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EUROPEAN COOPERATION
FOR SPACE STANDARDIZATION

Space product assurance

Standard methods for mechanical testing of metallic materials

This ECSS document is a draft standard circulated for ECSS Steering Board approval. It is therefore subject to change and may not be referred to as an ECSS Standard until published as such.

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ECSS Secretariat
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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-01-745, reviewed by the ECSS Product Assurance Panel and approved by the ECSS Steering Board.

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Scope

This Standard defines the 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 gives the requirements and guidelines for the evaluation, presentation and reporting of test results.

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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-Q-70	Space product assurance — Materials, mechanical parts and processes
ECSS-Q-70-36	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-70-46 [1)]	Space product assurance — General requirements for threaded fasteners
ASTM E 139-00e1	Standard test methods for conducting creep, creep-rupture, and stress-rupture tests of metallic materials
ASTM E 339-90(1997)	Standard test method for plane-strain fracture toughness of metallic materials
ASTM E 466-96(2002)e1	Standard practice for conducing force controlled constant amplitude axial fatigue tests of metallic materials
ASTM E 561-98	Standard practice for R-curve determination
ASTM E 606-92(1998)	Standard practice for strain-controlled fatigue testing
ASTM E 647-00	Standard test method for measurement of fatigue crack growth rates
ASTM E 739-91(1998)	Standard practice for statistical analysis of linear or linearized stress-life (S-N) and strain-life (e-N) fatigue data
ASTM E 1290-02	Standard test method for crack-tip opening displacement (CTOD) fracture toughness measurement

1) To be published.

ASTM E 1820-01	Standard test method for measurement of fracture toughness
EN 10002-1:2001	Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature
EN 10002-2:1992	Metallic materials — Tensile testing — Part 2: Verification of the force measuring system of the tensile testing machines
EN 10002-4:1995	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 3800:1993	Threaded fasteners — Axial load fatigue testing — Test methods and evaluation of results
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 desplacement

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Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

The following terms and definitions are specific to this Standard in the sense that they are complementary or additional to those contained in ECSS-P-001 and ECSS-Q-70.

3.1.1
creep
time-dependent increase in strain in a material resulting from force

3.1.2
damage tolerance
in a material or structure, the capability to withstand stresses or loads in the presence of defects

3.1.3
failure
condition generally caused by break or collapse so that a structural element can no longer fulfil its purpose

3.1.4
fatigue
in a material, the failure phenomenon which results from repeated fluctuation of stress.

3.1.5
fracture toughness
crack-extension resistance of a material

3.1.6
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

3.1.7
mechanical testing
determination of mechanical properties

3.1.8
plastic zone
plastically deformed region in a material adjacent to a crack tip

3.1.9
raw material
material from which specimens are manufactured

3.1.10
specimen
representative fraction of material tested or analysed in order to determine mechanical properties

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 to hold parts firmly together in an assembly

3.1.12
weld heat affected zone (HAZ)
portion of material in a welded joint whose properties are affected by the heat input during welding

3.2 Abbreviated terms

The following abbreviations are defined and used within this document:

ASTM	American Society for Testing and Materials
CEN	European Committee for Standardization
CTOD	crack tip opening displacement
ESDU	engineering sciences data unit
ISO	International Organisation for Standardisation
NDI	non-destructive inspection
PMTM	proposal for mechanical testing of materials
RMC	raw material certificate
RMTM	report of mechanical testing of materials

3.3 Symbols

The following symbols are defined and used within this document:

C(T)	compact tension specimen
J	J-integral
$\mathbf{J_{Ic}}$	J-integral plane-strain fracture toughness
K	stress intensity factor
$\mathbf{K_{Ic}}$	stress intensity plane-strain fracture toughness
$\mathbf{K_{max}}$	maximum stress intensity factor
Mode I	opening mode of loading
R	stress ratio
$\mathbf{R_{sx}}$	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

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Mechanical test methods

4.1 Selection of mechanical test methods

This clause gives procedures and guidelines to conduct tests to characterise mechanical behaviour and properties of metallic materials. Selection criteria of mechanical tests given in this clause are based on the significance and use of each test method.

