for manufacturing, provision, inspection and quality control of high-quality threaded fastening devices (bolts, nuts, studs and screws) hereafter referred to as threaded fasteners or fasteners, used in space hardware.

This Standard does not include a complete review of the factors relevant to the fabrication of high quality threaded fasteners. It provides guidelines to the customer and the supplier in the definition of the technical requirements and quality control procedures to be applied in the fabrication and supply of threaded fasteners for spacecraft applications.

NOTE Fasteners for spacecraft applications are those aerospace standard fasteners (i.e. in accordance with LN, DIN or other national or international aerospace standards), or those fasteners meeting or exceeding the requirements in ISO 4759-1 for "Product grade A", which also fulfil the requirements for space applications as specified in the present document.

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2

Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this ECSS Standard. For dated references, subsequent amendments to, or revisions of any of these publications do not apply. However, parties to agreements based on this ECSS 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 publication referred to applies.

ECSS-P-001	Glossary of terms
ECSS-E-30-01A	Space engineering — Fracture control
ECSS-Q-70	Space product assurance — Materials, parts and processes
ECSS-Q-70-02	Space product assurance — Thermal vacuum outgassing test for the screening of space materials
ECSS-Q-70-29	Space product assurance — The determination of offgassing products from materials and assembled articles to be used in a manned space vehicle crew compartment
ECSS-Q-70-36A	Space product assurance — Material selection for controlling stress-corrosion cracking
ECSS-Q-70-37	Space product assurance — Determination of the susceptibility of metals to stress— corrosion cracking
ECSS-Q-70-71	Space product assurance — Data for selection of space materials
ISO 204	Metallic materials — Uninterrupted uniaxial creep testing in tension — Method of test
ISO 225	Fasteners — Bolts, screws, studs and nuts — Symbols and designations of dimensions
ISO 1502	ISO general — purpose metric screw threads — Gauges and gauging
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 2859-2	Sampling procedures for inspection by attributes, Part 2: Sampling plans indexed by limiting quality (LQ), for isolated lots inspection

ISO 3353-1:2002	Aerospace — Lead and runout threads — Part 1: Rolled external threads
ISO 3800	Threaded fasteners – Axial load fatigue testing – Test methods and evaluation of results
ISO 4759-1	Tolerances for fasteners — Part 1: Bolts, screws, studs and nuts — Product grades A, B and C
ISO 6157-2	Fasteners — Surface discontinuities – Part 2: Nuts
ISO 6157-3	Fasteners – Surface discontinuities – Part 3: Bolts, screws and studs for special requirements
ISO 6506-1	Metallic materials — Brinell hardness test — Part 1: Test method
ISO 6506-2	Metallic materials — Brinell hardness test — Part 2: Verification and calibration of testing machines
ISO 6506-3	Metallic materials — Brinell hardness test — Part 3: Calibration of reference blocks
ISO 6507-1	Metallic materials — Vickers hardness test – Part 1: Test method
ISO 6507-2	Metallic materials — Vickers hardness test — Part 2: Verification and calibration of testing machines
ISO 6507-3	Metallic materials — Vickers hardness test — Part 3: Calibration of reference blocks
ISO 6508-1	Metallic materials — Rockwell hardness test — Part 1: Test method
ISO 6508-2	Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines
ISO 6508-3	Metallic materials — Rockwell hardness test — Part 3: Calibration of reference blocks
ISO 9140:1998	Aerospace – Nuts, plain or slotted (castellated) – Test methods
ASTM B 117-03	Standard practice for operating salt spray (fog) apparatus
ASTM E 1417-99	Standard practice for liquid penetrant examination
ASTM E 1444-01	Standard practice for magnetic particle examination

3

Terms, definitions and abbreviated terms

3.1 Terms and definitions

The following terms and definitions used in this document are complementary or additional to those specified in ECSS-P-001 and ECSS-Q-70.

3.1.1
bolt
cylindrical screwed bar provided with a head, generally not threaded along its entire length (i.e. shank plus threaded portion)

3.1.2
customer specification document for threaded fasteners
document that specifies the technical and quality requirements for threaded fasteners, and the criteria and procedures to be used to assess the fulfilment of such requirements

3.1.3
fail-safe
approach in which the structure is designed with sufficient structural redundancy to ensure that the failure of one structural element does not cause general failure of the entire structure

3.1.4
fastener
device used to hold parts firmly together in an assembly

3.1.5
galling
condition whereby excessive friction between high spots results in localized welding with subsequent splitting and a further roughening of rubbing surfaces of one or both or two mating parts

3.1.6
nut
metal collar, screwed internally, to fit a bolt; usually hexagonal in shape and operated by a spanner

3.1.7
safe-life
approach which requires that the largest undetected defect that can exist in the structure does not grow to failure when subjected to loads and environments encountered in service

3.1.8
shank
unthreaded portion of the cylindrical screwed bar of a bolt

3.1.9
stud
shank, or endless bolt, externally screwed from one end, both ends or along its entire length

3.1.10
(screw) thread
helical ridge of approximately triangular, square or rounded section, formed on a cylindrical core, the pitch and core diameter being standardised under various systems

3.1.11
threaded fastener
device composed by a cylindrical screwed bar provided with a head and a metal collar, screwed internally, to fit the cylindrical bar that is used to hold parts firmly together in an assembly

3.2 Abbreviated terms

The following abbreviated terms are defined and used within this Standard.

