INTERNATIONAL STANDARD

ISO 24917

First edition
2010-10-15

Space systems — General test requirements for launch vehicles

Systèmes spatiaux — Exigences générales d'essai pour véhicules lanceurs

Reference number
ISO 24917:2010(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 24917 was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

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

This International Standard 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 International Standard 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 referenced documents are indispensable for the application 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.

3.1
space-rocket complex
set of a space vehicle or space launch vehicles with functionally interconnected means and the constructions intended for transportation, storage, maintenance service, preparation, launching and flight control of space launch vehicles on a trajectory of launching of payload

3.2
space rocket
space launch vehicle plus space nose section integration

3.3
space launch vehicle
component of the space rocket designed for payload injection in a pre-assigned trajectory or orbit

3.4
rocket unit
space launch vehicle stage including the upper stage vehicle, body, propulsion system, control systems or control system elements, rocket units separation aids and telemetry hardware

3.5
upper stage vehicle
upper stage of flight vehicle capable of injecting a space vehicle or vehicles into their orbit from the sub-orbital trajectory that resulted from operation of a launch vehicle

3.6
space nose section
set of a space vehicle with fairing and adapter and upper stage vehicle

NOTE Upper stage vehicle can be absent.

3.7
fairing
technical device intended for protection of a space vehicle or of a space nose section from external influences at transportation of the space launch vehicle on a launcher and on a start of the space launch vehicle and on a trajectory of launching into an orbit of a space vehicle

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

[ISO/TR 17400:2003, definition 3.1]

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

[ISO/TR 17400:2003, definition 3.3]

3.10
launch pad for space launch vehicle
device intended to maintain the space launch vehicle in readiness for launch, and for the launch itself

3.11
technical project on development of a product
initial document establishing a complex of technical requirements to created products, and to the contents, volume and terms of performance of design experiment works as well

3.12
technical specification
specification expressing technical requirements for designing and developing the solution to be implemented

NOTE The technical specification evolves from the functional specification and defines the technical requirements for the selected solution as part of a business agreement.

[ISO 21351:2005, definition 3.1.11]

3.13
requirement
need or expectation that is stated, generally implied or obligatory

NOTE 1 “Generally implied” means that it is custom or common practice for the organization, its customers and other interested parties that the need or expectation under consideration is implied.

NOTE 2 A qualifier can be used to denote a specific type of requirement, e.g. product requirement, quality management requirement, customer requirement.

NOTE 3 A specified requirement is one which is stated, for example, in a document.

NOTE 4 Requirements can be generated by different interested parties.

[ISO 9000:2005, definition 3.1.2]

3.14
interface control document
ICD
document of launcher and fairing/payload which defines all physical, electrical and mechanical interfaces between the payload and the launch vehicle hardware and software, and interfaces between payload and support equipment and space site facilities, systems and hardware used for spacecraft launch preparation

3.15
test
formal process of exercising or putting to trial a system or item by manual or automatic means to identify differences between specified, expected and actual results

3.16
test conditions
combination of effects of factors, or object operation conditions, or both, during the test

3.17
test metrological provision
establishment and application of scientific and organizational basis, technical means, rules and standards necessary for achieving the measurement unity demanded, precision, completeness, operativeness and the reliability of parameters control and technical characteristics of items

3.18
ground test programme
organizational-methodological document obligatory for execution, which specifies the test object and objectives, types, sequence and scope of conducted experiments, order, conditions, place, time and support of test, test reporting, as well as responsibility for test support and conduct

3.19
reliability assurance programme
programme document specifying a set of requirements and measures aimed at providing and controlling the satisfaction of requirements established for the statement of work for a space launch vehicle and its components reliability during their development

3.20
space launch vehicle (unit) experimental optimization
operations of modelling units, mock-ups, test prototypes in order to assure operation of items in accordance with statement of work, definition their efficiency margins

3.21
safety assurance programme
programme document which establishes a set of requirements and measures aimed at assuring that all safety risks associated with the space launch vehicle design, development, manufacture and use are accordingly identified, assessed, minimized, controlled and accepted

3.22
telemetry measurement programme
programme document establishing the composition of telemetry measurement hardware born set on space launch vehicle, launch pad and positioned along the flight route necessary for satisfying the measurement requirements as well as places and orientation of sensors arrangement and their characteristics, frequency bands, minimal frequency of sensor polling

