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Quality assurance of test houses for ESA spacecraft and associated equipment

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ABSTRACT

This specification prescribes the minimum quality assurance (QA) requirements for test houses which supply a service of environmental testing, to ensure that such activities preserve the test item integrity, and the validity of the test.

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1. SCOPE

This specification prescribes the minimum quality assurance (QA) requirements for test houses which supply a service of environmental testing, to ensure that such activities preserve the test item integrity and the validity of the test.

2. GENERAL

2.1 INTRODUCTION

a) This document has been written as part of the ESA PSS-01 series of specifications and as such provides a summary of requirements associated with test houses, derived from the various specifications of the ESA PSS-01 series.

b) To comply with the conditions of document ESA PSS-01-0 (Basic requirements for product assurance of ESA spacecraft and associated equipment) ESA contractors are required to have their facilities for environmental testing of spacecraft hardware, materials and components, including control procedures, approved by ESA. The basic requirements for such approval are:

- the test-house must have an effective management system
- the test-house must have an approved quality assurance manual
- the test-house must be supervised by independent inspectors
- the test-house must have been successfully audited / assessed by ESA.

c) For all such test houses it is essential that their technical capability, the competence of their staff and their range of facilities be established. Furthermore, they shall establish and maintain an effective quality assurance programme describing their QA policy and all essential QA disciplines / requirements to operate the test house in a controlled manner and to ensure availability of facilities/equipment for the testing of test articles.

d) The quality assurance requirements are especially concerned with preserving the integrity of the facilities / test items and ensuring validity of the tests. The controlling document for these procedures is the test house **QUALITY ASSURANCE MANUAL.** The ultimate aim of these controls is to ensure that:

- Spacecraft hardware / materials / components are protected against deterioration and damage from all origins other than those defined to be necessary by the specified test criteria;
- Those performing and monitoring tests take the precautions and employing the measurement accuracy necessary to ensure the validity of the test results;
- Test facilities / equipment are properly maintained and calibrated in order to ensure their availability for any required test operation.

2.2 RELATED DOCUMENTS

Some or all of the content of the documents listed below is directly related to this specification. The applicability of these specifications is defined in the contract.

ESA PSS-01-10	Product Assurance Management and Audit Systems for ESA Spacecraft and Associated Equipment
ESA PSS-01-11	Configuration Management and Control for ESA Spacecraft and Associated Equipment
ESA PSS-01-20	Quality Assurance of ESA Spacecraft and Associated Equipment
ESA PSS-01-21	Software Quality Assurance of ESA Spacecraft and Associated Equipment
ESA PSS-01-40	Safety Assurance of ESA Spacecraft and Associated Equipment
ESA PSS-01-201	Contamination and Cleanliness Control

ESA PSS-01-202	Preservation, Storage, Handling and Transportation of ESA Spacecraft Hardware
ESA PSS-01-711	Product Assurance requirements for Micro VCM-Apparatus and Associated Equipment
ESA PSS-01-722	The Control of Limited-Life Materials.

2.3 DEFINITIONS

The definitions listed in Annex A shall apply.

3. REQUIREMENTS

3.1 PLANNING AND DOCUMENTATION

All the events, actions and tasks relating to the testing activities shall be fully planned and documented. Particular attention shall be paid to the planning with respect to the tasks related to quality assurance disciplines and the interfaces between the tasks of each discipline as indicated below:

- availability / maintenance of test equipment / facilities and calibration intervals
- nonconformance reporting
- logistic support activities, e.g. spares
- storage
- timely test schedules
- recertification / audits
- availability / update of appropriate documents, e.g. QA manual, operating instructions and test specifications, etc.
- traceability records
- safety instructions
- training / certification of personnel
- access control for special areas
- QA program (software), e.g. automatic test equipment
- configuration control
- test reviews

3.2 ORGANISATION

The test house organisation shall include nomination of experienced personnel to be responsible to management for all quality assurance activities. This organisational structure shall be functionally in compliance with Chart 1 of this specification. The detailed functions of these positions are:

a) Test House Manager (THM)

The THM shall be responsible for all operations of the test house, i.e.