ASTM	American Society for Testing and Materials
UTS	ultimate tensile strength
ISO	International Organisation for Standardisation
NDI	non-destructive inspection
PVC	polyvinyl-ion chloride
HB	Brinell hardness
HV	Vickers hardness
HRC	Rockwell hardness
RMC	raw material certificate
AQL	acceptance quality level
QL	quality level
PCR	product conformance report

4

Fabrication

4.1 General

This clause refers to the fabrication process of threaded fasteners (bolts, nuts, studs and screws). The fastener manufacturer shall have a quality assurance system. It is the manufacturer's responsibility to verify and assure conformance during production to the technical requirements specified in this clause.

4.2 Raw material

a. The raw material shall be suitable for threaded fastener applications and its selection shall be in accordance with metallic materials requirements as per ECSS-Q-70-71, if not otherwise specified in the customer specification document.

b. Nut material shall be more ductile than bolt material so that during tightening nut threads can deflect to seat on the bolt threads.

c. Materials for threaded fasteners shall be selected in order to avoid galling of the mating surfaces.

NOTE Galling in stainless steel fasteners can be prevented by using two different steels on the mating surfaces and by specific surface treatments.

4.3 Head forming

Fastener heads shall be formed by hot or cold forging before heat treating. Driving recesses and lightening holes in double hexagon design can be forged or machined.

4.4 Heat treatment

a. Headed forged blanks shall be heat treated and cold worked by rolling or drawing methods in accordance with the specifications in this Standard to obtain the mechanical properties as specified in the customer specification document for threaded fasteners and meet the requirements on the metallurgical properties as specified in clause 5 of this Standard.

b. Forged blanks belonging to the same batch shall be heat treated in one batch. The manufacturer shall re-treat a batch which, tested as in 6.3, did not meet the mechanical property requirements, no more than twice (three times for Titanium alloys).

c. In the case where the manufacturer is unable to carry out the blank fabrication as requested by the customer, the blanks may be produced by a different supplier. In this case, inspections and quality control shall be performed as specified in 7.2.1 under direct responsibility of the original supplier.

d. Grinding of shank and head bearing surfaces of blanks to obtain roughness values as specified in 5.4 shall be carried out after any heat treatment.

4.5 Head-to-shank fillet rolling

a. Head-to-shank fillet rolling shall be carried out after any heat treatment and machining processes. Cold rolling shall remove from the fillet surface any evidence of previous machining or etching process.

b. Geometrical distortion of the fillet surface shall be within the limits specified in 5.3.

c. In fasteners having compound radii between head and shank, cold rolling can be extended to the remaining part of the fillet surface.

d. There shall be no machining or etching of the fillet radius after rolling.

4.6 Threads

a. External threads shall be formed by rolling process.

b. Thread rolling shall be carried out on each fastener in one single continuous operation. If not possible due to specific size, length or manufacturing limitations, fasteners shall be subjected to a fatigue test in accordance with 6.5.

c. In fasteners of large diameter, threads can be machined oversized and subsequently rolled. No evidence of machining shall be observed on the thread surface after rolling.

d. Thread rolling shall be carried out after heat treatment and machining of fasteners.

e. Unless otherwise specified in the customer specification document, a single right-hand thread shall be obtained.

f. The thread run-out portion of a bolt or stud shall consist in a progressive and regular junction with the shank avoiding sharp changes in section. Thread lead and runout portions shall conform to the requirements in clause 4 of ISO 3353-1:2002.

4.7 Identification marking

a. Fasteners shall be marked by depressed characters only with character size in accordance with the customer specification document for threaded fasteners and drawings. Characters shall:

   1. be depressed no more than 0,25 mm from the surface and shall have rounded root form;
   2. unless otherwise specified in the customer specification document for threaded fasteners, be impressed on the upper surface of the fastener head.

b. Marks shall univocally identify the fastener batch and manufacturer.

c. Safe-life fasteners shall be identification marked separately after non-destructive inspection.

4.8 Surface treatment

a. A suitable surface treatment shall be selected in order to improve surface characteristics and corrosion resistance. The selected surface treatment shall be in accordance with the customer specification document for threaded fasteners.

b. In surface plated fasteners, surface plating shall be applied to the entire fastener surface including the threaded portion. Tolerance variations caused by surface plating should be taken into account.

c. Cadmium and zinc plated fasteners shall not be accepted.

d. Silver plating shall not be used on titanium alloy fasteners.

NOTE Silver and cadmium plating can cause embrittlement of titanium alloys.

Since electrolytic plating processes generate hydrogen, baking should be carried out after plating to prevent hydrogen embrittlement. The baking temperature should be adequately lower than the decomposition temperature of the plating and substrate material.

4.9 Workmanship, handling and packaging

a. Fasteners shall be free from burrs, tool marks, scale, other surface defects and contaminants.

b. Fasteners shall be handled and packed in order to prevent mechanical damage and contamination (e.g. from PVC or fibreboard) during storage and transportation.

- Fasteners of the same batch shall be packed in unit packages.
- No protective lubricants or substances shall be applied on fasteners unless otherwise specified in the customer specification document.

c. Each individual package shall be univocally identified by a durable and legible external marking indicating the product denomination, quantity, batch identification, manufacturer, product conformance report as in 7.2.5 and date of packing.

d. Safe-life fasteners shall be packed and stored separately.

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5

Dimensional and metallurgical requirements

5.1 General

Dimensional and metallurgical controls shall be carried out in accordance with the sampling procedures and acceptance criteria specified in 7.2.1.

- Designation of dimensions and symbols shall be in accordance with ISO 225.
- Dimensional control of fasteners (bolts, nuts and studs) shall be carried out at room temperature (22 ± 3) °C. Gauges and measuring devices shall be in accordance with ISO 1502.

