ECSS-Q-ST-70-06C
31 July 2008

EUROPEAN COOPERATION FOR SPACE STANDARDIZATION

Space product assurance

Particle and UV radiation testing for space materials

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

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.

This Standard has been prepared by the ECSS-Q-ST-70-06 Working Group, reviewed by the ECSS Executive Secretariat and approved by the ECSS Technical Authority.

Disclaimer

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1 Scope

Materials used in space applications need to be evaluated for their behaviour under Particle and UV Radiation. As part of this evaluation often an exposure to a simulated space environment is performed that can raise questions regarding its accuracy and representativeness. The role of this Standard is to establish a baseline for the testing specification.

NOTE The environments covered are electromagnetic radiation and charged particles.

This Standard defines the procedures for electromagnetic radiation and charged particles testing of spacecraft materials.

These materials include for instance thermal control materials, windows, coatings, and structural materials.

The procedures include simulation of the environment and the properties to be verified.

This Standard excludes electronic components.

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-E-ST-10-04	Space engineering – Space environment
ECSS-Q-ST-20	Space product assurance – Quality assurance
ECSS-Q-ST-20-07	Space product assurance – Quality assurance for test centres
ECSS-Q-ST-10-09	Space product assurance – Nonconformance control system
ECSS-Q-ST-70-02	Space product assurance – Thermal vacuum outgassing tests for the screening of space materials
ECSS-Q-ST-70-09	Space product assurance – Measurements of thermo-optical properties of thermal control materials
ISO 15856:2003	Space systems – Space environment – Simulation guidelines for radiation exposure of non-metallic materials
ASTM-E-490	Standard Solar Constant and Zero Air Mass Solar Spectral Irradiance Tables

3
Terms, definitions and abbreviated terms

3.1 Terms from other standards

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

clean area

contamination

3.2 Terms specific to the present standard

3.2.1 absorbed dose

energy absorbed locally per unit mass as a result of radiation exposure which is transferred through ionization and excitation

NOTE The absorbed dose D is expressed in Gy (1 Gy = 1 j/kg = 100 rad).

3.2.2 acceleration factor

ratio of the intensity of a degrading factor applied to a material at the laboratory during a space simulation versus the intensity of the same degrading factor in space

NOTE It applies to any degrading factor.

3.2.3 bremsstrahlung

high-energy electromagnetic radiation in the X-ray energy range emitted by charged particles slowing down by scattering off atomic nuclei

NOTE 1 The primary particle is ultimately absorbed while the bremsstrahlung can be highly penetrating. In space, the most common source of bremsstrahlung is electron scattering.

NOTE 2 Its energy is continuously distributed down from the energy of the incident particle.

3.2.4 contaminant

unwanted molecular or particulate matter (including microbiological matter) on the surface or in the environment of interest, that can affect or degrade the relevant performance or life time

3.2.5 degrading factors of environment

factors present in the environment that degrade materials

NOTE For example: UV, charged particles.

3.2.6 dose profile

distribution of the absorbed dose through the depth of the material

3.2.7 ex-situ measurement

measurement performed outside the testing facility

NOTE 1 Generally it means that these measurements are performed in air at ambient temperature.

NOTE 2 If specific conditions are applied ex-situ, they are described in a corresponding procedure.

3.2.8 fluence

time-integration of the flux

3.2.9 flux

amount of radiation crossing a surface per unit of time

NOTE It is often expressed in "integral form" as particles per unit area per unit time (e.g. electrons cm^{-2} s^{-1}) above a certain threshold energy.

3.2.10 in-situ measurement

measurement performed inside a chamber (in vacuum or pressurized)

3.2.11 induced space environment

environmental factors that result from interactions of the space system with the natural space environment

3.2.12 irradiance

quotient of the radiant flux incident on an element of the surface containing the point, by the area of that element

NOTE See also ISO 15856:2003

3.2.13 ionizing radiation

form of radiation that has sufficient energy to remove electrons from atoms to produce ions

NOTE It can consist of high energy particles (electrons, protons or alpha particles) or short wavelength electromagnetic radiation (ultraviolet, X-rays and gamma rays).

