INTERNATIONAL STANDARD

ISO 24917

Second edition
2020-07

Space systems — General test requirements for launch vehicles

Systèmes spatiaux — Exigences générales d'essai pour véhicules lanceurs

Reference number
ISO 24917:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

This second edition cancels and replaces the first edition (ISO 24917:2010), which has been technically revised. The main changes compared to the previous edition are as follows:

— correction of terms and definitions according to other existing standards;

— modification of the "Flight vehicle development test structure" (Figure 1);

— modification of the "Requirements applicability matrix" (Annex B).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document provides space launch vehicle customers, contractors and manufacturers with general requirements for test types and programmes for space launch vehicles and rocket units (modules) for use in the documentation associated with their test activity.

This document is intended to help reduce the development time and cost of space launch vehicles and rocket units, and to enhance their quality and reliability through the use of common, optimized and approved requirements in the space launch vehicle test scope and organization.

Space systems — General test requirements for launch vehicles

1 Scope

This document establishes general test requirements for launch vehicles equipped with liquid-propellant engines, launched from stationary ground-, sea- and air-based launchers, in all phases of their development.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14302, *Space systems — Electromagnetic compatibility requirements*

ISO 14303, *Space systems — Launch-vehicle-to-spacecraft interfaces*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
space-rocket complex
set of *flight vehicles* (3.2) with functionally relative technical facilities intended for transportation, storage, maintenance service, preparation, launching and flight control of flight vehicles with payload

3.2
flight vehicle
launch vehicle (3.3) including space *nose section* (3.6)

3.3
launch vehicle
vehicle designed to transport payloads to space

[SOURCE: ISO 10795:2019, 3.139, modified — The preferred term "launcher" has been removed.]

3.4
unit
lowest level of hardware assembly for which *acceptance* (3.26) and *qualification tests* (3.25) are required

[SOURCE: ISO 15864:2004, 3.1.13]

3.5
orbital stage
stage of *flight vehicle* (3.2) capable of injecting payloads into their planned orbit from the sub-orbital trajectory that resulted from operation of lower stages

3.6
nose section
set of a *fairing* (3.7) and fairing adapter

3.7
fairing
technical device intended to protect a spacecraft or a space *nose section* (3.6) from external influences during transportation on a launcher, and to keep it on trajectory when launching into orbit

3.8
integration site
equipment and facility designed for *launch vehicle* (3.3) storage, assembly, testing, preparation, maintenance, servicing and preparation for transportation to the *launch pad* (3.9)

[SOURCE: ISO/TR 17400:2003, 3.1]

3.9
launch pad
equipment and facility designed to provide for the pre-launch and launch operations of spacecraft

[SOURCE: ISO/TR 17400:2003, 3.3]

3.10
statement of work
contractual document prepared during project initiation and planning that describes what the project needs to deliver and outlines all work required to complete the project

[SOURCE: ISO 10795:2019, 3.229]

3.11
technical specification
specification expressing technical requirements for designing and developing the solution to be implemented

Note 1 to entry: The technical specification evolves from the functional specification and defines the technical requirements for the selected solution as part of a business agreement.

[SOURCE: ISO 10795:2019, 3.238]

3.12
test metrological support
establishment and application of scientific and organizational foundations, technical facilities, rules and standards necessary to achieve the measurement traceability, precision, completeness, operativeness and the reliability of parameters control and technical performance characteristics of items

3.13
development test programme plan
obligate organizational and methodological document which specifies the *test object* (3.23) and objectives, types, sequence and scope of experiments, order, conditions, place, time, support of test, test reporting and responsibilities for test support and performance

3.14
reliability assurance programme plan
document specifying a set of requirements and measures aimed at providing and controlling the satisfaction of requirements established in the *statement of work* (3.10) for a space *launch vehicle* (3.3) and its components' reliability during their development

3.15
development test
test to provide information that can be used to check the validity of analytic techniques and assumed design parameters, uncover unexpected system response characteristics, evaluate design changes, determine interface compatibility, prove qualification and acceptance procedures and techniques, check manufacturing technology, or establish accept/reject criteria

[SOURCE: ISO 10786:2011, 3.17]

3.16
safety assurance programme plan
document which establishes a set of requirements and measures aimed at assuring that all safety risks associated with the space *launch vehicle* (3.3) design, development, manufacture and use are accordingly identified, assessed, minimized, controlled and accepted

3.17
communications systems programme plan
document establishing the structure of communication systems (including telemetry measurement, command and tracking communication lines, etc.) hardware born set on *launch vehicle* (3.3), *launch pad* (3.9) and positioned along the flight route necessary for performance the measurement requirements, location and orientation of sensors and their characteristics, frequency bands, minimal frequency of sensor scanning

3.18
flight test
test in real conditions of the functioning and performance of target tasks

3.19
prototype model
item produced in the research and development process applying the newly developed working engineering and technological documentation for test verification of the conformity of its parameters and characteristics with the requirements specified in *statement of work* (3.10) to research and development and correctness of adopted technical solutions

3.20
model
test mock-up
structurally, or physically, or structurally and physically similar item presenting a simplified reproduction of a *test object* (3.23) or its part intended for testing

3.21
structural model
model (3.20) representing the structural flight characteristics

3.22
electrical model
model (3.20) representing the electrical flight characteristics

3.23
test object
item under test

3.24
test type
classified test grouping identified according to a certain attribute

3.25
qualification test
required formal contractual test used to demonstrate that the design, manufacturing, and assembly have resulted in hardware designs conforming to specification requirements

[SOURCE: ISO 14623:2003, 2.52, modified — The term has been changed to singular form.]

3.26
acceptance test
required formal test conducted on flight hardware to ascertain that the materials, manufacturing processes and workmanship meet specifications and that the hardware is acceptable for intended usage

[SOURCE: ISO 14623:2003, 2.2, modified — The term has been changed to singular form.]

3.27
operational test
test conducted at the *launch vehicle* (3.3) site in an operational environment, with the equipment in its operational configuration

3.28
critical unit
unit (3.4) whose failure can affect the system operation sufficiently to cause the failure of the stated vehicle objectives or a partial loss of the mission, or whose proper performance is essential from a safety standpoint

3.29
pyrotechnic device
device or assembly containing, or actuated by, propellants or explosives, with the exception of large rocket motors

EXAMPLE Initiators, ignitors, detonators, squibs, safe and arm devices, booster cartridges, pressure cartridges, separation bolts and nuts, pin pullers, linear separation systems, shaped charges, explosive guillotines, pyrovalves, detonation transfer assemblies (mild detonating fuse, confined detonating cord, confined detonating fuse, shielded mild detonating cord, etc.), through-bulkhead initiators, mortars, thrusters, explosive circuit interrupters, and other similar items.