5.2 Nominal dimensions

a. Nominal dimensions shall be in accordance with the detail drawings of the customer specification document for threaded fasteners. All dimensions shall refer to the final product and include any dimensional modification subsequent to chemically applied or electroplated coating.

b. Relevant ISO standards on thread geometry and dimensions shall apply.

c. Tolerances for fasteners shall be in accordance with national or international aerospace standards (e.g. LN, DIN aerospace standards) or meet or exceed tolerance values specified in ISO 4759-1 for “Product grade A”.

5.3 Head-to-shank fillet

In bolts, cold rolling of head-to-shank fillets can cause distortion of fillet areas. Figure 1 shows the typical distortion of the head-to-shank fillet profile. In all cases, the value of distortion shall not exceed 0,03 mm above and below the profile lines at points A and B in Figure 1. Table 1 indicates the maximum values of the extension C of the distorted area.

5.4 Non-destructive inspections

a. Fasteners shall be free from surface defects such as flaws and inclusions. Inspections on bolts, studs and screws shall be carried out by using liquid penetrant or magnetic particles in accordance with ASTM E 1417-99 and ASTM E 1444-01, respectively. Inspection results shall conform to the requirements e.1. and e.2. of this subclause. Non-destructive inspections shall be carried out by qualified personnel.

b. Sampling procedure shall be as specified in 7.2.3.

c. Fasteners for safe-life applications shall be inspected using a 100 % batch inspection plan. Fasteners belonging to this category shall be inspected by X-ray, ultrasonic or eddy current inspection methods to obtain 95 % (minimum) confidence level and 90 % (minimum) probability of defect detection. Results of NDI shall be evaluated in accordance with subclause 10.3 of ECSS-E-30-01A.

d. Fasteners with detected surface defects shall be visually re-examined at x15 (minimum) magnification factor. An accurate measurement of the defect size can be obtained by metallographic examination in accordance with 5.5.

e. Fasteners shall be considered as non-conformant if:

1. for fasteners for fail-safe applications, the size of any defect is larger than the size specified in ISO 6157-2 and ISO 6157-3; or
2. for fasteners for safe-life applications, the size of any defect is larger than the size specified in subclause 10.3 of ECSS-E-30-01A.

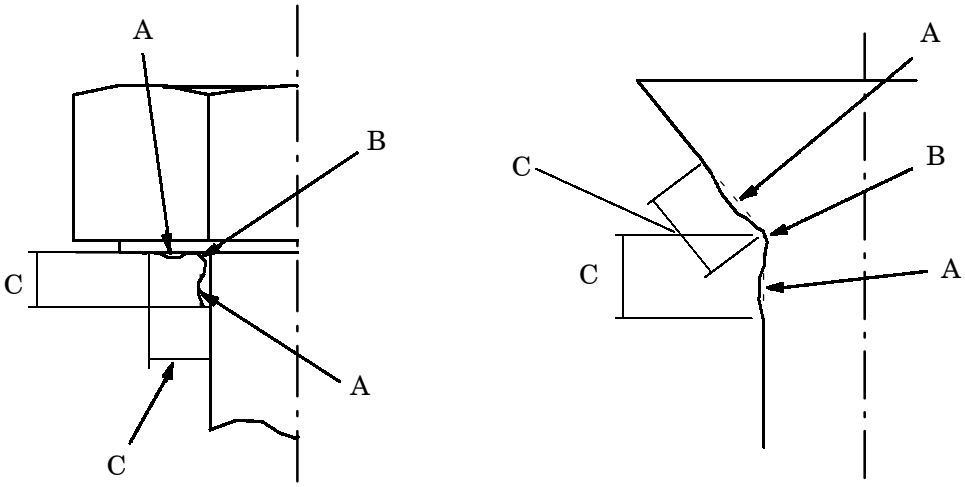


Figure 1: Tolerance of head-to-shank fillet profile

Table 1: Maximum allowed values of the extension C of the distorted area shown in Figure 1

Nominal diameter, d (mm)	d < 5	5 ≤ d ≤ 7	8 ≤ d ≤ 10	11 ≤ d ≤ 16	17 ≤ d ≤ 24	d > 24
C maximum (mm)	1,00	1,5	2,5	3,5	4,5	5,0

5.5 Metallurgical examination

a. Fasteners selected for metallurgical examination shall be cut and prepared for observation in accordance with good standard laboratory practice. Figure 2 shows the locations of microsections.

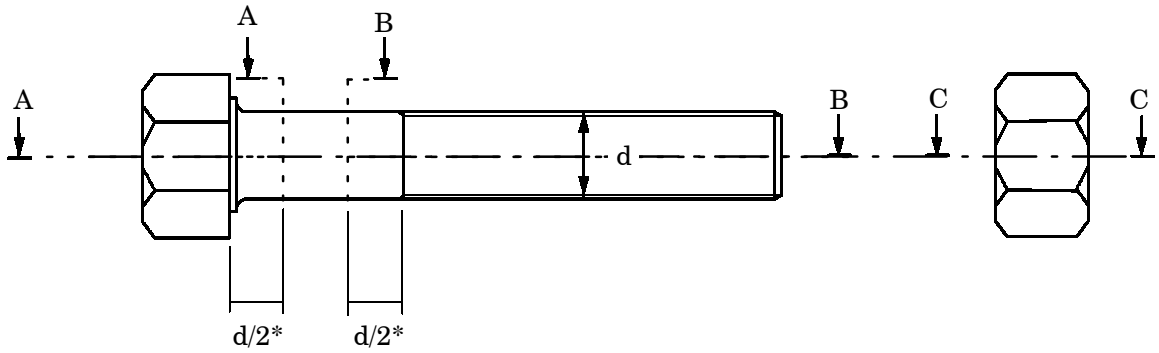
b. Fasteners when visually examined at a magnification of between ×10 and ×50 shall exhibit a continuous grain flow in the head area and head-to-shank transition zone.