3.2.14 mean free path

average distance that a subatomic particle, ion, atom, or molecule travels between successive collisions with ions, atoms, or molecules

3.2.15 natural space environment

environment that exists in space excluding any spacecraft system effect

NOTE This includes radiation, vacuum, residual atmosphere, and meteoroids.

3.2.16 near ultraviolet (NUV) radiation

solar electromagnetic radiation with the wavelength in the range from 200 nm up to 400 nm

3.2.17 reciprocity law

statement that the observed property change depends only on the fluence and is independent of the flux

3.2.18 synchrotron radiation

continuous electromagnetic radiation created by the acceleration of relativistic charged particles

NOTE For example: this radiation can be generated in a synchrotron or storage ring.

3.2.19 synergism

joint action of two or more stimuli whose combination induce a different effect (qualitative and quantitative) than the result of adding the effects of each stimulus taken separately

3.2.20 vacuum ultraviolet (VUV) radiation

solar electromagnetic radiations in the wavelength range from 10 nm up to 200 nm

NOTE Also called "Far UV".

3.3 Abbreviated terms and symbols

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

Abbreviation	Meaning
ESH	equivalent Sun hour
FUV	far ultraviolet
QCM	quartz crystal monitor
NUV	near ultraviolet
UV	ultraviolet
VUV	vacuum ultraviolet
λL	low wavelength limit
λH	high wavelength limit

4
Principles

The principles of the particle and electromagnetic radiation test of space materials is to evaluate their physical properties changes under specific laboratory simulations that imply a suitable simplification of space degrading factors and generally the reduction of the irradiation time.

Such approach is performed following the steps as described in Figure 4-1.

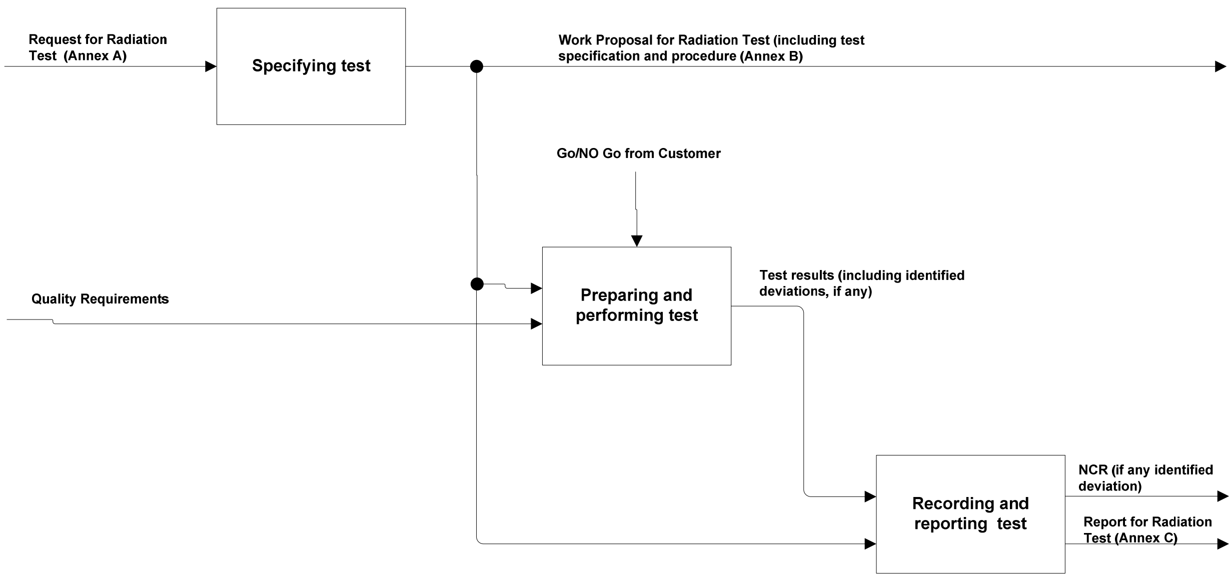

Figure 4-1: Test process overview

Clause 5.1 provides the specification of the radiation test related to given space simulation test requirements is based on the rationale of degrading factors definition, as described in Figure 4-2.