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

4.2 Tensile test

4.2.1 General

Tensile tests provide information on the strength and ductility of materials under uniaxial tensile stresses. This information can be used in comparing materials, alloy development, design and quality control.

4.2.2 Scope

This test method covers the tension testing of metallic materials in any form at room temperature, and specifically the methods of determination of yield strength, yield point elongation, tensile strength, elongation and reduction of area.

4.2.3 Test requirements

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

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

4.2.4 Tensile testing of weldments

Weldments are characterized by non-uniformity in tensile properties, and therefore the following special requirements shall be applied when testing welded specimens:

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 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.

4.3 Fracture toughness test

4.3.1 General

This subclause refers to tests methods for the determination of 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 clause is for opening mode (Mode I) of loading.

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

4.3.2.1 General

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.

4.3.2.2 Scope

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

4.3.2.3 Test requirements

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

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

c. A minimum number of three K_{Ic} valid tests, in accordance 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.

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

4.3.3.1 General

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.

4.3.3.2 Scope

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

4.3.3.3 Test requirements

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

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

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

4.3.4.1 General

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.

4.3.4.2 Scope

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

4.3.4.3 Test requirements

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

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

4.3.5 Characterization of fracture toughness using the CTOD test method

4.3.5.1 General

This test method provides a characterization of the fracture toughness of metallic materials and it should be used for materials that exhibit a change from ductile to brittle behaviour with decreasing temperature. This method may also be 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 values of CTOD can be affected by specimen dimensions. For this reason specimens of same dimensions should be used when comparing test results.

4.3.5.2 Scope

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

4.3.5.3 Test requirements

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

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

4.4 Fatigue test

4.4.1 General

This subclause 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

4.4.2.1 General

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 may be used as a guideline for the selection of metallic materials for service under conditions of repeated direct stress.

4.4.2.2 Scope

This test method covers the procedure for carrying out 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.

4.4.2.3 Test requirements

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

b. Fatigue strength values shall be determined in the finite life range (failure of all the test piece before a predetermined number of cycles is reached) and in the transition range where, up to a predetermined number of stress cycles (typically 5×10^6 to 5×10^7 stress cycles), failure as well as non-failure occurs.

c. The minimum number of tests and load levels shall be established in relation to the type of test programme conducted (i.e. exploratory research and development tests, design allowables data, reliability data). However:

   1. In the finite life range, a minimum of six tests per selected stress level should be conducted. A minimum of three stress levels should be selected.

   2. In the transition range (infinite life range), the staircase method, the boundary method or the arc-sine method should be used as a guideline for the selection of the test stress levels. A review of these methods can be found in ISO 3800.

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

e. Statistical analysis of test results shall be carried out in accordance with ASTM E 739.

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

g. Axial load fatigue testing of threaded fasteners shall be carried out in accordance with subclause 6.5 of ECSS-Q-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.

4.4.3 Strain-controlled fatigue test

4.4.3.1 General

Strain-controlled fatigue can be 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).

4.4.3.2 Scope

This method covers the procedure for carrying out axial strain-controlled fatigue tests to obtain the fatigue strength of materials in the fatigue regime where the strains are predominately plastic.

4.4.3.3 Test requirements

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

b. Fatigue strength values shall be determined in the finite life range (failure of all the test piece before a predetermined number of cycles is reached), up to a predetermined number of stress cycles (typically less than 10^5 strain cycles).

c. Test requirements as specified in c., d., e. and f. of subclause 4.4.2.3 shall apply.

4.5 Fatigue crack propagation test

4.5.1 General

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 can be 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.

4.5.2 Scope

This method covers the procedure for carrying out tests to determine the stable crack growth rates from near-threshold propagation regime to controlled crack propagation instability. Results are expressed in terms of da/dn versus ΔK.

4.5.3 Test requirements

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

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, in accordance with the validity criteria of ASTM E 647, shall be carried out for each set of materials and test conditions.

c. Accuracy and resolution of selected crack length measurement methods (e.g. optical, direct current potential drop technique and compliance method) shall be assessed before testing.

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

d. Crack length values obtained with the selected measurement method shall be correlated by fractographic examination, at the end of the test, to the physical crack length.

e. Tests to characterize the crack propagation behaviour in the threshold regime (typically at growth rates less than 10^{-8} m/cycle) shall be carried out to cover crack growth rates as specified by the customer.