3.23
flight test
tests in real conditions of functioning and performance of target tasks

3.24
test prototype of rocket and space technology item
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 to research and development and correctness of adopted technical solutions

3.25
test mock-up (model)
structurally, or physically, or structurally and physically similar item presenting a simplified reproduction of a test object or its part intended for test

3.26
structural model
model representing the structural flight characteristics

3.27
electrical model
model representing the electrical flight characteristics

3.28
test object
item under test

3.29
test type
classified test grouping identified according to a certain attribute

3.30
preliminary (development) tests
check test of test object prototypes conducted with the purpose of evaluating their conformity with the statement of work requirements and determining their readiness for flight test

NOTE Items are subjected to development tests as required, in order to minimize design risk, to demonstrate manufacturing feasibility, to establish packaging designs, to demonstrate electrical and mechanical performance and to demonstrate the capability to withstand environmental stress, including storage, transportation, extreme combined environments and launch base operations

3.31
qualification tests
required formal contractual tests used to demonstrate that the design, manufacturing, and assembly have resulted in hardware designs conforming to specification requirements

[ISO 14623:2003, definition 2.52]

3.32
acceptance tests
required formal tests conducted on flight hardware to ascertain that the materials, manufacturing processes and workmanship meet specifications and that the hardware is acceptable for intended usage

[ISO 14623:2003, definition 2.2]

3.33
operational tests
tests conducted at the launch vehicle site in an operational environment, with the equipment in its operational configuration

3.34
service (guarantee) life
period starting at the completion of fabrication and continuing through all acceptance testing, maintenance, handling, storage, transportation, pre-launch testing, all phases of launch, orbital operations, disposal, re-entry or recovery from orbit

3.35
critical unit
unit 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

3.36
explosive-ordnance device
device that contains explosives or is operated by explosives

NOTE A cartridge actuated device, one type of explosive device, is a mechanism that employs the energy produced by an explosive charge to perform or initiate a mechanical action.

4 Abbreviated terms

CTS	control-test station
EMC	electromagnetic compatibility
FTP	flight test programme
GTP	ground test programme
ICD	interface control document
IS	integration site
LPRE	liquid-propellant engine
LS	launching site
LV	launch vehicle
OCN	on-board cable network
PHS	pneumatic/hydraulic system
RAP	reliability assurance programme
SC	spacecraft
SLV	space launch vehicle
SNS	space nose section
SOW	statement of work
SGP	safety guarantee programme
SRC	space rocket complex
TMP	telemetry measurements programme
USV	upper stage vehicle

5 Testing philosophy

5.1 Objectives, tasks and principles of launch vehicle and rocket unit experimental optimization

5.1.1 Experimental optimization is one of the methods of verification which guarantees that all characteristics of the space launch vehicle (SLV) meet the requirements of the statement of work (SOW). The SLV is tested in the structure of the space rocket complex (SRC).

Experimental optimization of SLV, launch vehicle (LV) units and unit components includes ground experimental optimization phases and 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 SLV experimental optimization structure may be represented as a scheme (see Figure 1).

5.1.2 The major objective of ground experimental optimization is to optimize and verify the SLV preparation technology for launch and launch itself, preliminarily verify and evaluate implementation of the project-specified parameters and characteristics, operation and interaction patterns of all SLV components and SLV as a whole when the operation conditions are being simulated (or under effect of these conditions).

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

5.1.4 One of the major objectives of SLV [upper stage vehicle (USW)] ground experimental optimization is to achieve the SOW-assigned levels of reliability and safety indexes before flight test commencement to be confirmed during the flight test. The reliability and safety index levels are normalized in the reliability assurance programme (RAP) and the safety guarantee programme (SGP), the latter including environment safety guarantee.

5.1.5 The main objectives of experimental optimization of SLV, LV units and SLV unit components are as follows:

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

b) breadboarding;

c) optimization of technological cycle of preparing SLV for launch and launch itself;

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

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

f) optimization of SLV interfaces [LV, upper stage vehicle, spacecraft (SC)];

g) experimental confirmation of the correctness of adopted engineering solutions;

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

i) individual optimization of all SLV components;

j) verification of operation convenience;

k) personnel training.

5.1.6 The problems to be solved while testing specific LVs are identified according to the engineering make, assigned characteristics, LV optimization degree, design novelty (modification scope), dedicated operation conditions change and are presented in the test programmes.