- facilities, equipment
- integrity of test items
- test reviews
- health / safety of personnel
- safety of materials, gases, fluids
- training and certification of personnel
- planning

b) Test Facility Manager (TFM)

The TFM shall report directly to the THM and shall be responsible for:

- supervision of test facility / equipment
- maintenance of test facility / equipment
- calibration of facilities / equipment
- ensuring that procedures are complied with
- updating log books
- monitoring / logging measurements to monitor the functioning of test facilities
- right of access to test facility
- cleanliness / contamination

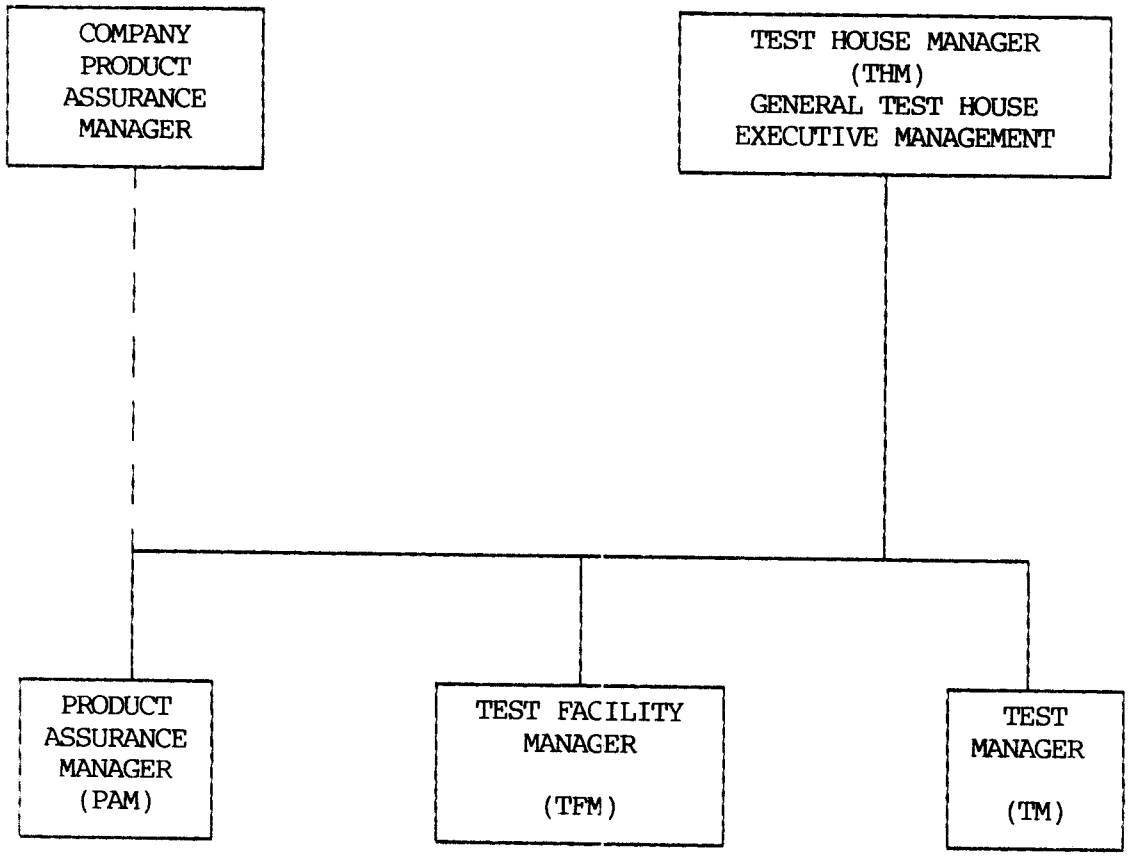

CHART 1

TEST HOUSE MANAGEMENT STRUCTURE

c) Test Manager (TM)

A TM shall be nominated for each test and shall be responsible for:

- liaison between customer and test house
- ensuring that correct test procedures are being used to meet customer requirements
- compliance of test with the test specification
- data recording / reporting of measurements to determine conformance of the test item with the performance specification
- data recording / reporting of measurements to determine conformance of the test parameters with those specified.

d) Product Assurance Manager (PAM)

The PA Manager shall report directly to the THM. However, if necessary, he shall also report to higher management. The PAM shall be responsible for:

- all QA activities within the test house
- safety activities within the test house if no safety officer is nominated
- compliance with QA procedures for all staff and visitors
- contamination control
- transportation and receipt of test items
- quality assurance manual
- focal point for ESA audits
- surveillance and/or verification of all test house activities.