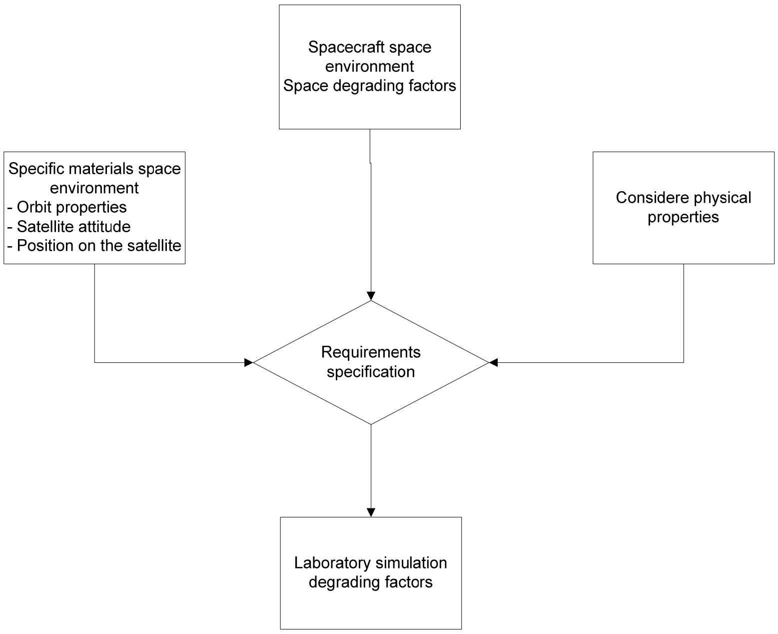

Figure 4-2: Degrading factors specification

Clauses 5.2 and 5.3 provide the requirements for preparing, performing, recording and reporting a radiation test.

5 Requirements

5.1 Specifying test

5.1.1 General provision

a. The customer shall provide a request for radiation test in conformance with the DRD in Annex A.

b. ECSS-Q-ST-20 shall be made applicable in the request for a radiation test.

c. ECSS-Q-ST-10-09 shall be made applicable in the request for a radiation test.

d. The test centre shall comply with the safety and security requirements in ECSS-Q-ST-20-07.

NOTE For example, for hazard and health (safety) and for access control (security).

e. The supplier shall provide a radiation test specification and procedure (Work proposal) in conformance with the DRD in Annex B.

5.1.2 Methodology for laboratory degrading factors definition

5.1.2.1 Specification of the general spacecraft environment

a. The customer shall identify, the spacecraft space environment, using models as defined in ECSS-E-ST-10-04.

NOTE 1 The spacecraft space environment is natural and induced environments encountered during its specific missions.

NOTE 2 The natural space environment of a given item is that set of environmental conditions defined by the external physical world for the given mission, e.g. residual atmosphere, meteoroids and electromagnetic and particle radiation.

NOTE 3 The induced space environment is that set of environmental conditions created or modified by the presence or operation of the item and its mission or other manmade items, e.g.

contamination, debris, secondary radiations and spacecraft charging.

5.1.2.2 Specification of the material environment

a. While determining the natural and induced space environment that a material encounters, the customer shall identify the location of this material on the spacecraft.

b. The supplier shall identify the parameters that can influence the "seen" fluence.

NOTE 1 These parameters can be shielding, view factors or mean sunlight incidence angle.

NOTE 2 For example: During one year (8760 hours) the solar irradiation is:

- on a Geostationary cylindrical satellite whose axis is parallel to earth revolution axis, 1112 ESH on the N/S faces and about 2500 ESH on the periphery,
- on the LEO ISS orbit, 2500 ESH on Ram and anti Ram, 250 ESH on nadir, 2200 ESH on zenith, and 1500 ESH on the side faces.

5.1.2.3 Specification of the materials properties to be measured

a. The customer shall identify (in the request for radiation test), the materials properties to be investigated.