The environmental factors specified in SOW tests are intended to be imposed sequentially, rather than in combination. Nevertheless, features of the hardware design or of the service environments may warrant the imposition of combined environments in some tests, e.g. combined shock, vibrations. In formulating the test requirements in these situations, a logical combination of environmental factors should be imposed to enhance test effectiveness.

5.1.7 Organization and order of conducting the experimental optimization are determined by the comprehensive experimental optimization programme.

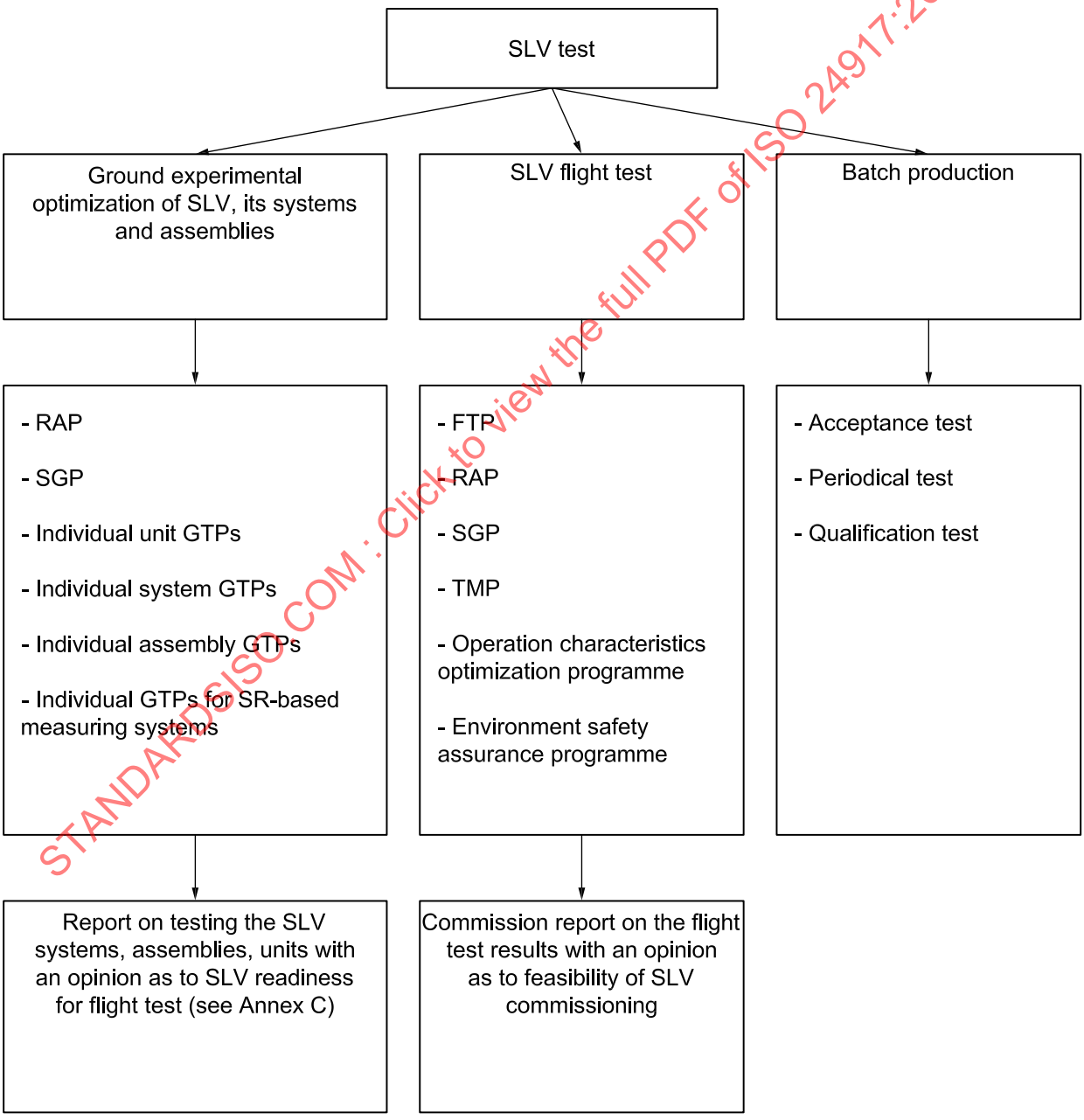

Figure 1 — Space launch vehicle experimental optimization structure

5.1.8 In order to meet the assigned LV (USV) characteristics requirements, the supplier plans experimental optimization.

5.1.9 The comprehensive experimental optimization programme is developed in accordance with the LV (USV) hierarchical structure. The main starting documents for developing the SLV ground test programme are the statement of work, the preliminary project and the reliability assurance programme.