3.3 QUALITY ASSURANCE PROGRAMME

A Quality Assurance Manual shall be established and maintained which describes up to the procedural detail the whole quality assurance programme.

3.3.1 Safety

The THM shall establish and maintain an effective safety programme in accordance with ESA PSS-01-40 (Safety Assurance of ESA Spacecraft and Associated Equipment), that is planned and integrated into all phases of operation. The safety programme activities shall be specified in the quality assurance manual.

The safety programme objectives are to ensure that:

- hazards associated with each facility are identified and evaluated, and are eliminated or controlled to an acceptable level
- control over hazards that cannot be eliminated is established to protect personnel, equipment and property
- minimum risk is involved in the acceptance and use of new materials and new testing techniques
- precautions are taken to minimise risks during testing, handling, etc.

3.3.2 Handling and Storage

Handling, storage, preservation, packaging, marking and labelling, transportation and shipping control and supervision is the responsibility of the PAM and shall be in accordance with ESA PSS-01-202, and the quality assurance manual. In addition, limited-life items shall be controlled in accordance with ESA PSS-01-722.

3.3.3 Access Control

The test house shall have a system for access control to all areas where flight standard hardware or hazardous items are stored, handled or tested. This access control system, which shall be described in the test house QA manual, may be flexible in the degree of its application depending on the type of hardware / facility / operation, but shall at all times when flight material is present be operated at the most advanced level. This shall include the recording of all persons allowed to enter the controlled areas and the controlled issuing of badges or other visible signs to be carried by all persons authorised to enter (including visitors as well as test house personnel and visiting project teams).

Test items shall always be guarded and/or kept within a locked area, the access to which is strictly limited to personnel authorised by the person having responsibility for the hardware. The guard shall be familiar with the rules of the test house and be aware of the special precautions relevant to the hardware concerned, as specified by the responsible project authority. He shall also be authorised to take corrective action immediately if unauthorised persons are seen in the controlled area, if any hazard to the hardware occurs or if safety rules are not observed.

3.3.4 Records and Traceability

Records/data and traceability shall be maintained in accordance with the "Quality Records and Traceability" requirements of ESA PSS-01-20.

3.3.5 Cleanliness and Contamination Control

Cleanliness and contamination shall be controlled in accordance with the "Contamination and Cleanliness Control" requirements of ESA PSS-01-201.

Furthermore, the environmentally controlled areas shall have a minimum cleanliness level of class 100.000. Depending on spacecraft requirements a higher class of cleanliness may be necessary. These requirements shall be specified in good time so as to allow necessary upgrading (see Annex B).

3.3.6 Metrology and Calibration/Maintenance

Metrology and calibration shall be performed/controlled in accordance with the "Metrology and Calibration" requirements of ESA PSS-01-20. However, calibration maintenance programmes shall not interfere with the test being performed, i.e. test facilities / equipment / jigs, etc. shall be available prior to the test and shall not require routine calibration / maintenance or reach wearout stage during the test period (see Annex B).

3.3.7 Configuration Control

A system of configuration control shall be established which provides for the control of baseline documentation and the procedures for document change control by which change / deviation / waiver authorisations are systematically received, identified, evaluated, prepared, classified, approved / disapproved and implemented. The system shall establish the names of those individuals, organisations or suppliers who may originate a request for change which will be ackowledged and acted upon for approval / disapproval by the Test Review Board and the procedures by which the request is submitted for consideration. The document ESA PSS-01-11 defines configuration management and control requirements.

3.3.8 Inspection System

There must be an inspection system implemented in the test facilities, to ensure that the procedures are followed. When hardware is tested or handled, the surveillance by inspectors is mandatory at all times during tests and other activities.

In-plant inspectors may be supplied by ESA or a National Inspectorate in collaboration with ESA. Inspectors from the test house itself may also be allowed when satisfactory assurance is given for the independence of these inspectors relative to the test executions and when full visibility into the inspection system is given to ESA.

When inspectors from customers are acting in the test house, the test house inspectors shall still remain ultimately responsible for the QA activities. When customer inspectors are performing mandatory inspection of tests, this shall not be duplicated by the in-plant inspectors, who for such cases shall draw back from mandatory to random inspection.