NOTE 1 The most common examples of properties used in space technology are:

- optical (transmission, absorption of windows),
- thermo-optical (spectral and solar absorptance, infrared emissivity),
- electrical properties (e.g. conductivity, charging).

NOTE 2 It is often impossible to measure additional physical properties at the end of a test, if these are not included in the initial test definition. The proposed test conditions are not necessarily relevant for these additional properties.

b. When thermo-optical properties are identified for measurement, ECSS-Q-ST-70-09 shall apply.

5.1.2.4 Specification of the laboratory degrading factors

a. The supplier shall identify (in the radiation test procedure proposal), the ground factors to be simulated by crossing or trading off the information given by the space environment, the specific material environment.

b. The supplier shall identify (in the radiation test proposal) simulation factors that are expected to have an impact on the degradation of selected properties in order to obtain a similar effect as in space.

c. Depending on the properties to be measured, the supplier shall use a particles fluxes or an absorbed based simulation.

d. The supplier shall trade off the simulated space simulation representativeness with respect to the availability of resources.

NOTE 1 E.g. availability of facilities, and cost.

NOTE 2 At contractual level, the final choice of simulation conditions is decided by the customer (e.g. through project specification).

5.1.2.5 Specification of the measurements

a. The supplier shall provide (in the radiation test proposal) the methodology for measuring the defined properties to be investigated.

NOTE 1 Materials suffer damage inducing different types of physical properties changes under radiation:

- Stable changes: changes are independent of time and measurement conditions.
- Unstable changes: changes are dependent of time and measurement conditions.

NOTE 2 Stable changes of physical properties can be assessed by ex-situ measurements. These can be mechanical or thermo-mechanical properties. They are of permanent nature.

NOTE 3 Unstable changes of physical properties are generally related to electrical and (thermo-) optical properties.

b. The customer and the supplier (the test organization) shall agree on the following:

1. type of simulation to be performed,
2. uncertainties,
3. margin philosophy.

5.1.3 Methodology for irradiations performance

5.1.3.1 Irradiations using ionizing radiations

a. When ionizing radiations are used, ISO 15856:2003 clause 6.3.2 shall apply for methodology “in case on dose dependant properties”.

NOTE 1 The methodology for ionizing radiations on dose dependant properties replaces the simulation of space environment charged particles or photons by the simulation of the absorbed dose profile through a material thickness that depends on the investigated physical property.

NOTE 2 When possible, simulate each part of the dose profile using the type of prevailing ionizing radiation to which the material would be exposed in the natural space environment (e.g. protons at the surface of the materials in GEO).

b. When ionizing VUV radiations are used, the supplier shall evaluate the dose and shall compare it to the total ionising particles dose at the same depth.

NOTE 1 In these cases where the VUV dose is small (< 1 %) compared to the particle radiation dose, VUV is neglected.

NOTE 2 For X-ray radiation the doses are small and mainly due to solar flares. Since the effect is limited, tests are generally not necessary except for specific cases.

NOTE 3 The lack of experimental and theoretical data on specific effects of low-energy protons and electrons as well as of X-radiation and UV, at the same absorbed dose, makes it difficult to give rules to replace one kind of radiation by another.

5.1.3.2 Irradiations using non-ionizing radiations

a. When non-ionization radiations (Solar photons) are used, the supplier shall perform a spectral simulation of sun irradiance.

NOTE 1 The light absorption of a material is dependant on its nature, its previous degradation state and the wavelength of the light.

NOTE 2 The solar non ionizing radiation consists of photons with energy between 200 nm and 400 nm, the so-called near UV.

NOTE 3 In general the spectrum used for solar simulation is limited to the UV-region, because it is assumed that the major degradation is due to these photons.

b. The supplier shall calculate the integrated UV and VUV source irradiance, given by the source at the normal in the wavelength range between λ_L and λ_H.

NOTE The wavelengths λ_L and λ_H are contained within or equal to the complete 200 nm - 400 nm near UV range. In other words, the integrated irradiance of the source outside of the λ_L to λ_H wavelength range is not taken into account in the acceleration factor.

c. The supplier shall evaluate the integrated irradiance of the source outside of the λ_L to λ_H wavelength range.