c. Interruptions in grain flow within the area defined by Z dimensions in Figure 3. Z values shall be equal to or less than the maximum fillet radius R ($Z \leq R_{max}$) as specified in the detail drawings of the customer specification document for threaded fasteners.

d. Fasteners visually examined at a magnification of ×50 shall exhibit continuous grain flow following the thread profile with maximum density of flow lines at thread roots, as shown in Figure 4.

e. Fastener microstructure shall be free from internal defects such as voids, cracks, inclusions, gross alloy segregation and indication of overheating. Fastener microstructure shall be visually inspected for internal defects at a magnification of ×100 or higher in un-etched condition.

f. Surface coated or plated fasteners shall exhibit adequate thickness, uniformity and integrity of the protective layer.



(*) minimum required

Figure 2: Location of microsections for metallurgical examination

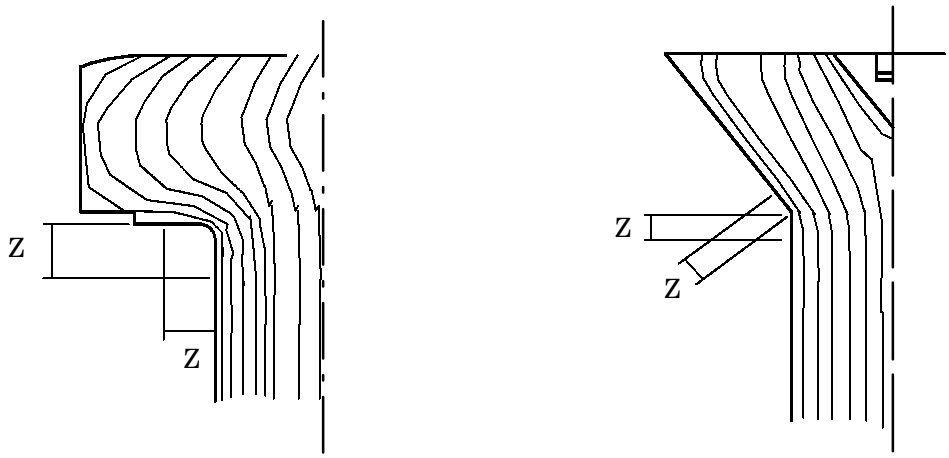


Figure 3: Area delimiting interruptions in grain flow in the head-to-shank region

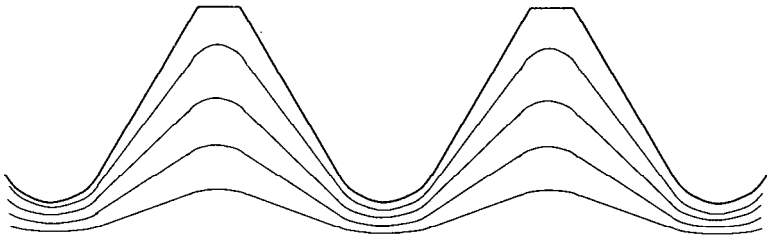


Figure 4: Example of a regular grain flow in a threaded surface

5.6 Measurement of hydrogen content

Hydrogen contamination can cause embrittlement and degradation of mechanical properties of metals. Titanium alloys are particularly prone to embrittlement by hydrogen absorption.

a. Embrittlement by hydrogen absorption shall be prevented.

b. Hydrogen content in fasteners shall be measured by an approved vacuum fusion or vacuum extraction method. Samples of material can be extracted from the fastener head after the removal of any surface coating.

c. Hydrogen content in fully finished fasteners made of Titanium alloys shall not exceed 0,0125 %.

5.7 Outgassing and offgassing

a. Thermal vacuum outgassing test in accordance with ECSS-Q-70-02 shall be carried out on fasteners with organic inserts or collars, lubricants or protective substances if exposed to vacuum during service.

b. Offgassing test in accordance with ECSS-Q-70-29 shall be carried out on fasteners with organic inserts or collars, lubricants or protective substances if used in crew compartments of manned space vehicles.

6

Mechanical testing

6.1 General

a. With the exception of the cases covered in 6.6, 6.7 and 6.8, mechanical testing for quality control purposes shall be performed at room temperature (22 ± 3) °C and laboratory air, (55 ± 10) % relative humidity. Mechanical properties of fasteners shall be in accordance with the specifications in the customer specification document for threaded fasteners.

b. Mechanical testing shall be carried out in accordance with the sampling procedures and acceptance criteria specified in 7.2.3.

c. Fasteners shall be retained in an approved quarantine facility for record or traceability purposes or destroyed in accordance with company practice after mechanical testing.

NOTE The test methods specified in this Standard are intended for quality control and acceptance only, ensuring that fastener properties are within the limit values specified in the customer specification document for threaded fasteners.

6.2 Hardness test

a. Hardness tests shall be carried out in accordance with:

1. the Brinell Hardness Test (HB) in accordance with ISO 6506 (all parts), or
2. the Vickers Hardness Test (HV) in accordance with ISO 6507 (all parts), or
3. the Rockwell Hardness Test (HRC) in accordance with ISO 6508 (all parts).