There shall be an inspection programme of incoming items to verify that their performance, material composition, physical properties etc and review of data are compliant with the purchase requirements.

3.3.9 Audits

The test house must allow ESA or an Inspectorate operating for ESA to audit the facility at random. In addition, one ESA audit of the facilities must be carried out before a certificate of approval can be granted to the test house. For this certificate to be updated, audits must be held with a maximum interval of two years. ESA shall be notified of any change in facilities, key personnel or procedures with respect to previous audit.

During the audit, ESA will ascertain that all plans and specifications are fulfilling ESA requirements, that facilities are adequately kept, that procedures are implemented and that the information / documentation system is in order. Any shortcomings will be discussed at the end of the audit and the test house will be given the opportunity to propose a plan for improving the situation, if this is deemed necessary, in which case a limited follow-up audit may take place at a later date before a certificate is issued or renewed.

3.3.10 Training and Certification of Personnel

The Test House Management shall ensure that its personnel are adequately trained / certified to perform their assigned tasks, and be in compliance with all safety regulations. Personnel performing selected operations (fork lift truck drivers, crane operators, etc.) shall be certified. Certification shall be based upon objective evidence of proficiency and professional skill.

3.3.11 Nonconformance

Any nonconformance relating to facilities and equipment which are observed, either during a test or at any other time, (e.g. during maintenance, calibration, storage, etc.) shall be dispositioned in accordance with the nonconformance requirements of ESA PSS-01-20.

3.3.12 Quality Assurance Manual

The Quality Assurance Manual (Handbook or Standard) shall describe in full the test house quality assurance system and is intended to record for reference the testing and organisation arrangements as approved by ESA. As a minimum the manual shall describe the following functions, procedures and organisation and shall be signed by the PAM (with the THM's approval) and an ESA representative.

a) **Services**

The test services offered under the ESA approval and the approved scope shall be stated. This can best be given in terms of tests and measurements which can be made, together with the relevant range of measurement values and limits of accuracy. The items of major apparatus shall be listed, and details given.

b) Organisation

The manual shall describe the organisation of the test house to show the line of responsibility to the senior management and the departmental relationships. This shall be in the form of an organisation tree / chart with a list to show the duties and responsibilities of the various posts which are relevant to ESA requirements.

c) Facilities

The laboratory buildings and equipment shall be briefly described in terms of construction, area and environmental facilities. Brief details of specially controlled areas for temperature, humidity, and clean conditions, shall be given. For each facility the following shall be specified:

- a technical description including capacity and capability, as well as a functional and a reliability block diagram for the test system;
- the environmental conditions required in the area;
- a description of system failure modes and their possible effects on test items and the test system as well as a fault tree (or a systematic list) for the diagnosis of causes of failures;
- safety procedures including emergency shut down operations;
- requirements on customers using the facility;
- a drawing of the facility covering the location of all major test equipment as well as areas for preparations and storage;
- methods / procedures to maintain the required level of cleanliness / contamination control.

d) Metrology and Calibration

The procedures and arrangements used to ensure regular maintenance, periodic calibration or evaluation of the laboratory apparatus shall be described and the system for recording those operations shall be stated.

e) **Test Standards**

The manual shall show the standards held and state the arrangements made to ensure the standardisation at appropriate intervals. The system of recording shall be stated.

f) **Procedures**

The manual is to describe the system and procedures operating for:

- dealing with enquiries and orders from customers and passing their instructions to the laboratory staff;
- ensuring that the specified quantities are available before testing commences;
- ensuring that all testing and conditioning of samples entirely complies with the customer's instructions;
- preserving the identity and integrity of samples from the time of receipt to the return to customer and ensuring accurate correlation of samples, test results and reports;
- allocating and programming the work;
- ensuring the identity, accuracy and completeness of the test report at the time of signature;
- preserving on the laboratory files copies of all issued test reports suitably indexed under correct means of identification or reference.

g) **Specifications**

The manual shall describe the system for maintaining the specifications up-to-date.

h) **Forms**

The manual shall be illustrated by copies of all documentation (forms and labels, etc.) used in the test house.

i) **Staff**

The technical level required for laboratory staff posts, the procedure for maintaining the efficiency of staff and the method of recording periodic checks on efficiency shall be detailed.