NOTE This additional irradiance can contribute to degradation and additional heating of the samples.

5.1.3.3 Choice of facilities and sources

a. The supplier shall justify the facility configuration choice and the chosen irradiation sources in terms of representativeness and acceleration factor compared to space.

b. The source's characterization shall be part of

1. The radiation test specifications and procedures in conformance with Annex B- DRD for customer approval.

2. The radiation test report in conformance with the DRD in Annex C

NOTE 1 In the case of filtered continuous UV sources, λ_H is defined at the half height cut off of high wavelengths light emission.

NOTE 2 The simulation of degrading factors can be investigated through separate tests or during the same test. In single testing a single degrading factor is simulated at once, the measurements being done in- or ex-situ. In combined testing, the degrading factors of space environment are simulated in sequence, or with a partial simultaneity instead of simultaneously as in space.

NOTE 3 The purpose of combined testing is to obtain a more accurate evaluation of global space environment effects due to the fact that in space the different degrading factors act in synergy. It is used because, in general, it is impossible to simulate the space degradation components (e.g. UV, charged particles) simultaneously with the same acceleration factors.

NOTE 4 Combined environment degrading factors exposures can produce material properties changes that are different (greater or lower) than separate degrading factors exposures.

NOTE 5 When combined environment testing is performed, including several different irradiation and measurements, the effect of exposure to air during intermediate and final measurements of degradation effects is controlled and minimized.

5.1.4 Specifying the irradiation test procedure

5.1.4.1 Test procedure

a. The test procedures shall address, in conformance with the DRD in Annex B, the test conditions control and monitoring of:

1. irradiations,
2. temperature,
3. vacuum,
4. contamination.

5.1.4.2 Determining the acceleration factors

a. ISO 15856:2003, subclause 6.3.3 shall be applied as general rules for the determination of the dose rates and acceleration factors.

b. The value of maximum dose rate (or an energy flux on a material surface) shall be determined both by the allowable temperature increase of a sample and the admissible acceleration factor.

c. The UV acceleration factor shall take into account the ASTM-E-490 standard and the incidence effect of sun light on the integrated irradiance received by the materials.

NOTE Due to its position on a satellite, a material can receive different irradiances of UV. The consequence is that for the same irradiance of UV at the laboratory, the acceleration factors depend on the materials position on the satellite.

d. The test supplier shall submit the defined acceleration factors and temperature for customer approval.

e. Thermal effects on the sample shall be assessed during radiation to ensure that the maximum temperature is not exceeded.

5.1.4.3 Controlling the contamination

a. In case of optical or thermo-optical properties measurements, contamination effects on the sample shall be controlled.

NOTE 1 Cross contamination can occur between samples or be induced by internal vacuum chamber residual pressure.

NOTE 2 Contamination control evaluation can be performed with any method (witness sample, UV absorption, Infrared analysis of contaminants deposit on CaF_2 or ZnSe windows and/or QCM measurements.

5.1.4.4 Measuring the temperatures and the pressure

a. The method used to measure the temperature shall be agreed between customer and supplier.

b. During testing, the temperature of the sample (test item) shall be measured.

c. The actual or predicted operating temperatures of the material in its space application shall be considered when selecting test temperature requirements.

NOTE When possible and needed, measurements are performed at the same temperature than irradiation temperature.

d. The test supplier shall specify the temperature measurement procedure and accuracy.

e. Radiation tests shall be conducted under vacuum conditions (equal or less than 10^{-3} Pa).

NOTE Tests in air, inert gas or primary vacuum can be performed if it is demonstrated that this has no effect on the property to be investigated.

5.2 Preparing and performing test

5.2.1 General

a. The customer shall approve the radiation test proposal including the procedures.

b. ECSS-Q-ST-20 shall apply for the establishment of the test procedures.