5.1.10 The SLV comprehensive experimental optimization programme is a common system of independent, particular programme-technical documents, identifying the individual test objectives and scope, establishing the criteria of USV 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 experimental optimization programme, other test programmes.

5.1.11 The LV (USV) ground test programme (GTP) is planned and arranged on the basis of the following principles:

a) system approach to the optimization planning with a detailed coordination of all types and phases of optimization 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 major optimization work scope applying test facilities (benches, rigs, models, etc.) before starting ready-made (standard) LV (USV) test under real operation conditions (full-scale test);

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

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

   2) use (if necessary with updating) of test facilities, benches 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 multiple starting the systems and assemblies under ground conditions for conducting multiple optimization tests (including different test types) applying limited number of items;

   5) complex components control during the test;

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

   7) feasibility study of the test tasks, types and scopes stipulated in the comprehensive experimental optimization 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 optimization 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 bench 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 bench items;

14) multiple use of material (bench items) designed for optimization (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 elements;

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 SLV 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 optimization;

25) justification of all changes of test scopes and types made while realizing the comprehensive experimental optimization programme and flight test (applying the previous test results, etc.) taking into account the necessity of assuring the achievement of given optimization 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 optimization and preparation of an opinion as to LV (USV) 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 SLV readiness for flight test;

30) reduction of optimization 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.

5.1.12 Implementation during the test of the principles stated in 5.1.11 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 SLV 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 SLV systems under full-scale conditions;

4) to find defects in the systems interfaces;

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

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

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

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

9) to identify unacceptable risks during operation of SLV;

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

5.2 LV and rocket unit test types during their development

5.2.1 When developing space launch vehicles, as a rule the latter undergo the following tests:

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

b) scaled SLV model test (for identifying their aerogasdynamic characteristics);

c) integration/check-out mock-up test;

d) electrical mock-up test;

e) functional mock-up test;

f) fuelling mock-up test;

g) hydraulic test;

h) static rating test;

i) vibration test;

j) acoustic test;

k) separation test;

l) explosive-ordnance device response test;

m) cold unit test;

n) firing bench test;

o) lifetime test;

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

q) climatic test;

r) thermal vacuum test;

s) thermal cycle test;

t) antenna mock-up test;

u) SLV and ground radio-electronic aids EMC test;

v) fire and explosion safety test;

w) transportability test;

x) lightning and statics resistance test;

y) mathematical software and information support test;

z) IS and LS test;

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

bb) flight test;

cc) batch production test;

dd) operation test;

ee) LV components disposal.

5.2.2 Upon agreement with the customer (or with the customer's organization, at his 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 experimental test programme.

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

5.2.4 The requirements applicability matrix is illustrated in Annex B.

5.2.5 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 bench test as a propulsion system component, throwing test, flight test) tests;

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

c) verification (control-technological) test;

d) acceptance (control/batch-by-batch) test;

e) periodical test;

f) type test.

5.2.6 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 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 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 At least the following tasks should be fulfilled applying the engineering mock-up:

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 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 optimization;

j) breadboarding of the detachable equipment assembly and sealing;

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

l) optimization 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) optimization 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) optimization 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 SLV, 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) optimization of the operation documentation; verification of the sufficiency and employment of the (SLV, 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 agreed 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) optimization of the ways out of non-standard situations;

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

c) optimization 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) optimization 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 SLV and its systems agreed upon 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 rocket propellant components and propulsive masses.

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

a) optimization 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) optimization of the operation manuals;

c) optimization of the thermal regimes;

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

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

f) verification of the conformity with the safety precautions when filling and venting propellant components 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 agreed upon 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 optimization of the LV assembly and testing at IS and its haulage to LS;

b) optimization of the technology of SLV 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 optimization 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 rocket propellant components), “charging-discharging” cycles (for gases), time of stay of a fuelled space rocket at LS, etc.

