EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space product assurance

Mechanical testing of metallic materials

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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.

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Change log

ECSS-Q-70-45A 7 April 2006	Transformation of ESA PSS-01-745 into ECSS format
ECSS-Q-70-45B	Never issued
ECSS-Q-ST-70-45C 31 July 2008	Redrafting of ECSS-Q-70-45A according to new ECSS template and ECSS drafting rules. In particular: • Introduction of Section 4 "Principles" to collect descriptive text, contained formerly in requirements section. • Collection of all requirements in one Section 5 "Requirements" • Deletion of Annex A (informative) and moving of requirements into body text. • Revision of normative annexes (now Annex A, B and C) according to new template and adaptation of order of appearance (Annex A: DRD for test request, Annex B: DRD for test proposal, Annex C: DRD for test report) • Editing of text to comply with ECSS drafting rules

Table of contents

1 Scope

This Standard specifies requirements for mechanical testing of metallic materials to be used in the fabrication of spacecraft hardware.

This Standard establishes the requirements for most relevant test methods carried out to assess the tensile, fatigue and fracture properties of metallic materials. It does not give a complete review of all the existing test methods for the evaluation of mechanical properties of metallic materials.

Furthermore, this Standard specifies requirements for the evaluation, presentation and reporting of test results.

This standard may be tailored for the specific characteristic and constrains of a space project in conformance with ECSS-S-ST-00.

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 revision 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 more recent editions of the normative documents indicated below. For undated references, the latest edition of the publication referred to applies.

ECSS-S-ST-00-01	ECSS system — Glossary of terms
ECSS-Q-ST-10-09	Nonconformance control system
ECSS-Q-ST-70	Space product assurance — Materials, mechanical parts and processes
ECSS-Q-ST-70-37	Space product assurance — Determination of the susceptibility of metals to stress-corrosion cracking
ECSS-Q-ST-70-46	Space product assurance — Requirements for manufacturing and procurement of threaded fasteners
ASTM E 139	Standard test methods for conducting creep, creep-rupture, and stress-rupture tests of metallic materials
ASTM E 399	Standard test method for plane-strain fracture toughness of metallic materials
ASTM E 466	Standard practice for conducing force controlled constant amplitude axial fatigue tests of metallic materials
ASTM E 561	Standard practice for R-curve determination
ASTM E 606	Standard practice for strain-controlled fatigue testing
ASTM E 647	Standard test method for measurement of fatigue crack growth rates
ASTM E 739	Standard practice for statistical analysis of linear or linarized stress-life (S-N) and strain-life (e-N) fatigue data
ASTM E 1290	Standard test method for crack-tip opening displacement (CTOD) fracture toughness measurement
ASTM E 1820	Standard test method for measurement of fracture

	toughness
EN 10002-1	Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature
EN 10002-2	Metallic materials — Tensile testing — Part 2: Verification of the force measuring system of the tensile testing machines
EN 10002-4	Metallic materials — Tensile testing — Part 4: Verification of the extensometers used in uniaxial testing
ESDU 96013:1996	Fracture toughness (K_{Ic}) values of some aluminium alloys
ISO 7539-6:2003	Corrosion of metals and alloys — Stress corrosion testing — Part 6: Preparation and use of pre-cracked specimens for tests under constant load or constant displacement

3 Terms, definitions and abbreviated terms

3.1 Terms defined in other standards

For the purpose of this Standard, the terms and definitions from ECSS-S-ST-00-01 and ECSS-Q-ST-70 apply.

3.2 Terms specific to the present standard

3.2.1 crack tip plastic zone

plastically deformed region in a material adjacent to a crack tip

3.2.2 creep

time-dependent increase in strain in a material resulting from force

3.2.3 damage tolerance

in a material or structure, the capability to withstand stresses or loads in the presence of defects

3.2.4 failure

condition generally caused by break or collapse so that a structural element can no longer fulfil its purpose

3.2.5 fatigue

in a material, the failure phenomenon which results from repeated fluctuation of stress

3.2.6 fracture toughness

inherent resistance of a material in the presence of a crack-like defect

3.2.7 finite life range

life range, in which all test pieces before a predetermined number of cycles fail

3.2.8 mechanical properties

those properties of a material that are associated with elastic and inelastic reaction when force is applied, or that involve the relationship between stress and strain

3.2.9 mechanical testing

determination of mechanical properties

3.2.10 raw material

material from which specimens are manufactured

3.2.11 specimen

representative fraction of material tested or analysed in order to determine mechanical properties

3.2.12 transition range

predetermined number of cycles of stress cycles (typically 5 x 10^{-6} to 5 x 10^{-7} cycles), where failure as well as non-failure occur.