[SOURCE: ISO 26871:2012, 3.1.31]

4 Abbreviated terms

CSP	communications systems programme plan
CTS	control and test station
DTP	development test programme plan
EMC	electromagnetic compatibility
FTP	flight test programme plan
FV	flight vehicle
IS	integration site
LPRE	liquid-propellant engine
LS	launching site
LV	launch vehicle

OCN	on-board cable network
OS	orbital stage
PHS	pneumatic/hydraulic system
RAP	reliability assurance programme plan
SAP	safety assurance programme plan
SC	spacecraft
SNS	space nose section
SOW	statement of work
SRC	space-rocket complex

5 Testing philosophy

5.1 Objectives, tasks and principles of development test for launch vehicle and its units

5.1.1 Development test

A development test is one of the methods of verification which guarantees that all characteristics of the FV meet the requirements of the SOW. The FV is tested in the SRC during the launch preparation for test flight.

The development test of an FV and units of an LV includes ground development test phases and a flight test. The complete test programme for launch vehicles, upper stage, encompasses development, qualification, acceptance, pre-launch validation and follow-on operational test and evaluations. The test programme encompasses the testing of progressively more complex assemblies of hardware and computer software. Generally, the FV development test structure may be represented as a scheme in compliance with ISO 14300-1 (see Figure 1).

5.1.2 Objectives

5.1.2.1 Objectives of ground development test

The main objective of a ground development test is to verify the FV preparation technology for launch and launch itself, preliminarily to verify and evaluate the implementation of the specified parameters and characteristics, operation and interaction of the FV and its components when the operation conditions are being simulated (or under effect of these conditions).

5.1.2.2 Objectives of flight test

The main objective of a flight test is to comprehensively check the FV serviceability and confirm the SOW-specified requirements for the space rocket complex under real operation conditions.

5.1.2.3 Objectives for reliability and safety programmes

One of the main objectives of the LV (OS) ground development test is to achieve the SOW-assigned levels of reliability and safety indexes before flight test commencement and confirm these during the flight test. The reliability and safety index levels are normalized in the RAP and SAP, the latter including an environmental safety guarantee.

5.1.2.4 Objectives of test for launch vehicle and its units

The main objectives of the development test of an FV, LV and its units are as follows:

a) verification of unit structure strength, rigidity, confirmation of rocket module parameters, verification of equipment mechanical loading regimes;

b) breadboarding;

c) test of technological cycle of preparing FV for launch and launch itself;

d) comprehensive verification of units functioning during launch and propulsion systems operation in the assigned regimes;

e) verification of the ground technical means/launch vehicle compatibility;

f) test of FV interfaces [LV, upper stage vehicle, spacecraft (SC)];

g) confirmation of the correctness of adopted engineering solutions;

h) verification of the sufficiency of measuring aids and telemetry data processing techniques;

i) individual tests of all FV components;

j) verification of operation convenience;

k) personnel training.

5.1.3 Test planning

The tasks to be solved during LVs testing are identified according to the design, assigned characteristics, LV test maturity, design (modernization) novelty, dedicated operation conditions change and are presented in the test programmes.

5.1.4 Organization and test sequence

The organization and order for conducting the development test are determined by the comprehensive development test programme plan.

5.1.5 Development test programme plan

5.1.5.1 Planning

In order to meet the assigned LV (OS) characteristics requirements, the supplier plans a development test.

5.1.5.2 Initiation of the programme

The comprehensive development test programme plan is developed in accordance with the LV (OS) hierarchical structure. The main starting documents for developing the FV development test programme are the statement of work, the preliminary project and the reliability assurance programme.

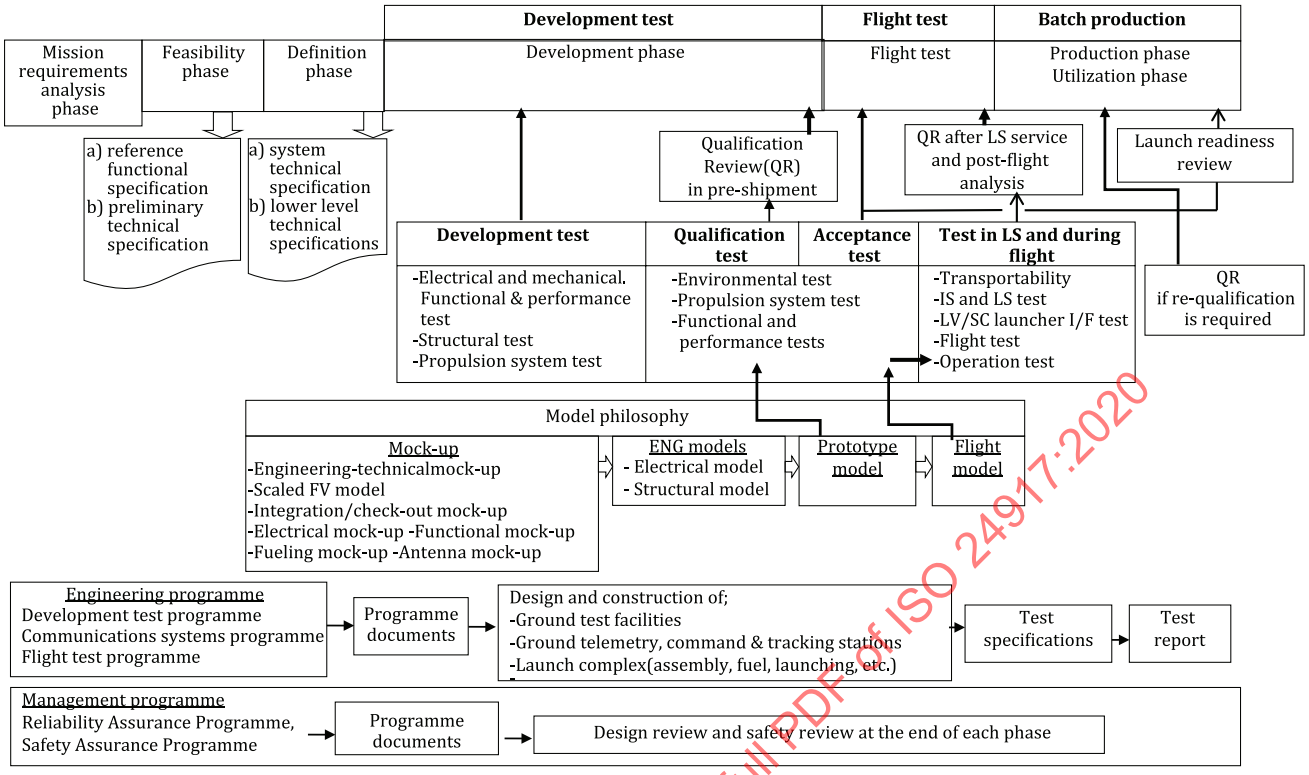

Figure 1 — Flight vehicle development test structure

5.1.5.3 Contents of development test programme plan

The FV comprehensive development test programme is a common system of independent, particular programme-technical documents, identifying the individual test objectives and scope, establishing the criteria of OS or LV completeness and readiness for transferring to higher test levels.

The test sequence, scope and object, controlled characteristics, types of test and test phasing in the course of LV (rocket unit) development are assigned by the LV (rocket unit) manufacturers-contractors in the comprehensive development test programme, other test programmes.