5.2.2 Preparing the samples

a. The material samples shall be prepared according to the relevant process specification or manufacturer's data.

b. The material samples shall be representative of batch variance.

c. The cleaning and other treatments of the samples shall be the same as that to which the samples is submitted before incorporation in the spacecraft.

d. When samples are handled, contamination shall be avoided.

e. Samples shall be stored in a clean area.

f. Samples shall be protected from exposure to light and kept at ambient temperature of (22 ± 3) °C, and with a relative humidity of (55 ± 10) %.

g. Coated surfaces shall be shielded from contact.

NOTE For example: coated surfaces can be shielded in using polyethylene or polypropylene bags or sheets.

h. Mechanical damages shall be avoided by packing the polyethylene or polypropylene-wrapped work pieces in clean, dust- and lint-free material.

i. A material identification card shall accompany sample submitted for radiation.

j. The material identification card contents shall be in conformance with the “Material Identification card” DRD in ECSS-Q-ST-70-02.

5.2.3 Preparing the facilities and equipments

a. The work area shall be a clean area.

b. Contamination of the samples shall be avoided (when handling or storing) and monitored.

NOTE Monitoring of the sample contamination can be done by witness samples described in ECSS-Q-ST-70-01.

c. The ambient conditions for the process and work areas shall be (22 ± 3) °C with a relative humidity of (55 ± 10) %.

d. The specific equipments shall be defined in the radiation test proposal.

e. The supplier shall provide evidence that all measuring equipments, part of the test set up are calibrated.

5.2.4 Running the radiation test procedure

a. The supplier shall run the approved test procedure in conformance with the DRD in Annex B.

5.3 Recording and reporting the test results

5.3.1 Test records

a. The test records of the radiation test shall be retained for, at least, ten years or in accordance with project contract requirements.

b. The test records of the radiation test shall be composed of:

1. the specific test requirements documented in the request for radiation testing in conformance with the DRD in Annex A,
2. the test specifications and procedures documented in radiation test proposal in conformance with the DRD in Annex B,
3. the radiation test report in conformance with the DRD in Annex C,
4. a conclusion with respect to the compliance with the project requirements (acceptance criteria) and associated nonconformances.

5.3.2 Test report

a. The supplier shall apply the "Test report" requirements in ECSS-Q-ST-20, for the establishment of the test report.

b. The supplier shall submit the test report to the customer for approval.

5.3.3 Acceptance criteria and nonconformance

a. Acceptance criteria shall be defined (on beforehand) in common agreement between the test authority and the customer.

b. Any suspected or actual equipment failure shall be recorded as project nonconformance report so that previous results may be examined to ascertain whether or not re-inspection and re-testing.

c. The supplier shall notify the customer of the nonconformance details.

d. Traceability shall be maintained throughout the process from incoming inspection to final measurements and calculations, including details of the test equipment and personnel employed in performing the task.

Annex A (normative) Request for radiation test - DRD

A.1 DRD identification

A.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-06, requirements 5.1.1a and 5.3.1b.1.

A.1.2 Purpose and objective

The purpose of the request for radiation test is to confirm that the materials is to be evaluated with respect to the specific radiation test specification of the project and prior to its validation and approval for selection as item of "as designed" the DML.

A.2 Expected response

A.2.1 Scope and content

a. The request for radiation test shall include or refer to the following information:

1. objective of the test activity,
2. Applicable documents,
3. background and justification to the test activity,
4. spacecraft space environment models to be used,
5. location of the materials to be tested on the spacecraft,
6. Identification of the "seen" fluence,
7. material to be investigated,
8. description of test activity, and
9. deliverables.

A.2.2 Special remarks

None.

Annex B (normative) Radiation test specifications and procedures (Work proposal) - DRD

B.1 DRD identification

B.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-06, requirements 5.1.1e, 5.2.4a, and 5.3.1b.2.

B.1.2 Purpose and objective

The radiation test specifications and procedures (Work proposal) is a document that defines the test activity for particle and electromagnetic-testing of space materials proposed by the supplier. The work proposal for Particle and electromagnetic radiation testing for space 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.2 Expected response

B.2.1 Scope and content

<1> Objectives of the test activity

b. The Work proposal shall describe the objectives of the test activity.