3.2.13 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 to hold parts firmly together in an assembly

3.2.14 weld heat affected zone (HAZ)

portion of material in a welded joint whose microstructure and physical properties are affected by the heat input during welding

3.3 Abbreviated terms

For the purpose of this Standard, the abbreviated terms from ECSS-S-ST-00-01 and the following apply:

Abbreviation	**Meaning**
ASTM	American Society for Testing and Materials
CEN	European Committee for Standardization
CTOD	crack tip opening displacement
ESDU	engineering sciences data unit
HAZ	heat affected zone
ISO	International Organization for Standardization
NCR	nonconformance report
NDI	non-destructive inspection
RMC	raw material certificate

3.4 Symbols

Symbol	Meaning
C(T)	compact tension specimen
J	J-integral
J_{Ic}	J-integral plane-strain fracture toughness
K	stress intensity factor
K_{Ic}	stress intensity plane-strain fracture toughness
K_{max}	maximum stress intensity factor
Mode I	opening mode of loading
R	stress ratio
R_{sx}	specimen stress ratio
M(T)	middle tension specimen
da/dn	crack growth rate
ΔK	stress intensity factor range
ΔK_{th}	fatigue crack propagation threshold
K_{ISCC}	threshold stress intensity factor for susceptibility to stress corrosion cracking

4
Principles

4.1 Overview

This Standard specifies requirements to conduct tests in order to characterize mechanical behaviour and properties of metallic materials. Selection criteria of mechanical tests are based on the significance and use of each specified test method. Test methods, which are covered in this Standard, are characterized in the following paragraphs.

4.2 Tensile test

Tensile tests provide information on the strength and ductility of materials under uniaxial tensile stresses. Test results can be used in comparing materials, alloy development, design and quality control. The test method covers the tension testing of metallic materials in any form at room temperature, and specifically the methods determine yield strength, yield point elongation, tensile strength, elongation and reduction of area.

4.3 Fracture toughness test

4.3.1 Overview

This test refers to methods to determine fracture toughness of metallic materials using the following parameters: stress intensity factor (K), J-integral (J), R-curve and crack tip opening displacement (CTOD). The fracture toughness determined in accordance with this method is for opening mode (Mode I) of loading.

4.3.2 Determination of fracture toughness using the K_{Ic} test method

This method provides the measurement of crack-extension resistance at the start of a crack extension for slow rates of loading and when the crack-tip plastic zone is small compared to both the crack size and to the specimen dimension in the direction of the constraint.

The method covers the determination of linear elastic plane-strain fracture toughness (K_{Ic}) of metallic materials by tests using a variety of fatigue-precracked specimens.

4.3.3 Determination of fracture toughness using the J_{Ic} test method

This method provides the measurement of crack-extension resistance near the onset of stable crack extension for slow rates of loading and substantial plastic deformation.

The method covers the determination of the J-integral plane-strain fracture toughness (J_{Ic}) of metallic materials.

4.3.4 Characterization of fracture toughness using the R-curve test method

This method provides a characterization of the resistance to fracture of metallic materials during incremental slow stable crack extension and result from growth of the plastic zone as the crack extends from a sharp notch. Materials that can be tested for R-curve development are not limited by strength, thickness, or toughness provided that specimens are of sufficient size to remain predominantly elastic.

The method covers the determination of resistance to fracturing of metallic materials by R-curves obtained by testing compact tension specimens C(T) or middle tension specimens M(T).

4.3.5 Characterization of fracture toughness using the CTOD test method

This test method provides a characterization of the fracture toughness of metallic materials and is used for materials that exhibit a change from ductile to brittle behaviour with decreasing temperature. This method is also used to characterize the toughness of materials for which the properties and thickness of interest preclude the determination of K_{Ic} fracture toughness in accordance with ASTM E 399.

The specimen dimensions can affect the values of CTOD. For this reason specimens of same dimensions are used when comparing test results.