4.5.4 Determination of a fatigue crack propagation threshold

4.5.4.1 General

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

4.5.4.2 Scope

This method covers the procedure for carrying out tests to determine a fatigue crack propagation threshold of metallic materials.

4.5.4.3 Test requirements

A test procedure for the determination of an operational value of ΔK_{th} is given in subclause 9.4 of ASTM E 647. Annex A gives an alternative test method that allows the determination of ΔK_{th} values by testing at constant K_{max}.

4.6 Fracture and fatigue tests in special environments

4.6.1 General

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 can be used to evaluate the influence of certain environments on the material behaviour.

4.6.2 Scope

This method covers the procedures for carrying out tests to determine the influence of environments representative of service conditions on the fatigue and fracture behaviour of metallic materials.

4.6.3 Test requirements

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

b. Transportation, handling and disposal of hazardous substances shall be in agreement with the applicable health and safety roles (e.g. material safety data sheets, national health and safety roles).

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

4.7 Stress corrosion cracking test

4.7.1 General

This subclause refers to tests methods for the determination of the susceptibility of metallic materials to stress corrosion cracking.

4.7.2 Stress corrosion cracking test using smooth specimens

4.7.2.1 General

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

4.7.2.2 Scope

This method covers the procedure for carrying out tests to determine the susceptibility of metals and weldments to stress corrosion cracking by alternate immersion in 3,5 % sodium chloride water solution under constant load.

4.7.2.3 Test requirements

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

4.7.3 Stress corrosion cracking test using pre-cracked specimens

4.7.3.1 General

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 service 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.

4.7.3.2 Scope

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

4.7.3.3 Test requirements

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

b. Tests shall be carried out under constant load.

c. The minimum 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, otherwise the stressed specimens shall be exposed to the test environment as soon as possible after stressing.

4.8 Creep test

4.8.1 General

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

4.8.2 Scope

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

4.8.3 Test requirements

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

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

5

Evaluation of test results

5.1 General

Before the values obtained from mechanical tests can be applied with any confidence, an allowable value should be 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.

5.2 Scope

This clause provides procedures and statistical methods to support the evaluation and reduction of numerical test results.

5.3 Requirements

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 accordance with clause 4 of ESDU 96013.

c. Statistical analysis of numerical results of fatigue tests shall be conducted in accordance with subclause 4.4.2.3 e.

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

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Reporting of test results

6.1 General

a. The test activity and test results shall be presented and discussed in a technical report, the report on mechanical testing of materials (RMTM), prepared by the test house.

b. The RMTM shall be submitted to the customer for review and approval.

c. The RMTM shall be submitted to the customer in hardcopy and electronic format.

6.2 Report of mechanical testing of materials

6.2.1 General

a. The RMTM shall contain all the elements and information relevant to the understanding and correct interpretation of the test activity and test results, and be in accordance with the requirements as specified in Annex B.

b. The RMTM shall contain:

1. an abstract summarizing the test procedure and findings;
2. an introduction which provides the background information to the test (i.e. reason for testing, use and applicability of results);
3. the objective of the test activity;
4. information on the raw material;
5. a description of the test procedure;
6. presentation of results;
7. discussion of results;
8. conclusions and recommendations;
9. numerical data in a format agreed by the customer.

6.2.2 Information on raw material

a. The RMTM shall include a raw material certificate (RMC) issued by the supplier of the raw material. The RMC, delivered to the test house together with the raw material, shall indicate:

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, if any,
8. description of other manufacturing processes (e.g. welding, cutting and milling), and
9. non-destructive inspection.

b. The RMTM shall indicate the raw material tensile properties with respect to the grain orientation (elastic modulus, 0,2 % proof stress, tensile strength and elongation) and hardness, either already specified in the RMC or obtained by testing the raw material upon delivery.

6.2.3 Description of test procedures

a. The RMTM shall provide a univocal and complete description of the specimen preparation, test equipment and test procedure. The information provided shall be in accordance with the requirements specified in the relative sections of the applicable test standards.