5.1.5.4 Principles of development test programme plan

The LV (OS) development test programme plan (DTP) is based on the following principles:

a) system approach to the test planning with a detailed coordination of all types and phases of test; absolute assurance and confirmation of the assigned characteristics of the SRC items during ground test; use of results of optimizing the complex systems functioning as a component of other complexes;

b) fulfilment of the main test work scope applying test facilities (stands, rigs, models, etc.) before starting ready-made (standard) LV (OS) test under real operation conditions (full-scale test);

c) confirmation of all-round interaction of all FV components and demonstration of their functioning reliability under full-scale conditions, as well as conduct of that part of test applying test means which cannot be technically performed or are economically inexpedient within the assigned time during the flight test, and on the basis of the following provisions:

   1) determination of nomenclature and characteristics of modified and newly developed test stands (rigs) on condition that they would assure fulfilment of the planned test types and scopes;

   2) use (if necessary with updating) of test facilities, stands and technological fittings developed for previous items;

3) assessment of the sufficiency and correctness of selecting equipment, control-measuring aids, mathematical software for test;

4) planning of each experiment with the aim of obtaining a maximal data volume necessary for evaluating the operation reliability; use of the capability of starting repeatedly the systems and units under the conditions for conducting multiple tests (including different test types) and applying limited number of items;

5) complex components control during the test;

6) all-round coordination of all test types of items at LV (OS) hierarchical structure levels with due regard for the values of tested characteristics, measurement precision, reproducibility of stand test, as well as test completeness requirements;

7) feasibility study of the test tasks, types and scopes stipulated in the comprehensive development test and flight test programmes (FTP);

8) satisfaction of the active normative document requirements (including standards for test types and norms, technical state review, information exchange, industrial safety measures, etc.);

9) planning of experimental works to optimize new technological processes including the planning of test technology for assuring the cleanness of internal cavities of propulsion system tanks, pneumatic/hydraulic systems, internal volume of the integration-protection block;

10) keeping to the test phasing (individual, integrated, flight test);

11) timely preparation of stand and metrological facilities, data processing aids for test applying the test product;

12) manufacture of test objects maximally corresponding to the standard make, as a minimum concerning that part of the engineering make and characteristics which are decisive for the corresponding test types;

13) if practicable, use of the material available after completing the individual test of assemblies and systems for making up stand items;

14) multiple use of material (stand items) designed for test (testing) at the expense of its updating and replenishment;

15) development and introduction of means, measures and methods of safety assurance of all test types (including environmental safety), with due regard for data obtained while analysing the types of critical failures, their consequences and critical units;

16) preparation and uninterrupted specification of the list of unacceptable risks and mitigation measures either already performed or currently being carried out, as well as the list of actions and the devices providing the exception of space debris formation during the FV launch;

17) test conduct under real complicated operation regimes, and non-standard situation simulation;

18) test simulation of external affecting factors in the volumes specified by the test programmes and methods; in this case the test is conducted in the tolerable serviceability regimes simultaneously simulating various affecting factors (with their most unfavourable combination) and modelling items interaction;

19) optimal combination of aids and methods of physical and mathematical modelling with subsequent confirmation of object test results;

20) use of computerized data processing and analysis aids in all test phases;

21) use of serviceability diagnostics systems, non-destructive serviceability control aids and non-destructive control aids for elements and assemblies;

22) obligatory failure examination, analysis of effect of the reasons of all faults and defects detected during the test on the system and assembly operation with publication of relevant reports (statements, opinions) and relevant modification of engineering, technological and operation documentation;

23) confirmation by additional test of modification efficiency performed because of revealed defects with publication of corresponding opinions as to clearing the modified assembly (system) for further higher-level test;

24) observance of the order of assigning letters to design documentation in the course of individual and comprehensive test;

25) justification of all changes of test scopes and types made while realizing the comprehensive development test programme and flight test (applying the previous test results, etc.) taking into account the necessity of assuring the achievement of given test objectives and tasks;

26) system analysis of the technical state of the complex items during ground and flight test; entry of faults revealed during test, results of analysing their reasons and corrective actions in the database;

27) repeated test to be conducted due to revealed faults or necessity to update the test object;

28) keeping the strict reporting on the results of conducted test types;

29) analysis of the previous test and preparation of an opinion as to LV (OS) clearance for subsequent test when transferring from one test phase to another (before starting the comprehensive and flight test), issue of the final report on the ground test results and FV readiness for flight test;

30) reduction of test time and costs with satisfaction of requirements for the LV technical characteristics and reliability, test conduct and control automation;

31) planning of experimental works on confirming new periods of guarantee for attracted systems and assemblies operation;

32) the test scope shall be sufficient for validated experimental confirmation of the structure serviceability issuing of an opinion as to the test object clearance for flight test;

33) distribution of responsibilities among organizations-subcontractors for conduct of all test types.

5.1.6 Effects of implementation of principles

Implementation during the test of the principles stated in 5.1.5.4 enables the following:

a) when testing the elements: to assess the external factors effect and physical parameters limits and their spread;

b) when testing the units and elements: to detect failures brought about by the structure peculiar features and determine the conditions of operation and use for fulfilling the dedicated tasks;

c) when testing the assemblies: to assess their interaction and mutual influence, to check supplementary equipment;

d) when testing the complex as a whole:

1) to verify satisfaction of the SC/LV/LS requirements;

2) to conduct FV testing at the integration site (IS) and launching site (LS) simultaneously;

3) to check their interaction taking into account the operation time line of all FV systems under full-scale conditions;

4) to find defects in the systems interfaces;

5) to optimize the FV preparation technology for performing the dedicated tasks;

6) to assure the sufficiency and efficiency of mathematical software control and test;

7) to assure test of the order of eliminating non-standard and emergency situations;

8) to assure the sufficiency of FV-born measuring aids;

9) to identify unacceptable risks during operation of FV;

10) to reduce the level of space debris formation during FV launches.

5.2 LV and rocket unit test types during their development

5.2.1 Tests in development phase

5.2.1.1 General

During the development phase of launch vehicles, as a rule the latter undergo the following tests.

5.2.1.2 Mock-up test

a) engineering-technological (LV, unit) mock-up test (see 6.1.1);

b) scaled FV model test (for identifying their aerodynamic characteristics);

c) integration/check-out mock-up test (see 6.1.2);

d) electrical mock-up test (see 6.1.3);

e) functional mock-up test;

f) fuelling mock-up test (see 6.1.4);

g) antenna mock-up test (see 6.1.5).

5.2.1.3 Environmental test

a) static load test (see 6.1.6);

b) vibration test (see 6.1.7);

c) acoustic test (see 6.1.8);

d) thermal vacuum test;

e) thermal cycle test;

f) shock load test (see 6.1.9).

5.2.1.4 Propulsion system test

a) cold test of rocket units (see 6.1.10);

b) pressurization test [for LV with liquid-propellant engine (LPRE)];

c) hot firing test (see 6.1.11).

5.2.1.5 Other functional and performance test

a) electromagnetic compatibility (EMC) test (see 6.1.12);

b) hydraulic test;

c) mathematical software and information support test;

d) separation test;

e) climatic test (see 6.1.13);

f) fire and explosion safety test (see 6.1.14);

g) lightning and statics resistance test (see 6.1.15);

h) lifetime test (see 6.1.17).