The method covers the determination of critical crack tip opening displacement (CTOD) values at one or more of several crack extension events. These CTOD is used as measures of fracture toughness for metallic materials.

4.4 Fatigue test

4.4.1 General

Fatigue test refers to tests methods for the determination of fatigue strength of metallic materials subjected to constant amplitude cycling loading.

4.4.2 Force controlled constant amplitude axial fatigue test

The force controlled axial fatigue test is used to determine the effect of variations in stress, material, geometry and surface condition on the fatigue resistance of materials subjected to fatigue loading. The results can also be used as a guideline for the selection of metallic materials for service under conditions of repeated direct stress.

The method covers axial force controlled fatigue tests to obtain the fatigue strength of materials in the fatigue regime, where the strains are predominately elastic throughout the test.

4.4.3 Strain-controlled fatigue test

Strain-controlled fatigue is important for situations in which components or portions of components undergo either mechanically or thermally induced cyclic plastic strains that cause failure within relatively few cycles (i.e. fatigue life $< 10^5$ cycles).

The method covers axial strain-controlled fatigue tests to obtain the fatigue strength of materials in the fatigue regime where the strains are predominately plastic.

4.5 Fatigue crack propagation test

4.5.1 Stable crack growth rate

Fatigue crack growth rate (da/dn) expressed as a function of crack tip stress intensity factor range (ΔK), characterizes a material's resistance to stable crack propagation under cyclic loading. Results from this test together with data on toughness are used in the prediction of the damage tolerance behaviour (typically the cycles or service period to grow a crack to a certain crack size, the maximum permissible crack size and residual strength) and fatigue life prediction for structural components.

The method covers the determination of stable crack growth rates from near-threshold propagation regime to controlled crack propagation instability. Results are expressed in terms of da/dn versus ΔK.

4.5.2 Crack propagation threshold

Although the fatigue-crack propagation threshold (ΔK_{th}) is defined as the asymptotic value of ΔK at which da/dn approaches zero, an operational, though arbitrary, definition of ΔK_{th} is given for most materials. This value is defined as ΔK, which corresponds to a specified fatigue crack growth rate (typically for crack growth rates of 10^{-8} m/cycle or less).

It is found that the propagation threshold behaviour of long cracks can be described in terms of stress ratio (R) as well as in terms of maximum stress intensity K_{max}, (see references [1], [2] and [3] in Annex D). From a practical point of view, testing at constant K_{max} allows to proceed faster compared to testing at constant R, since load history effects are generally negligible. The approach is based on the observation that for many alloys ΔK_{th} vs. K_{max} relationships show a quasi-linear dependency above certain K_{max} values. Similarly, K_{max} vs. R relationships at low R values can be approximated by linear relations.

Under the assumption of linear dependence, ΔK_{th} vs. K_{max} or K_{max} vs. R, relations for a material can be determined by a relatively low number of tests.

Accordingly the requirement section covers two methods to determine the fatigue crack propagation threshold for metallic materials:

Determination of an operational value of ΔK_{th}) according to ASTM E 647.

Determination of (ΔK_{th}) by testing at constant K_{max}.

4.6 Fracture and fatigue test in special environment

Fatigue and crack propagation behaviour of metallic materials exposed to gaseous or liquid environments can differ from that exhibited in air. Test results obtained from fatigue and fracture tests in environments representative of the service conditions are used to evaluate the influence of specific environments on the material behaviour.

The method covers tests to determine the influence of environments representative of service conditions on the fatigue and fracture behaviour of metallic materials.

4.7 Stress corrosion cracking test

4.7.1 Overview

The test refers to methods for the determination of the susceptibility of metallic materials to stress corrosion cracking.

4.7.2 Stress corrosion cracking test using smooth specimens

The results of this tests are used to classify alloys, weldments and their individual heat treatment conditions with respect to the material resistance against stress corrosion cracking. When sufficient stress corrosion data exists the alloy designation can be submitted for inclusion into relevant tables contained in ECSS-Q-ST-70-36.

The method covers the determination of the susceptibility of metals and weldments to stress corrosion cracking by alternate immersion in 3,5 % sodium chloride water solution under constant load.

4.7.3 Stress corrosion cracking test using pre-cracked specimens

This test method allows the determination of the threshold stress intensity factor value for stress corrosion cracking K_{ISCC}, and the kinetics of crack propagation.