<2> Test procedures and reference to standards

a. The Work proposal shall contain the test procedure for the characterization, control and monitoring of the irradiation source or refer to the source characterization’s report as part of Annex C.

b. The test procedure for the characterization, control and monitoring of the irradiation source shall contain the following information:

1. selected acceleration factors,

2. dose rates/ instantaneous doses/ total dose (taking into account energy distribution),

3. the measure of the evolution of sources characteristics as function of time, the changes of homogeneity over sample surface.

c. The test procedure for controlling and monitoring the temperature shall contain the following information:

1. sample temperatures measurement and recording methods,

2. temperature data acquisition during testing.

NOTE There is a difference between real sample temperature and temperature of the holder.

d. The test procedure for controlling and monitoring the vacuum shall contain the following information:

1. sample vacuum and residual atmosphere measurements and recording methods,

2. pressure data acquisition during testing.

e. The test procedure for controlling and monitoring the contamination shall contain the following information:

1. contamination check methods used during tests,

2. contamination results.

<3> Materials, number and dimensions of samples

a. The Work proposal shall include the material identification, number and dimensions of samples.

<4> Test conditions (i.e. environment, properties evaluated and measurement techniques)

a. The spacecraft space environment models to be used shall be specified.

b. The location of the materials to be tested on the spacecraft shall be specified.

c. The “seen” fluence shall be specified.

<5> Radiation source’s characterization (or a reference to the document containing this information)

a. The source characterization information shall contain:

1. operational conditions (operating range, maximum ratings),

2. energies, spectral range,

3. deviation between the Solar Spectrum and the source,

4. dose rates/ instantaneous doses/ total dose (taking into account energy distribution),

5. selected acceleration factors,

6. size and uniformity of irradiated surface, used method to cover large surfaces (optics, sweeping plates, diffusion window),

7. ageing of the source.

<6> Expected test output

a. The Work proposal shall contain the expected test output.

<7> Problem and nonconformance handling

a. The Work proposal shall include the procedure for the handling of problem and nonconformance or an adaptation for the test item of the nonconformance processing flow chart as described in ECSS-Q-ST-10-09.

b. In the frame of research and development activities, this is not necessary.

<8> List of deviation from the conditions initially requested by the customer

a. The procedure shall contain the list of deviation from the conditions initially requested by the customer.

<9> Financial and administrative proposal

a. The WP shall include financial information.

B.2.2 Special remarks

None.

Annex C (normative) Radiation test report - DRD

C.1 DRD identification

C.1.1 Requirement identification and source document

This DRD is called from ECSS-Q-ST-70-06, requirements 5.1.3.3b.2 and 5.3.1b.3.

C.1.2 Purpose and objective

The purpose of the radiation test report is to provide evidence that the material was selected according to the radiation test specifications and procedures.

C.2 Expected response

C.2.1 Scope and content

a. The radiation test report shall include or refer to the following information:

1. description of the purpose, objective, content and the reason prompting its preparation,
2. description of the radiation test facility,
3. description of the item to be tested or a reference to the document containing its identification characteristics (e.g. request for radiation testing),
4. calibration tools, flux monitoring method, (periodic adjustments or controlled constant flux),
5. the test procedure or a reference to the document containing the description of the test procedure (e.g. radiation test specifications and procedure DRD),

NOTE It often consist in describing the as- run test procedure as well as any deviation from the initial test procedure (including a discussion of possible effect on test).

6. the irradiation source characterization (or a reference to the document containing this information,
7. the test results,
8. discussion about the tests results,
9. conclusion and recommendations.

b. The source characterization information shall contain:

1. operational conditions (operating range, maximum ratings),
2. energies, spectral range,
3. deviation between the Solar Spectrum and the source,
4. dose rates/ instantaneous doses/ total dose (taking into account energy distribution),
5. selected acceleration factors,
6. size and uniformity of irradiated surface, used method to cover large surfaces (optics, sweeping plates, diffusion window),
7. ageing of the source.

C.2.2 Special remarks

None.

Bibliography

ECSS-S-ST-00	ECSS system- Description, implementation and general requirements
ECSS-Q-ST-70-01	Space product assurance – Cleanliness and contamination control