5.2.1.6 Launch site verification and validation test and flight demonstration

i) transportability test (see 6.1.16);

j) IS and LS test (see 6.1.18);

k) LV/SC launcher interfaces test (shall be conducted in accordance with ISO 14303);

l) flight test (see 6.1.19);

m) operation test.

5.2.1.7 Other consideration

LV components disposal (see 6.1.20).

5.2.2 Test in routine production phase

5.2.2.1 Consensus with customer

Upon agreement with the customer (or with the customer's organization, at the customer's instruction), permission can be given to conduct additional test types not stipulated by the given standard, just as permission can be refused to conduct certain test types stipulated by the said standard or to combine separate test types planned in the comprehensive development test programme.

5.2.2.2 Models and test categories

The manufacturing stage, item categories and test categories conducted during the development of the LV and its units are illustrated in Annex A.

5.2.2.3 Requirements applicability matrix

The requirements applicability matrix is illustrated in Annex B.

5.2.2.4 Test for rocket engines

The liquid-propellant rocket engine is the most intensive assembly of a propulsion system; therefore, success of designing an LPRE in many respects determines the success of developing a propulsion system and an LV as a whole. The LPRE as a whole is tested in the following sequence:

a) tentative (comparative test, specifying test, updating test, final updating test, LPRE stand test as a propulsion system component, throwing test, flight test) tests;

b) verification test;

c) acceptance test (interagency LPRE test and LPRE test as a propulsion system component);

d) acceptance test for engines;

e) batch production (periodical) test (see 6.1.21).

5.2.3 Test for units

During the cold technological test, firing control technological test of individual LPREs, or firing technological test of LPRE as a component of the rocket unit, the following steps are carried out:

— the production quality of a specific item is checked,

— the characteristics conformity with the assigned requirements is assessed, and

— the feasibility of presenting the given LPRE model for operation as a space launch vehicle component is evaluated.

6 Test type and programme requirements

6.1 Test object and type requirements

6.1.1 Engineering and engineering-technological breadboarding

6.1.1.1 General

The engineering and engineering-technological breadboarding is aimed at coordinating LV individual elements, optimizing the production and integration technology, and specifying starting design data.

6.1.1.2 Two types of mock-up

Breadboarding is divided into two phases:

a) tentative breadboarding applying an engineering mock-up;

b) final breadboarding applying an engineering-technological mock-up.

6.1.1.3 Test for engineering mock-up

At least the following tasks should be fulfilled applying the engineering mock-up to confirm mechanical interface for movable components, layout of cables or piping, connecting parts, and handling aids, etc.:

a) verification of the arrangement and mutual positions of the parts and integration units, feasibility of LV (unit) integration;

b) verification of tolerable clearances between mutually moving integration units when they are integrated;

c) laying of pneumatic/hydraulic lines (verification of their sufficiency and feasibility of pipeline fastening taking into account the vibration strength conditions) and building of pipeline prototypes (assurance of the tolerable pipeline bending radii);

d) identification of a preliminary on-board cable network (OCN) configuration and lengths, assessment of electrical connection positions, correctness of OCN laying and sufficiency of attaching points on the structure elements;

e) breadboarding of the detachable equipment installation (assembly) and sealing;

f) preliminary assessment of the sufficiency of measures for ruling out inadequate mating of the electrical, pneumatic and hydraulic systems;

g) confirmation of the correctness of selecting the support, lift and handling patterns, transportation conditions, etc.

6.1.1.4 Test for engineering-technological mock-up

At least the following tasks should be fulfilled during the unit engineering-technological mock-up test:

a) verification of the practicability of manufacturing LV assemblies and systems applying the engineering documentation;

b) specification of the arrangement and mutual positions of the parts and integration units;

c) control of tolerable clearances between the mutually moving integration units when integrated and operating;

d) specification of the pneumatic/hydraulic line laying and reference pipeline building;

e) specification of the OCN configuration and lengths and assessment of the electrical connection positions, cable network laying;

f) verification of the practicability of replacing the control system devices without dismantling the adjacent devices and other structural elements;

g) ruling out of the situations leading to inadequate mating of the electrical/pneumatic/hydraulic system elements;

h) verification of the structure interface requirement satisfaction;

i) integration technology test;

j) breadboarding of the detachable equipment assembly and sealing;

k) test of the technology and safety of haul-transport operations, assembly-mating operations when transporting an item, and technological processes of FV preparation at IS and LS;

l) test of the control technology and the problems of system and assembly maintainability, ecology, ergonomics, operational safety.

6.1.2 Integration/check-out mock-up test

6.1.2.1 The LV integration/check-out mock-up elements are directly mated with the ground equipment assemblies defining the external dimensions. The mock-up mass, its centre-of-mass and strength characteristics shall be in accordance with those of the standard-completeness LV.

6.1.2.2 The integration/check-out mock-up test is aimed at optimizing the launch vehicle/launch pad/ground technological equipment interface, verifying the works technology on LV and simultaneous interaction of assemblies.

6.1.2.3 At least the following tasks should be fulfilled during the integration/check-out mock-up test:

a) test of the LV preparation technology for launch at IS and LS including simultaneous preparation of the ground equipment set and space nose section (SNS);

b) test of interaction of the technological equipment, technical systems and movable assets with LV;

c) verification of the industrial safety rules observance when simultaneously carrying out works on FV, launcher, technological equipment, technical systems and movable assets;

d) verification of the sufficiency of the arrangement and engineering solutions, specified in the engineering documentation on LV protection against statics;

e) test of the operation documentation; verification of the sufficiency and employment of the (FV, LV) crew personnel.

6.1.2.4 The integration/check-out mock-up test is conducted under the programme to be developed by the contractor of ground equipment upon agreement upon with the LV contractor and organizations concerned. Operations are carried out applying the operation documents.

6.1.3 Electrical mock-up test

6.1.3.1 Electrical mock-up is an LV mock-up fully conforming to electrical system parameters of the LV flight sample. If necessary, instead of the standard set of devices and assemblies, it is permitted to install dummies having electrical parameters and attaching points identical to those of the standard devices and assemblies. The electrical mock-up shall enable the carrying out of loading/unloading works and transportation operations provided for the standard LV. Explosive-ordnance devices (stage separation means, deceleration engine ignition means, etc.) are installed with inert filling simulating electrical characteristics, attaching points and techniques of the standard devices.

6.1.3.2 The electrical mock-up test is aimed at optimizing the LV electrical test technology at the control-test station (CTS) of the manufacturer and the launch pad, checking the CTS equipment of the manufacturer (supplier).

6.1.3.3 At least the following tasks should be fulfilled when carrying out the electrical mock-up test:

a) test of the ways out of non-standard situations;

b) verification of the serviceability of LV electrical and radio systems individually and integrally;

c) test of the launch preparation schedule;

d) simulation of in-flight failures of LV systems;

e) verification of simultaneous operation of on-board and ground electrical and radio systems;

f) test of engineering documentation and operation manuals;

g) verification of the sufficiency and employment of the team personnel;

h) verification of electrical circuits of on-board equipment;

i) verification of the conformity with the electrical interface requirements (explosive-ordnance device interface, LV-generated electrical commands interface, interface of upper stage vehicle-generated commands to spacecraft, telemetry information interface, etc.).