3.4 TEST REVIEWS

3.4.1 Introduction

The Test House Manager shall assure that test reviews are performed before and after the test sequence as indicated in the succeeding paragraphs. Moreover, before any test is accepted for execution by the test house, the test requirements must be documented by the customer in a test procedure and be agreed by the test house, the customer and ESA, or otherwise mutually agreed between the parties. Furthermore, for all formal tests, the test procedures must be authorised for implementation by the THM (or by a person delegated by him) before the test items are received and/or unpacked.

3.4.2 Test Readiness Review

Before the start of a formal test, the readiness of the facility/equipment to perform the test shall be assessed. The purpose of this review is to:

- verify that approved test and inspection documentation (test plans, test procedures, handling procedures, etc.) are available and agreed by the Test House Manager;
- ensure that requirements for facility preparation have been met;
- ensure that environmental and contamination controls are adequate;
- verify that all test equipment is within calibration requirements;
- verify that all GSE is calibrated, is in the correct configuration and is ready for the test;
- establish in a protocol whether the facility is ready for test or not and, in the latter case, which actions need to be taken.

3.4.3 Post-Test Review

The purpose of the post-test review is to:

- review test data packages and logbooks and to verify the results from the intermediate test-data evaluation;
- ensure the completeness of all test data and the appropriateness of test decisions due to test errors or failures;
- determine the acceptance disposition of the previous test and initiate the next phase of testing;
- attest by signature that the test data meet requirements and certify that the item is acceptable for further tests or processing.

3.4.4 Test Review Boards

The test readiness review and post-test review shall be conducted by a formal board (see PSS-01-20). As a minimum the board shall consist of the following members:

- Test House Manager
- Test Facilities Manager
- Product Assurance Manager (of the test house)
- Test Manager
- Customers representative (at their discretion)
- ESA representative (at ESA's discretion)

3.4.5 Reports

The test house shall establish a report on each test review board activity stating that the item and facilities are ready for the test, that adequate tests have been performed in compliance with the approved test plan and procedures, and that the results confirm the compliance of the system with the relevant approved design / test specification. The report shall include test data, configuration control documentation, certificates of conformances and nonconformances, if any.

ANNEX A

DEFINITIONS

TEST HOUSE

A combination of facilities, equipment, staff, and procedures, set up in order to carry out testing activities on items with a view to verifying the ability of those items to operate according to a defined requirement during or after being subjected to a defined environment.

ABBREVIATIONS

ESA	European Space Agency
ESTEC	European Space Research and Technology Centre
PA	Product Assurance
PAM	Product Assurance Manager
QA	Quality Assurance
TFM	Test Facility Manager
THM	Test House Manager
TM	Test Manager
VCM	Volatile Condensible Material

ANNEX B

GUIDELINES

1. CLEANLINESS

The requirements on cleanliness and contamination control as specified in Para. 3.2.5 imply that the cleanliness and environmental conditions as specified for a particular operation in the test house shall be maintained under the worst conditions. This means that:

a) the conditioning equipment (filters, heaters, coolers, dehumidifiers)
b) the maintaining methods (cleaning methods, cleaning intervals, etc.)
c) the amount of hardware brought into the controlled area
d) the maximum number of persons present in the controlled area

be specified and monitored, and that under the worst combination of these factors the cleanliness, temperature and humidity fulfil the specified values. To achieve and maintain this requirement the THM shall ensure that staff and visitors follow the instructions of the QA Manual. In addition, there shall be a maintenance and control plan for the air conditioning equipment and the filters, and the environment parameters shall be recorded as relevant. Automatic warnings for temperature, humidity and particle / chemical contamination may be considered. The PAM shall have the authority to stop activities and/or to ban visitors and staff from the controlled area when one or more of the controlled parameters exceed an acceptable level.

The cleanliness level and the climatic conditions offered by the test house shall be specified with reference to the outside conditions and to the allowable number of persons present in the controlled area.

2. METROLOGY AND CALIBRATION

The requirements on metrology and calibration / maintenance as specified in Para 3.2.6 imply that there shall be a calibration plan specifying the calibration intervals and making reference to calibration procedures for all instruments. The standards against which the instruments are calibrated shall be traceable to national standards.