The use of pre-cracked specimens acknowledges the fact that defects introduced during manufacturing and subsequent services are always present in real structures. Furthermore, the presence of such defects can cause a susceptibility to stress corrosion cracking, which in some materials (e.g. titanium alloys) is not always evident from tests conducted on smooth specimens.

This test method covers preparing and testing of pre-cracked specimens for investigating susceptibility to stress corrosion cracking of metallic materials.

4.8 Creep test

The results of this test method are used to assess the load-carrying ability of a material at high temperatures for limited deformations and as a function of time. The test provides information to assess the suitability of materials for high temperature structural applications.

The method covers the determination of the amount of deformation as a function of time (creep test) and of the time for fracture to occur (rupture test) in materials subjected to constant tensile forces at constant temperature.

4.9 Test results presentation

Before results obtained from mechanical tests can be applied with confidence, allowable values are statistically determined. The applicability of statistical methods to the evaluation of numerical results depends on:

- the number of tests performed on a specific material and test conditions, which should be large enough to constitute a statistically significant sample;
- the assumption that test data constitute a random sample of (or representation of) the population of the material under investigation.

5 Requirements

5.1 Customer agreement

a. Test methods and procedures shall be agreed with the customer prior to testing.

5.2 Tensile testing

5.2.1 General

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with EN 10002-1.

b. A minimum number of three tests shall be carried out for each set of material and test conditions.

5.2.2 Tensile testing of weldments

a. Specimens with a transverse weld shall be manufactured with the weld joint line on the centre of the specimen gauge length.

b. Specimens with a longitudinal weld shall be manufactured with the weld joint line on the specimen longitudinal axis.

c. For specimens with a transverse weld, the specimen gauge length shall be equal or greater than the weld heat affected zone (HAZ).

NOTE 1 When testing specimens with a transverse weld, note that the strain distribution within the HAZ varies as a function of the distance from the weld centre line. This implies that elongation varies as a function of the gauge length.

NOTE 2 Weldments are characterized by non-uniformity in tensile properties.

5.3 Fracture toughness test

5.3.1 K_{Ic} test method

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 399.

b. The crack plane orientation code for rectangular sections, for bars and hollow cylinders in conformance with ASTM E 399 shall be used throughout testing and reporting.

c. A minimum number of three K_{Ic} valid tests, in conformance with the validity criteria of ASTM E 399, shall be carried out for each set of material and test condition.

d. If any dimension of the available stock of a material is insufficient to provide a specimen of the required size to produce a valid K_{Ic} result, the specimen strength ratio (R_{sx}) shall be used to provide a comparative measure of the toughness when the specimens are of the same form and size.

NOTE In certain materials (e.g. some structural grade steels) the plane-strain toughness is sensitive to the loading rate. In these cases the test-loading rate is selected with respect to the specific application of the test results.

5.3.2 J_{Ic} test method

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 1820.

b. A minimum number of three J_{Ic} valid tests, in conformance with the validity criteria of ASTM E 1820, shall be carried out for each set of material and test condition.

5.3.3 R-curve test method

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 561.

b. A minimum number of three valid tests, in conformance with the validity criteria of ASTM E 561, shall be carried out for each set of material and test condition.

5.3.4 CTOD test method

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 1290.

b. A minimum number of three valid tests, in conformance with the validity criteria of ASTM E 1290, shall be carried out for each set of material and test condition.

5.4 Fatigue test

5.4.1 Force controlled constant amplitude axial fatigue test

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 466.

b. Fatigue strength values shall be determined in the finite life range and in the transition range.

c. The minimum number of tests and load levels shall be established in relation to the type of test programme conducted.

NOTE For example: exploratory research and development tests, design allowables data, reliability data.

d. For the finite life range, the following minimums shall apply:

1. a minimum of six tests per selected stress level;
2. a minimum of three stress levels.

e. In the transition range (infinite life range), the selection of the test stress levels shall be according to the staircase method, the boundary method or the arc-sine method.

NOTE A review of these methods can be found in ISO 3800

f. Fatigue test stress levels shall be selected in order to obtain constant stress ratio (R) stress-life data sets.

g. Statistical analysis of test results shall be carried out in conformance with ASTM E 739.

h. When testing a nominally homogeneous material, specimens with continuous radius between ends shall be used.

i. Axial load fatigue testing of threaded fasteners shall be carried out in conformance with clause “Fatigue test” of ECSS-Q-ST-70-46.