6.1.5 Antenna mock-up test

6.1.5.1 The antenna mock-up test is aimed at complex optimization of electrical and radio-technical characteristics of antennas and feeders and optimization of SLV 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 HF 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 rating 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 SLV 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 SLV 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 SLV engines at launch as well as during SLV transonic flight with a maximum dynamic head.

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

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

b) verification of the SLV 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 SLV at the time of stages, nose fairing and SC separation, is aimed at demonstrating the ability of the SLV 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-bench 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 propellant component pair “liquid oxygen – kerosene”):

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

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

c) optimization 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 component rate of flow 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 component venting;

f) optimization 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 propellant components (tank pressure change, change of the thermal and phase state of propellant components 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 unit 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 multiple fuellings of the unit;

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

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 propellant components;

o) optimization 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 Firing bench test

6.1.11.1 The firing bench 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 firing bench test is aimed at comprehensive test bench 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 firing bench 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 parameter values 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 rocket propellant components;

h) determination of the rocket propellant components purity when draining;

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

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

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

l) determination of remaining unspent rocket propellant components amount;

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

n) specification of the functional mission profile;

o) specification of the ignition conditions and engine bench test when the rocket is in its standard position;

p) determination of the pressurization metering jet diameters;

q) verification of the functional regimes and adjustment of the engine operation (changes of thrust level, propellant component ratio, engine tilt);

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 bench.

6.1.11.4 In order to conduct the firing bench 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 agreed upon 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 optimization 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) optimization 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 functionability 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) experimental optimization 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) optimization 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) optimization of the technical means of protecting the SLV 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 SLV and its components is optimized by the manufacturer. The SLV lightning resistance is tested and confirmed when the SLV 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 rocket propellant components effect;

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 (USV).

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 SLV conformity with the technical file, SOW requirements after the SLV has been stored and transported, as well as at controlling the SLV readiness for launch.

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

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

b) optimization of the technology of preparing the LV and SLV for launch at IS;

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

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

e) optimization of the operation documentation during works on LV and SLV;

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 SLV for flight test.

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

6.1.18.4 The tasks of this phase are as follows:

a) testing of SLV erection (SLV 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 SLV in the vertical position and when lowering;

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

d) optimization of the technology of charging SLV with propellant components and compressed gases;

e) overall check of the on-board and ground safety assurance means during SLV fuelling operations;

f) verification of the assigned thermal regimes assurance of propellant components and compressed gases during SLV 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 SLV (LV, USV, 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 SLV components and SLV as a whole with electrical and radio systems of the launch area-adjacent zone;

j) verification of the technological operations for propellant components venting from the SLV tanks and pipelines;

k) optimization of the technology of neutralizing the rocket unit propellant systems after propellant components venting;

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

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

n) launch time line optimization;

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

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

s) optimization of the operation documentation during operations on SLV at LS;

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

6.1.18.5 The SLV (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 SLV 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 Batch production test

6.1.20.1 During batch production LVs are subject to acceptance, periodical and qualification test.

6.1.20.2 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.

6.1.20.2.1 The acceptance test is carried out as 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.

6.1.20.2.2 The LV periodical 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.

6.1.20.2.3 The LV qualification test is conducted in the course of mastering the batch production or before its renewal 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 periodical test.

6.1.20.3 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).

6.1.21 LV components disposal requirements

6.1.21.1 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 SLV elements disposal along the flight route;

d) order of mitigating (weakening) the SLV launch effect on the environment (acoustic effect, propellant components release, SLV accidents);

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

6.1.21.2 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 SLV test and disposal.

6.2 General requirements to ground test programme and individual test programme

6.2.1 The item ground test programme 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 optimization of design and technological documentation sets applying design-technological and other mock-ups and test samples;

d) order and scope of optimization 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 optimization 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 optimization of technical means applied for assuring the ecological safety including those used for eliminating emergency situations;

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

n) order and scope of optimization 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 SLV 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 (benches, 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 The test programmes of 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 The test programmes 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 As a rule the test programmes 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 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).

6.2.5 The test programmes 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.

6.2.6 The telemetry measurements programme (TMP) should include:

a) measurement tasks;

b) makeup of the telemetry measuring equipment mounted on LV, launch pad and along SLV 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) TM equipment operation algorithm and controlled parameters distribution;

j) SLV telemetry data processing algorithm;

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

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