Measured hardness values shall conform to the hardness values specified in the customer specification document for threaded fasteners.

b. Hardness tests on fasteners shall be carried out on the circular surface at the end of the threaded portion of the fastener shank after removing any surface coating. For fasteners with nominal diameter greater than 6 mm, hardness shall be measured in the centre of the circular surface and at two other locations at different distances from the centre of the surface, Figure 5.

c. For short fasteners which cannot be tensile tested (usually with a grip length less than twice the nominal diameter), Vickers hardness measurements shall

be carried out on a longitudinal microsection of the shank. In this case hardness shall be measured along the shank longitudinal axis.

d. When deemed necessary to check the heat treatment batch homogeneity by hardness testing, hardness tests shall be carried out after the completion of any heat treatment and before any rolling operation.

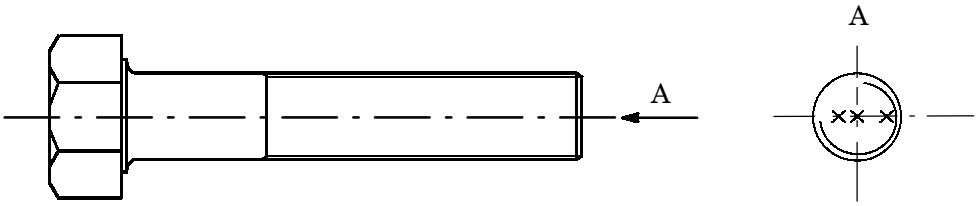


Figure 5: Locations for hardness testing (indicated with cross symbol)

6.3 Tensile test

a. The present tensile test method shall apply to finished fasteners having:
   1. A protruding head with grip length equal or greater than twice the nominal diameter, or
   2. A countersunk head and an overall length equal or greater than three times the nominal diameter, or
   3. A minimum length of 18 mm.

b. Test jigs shall be designed and manufactured in accordance with ISO 3800. Test jigs shall ensure a tensile loading parallel to the fastener main axis and no torsional stress shall be induced by the assembly. Specimens shall be assembled freely in the fixture without bending or forcing. The bearing face of the threaded part of the jig, Figure 6 (a), or of the nut, Figure 6 (b), shall be located at least four pitches of distance from the unthreaded portion of the shank and the nut threads shall be fully engaged. A bolt length of at least two pitches shall protrude beyond the threaded part of the jig, Figure 6 (a), or the test nut, Figure 6 (b).

c. Test nuts shall be used once only. When tested separately, axial load test of nuts shall be in accordance with clause 3.3 of ISO 9140.

d. Speed of testing shall be defined in terms of rate of separation of the two heads of the testing machine during a test. Speed of testing shall not exceed 25 mm/min and be preferably between 0,5 mm/min and 1,0 mm/min.

e. Static failure shall only be tolerated in the shank. Fasteners with static failures occurring at the head-to-shank fillets shall be considered as non-conformant. The yield and ultimate tensile load of a tested fastener shall not be less than the values specified in the customer specification document for threaded fasteners.

f. The cross sectional area, S, used in the interpretation of the tensile test results, expressed in mm^2, shall be assumed as the minimum of the two values S_1 and S_2 given by:

$$S_1 = \frac{\pi}{4}(d_3)^2\left[2 - \left(\frac{d_2}{d_3}\right)^2\right], \text{ or}$$

$$S_2 = \frac{\pi}{4}\phi_{\min}{}^2$$

where:

d_2 is the nominal pitch diameter in mm;

d_3 the thread root nominal diameter in mm; and

ϕ_{min} the diameter of the minimum fastener cross sectional area if not in the threaded portion.

6.4 Shear test

a. The present shear test method shall apply to finished fasteners of all sizes which meet one of the three requirements as specified in 6.3.a.

b. Fasteners with stepped threads (shouldered fasteners) shall always be tested in shear.

c. Shear test shall be carried out in double-shear loading configuration. Figure 7 shows an example of double-shear loading jigs. The shear loads to failure shall be no less than the allowable values specified in the customer specification document for threaded fasteners.

6.5 Fatigue test

a. The present fatigue test method shall apply to finished fasteners of all sizes which meet one of the three requirements as specified in 6.3.a.

b. Fatigue tests shall be carried out in accordance with ISO 3800. Fasteners shall be loaded in tension in accordance with one of the loading schemes shown in Figure 5 of this Standard.

c. The fatigue test conditions shall be specified in the customer specification document for threaded fasteners in terms of type of load fluctuation (sinusoidal unless otherwise agreed), stress range in MPa, stress ratio (R), frequency of load fluctuation in Hertz and specified mean and minimum fatigue life in cycles. The frequency of load fluctuation shall be between 4 Hz and 250 Hz and shall be selected so that the temperature of the test specimen measured at the first engaged thread is always less than 50 °C.

d. Stress calculation shall be based on the expressions for fastener cross sectional area given in 6.3. Fatigue strength values shall be determined in the finite life range (failure of all test pieces before a predetermined number of stress cycles is reached) and in the transition range where, up to a predetermined number (typically 5×10^6 to 5×10^7) of stress cycles, failure as well as non-failure occurs.