NOTE Fatigue strength of welded components is typically influenced by weld residual stress. For this reason, fatigue testing of weld coupons is not representative of the effects of weld residual stress on the fatigue strength of real components.

5.4.2 Strain-controlled fatigue test

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 606.

b. Fatigue strength values shall be determined in the finite life range up to a predetermined number of stress cycles.

NOTE The number of predetermined stress cycles for the finite life range is typically 10^5 strain cycles

c. Test requirements as specified in 5.4.1c, 5.4.1d, 5.4.1e and 5.4.1f shall apply.

5.5 Fatigue crack propagation test

5.5.1 Determination of fatigue crack growth rate

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 647.

NOTE C(T) specimens should be used for tests carried out at positive stress ratios, and M(T) specimens for tests carried out at negative stress ratios. Specimen configurations other than C(T) and M(T) may be used providing that well established stress intensity factor solutions are available and that specimens are of sufficient planar size to remain predominantly elastic during testing.

b. A minimum of three valid tests shall be carried out for each set of materials and test conditions.

NOTE For validity criteria see ASTM E 647.

c. Accuracy and resolution of selected crack length measurement methods shall be assessed before testing.

NOTE Measurement methods are optical, direct current potential drop technique and compliance methods.

d. The film replica technique should be used to measure the length of short cracks.

e. At the end of the test crack length values obtained with the selected measurement method shall be correlated to the physical crack length by fractographic examination.

f. Tests to characterize the crack propagation behaviour in the threshold regime shall be carried out to meet crack growth rates as specified by the customer.

NOTE Typical growth rates of the threshold regime are less than 10^8 m/cycles.

5.5.2 Determination of a fatigue crack propagation threshold

5.5.2.1 Operational value of ΔK_{th}

a. Determination of operational values of ΔK_{th} shall be carried out according to the test procedure of ASTM E 647, clause 9.4.

5.5.2.2 Alternative determination of ΔK_{th} values by testing at constant K_{max}

a. Crack propagation tests shall be carried out under constant maximum stress intensity factor K_{max} and in conformance with clause 5.5.1.

5.6 Fracture and fatigue tests in special environments

a. Test apparatus, specimens, test procedures, precision and bias shall be agreed with the customer prior to testing.

b. Transportation, handling and disposal of hazardous substances shall be in agreement with the applicable health and safety rules.

NOTE For example: material safety data sheets, national health and safety rules.

c. Composition and purity of the test environment shall be monitored and controlled throughout the test.

5.7 Stress corrosion cracking test

5.7.1 Stress corrosion cracking test using smooth specimens

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ECSS-Q-ST-70-37.

5.7.2 Stress corrosion cracking test using pre-cracked specimens

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ISO 7539-6:2003.

b. Tests shall be carried out under constant load.

c. The number of tests to be carried out for each set of material and test conditions shall be agreed with the customer.

d. Specimens shall be stressed after being brought into contact with the test environment,

e. Alternatively the specimens shall be exposed to the test environment as soon as possible after stressing.

5.8 Creep test

a. Test apparatus, specimens, test procedures, precision and bias shall be in conformance with ASTM E 139.

b. The minimum of number of tests to be carried out for each set of material and test condition shall be agreed with the customer.

5.9 Evaluation of test results

a. Arithmetic mean value and standard deviation shall be calculated from each set of numerical results obtained by testing a specific material under same test conditions.

b. Statistical analysis of numerical results of toughness tests shall be conducted in conformance with clause 4 of ESDU 96013.

c. Statistical analysis of numerical results of fatigue tests shall be conducted in conformance with clause 5.4.1g.

d. Data reduction of numerical results of fatigue crack propagation tests shall be conducted in conformance with ASTM E 647, Appendix X1.

5.10 Storage

a. Storage of materials and specimens shall be agreed with the customer.

5.11 Reporting

a. The "Request for mechanical testing of materials" shall be issued by the customer in conformance with the DRD of Annex A.

b. The "Proposal for mechanical testing of materials" shall be issued by the supplier in conformance with the DRD of Annex B and submitted to the customer for review and approval.

c. The "Report of mechanical testing of materials" shall be issued by the supplier in conformance with the DRD of Annex C and submitted to the customer for review and approval.