6.1.3.4 The electrical mock-up test is conducted under programmes, applying methods (instructions) worked out by the manufacturer of the FV and its systems upon agreement by the customer's representative and organizations concerned.

6.1.3.5 The electrical mock-up test is conducted at the manufacturer's CTS, at IS and LS.

6.1.4 Fuelling mock-up test

6.1.4.1 The fuelling mock-up test is aimed at optimizing the fuelling and drainage systems of propellants.

6.1.4.2 At least the following tasks should be fulfilled with the fuelling mock-up:

a) test of the ground fuelling equipment, fuelling system, as well as verification of the efficiency of the LV automation subassemblies responsible for fuelling/drainage operations;

b) test of the operation manuals;

c) test of the thermal regimes;

d) verification of the sufficiency and employment of the team personnel;

e) test of the fire-extinguishing techniques and propellant neutralization;

f) verification of the conformity with the safety precautions when filling and venting propellants and other propulsive masses (gases, liquids).

6.1.4.3 The fuelling mock-up is tested under a programme, worked out by the contractor of the fuelling equipment upon agreement with the LV contractor, primary contractor of ground equipment and organizations concerned.

6.1.4.4 The fuelling mock-up is tested by a commission having on its staff representatives of enterprises developing fuelling facility, LV, test facility and other enterprises concerned chaired by a test facilities representative.

6.1.4.5 In addition to 6.1.4.1 to 6.1.4.4, the following tasks are fulfilled in the course of testing the fuelling mock-up:

a) integrated test of the LV assembly and testing at IS and its haulage to LS;

b) test of the technology of FV pre-launch checks and preparation simultaneously with ground equipment set at LS;

c) verification of the serviceability, maintainability of assemblies and systems; operational ergonomics, bionomics and safety as well as test of the technological processes of transferring the space rocket in different levels of preparedness;

d) verification of the conformity with the SOW requirements to the number (multiplicity) of "fuelling-drainage" cycles (for propellant), "charging-discharging" cycles (for gases), time period during a launch vehicle standing with being loaded the propellants on the launch pad, etc.

6.1.5 Antenna mock-up test

6.1.5.1 The antenna mock-up test is aimed at testing the electrical and radio-technical characteristics of antennas and feeders and testing FV antenna patterns.

6.1.5.2 At least the following tasks should be fulfilled when testing the antenna mock-up:

a) determination of electrical and radio-technical characteristics of antennas and feeders mounted on space rocket stages and nose fairing;

b) antenna pattern parameter determination;

c) determination of the interconnection levels between high frequency channels of different feeders;

d) assessment of configurations (contours) and materials of structures in terms of the antenna electrical characteristics;

e) feeder verification for electrical strength and endurance in vacuum;

f) feeder tuning verification.

6.1.6 Static load test

6.1.6.1 The static rating test is aimed at verifying the strength and rigidity of the LV and its stage structure.

6.1.6.2 At least the following tasks should be fulfilled when carrying out the static rating test:

a) identification of the stress-strain state of individual assemblies and units, as well as verification of the correctness of theoretical strength calculations;

b) verification of the strength and stability of the LV structure under static loads simulating quasi-static loads during FV ground and in-flight operation;

c) determination of rigidity characteristics of the rocket sections;

d) determination of breaking loads and the structure strength margins.

6.1.6.3 The static rating test is carried out using LV standard load-carrying elements. To create full-scale conditions of fixing and loading the LV body sections during test the adjacent sections and relevant rigidity simulators are used.

6.1.7 Vibration test

6.1.7.1 The vibration test is aimed at obtaining experimental data on elastic vibrations of LV and rocket units, as well as checking assemblies, devices, systems and the LV as a whole for strength and stability to vibration loads action.

6.1.7.2 At least the following tasks should be fulfilled during the vibration test:

a) verification of the correctness of calculating the main aerodynamic characteristics of LV body, assembly and device oscillations included in the structural design and applied when selecting the control system parameters;

b) experimental specification of the LV dynamic layout;

c) verification of the FV structure and its element strength under expected vibrational loads.

6.1.7.3 The vibration test is conducted using LVs, rocket units or LV individual sections.

6.1.8 Acoustic test

6.1.8.1 The acoustic test is aimed at demonstrating the conformity with the SOW requirements for maintaining the acoustic pressure levels brought about by FV engines at launch as well as during FV transonic flight with a maximum dynamic head.

6.1.8.2 At least the following tasks should be fulfilled during the FV acoustic test:

a) acquisition of test data and assessment of the acoustic pressure effect on the FV equipment;

b) verification of the FV equipment serviceability under non-stationary loads of acoustic pressure;

c) specification of the design values of the acoustic pressure parameters applying test data;

d) development of shielding methods reducing acoustic pressure levels;

e) determination of the acoustic pressure level applied to SC equipment;

f) specification of the measuring aid makeup.

6.1.9 Shock load test

6.1.9.1 The test for shock loads applied to LV and SC equipment, brought about by actuation of explosive-ordnance and mechanical devices on board FV at the time of stages, nose fairing and SC separation, is aimed at demonstrating the ability of the FV structure and equipment to satisfy the requirements for normal functioning during and after shock load application.

6.1.9.2 As a rule, the shock load action is checked and the shock load levels are determined during the functional test of the stage, nose fairing and spacecraft separation systems.

6.1.10 Cold test of rocket units

6.1.10.1 The cold test of rocket units is aimed at comprehensive test-stand verification of the serviceability of rocket unit systems, without igniting the propulsion system and experimental confirmation of the validity of adopted project and engineering approaches.

6.1.10.2 The following main problems are solved during the cold test of units (e.g. the set of propellant "liquid oxygen – kerosene"):

a) verification of technological operations carried out on the experimental unit of a stage before propellant loading (e.g. purging, ventilation, replacement of air atmosphere with nitrogen and then hydrogen atmosphere);

b) verification of the technology of filling tanks with propellants, verification of fuelled unit at rest, tank propellant venting; specification and confirmation of the adopted fuelling operations technology;

c) test of the regimes of pre-launch cooling of the sustainer oxidizer and fuel pipelines, optimization of the cooling system functional cyclogram;

d) acquisition of data on the thermal and phase state of the cooling system liquid, propellant flow rate in all operational phases of the unit;

e) acquisition of test data on the pneumatic/hydraulic system operation during preparation of the propulsion system for ignition and propellant venting;

f) test of the technological operations for setting the unit in the initial state after abortive ignition (evaporation, thawing out, change of gas atmosphere in tanks and pipelines, etc.);

g) acquisition of test data and specification of the parameters characterizing the main processes of fuelling, preparing the unit for its propulsion system firing, venting the propellants (tank pressure change, change of the thermal and phase state of propellants in tanks and supply pipelines, replenishment regime change, change of drainage, section thermal control, change of process duration, etc.);

h) acquisition of data on thermal flows to oxidizer, the characteristics and efficiency of the oxidizer tank and pipeline thermal insulation;

i) verification of the characteristics and state of the oxidizer tank and pipelines during multiple fuelling and fuelled tanks at rest;

j) verification of the serviceability of standard on-board and inter-tank systems controlling the oxidizer level, pressure, temperature and measuring system elements (transducers) during propellant loading to the units;

k) check of the fittings and the quality of their individual test;

l) verification of the efficiency of operations conducted on the unit when the launch is cancelled in different phases of its preparation;

m) verification of the pre-launch tank pressurization regimes;

n) determination of actual strains of the rocket unit structure elements generated by the temperatures and masses effect of the filled-in propellants;

o) test of the technology of preparing the unit for firing before the command to fire is given (fuelling, level correction, etc.);

p) specification of the complex measures for assuring the test safety.