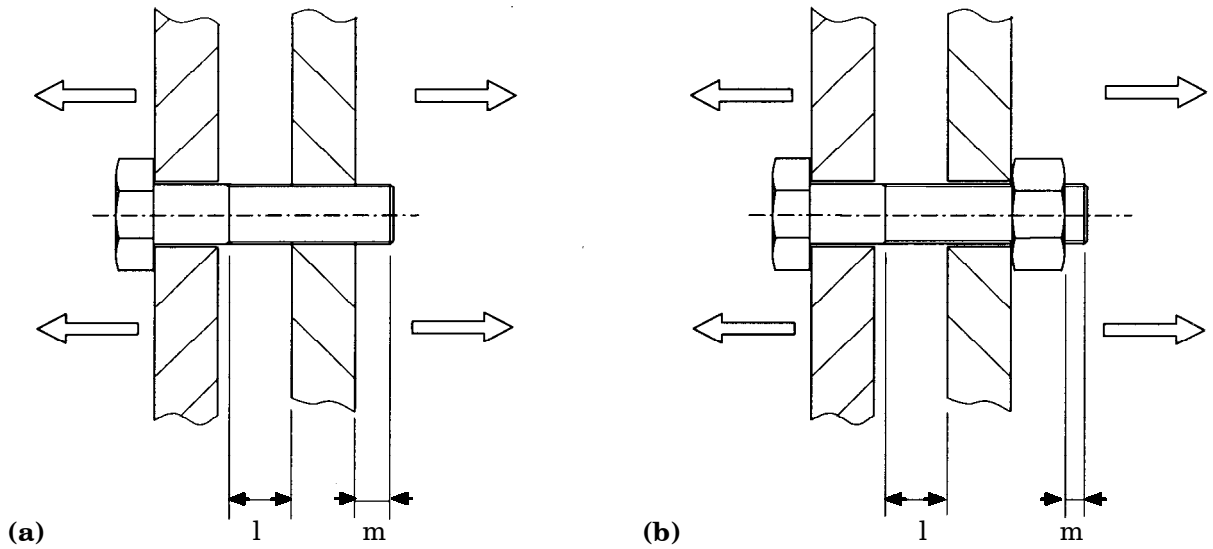
e. All the tested fasteners shall exceed the minimum number of cycles specified for each applied stress range in the customer specification document for threaded fasteners. For fasteners with fatigue lives less than the expected mean fatigue life, failure shall not occur in the head-to-shank fillet. No restrictions in failure location apply for fasteners with fatigue lives exceeding the expected mean fatigue life.

6.6 Creep test

a. The creep tests shall be carried out in accordance with ISO 204. Calculations shall be based on the expressions for fastener cross sectional area given in 6.3.f.

NOTE Creep test is particularly recommended for Titanium alloy fasteners.

b. The percent elongation after fracture, the reduction of area at failure and the time to fracture shall be within the values specified in the customer specification document for threaded fasteners.



(l ≥ four times the thread pitch and m ≥ two times the thread pitch)

Figure 6: Loading schematic for tensile testing of threaded fasteners

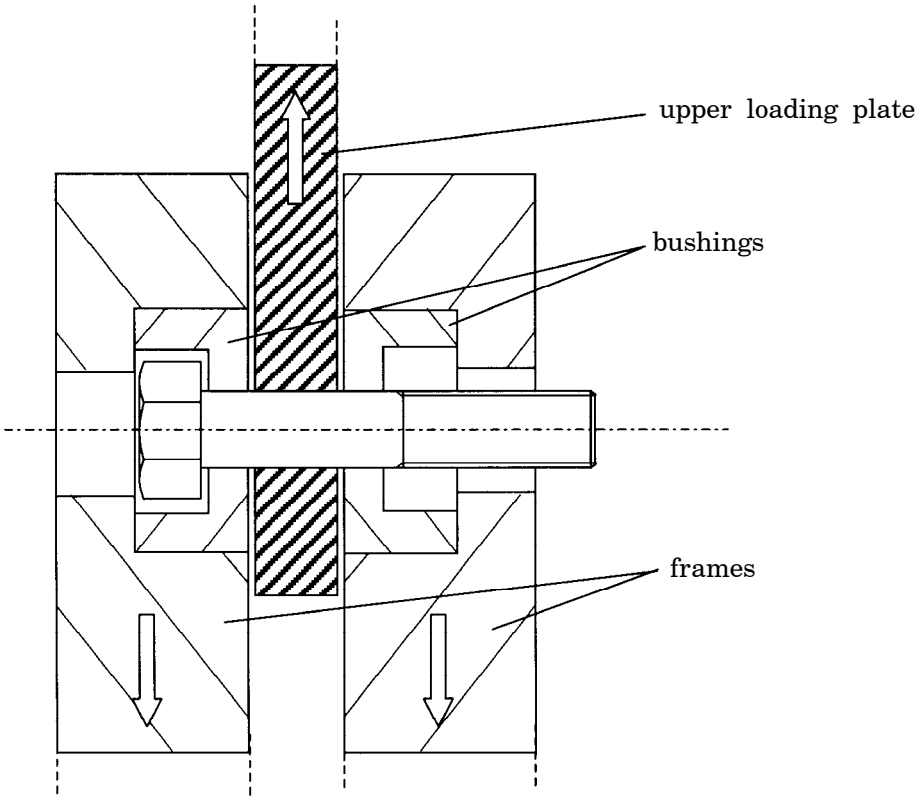


Figure 7: Schematic of an example of double-shear loading jigs

6.7 Corrosion test

Fasteners shall be manufactured using corrosion resistant materials. On customer request, fasteners shall be tested for corrosion in accordance with ASTM B 117-03. Sample geometry, exposure time and acceptance criteria shall conform to the requirements specified in the customer specification document for threaded fasteners.

Due to considerable risk of corrosion, metallic fasteners shall not be in contact with carbon fibre composite materials.

6.8 Stress-corrosion test

Materials used for fabrication of fasteners shall possess high resistance to stress-corrosion cracking. Materials with demonstrated high stress-corrosion resistance, listed in Table 1 of ECSS-Q-70-36A, should be used. Any other material should be considered for use only in cases where a suitable alloy cannot be found among those listed in Table 1 of ECSS-Q-70-36A, and the customer approval shall be obtained prior use.

Stress-corrosion testing shall be carried out in accordance with ECSS-Q-70-37.