5.12 Quality assurance

5.12.1 General

a. The supplier shall implement quality assurance, inspection and quality control procedures before any test activity.

b. The implementation of the procedures shall be maintained for the entire duration of the test activity.

c. The supplier shall establish and implement quality control actions and inspections to provide evidence of conformity to test requirements.

NOTE Quality control actions and inspections for test activities carried out by sub-contracted laboratories are under the responsibility of the supplier.

5.12.2 Calibration

a. Calibration of test equipment shall be carried out and maintained throughout the test activity.

b. Calibration of tensile testing machines and extensometers shall be carried out in conformance to EN 10002-2 and EN 10002-4, respectively.

c. Calibration records shall be readily accessible and retrievable on customer request for the entire duration of the business agreement.

5.12.3 Quality control of raw materials

a. The supplier shall provide documented evidence that only materials in conformance with the customer specifications are used in the test activity.

b. The supplier of raw materials shall include a raw material certificate (RMC) in each test report in conformance with the DRD of Annex C.

5.12.4 Nonconformance

a. Nonconformance of materials, specimen preparation, testing, evaluation and reporting shall be documented in a non-conformance report in conformance with the NCR DRD of ECSS-Q-ST-10-09, and reported to the customer.

b. Upon customer request, results affected by nonconformities shall be invalidated and tests repeated.

5.12.5 Traceability and records

a. Materials shall be durably marked to univocally identify manufacturer's code, batch number, material standard designation and grain orientation.

b. Specimens shall be durably marked to univocally identify individual specimens and grain orientation.

c. Test records shall be maintained and on customer request accessible and retrievable for the entire duration of the business agreement.

d. The customer shall authorize disposal of materials and specimens.

Annex A (normative) Request for mechanical testing of materials – DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-45, requirement 5.11a.

A.1.2 Purpose and objective

The document "Request for mechanical testing of materials" specifies the test activity requested by the customer for mechanical testing of metallic materials. The request for mechanical testing is basis for the supplier to submit a proposal for the relevant test activity.

A.2 Expected response

A.2.1 Scope and content

<1> Background information

a. Information to the technical, business agreement and project background of the test activity shall be described.

<2> Objective of test activity

a. The objective of the requested test activity shall be described.

<3> Material identification

a. Material, designation, heat treatment, form and configuration, procurement source shall be identified.

<4> Test definition

a. Environment, number of tests and measurement techniques shall be identified.

b. Reference to applicable standards shall be given.

<5> Test output

a. The requested test output shall be specified.

NOTE For example: Number of cycles, determined crack length and crack growth rates.

<6> Additional request

a. Any other specific customer request shall be specified.

A.2.2 Special remarks to document title

a. The document shall be titled "[insert a descriptive modifier] – Request for mechanical testing of materials".

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

NOTE 1 For example: "Measurement of fracture toughness of AA 7175-T7351 plate – Request for mechanical testing of materials".

NOTE 2 For example: "Fatigue crack propagation behaviour of Ti-6Al-4V STA sheet at different stress ratios – Request for mechanical testing of materials".

Annex B (normative) Proposal for mechanical testing of materials – DRD

B.1 DRD identification

B.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-45, requirement 5.11b.

B.1.2 Purpose and objective

The document "Proposal for mechanical testing of materials" defines the test activity for mechanical testing of metallic materials proposed by the supplier. The supplier prepares the document and submits it to the customer for review and approval.

B.2 Expected response

B.2.1 Scope and content

<1> Description of work

a. The proposed test activity shall be described in the form of a statement of work including:

1. Description of the objective of the test activity.
2. Description of proposed test method including reference to applicable standards
3. Identification of the material to be tested.
4. Definition and confirmation of test conditions (i.e. environment, specimen geometry and orientation, number of specimens and measurement techniques)
5. Description of expected test output (i.e. crack length, number of cycles, crack growth rates).

<2> Test procedures

a. Proposed test procedures shall be described and deviations from standard test procedures identified.