6.1.11 Hot firing test

6.1.11.1 The hot firing test of propulsion systems is carried out on a rocket unit manufactured in accordance with the engineering documentation, with possible updating needed to support the test conduct.

6.1.11.2 The hot firing test is aimed at comprehensive test stand verification of the rocket unit system serviceability with propulsion system firing, as well as experimental confirmation of the correctness of the adopted project and engineering approaches.

6.1.11.3 At least the following main tasks should be fulfilled during the hot firing test:

a) verification of the launch mission profile, regime settling down and propulsion system shut-down;

b) confirmation of the adopted project and engineering solutions;

c) verification of the LV LPRE cluster serviceability;

d) check of propulsion system operation in non-standard situations and emergency protection system efficiency;

e) confirmation of the parameters conformity of different systems with the requirements set forth in the documentation;

f) detailed inspection of the on-board pressurization systems, confirmation of the cylinder pressurization gases sufficiency;

g) chemical analysis of filled-in and drained propellants;

h) determination of the propellants purity when draining;

i) confirmation of the pneumatic/hydraulic system (PHS) elements serviceability at normal flow rates of propellants (gases and liquids);

j) determination of the hydraulic characteristics of the propellant systems;

k) confirmation of the sufficiency of pressurization gas flow rate for assuring the required pressure at the pump inlets;

l) determination of amount of remaining propellant;

m) check of the on-board aids for measuring propellant levels and temperature;

n) specification of the functional mission profile;

o) specification of the launch conditions and engine stand test when LV is in its standard position;

p) determination of the pressurization jet diameters;

q) verification of the function, performance and adjustment of the performance to the designated range (adjustment of thrust level, propellant mixture ratio, thrust vector alignment);

r) assessment of the actual rigidity of control actuator attaching points;

s) specification of the frequency spectrum and the value of vibrational accelerations of the unit structure elements at test stand.

6.1.11.4 In order to conduct the hot firing test, the standard on-board control system devices are used and the standard time line of propulsion system operation is implemented.

6.1.12 Electromagnetic compatibility (EMC) test

6.1.12.1 The electromagnetic compatibility test is aimed at verifying the technical means conformity of the space rocket system with the tolerable electromagnetic interferences level generated by the said means and other external radiation sources, with requirements to the electromagnetic interferences effect resistance, as well as at verifying the normal on-board systems functioning during their simultaneous operation in accordance with the flight programme.

6.1.12.2 The EMC test should demonstrate the compatibility of electrical/radio systems with the external environment-generated factors.

6.1.12.3 The EMC requirements are specified by the customer of payload upon reaching an agreement on the subject with the customer of launch capabilities in the statement of work for the space rocket system, in the statement of work for SC launch services, in the interfaces control document or other normative document.

6.1.12.4 At least the following tasks should be fulfilled during the EMC test:

a) measurement of radiated and conductive interferences initiated in the on-board cable network by operation of systems and devices;

b) study of the resistance of systems and devices to radiated and conductive interferences of different levels;

c) measurement of radiated interferences in the LV-SC interface plane, monitoring of the conductive interferences level in the LV-SC electrical circuits;

d) specification of actual LS electronic environment parameters;

e) EMC verification during IS and LS test during simultaneous operation of the on-board and ground systems.

6.1.12.5 The EMC test is conducted under a programme elaborated by the leading manufacturer of their space rocket system upon agreement with the manufacturers of the control system, IS and LS.

6.1.12.6 The EMC test scope and methods shall be in accordance with ISO 14302. The EMC test shall be conducted both at the level of equipment (individual tests) and at the level of the space rocket system (integrated tests). In cases substantiated by the contractors of space rockets and space vehicles, the space rocket system EMC may be evaluated applying the calculation/theoretical method with due regard for the results of testing space rocket analogues.

6.1.12.7 The results of ground test of space rocket system electromagnetic compatibility should be given in the primary contractor's opinion as to the space rocket system preparedness for launch in the certificate of compliance and should be reported to the commission carrying out the space rocket system test.

6.1.13 Climatic test

6.1.13.1 The climatic test is aimed at proving the LV serviceability under conditions maximally simulating the climatic operational conditions.

6.1.13.2 The following tasks are fulfilled when carrying out the climatic test:

a) determination of the climatic factors' effect on the LV safety;

b) verification of the effect of extreme temperature values, humidity, tropical and maritime climates and other factors on the LV serviceability and its components, as well as on the convenience of operation;

c) study of the environmental effects on the safety of lubricants, paint-and-varnish and other coatings;

d) identification of materials insufficiently resistant to the environmental effects and determination of methods for enhancing their resistance; verification of the conformity of the customer's SOW with the characteristics of the LV and its components obtained under the extreme temperature conditions;

e) functional test of the LV components;

f) specification of the environment factors (air temperature, surface wind speed in the space rocket launch area, atmospheric precipitations, etc.), imposing restrictions on space rocket launches.

6.1.13.3 The number of climatic test objects and the test duration are set forth in the test programme. A programme of accelerated climatic tests may be developed for creating more severe climatic conditions.

6.1.14 Fire and explosion safety test

6.1.14.1 The fire and explosion safety test is aimed at proving the LV operational safety in emergency situations.

6.1.14.2 At least the following tasks should be fulfilled when conducting the firing and explosion safety test:

a) identification of the accident character and the level of its effect on the space rocket system components and crews;

b) assessment of the emergency situation effect on the space rocket system characteristics;

c) test of the transducers location layout and confirmation of the fire and explosion prevention system serviceability;

d) acquisition of test data for working out measures to overcome accident after-effects.

6.1.14.3 The LV and rocket units fire and explosion safety is tested when the LV rests at the launch pad. It is permitted to confirm the fire and explosion safety applying the results of similar tests of previously developed LVs or test results of components of a newly developed LV, while the efficiency of a fire and explosion prevention system is confirmed by mock-up test.

6.1.14.4 Empirical data are obtained on function of the systems providing the exception of development of emergencies which can lead to explosion and dispersion of configuration items in space.

6.1.15 Lightning and statics resistance test

6.1.15.1 The test for resistance to lightning is aimed at assessing the conformity of the achieved lightning protection level with the requirements established applying the models of lightning statics effect on LV.

6.1.15.2 As a rule, the following tasks should be fulfilled when testing for confirmation of the lightning and statics resistance:

a) plating materials testing;

b) development test of techniques for confirming the space rocket system resistance to statics;

c) experimental assessment of shielding assemblies and systems of the space rocket system against pulsating currents, determined by the model of lightning effect on LV;

d) test of methods and aids for measuring amplitude-temporal parameters of pulsating currents and voltages in equipment electrical circuits;

e) acquisition of experimental data on response of the LV equipment, systems and assemblies to lightning effect for consequent assessment of the lightning protection and specifying the calculation-experimental methods of assessing the lightning protection;

f) test of the technical means of protecting the FV against lightning effect when it rests at the launch pad;

g) accumulation of test data for further perfection of test techniques and protection means.