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

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

6.2.4 Presentation of test results

a. Test results shall be presented in the RMTM in an appropriate format (e.g. drawings, plots, diagrams and photos) together with a written description (i.e. caption).

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

7

Quality assurance

7.1 General

The test house shall implement the quality assurance, inspection and quality control procedures herein specified before any test activity. The implementation of the procedures shall be maintained for the entire duration of the test activity.

7.2 Quality requirements

7.2.1 General

The test house shall establish and implement adequate quality control actions and inspections to provide evidence of conformity to the test requirements. Quality control actions and inspections for test activities carried out by laboratories sub-contractors to the test house are entirely under the test house direct responsibility.

7.2.2 Request for mechanical testing of materials

The customer shall issue a request for mechanical testing of materials. The request for mechanical testing of materials shall specify:

a. objective of the test activity,

b. background and justification to the test activity,

c. material to be investigated,

d. description of test activity, and

e. deliverables.

The request for mechanical testing of materials shall be in accordance with the requirements as specified in Annex C.

7.2.3 Work proposal for mechanical testing of materials

The test house shall issue a work proposal for mechanical testing of materials (PMTM). The work proposal for mechanical testing of materials shall specify:

a. test objective,

b. test method and reference to test standards,

c. material,

d. description of proposed test procedure,

e. deliverables,

f. work breakdown structure,

g. planning and time schedule, and

h. itemised cost list and payment.

The PMTM shall be in accordance with the requirements as specified in Annex D.

7.2.4 Calibration

a. The test house shall carry out and maintain calibration of the test equipment throughout the duration of the test activity.

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

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

7.2.5 Quality control of raw materials

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

b. The supplier of raw materials shall issue a raw material certificate (RMC) as specified in 6.2.2.

7.2.6 Testing, evaluation and reporting

The test house shall provide evidence that the test activity, evaluation and reporting is carried out in agreement with clause 4, clause 5. and clause 6, respectively.

7.2.7 Nonconformities

a. Nonconformities of materials, specimen preparation, testing, evaluation and reporting shall be documented and reported to the customer.

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

7.2.8 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. The test house shall maintain test records for the entire duration of the contract. Test records shall be accessible and retrievable on customer request.

d. Storage of materials and specimens by the test house shall be agreed with the customer.

e. Disposal of materials and specimens shall be authorized by the customer.

Annex A (informative)

Test method for the determination of fatigue crack propagation threshold at constant K_{max}

A.1 General

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 Bibliography). From a practical point of view, testing at constant K_{max} allows one to proceed faster than when testing at constant R, since load history effects are generally negligible. This approach is based on the observation that for many alloys ΔK_{th} vs. K_{max} plots show a quasi-linear dependency above certain K_{max} values. Similarly, K_{max} vs. R plots 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.

A.2 Scope

This test method covers a procedure for the determination of an operational value of the fatigue crack propagation threshold (ΔK_{th}) by testing at constant K_{max}.

A.3 Test requirements

a. Crack propagation tests shall be carried out under constant maximum stress intensity factor K_{max}.

b. Test requirements shall be as specified in 4.5.3.

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Annex B (normative)

Report of mechanical testing of materials — Document requirements definition (DRD)

B.1 Introduction

This document defines the requirements for the preparation of the report of mechanical testing of metallic materials.

B.2 Scope and applicability

B.2.1 Scope

This document requirements definition (DRD) establishes the data content requirements of the report of mechanical testing of metallic materials.

B.2.2 Applicability

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

B.3 Description and purpose

The report of mechanical testing of materials is a technical report that describes and discusses test procedures and results of mechanical testing of metallic materials. The report of mechanical testing of materials is prepared by the test house, which is responsible for the test activity, and it is submitted to the customer for review and approval.

B.4 Preliminary elements

B.4.1 Title

The document to be created based on this DRD shall be titled "[insert a descriptive modifier] – Report of mechanical testing of materials".

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

EXAMPLE 1 "Measurement of fracture toughness of AA 7175-T7351 plate – Report of mechanical testing of materials".

EXAMPLE 2 "Fatigue crack propagation behaviour of Ti-6Al-4V STA sheet at different stress ratios – Report of mechanical testing of materials".