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7

Quality assurance

7.1 General

The supplier (contractor or subcontractor) shall implement the quality assurance, inspection and quality control procedures specified herein before any supply activity. The implementation of the procedures shall be maintained for the entire duration of the contract.

7.2 Quality requirements

7.2.1 General

a. The supplier shall establish and implement adequate quality control actions and inspections to provide evidence of conformity to the product requirements. Quality control actions and inspections may be performed by the supplier or by different companies (e.g. manufacturers, test houses and external laboratories) entirely under the supplier's direct responsibility.

b. The fasteners manufacturer shall have a recognised quality assurance system in place (e.g. ISO 9001).

c. Due to possible time-dependent degradation phenomena (e.g. corrosion, stress corrosion, design modifications, improvements in materials and manufacturing processes) fasteners manufactured more than 10 years before use shall not be used in space hardware

7.2.2 Quality control of materials

a. Selection and control of suitable materials for fastener fabrication shall be based on the requirements defined in ECSS-Q-70-71. The supplier shall provide evidence that only materials in accordance with the customer specification document for threaded fasteners are used in the fabrication.

b. The supplier shall issue a raw material certificate (RMC) specifying: material standard designation, heat treatment, form, manufacturer, batch number, batch chemical analysis, batch tensile test results (0,2 % proof stress, ultimate stress and elongation) and batch hardness value.

c. In the case where NDI is requested in the customer specification document for threaded fasteners, the supplier shall include in the RMC the date of the NDI, name of inspector, NDI results with description of any non-conformance.

7.2.3 Sampling procedure

a. The supplier in agreement with the customer shall determine a sampling procedure. A sampling procedure shall be determined in accordance with:
   1. ISO 2859-1 for batch-by-batch inspections, or
   2. ISO 2859-2 for isolated batch inspections.

b. The selected sampling procedure shall be specified in the customer specification document for threaded fasteners by defining a sampling plan. A sampling plan is defined by a combination of sample size to be used and associated batch acceptability criteria. Batch acceptability criteria shall be defined in terms of:
   - acceptance quality limit (AQL), if the batch-by-batch inspection method is selected, or
   - limiting quality (LQ), if the isolated batch inspection is selected.

   Sample size shall be defined in terms of inspection levels. Table 2 gives the recommended inspection levels, QL and AQL values to be used.

c. All the specified sample units shall be drawn at random from the batch and tested. If the number of non-conforming units is less or equal to the acceptance level specified in the customer specification document for threaded fasteners, the batch shall be accepted. Any non-conforming units found during batch inspection shall be rejected.

   NOTE A batch of fasteners is a set of fasteners of the same type and diameter, obtained from the same batch of raw material, manufactured by the same process and heat treated as one batch.

7.2.4 Non-conforming batches

a. In the case where the number of non-conforming units is greater than the acceptance level specified in the customer specification document for threaded fasteners, the batch shall be rejected.

b. Re-submission for inspection of rejected batches shall be subjected to the customer approval. The customer shall determine the method of acceptance to be applied to re-submitted batches.

c. In re-submitted batches, all units in the batch shall be re-examined or re-tested and all non-conforming units removed or replaced by conforming units. On re-submission, the supplier shall indicate the non-conforming batches as re-submitted specifying the cause for previous non-conformance.

d. Batches of fasteners for safe-life applications shall be subjected to NDI in all their units.

7.2.5 Product conformance report

The supplier shall issue a product conformance report (PCR) for each delivered batch of fasteners. The PCR shall be delivered to the customer together with the batch of fasteners. The PCR shall indicate:

- batch supplier name/code;
- date of batch manufacturing;
- purchase order form;
- raw or semi-finished material supplier name/code;
- date of raw or semi-finished material production;
- batch identification number and fastener identification marks;
- reference to fastener specifications;

- the raw material certificate (RMC) including a report of quality the inspections (destructive and non-destructive) carried out on the raw or semi-finished material as specified in this document;
- report of the fasteners quality control inspections (destructive and non-destructive) as specified in this document;
- report of conformance/nonconformance and corrective actions;
- any other relevant documentation.

7.2.6 Incoming inspection

a. On delivery the customer shall carry out an incoming inspection of the batch. The customer shall establish if the information given in the PCR is complete, clear and satisfactory, and verify that the fastener identification marks are consistent with the information given in the PCR.

b. In addition, for structural fasteners with nominal diameters larger than 4 mm (M4) which are not directly procured from a fastener manufacturer (i.e. procured through a distributor or vendor), the customer shall carry out as a minimum: dimensional check, tensile test, chemical analysis, hardness test and non-destructive inspections in accordance with 5.4. Sampling procedure shall be in accordance with 7.2.3. Tests shall be carried out by qualified test laboratories.

NOTE A structural fastener is a fastener used in either the primary or secondary load path of a structure.

Unless otherwise specified, it is the supplier's responsibility to provide evidence that the batch complies with the customer specifications.