<3> Financial and administrative proposal

a. A financial and administrative proposal shall be presented including:

1. Identification of responsible person for the activity;
2. List of deliverable items including test records with tabulated values of crack length, number of cycles, growth rates, stress intensity and respective units of measure;
3. Work breakdown structure defining responsibilities for:
   (a) procurement of raw material,
   (b) preparation of specimens,
   (c) heat treatment,
   (d) testing,
   (e) evaluation of results,
   (f) reporting.
4. Time schedule;
5. Travel and subsistence plan;
6. Itemized cost list;
7. Milestone payment plan.

B.2.2 Special remarks to document title

a. The document shall be titled "[insert a descriptive modifier] – Proposal for mechanical testing of materials".

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

NOTE 1 For example: "Measurement of fracture toughness of AA 7175-T7351 plate – Request for mechanical testing of materials".

NOTE 2 For example: "Fatigue crack propagation behaviour of Ti-6Al-4V STA sheet at different stress ratios – Request for mechanical testing of materials".

Annex C (normative) Report of mechanical testing of materials – DRD

C.1 DRD identification

C.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-45, requirement 5.11c and 5.12.3b.

C.1.2 Purpose and objective

The document "Report of mechanical testing of materials" describes and discusses test procedures and results of mechanical testing of metallic materials.

The document contains the elements and information relevant to the understanding and correct interpretation of the test activity and test results.

The supplier prepares the document and submits it to the customer for review and approval.

C.2 Expected response

C.2.1 Scope and contents

<1> Abstract

a. The abstract shall summarize the test procedure and the most relevant findings of the test activity.

<2> Introduction

a. The introduction shall provide background information to the test including:

1. Reasons for carrying out the test activity;
2. Reference to any previous relevant test activities and technical reports;

3. Use and applicability of the results;
4. Identification of other organizations that contributed to the test activity;
5. Objectives of the test activity.

<3> Information on raw material

a. The document shall include a raw material certificate (RMC) issued by the supplier of the raw material.

b. The RMC shall be delivered together with the raw material,

c. The RMC shall include:

1. batch supplier's name and code,
2. material standard designation and heat treatment,
3. date of batch manufacturing,
4. specified chemical composition,
5. material and heat treatment specifications,
6. product form, quantity, dimensions and grain orientation,
7. surface treatment,
8. description of manufacturing processes.

   NOTE For example: welding, cutting and milling.

9. non-destructive inspection.

d. The document shall indicate the raw material tensile properties with respect to the grain orientation and hardness.

NOTE 1 Tensile properties include elastic modulus, 0,2 % proof stress, tensile strength and elongation

NOTE 2 These properties are either specified in the RMC or obtained by testing the raw material upon delivery

<4> Description of test procedures

a. The document shall provide an univocal and complete description of the specimen preparation, test equipment and test procedure.

b. The information provided shall be in conformance with the requirements specified in the relative sections of the applicable test standards.

c. Estimated values of precision and bias for the test results shall be indicated.

d. Anomalies and deviations from standard procedures shall be reported.

<5> Test results

a. Test results shall be presented in an appropriate format using drawings, plots, diagrams and photos.

b. Test results shall be described and conformance to requirements discussed.

c. Units of measure and scales shall be consistent and in agreement with the customer specifications.

C.2.2 Special remarks to document title

a. The document shall be titled “[insert a descriptive modifier] – Proposal for mechanical testing of materials”.

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

NOTE 1 For example: “Measurement of fracture toughness of AA 7175-T7351 plate – Request for mechanical testing of materials”.

NOTE 2 For example: “Fatigue crack propagation behaviour of Ti-6Al-4V STA sheet at different stress ratios – Request for mechanical testing of materials”.

Annex D (informative) References

[1] H. Doeker, Y. Bachmann and G. Marci, A comparison of different methods of determination of the threshold for fatigue crack propagation, Fatigue Thresholds, 1-6 June 1981, Stockholm.

[2] H. Doeker and M. Peters, Fatigue threshold dependence on material environment and microstructure, Fatigue 84, 3-7 September 1984, Birmingham, UK.

[3] H. Doeker, Fatigue crack growth threshold: implications, determination and data evaluation, International Conf. on Fatigue Damage in Structural Materials, Engineering Foundation, 1996, Massachusetts, US.

Bibliography

ECSS-S-ST-00	ECSS system – Description, implementation and general requirements
ECSS-Q-ST-70-36	Space product assurance — Material selection for controlling stress-corrosion cracking
ISO 3800	Threaded fasteners — Axial load fatigue testing — Test methods and evaluation of results.