B.4.2 Title page

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

B.4.3 Abstract

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

B.4.4 Contents list

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

B.4.5 Introduction

The introduction shall contain as many of the following items as appropriate, and provide the background information to the test (i.e. reason for testing, use and applicability of results):

- reasons for carrying out the test activity;
- reference to any previous relevant test activities and technical reports;
- use and applicability of the results;
- identification of other organisations that contributed to the test activity;
- the objectives of the test activity.

B.5 Content

The report of mechanical testing of materials shall specify:

a. any relevant information on the material investigated, and data as specified in 6.2.2;

b. a description of the test procedure as specified in 6.2.3;

c. the presentation of the test results as specified in 6.2.4;

d. a discussion of the test results (i.e. comments of the results with respect to the specific test conditions, limits of validity of the results, and comparison with available data);

e. conclusions and recommendations.

Annex C (normative)

Request for mechanical testing of materials — Document requirement definition (DRD)

C.1 Introduction

This document defines the requirements for the preparation of the request for mechanical testing of metallic materials.

C.2 Scope and applicability

C.2.1 Scope

This document requirement definition (DRD) establishes the data content requirements of the request for mechanical testing of metallic materials.

C.2.2 Applicability

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

C.3 Description and purpose

The request for mechanical testing of materials is a document that specifies the test activity requested by the customer. The request for mechanical testing of materials is sent to the test house and represents an invitation to submit a proposal for mechanical testing of materials.

C.4 Preliminary elements

C.4.1 Title

The document to be created based on this DRD shall be titled "[insert a descriptive modifier] – Request for mechanical testing of materials".

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

EXAMPLE 1 "Measurement of fracture toughness of AA 7175-T7351 plate – Request for mechanical testing of materials".

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

C.4.2 Title page

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

C.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.

C.5 Content

The document shall contain:

a. any relevant background information,

b. the objectives of the test activity,

c. information on material (e.g. materials designation, heat treatment, form, and procurement source),

d. test method, test conditions (e.g. environment, number of tests, and measurement techniques) with reference to standards,

e. test output (e.g. crack length, number of cycles, and crack growth rates), and

f. any other specific request.

Annex D (normative)

Proposal for mechanical testing of materials — Document requirements definition (DRD)

D.1 Introduction

This document defines the requirements for the preparation of the work proposal for mechanical testing of metallic materials.

D.2 Scope and applicability

D.2.1 Scope

This document requirements definition (DRD) establishes the data content requirements of the work proposal for mechanical testing of metallic materials.

D.2.2 Applicability

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

D.3 Description and purpose

The work proposal for mechanical testing of materials is a document that defines the test activity for mechanical testing of metallic materials proposed by the test house. The work proposal for mechanical testing of materials is prepared by the test house, which is responsible for the test activity, and it is submitted to the customer for review and approval.

D.4 Preliminary elements

D.4.1 Title

The document to be created based on this DRD shall be titled "[insert a descriptive modifier] – Proposal for mechanical testing of materials".

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

EXAMPLE 1 "Measurement of fracture toughness of AA 7175-T7351 plate – Proposal for mechanical testing of materials".

EXAMPLE 2 "Fatigue crack propagation behaviour of Ti-6Al-4V STA sheet at different stress ratios – Proposal for mechanical testing of materials".

D.4.2 Title page

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

D.4.3 Contents list

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

D.5 Content

The report shall contain:

a. A statement of work giving:
   1. the objectives of the test activity,
   2. test method and reference to standards,
   3. material,
   4. test conditions (i.e. environment, specimen geometry and orientation, number of specimens, and measurement techniques), and
   5. test output (i.e. crack length, number of cycles, and crack growth rates).

b. A proposed settlement describing the test procedures and any deviation from the standard test procedures.

c. A financial and administrative proposal including:
   1. responsible person for the activity,
   2. list of deliverable items (i.e. tabulated values of crack length, number of cycles, growth rates, stress intensity and respective units of measure),
   3. work breakdown structure defining the required operations (i.e. procurement of raw material, preparation of specimens, heat treatment, testing, evaluation of results, reporting) and responsibilities,
   4. time schedule,
   5. travel and subsistence plan,
   6. itemized cost list, and
   7. milestone payment plan.

Bibliography

[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*

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