Table 2: Inspection levels, acceptance quality limits (AQL) and limiting quality levels (LQ) for inspection of fasteners

Inspection method	**High-strength steel**	**Stainless steel**	**Titanium alloys**	**Alloys for high temperature applications**
Hardness test	Inspection level S-3, AQL 0,65 LQ 5,0 %	Inspection level S-3, AQL 0,65 LQ 5,0 %	–	Inspection level II, AQL 0,65 LQ 2,0 %
Dimensional and surface control	Inspection level II, AQL 0,65 LQ 2,00 %	Inspection level II, AQL 0,65 LQ 2,00 %	Inspection level II, AQL 0,65 LQ 2,00 %	Inspection level II, AQL 0,65 LQ 2,0 %
Microstructural examination and chemical analysis	Inspection level S-1, AQL 1,5 LQ 12,5 %	Inspection level S-1, AQL 1,5 LQ 12,5 %	Inspection level S-1, AQL 1,5 LQ 12,5 %	Inspection level S-1, AQL 1,5 LQ 12,5 %
Inspection for surface defects by NDI	Inspection level II, AQL 0,065 LQ 0,5 %	Inspection level II, AQL 0,065 LQ 0,5 %	Inspection level II, AQL 0,065 LQ 0,5 %	Inspection level II, AQL 0,065 LQ 0,5 %
Inspection for surface defects by NDI – Safe-life applications	100 % batch inspection	100 % batch inspection	100 % batch inspection	100 % batch inspection
Tensile test	Inspection level S-1, AQL 1,5 LQ 12,5 %	Inspection level S-1, AQL 1,5 LQ 12,5 %	Inspection level S-3, AQL 1,0 LQ 8,0 %	Inspection level S-1, AQL 1,5 LQ 12,5 %

NOTE (*) Test carried out on customer request.

Table 2: Inspection levels, acceptance quality limits (AQL) and limiting quality levels (LQ) for inspection of fasteners *(continued)*

Inspection method	**High-strength steel**	**Stainless steel**	**Titanium alloys**	**Alloys for high temperature applications**
Shear test	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)
Corrosion test	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)
Stress-corrosion test	As specified by the customer	As specified by the customer	As specified by the customer	As specified by the customer
Fatigue test	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)
Creep test	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)	As specified by the customer (*)
Hydrogen content	As specified by the customer (*)	As specified by the customer (*)	Inspection level S-1, AQL 2,5 LQ 20,0 %	As specified by the customer (*)
Outgassing	As specified by the customer	As specified by the customer	As specified by the customer	As specified by the customer
Offgassing	As specified by the customer	As specified by the customer	As specified by the customer	As specified by the customer

NOTE (*) Test carried out on customer request.

Annex A (normative)

Customer specification document for threaded fasteners – Document requirements definition (DRD)

A.1 Introduction

This document defines the requirements for the preparation of the customer specification document for threaded fasteners.

A.2 Scope and applicability

A.2.1 Scope

This document requirements definition (DRD) establishes the data content requirements for the customer specification document for threaded fasteners.

This DRD does not define format, presentation or delivery requirements of the customer specification document for threaded fasteners.

A.2.2 Applicability

This DRD is applicable to all projects using the ECSS Standards.

A.3 Description and purpose

Within the contractual relation between the customer and the supplier, the customer specification document for threaded fasteners specifies the technical and quality requirements, and the criteria and procedures to be used to assess the fulfilment of such requirements. The customer specification document for threaded fasteners is prepared by the customer, who sets the technical and quality requirements, in collaboration with the supplier, who agrees to the requirements and procedures.

A.4 Preliminary elements

A.4.1 Title

The document to be created based on this DRD shall be titled "[insert a descriptive modifier] – Customer specification document for threaded fasteners".

The descriptive modifier shall be selected to clearly identify the applicable product.

EXAMPLE "M10 12-point tension Titanium alloy threaded fasteners – Customer specification document for threaded fasteners"
"M12 hexagon stainless steel threaded fasteners — Customer specification document for threaded fasteners"

A.4.2 Title page

The title page shall identify the project document identification number, title of the document, date of release and release authority.

A.4.3 Content list

The content list shall identify the title and location of every clause and major subclause, figure, table and annex contained in the document.

A.4.4 Foreword

A foreword shall be included which describes as many of the following items as are appropriate:

- identification of which organization prepared the document;
- information regarding the approval of the document;
- identification of other organizations that contributed to the preparation of the document;
- a statement of effectivity identifying which other documents are cancelled and replaced in whole or in part;
- a statement of significant technical differences between this document and any previous document;
- the relationship of the document to other standards or documents.

A.5 Content

The customer specification document for threaded fasteners shall specify:

a. The selected raw material in terms of: standard designation, heat treatment, form, minimum mechanical properties (hardness, 0,2 % proof stress, UTS, elongation and toughness). On procurement, the supplier shall issue a raw material certificate (RMC), in accordance with 7.2.2, to provide evidence that the raw material requirements set in the customer specification document for threaded fasteners are fulfilled.

b. The complete fastener manufacturing process in terms of all the single operations required from the raw material to obtain the finished product.

c. The nominal dimension, tolerance and geometry of the finished fastener. Fastener designation and thread type shall be indicated. Technical drawings shall be enclosed to the customer specification document for threaded fasteners.

d. Surface treatment of finished fasteners.

e. Minimum hardness values of finished fasteners.

f. Tensile mechanical properties of finished fasteners in terms of: load to yield, ultimate load and elongation to failure.

g. Minimum shear load to failure of finished fasteners.

h. Minimum and mean required fatigue strength of finished fasteners in terms of stress range versus fatigue cycles (S-N curves) at specified constant stress ratios.

i. Minimum creep properties of finished fasteners in terms of elongation, reduction of area and time to failure.

j. Corrosion requirements in terms of exposure time and acceptability criteria (maximum number and density of corrosion pits).

k. Stress-corrosion testing if requested.

l. Definition of mechanical test methods and conditions for e. f. g. h. i. j. and k. in accordance with the relevant clauses of this Standard and other applicable standards.

m. Quality control plan in terms of: identification marking, sampling procedure, sampling plan and non-destructive inspection (NDI) plan. The supplier shall issue a product conformance report (PCR), in accordance with 7.2.5, to provide evidence that the quality requirements set in the customer specification document for threaded fasteners are fulfilled.

n. Definition of procedures and time schedule for handling, storage, transportation and delivery.

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