6.1.15.3 The statics resistance of the FV and its components is optimized by the manufacturer. The FV lightning resistance is tested and confirmed when the FV rests at the launch pad.

6.1.16 Transportability test

6.1.16.1 The transportability test is aimed at verifying the realization of the customer's statement of work concerning assurance of the LV (rocket unit) serviceability after its haulage over an assigned distance under the given conditions by the assigned transport facility.

6.1.16.2 At least the following tasks should be fulfilled during the transportability test:

a) gathering of statistical data for assessing the LV and its components reliability;

b) identification of the LV actual temperature-humidity regime when hauling;

c) acquisition of test data on loading parameters (shock loads, vibrational strength, etc. in the three mutually perpendicular planes) of LV structure elements, completing parts, their attaching points to the transport facility and determination of the conformity of the obtained characteristics with the tolerable design values;

d) verification of the completeness and sufficiency of the operation documentation requirements determining the haulage;

e) determination of the effect of LV reloading from one transport facility to another;

f) checking of the LV components functioning after haulage.

6.1.16.3 LVs or rocket units are tested for transportability under a special programme.

6.1.17 Lifetime test

6.1.17.1 The test is aimed at confirming the LV serviceability for the time period and under operational conditions specified in the customer's statement of work.

6.1.17.2 At least the following tasks should be fulfilled during the test:

a) assessment of the LV and its components serviceability within the guarantee period under the given conditions;

b) study of the environment effect on the parameters stability and the LV components serviceability;

c) identification of materials and coatings insufficiently resistant to the environment and influence of propellants;

d) determination of the techniques for enhancing their resistance;

e) assessment of the LV systems lifetimes;

f) assessment of the frequency and scope of maintenance operations and determination of the ways to shorten the latter;

g) assessment of the conformity of consumable materials and spare parts, tools and instruments with the actually consumed materials and spare parts, tools and instruments;

h) confirmation of the inter-tank pressure range during operation.

6.1.17.3 The guaranteed lifetime test duration is dependent on the general guaranteed lifetime specified in the statement of work for LV (OS).

6.1.18 Test at integration site and launching site

6.1.18.1 The test at IS and LS is aimed at controlling the FV conformity with the technical file, SOW requirements after the FV has been stored and transported, as well as at controlling the FV readiness for launch.

6.1.18.2 At least the following tasks should be fulfilled during the test:

a) specification of the LV and FV integration technology including loading-unloading operations;

b) test of the technology of preparing the LV and FV for launch at IS;

c) test of reloading FV to the transport-erecting assembly (erecting FV in the tower) and its haul to LS simultaneously determining the effect of the reloading process from one transport facility to another on FV and its components;

d) determination of the depressurization of FV and space nose section (SNS) of FV to confirm their venting system calculation;

e) test of the operation documentation during works on LV and FV;

f) determination of the technical readiness of the IS equipment for flight tests;

g) specification of the makeup (number) and qualification of the maintenance personnel assigned to prepare FV for flight test.

6.1.18.3 Technical operations and time line of FV preparation for launch are comprehensively optimized at LS.

6.1.18.4 The tasks of this phase are as follows:

a) testing of FV erection (FV dismantling at abortive launch) on the launcher including the operations of mating the composite systems and assemblies;

b) acquisition of test data on loading parameters when hoisting FV in the vertical position and when lowering;

c) test of preparing the fuelling, venting and supply pipelines and tanks of SLV (i.e. LV and SNS) for propellants and compressed gases charging;

d) test of the technology of charging FV with propellants and compressed gases;

e) overall check of the on-board and ground safety assurance means during FV propellant loading operations;

f) verification of the assigned thermal regimes assurance of propellants and compressed gases during FV fuelling and rest at LS;

g) verification of the operation regimes and efficiency of the thermal control systems (purging, ventilation of sections and control system devices locations, etc.);

h) verification of all LS and FV (LV, OS, nose fairing, SC) interface types: electrical, thermal, mechanical, etc., as well as interface documentation;

i) verification of the electromagnetic compatibility of electrical and radio equipment of the FV components and FV as a whole with electrical and radio systems of the launch area-adjacent zone;

j) verification of the technological operations for propellants venting from the FV tanks and pipelines;

k) test of the technology of neutralizing the rocket unit propellant systems after propellants venting;

l) verification of the sufficiency of the layout and engineering solutions specified in the design documentation on shielding FV (LV and SNS) against statics effect;

m) individual verification of the serviceability of FV electrical and radio systems when operating simultaneously;

n) launch time line test;

o) verification of simultaneous operation of the on-board and ground electrical and radio systems;

p) verification of the impossibility of sending unauthorized commands during failures and mistaken actions of the service personnel;

q) test and verification of the interaction of on-board and ground measuring systems at LS;

r) test of the on-board telemetry data decoding and analysis;

s) test of the operation documentation during operations on FV at LS;

t) determination of the technical preparedness of the LS equipment for flight tests.

6.1.18.5 The FV (LV) is checked in accordance with the operation documentation.

6.1.19 Flight test

6.1.19.1 The aims, tasks and procedure of conducting the flight test are in accordance with the currently valid provisions on the subjects.

6.1.19.2 Analysis and assessments are made applying flight test data (see ISO 15865).

6.1.19.3 In order to meet given requirements on reduction of space debris formation during FV launches, after separation the upper stage should execute the manoeuvre necessary for prevention pollution of spacecraft and an outer space, collision with spacecraft and maintenance of positive increase in distance between spacecraft vehicle and upper stage.

6.1.20 LV components disposal requirements

6.1.20.1 The supplier shall identify:

a) order of handling inappropriate items;

b) order of handling items containing precious and rare-earth elements after completing ground and flight test;

c) order of searching and techniques of separated FV elements disposal along the flight route;

d) order of mitigating (weakening) the FV launch effect on the environment (acoustic effect, propellants release, FV accidents);

e) methods of training the personnel disposal actions and safety measures.

6.1.20.2 The supplier shall have an opinion of the state supervision body as to the adequacy of the measures undertaken to assure the ecological safety and prevent environment pollution during FV test and disposal.

6.1.21 Batch production test

6.1.21.1 General

During batch production LVs are subject to the acceptance test.

6.1.21.2 Acceptance test

6.1.21.2.1 Before the test

Before the stated test the supplier:

a) assigns the parameters for controlling the technological processes;

b) works out the process of tracing the items technical characteristics during acceptance, inspection and acceptance test;

c) analyses revealed failures and discrepancies in production and operation, and efficiency of corrective actions for their elimination.

6.1.21.2.2 Procedure for acceptance test

6.1.21.2.2.1 Test in factory

The acceptance test is carried out as a factory check test. At least the following tasks should be fulfilled during the factory check test:

a) PHS assembly and mounting quality control;

b) PHS units functioning control;

c) pressurization check;

d) control of the integrity of electrical circuits, quality and corrections of the OCN connections mating;

e) check of the electrical and radio equipment and LV flight control actuators.

6.1.21.2.2.2 Acceptance firing test

LPRE shall be served to firing test to confirm function and performance, including steady state performance and transient characteristics, to be complied with technological specifications.

By the end of firing test, steady state performance and alignment of thrust vector will be tuned for required range.

After the firing test, engines are checked and cleaned, and served to factory test stated in 6.1.21.2.2.1, and confirmed for its electrical and mechanical functions.

6.1.21.2.3 Re-qualification in the case for design change

The LV re-qualification test is conducted as check launches with the purpose of controlling the serviceability of the LV systems and assemblies and the LV as a whole under an extensive programme.

6.1.21.2.4 Re-qualification in other cases

The LV qualification test is conducted in the course of mastering the batch production or before its renewal of production lines after a production break lasting a year or more (unless another term has been specified in the statement of work or contract) or when the LV production is transferred from one enterprise to another.

In the batch production phase the LPRE production quality and technological process stability are controlled by conducting check, acceptance and re-qualification test.

6.1.21.3 Acceptance test in butch production phase

In the batch production the rocket units are subject to acceptance test. The following tasks are fulfilled during the acceptance test:

a) control of the PHS units functioning;

b) control of the electrical circuits integrity;

c) control of the insulation resistance;

d) control of quality and correctness of assembly and mounting of the rocket unit equipment, elements, subassemblies and systems;

e) mass control, alignment;

f) pressurization control;

g) control of absence of strange items in the inner cavities (of LPRE-equipped rocket units).

6.2 General requirements to development test programme and individual test programme

6.2.1 Contents of development test programme plan

The development test programme plan shall contain:

a) list and makeup of items subject to individual and integrated test;

b) test purposes and tasks, order and sequence of individual and integrated test;

c) order and scope of test of design and technological documentation sets applying design-technological and other mock-ups and test samples;

d) order and scope of test of new technological processes (including those based on use of new physical and chemical principles, items fabrication methods and control, as well as critical technological processes and operations);

e) order of experimental confirmation of characteristics and regimes;

f) order of assuring the precision and stability of technological processes, reliability of relevant technological systems and items;

g) types of individual and integrated test [thermal, thermal/vacuum, firing (for propulsion systems), electrical, strength, vibration/strength, acoustic, climatic test, etc.];

h) number of items distributed for test types and test phases with due regard for reliability requirements satisfaction;

i) number of item tests;

j) order and scope of test of interaction of coupled (interfacing) assemblies (devices) and systems at simultaneous simulation of various affecting factors by electrically-operated and other mock-ups defined by the contractors;

k) order of validating the reliability requirements;

l) order of test of technical means applied for assuring the ecological safety including those used for eliminating emergency situations;

m) order and scope of test and confirmation of the main operational requirements as well as test of the operation documentation with operations phasing;

n) order and scope of test of hardware and software (programme algorithms) necessary for items functioning, including on-board computers and computer-aided flight control systems, by tests and control of FV preparation at the supplier's and operator's premises;

o) order of implementing the metrological support of the item and its components including operations on specifying the composition of controlled parameters and their tolerable deviations as well as metrological attestation of measurement methods;

p) list of programmes, methods of test conduct and assessment of test data and other technical documentation for test, methodological instructions on conduct of especially important test and measurements, as well as test associated with higher risks;

q) list of test and measurement hardware (stands, equipment, measuring systems), main requirements to their precision and a list of data processing hardware as well requirements to safety assurance of the personnel engaged in test and measurements;

r) requirements to assurance of full-scale simulation of real conditions of items functioning during the ground testing and test conduct in the tolerable (extreme) functional regimes;

s) order of delivering test objects, equipment and documentation;

t) reporting on individual, integrated tests and their types;

u) list of test programmes to be agreed upon with the customer;

v) list of special test programmes;

w) order of LV components after-test disposal.

6.2.2 Test programme plans for test models

The test programme plans for test models are worked out on the basis of statements of work, engineering and programme documentation and normative documents concerning the problems of organizing and conducting test of a specific item.

6.2.3 Requirements for test methods established by test programme plans

The test programme plans should provide for the use of advanced economically substantiated methods of conducting test assuring the desired reliability, applying if necessary:

a) previously obtained results of theoretical and experimental works on building a test model;

b) results of modelling the processes of the model and its components functioning especially under conditions which cannot be completely or partially simulated in the course of tests;

c) modelling of the prototype usage conditions especially when it is impossible to carry out full-scale tests at full length;

d) software for modelling test processes and processing test data;

e) accelerated test methods if application of usual methods takes an unacceptably long-term test duration.

6.2.4 Contents of test programme plans

As a rule the test programme plans should contain the following sections:

a) test object, its composition and designation;

b) test objective and tasks;

c) general provisions;

d) test scope (number of objects subject to test);

e) test conditions, regimes, order, place, types and phases;

f) test logistic support;

g) test metrological support;

h) test product confidentiality;

i) reporting;

j) annexes (a test programme plan should enclose the following annexes: a standard test object functioning time line; list of probable emergency situations and procedure of overcoming the situations; data on the test object protection against researchers' unauthorized actions).

The test programme plans should contain provisions determining the readiness for test conduct, order of completing separate test phases and provisions for changing over to the next test phase.

The contents of a typical test programme are given in Annex D.

6.2.5 Requirements for communications systems programme plan

The communications systems programme plan (CSP) should include:

a) measurement tasks;

b) makeup of the telemetry measuring equipment mounted on LV, launch pad and along FV flight route;

c) list of measured parameters;

d) list, places and orientation of the measuring system sensors installation;

e) characteristics of sensors;

f) minimal frequency of sensor polling;

g) universal time system characteristics;

h) list of ground telemetry data reception stations;

i) telemetry equipment operation algorithm and controlled parameters distribution;

j) FV telemetry data processing algorithm;

k) sensor calibration characteristics and data necessary for recorded information processing.

The measured parameters list should enable to evaluate the FV structure and on-board systems state and the processes taking place on board space rocket.

6.3 General test object requirements

6.3.1 Test objects

The test objects should be manufactured in accordance with the engineering documentation, accepted by authorized representatives of the manufacturer and the customer.

6.3.2 Documentation for test objects

Each object delivered to be tested should be supplied with the documentation, certain test programme and valid normative documents.

7 Criteria

The following criteria should be verified when assessing the LV test completeness:

a) the LV has been built and its documentation has been approved;

b) the LV is in conformity with the technical file (production drawings);

c) the test programmes have been fulfilled;

d) the LV has proved its serviceability and reliability;

e) the parameters values are in accordance with the values specified in the customer's SOW;

f) the LV safety, its dedicated use as well as ecological safety are assured in accordance with ISO 14620-1;

g) the customer has received an LV with the required quality level;

h) the reasons for malfunctions have been detected, corrective measures for updating have been undertaken and their efficiency has been proved by positive test results and calculation-theoretical means.

8 Reporting

The development test results shall be given in reports with the review of all conducted tests of the given type and an opinion as to transfer to a subsequent test phase. Annex C contains the typical test report contents.