
**Space systems — The measured
parameters at firing bench and flight
tests of liquid rocket engines**

*Systèmes spatiaux — Paramètres mesurés au banc d'allumage et
essais de vol des moteurs à propergol liquide*

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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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: [Foreword — Supplementary information](#).

The committee responsible for this document is ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

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Introduction

This International Standard provides customers, designers, and manufacturers of liquid rocket engines with general provisions to the parameters measured under firing stand tests, under break-in, and flight tests. Parameters subjected to be measured are determined in the design documentation and are used under the analysis of reliability and quality control of liquid rocket engines.

The determination of common requirements to the parameters of liquid rocket engines measured at firing stand and flight tests on a global scale was developed:

- to provide the required quality and reliability of rocket engines being created and used;
- to compare tests results and engines impartially;
- to provide safety of final items and environmental protection.

This International Standard will allow the development of a common criteria of evaluating and comparing of liquid rocket engines created by different countries according to the results of firing stand and flight tests.

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Space systems — The measured parameters at firing bench and flight tests of liquid rocket engines

1 Scope

This International Standard applies to all types of liquid rocket engines for expendable launch systems and satellites:

- a) Combustible fuel (including cryogenic);
- b) Large-thrust, multiple component engines, with and without afterburning;
- c) Low-thrust engines, one component (mono-propellant) and two-component (bi-propellant).

This International Standard establishes a list of parameters to be measured and registered with the firing stand and flight tests of serial LRE.

The order of preparation and carrying out of stand and flight tests, methods of processing, and analysis of tests results of liquid rocket engines, also measurement accuracy requirements are not regulated by this International Standard. Measurement accuracy requirements are established by engine designer.

Parameters listed in this International Standard characterize performance attributes of liquid rocket engines and are used for evaluating of technical state of engines (operative, inoperative), if they correspond to the requirements specified and possibilities of putting them into operation.

There are parameters specified in this International Standard, obligatory for registration and optional ones.

The manufacturer of liquid rocket engines can determine additional list of parameters for specific items taking into account their design and diagrammatical features.

The meaning “optional parameter” denotes (in cases when a proper unit or a component can be the part of an engine) that according to the manufacturer’s decision, measurements are allowed not to be made.

Measurement of parameters at firing stand and flight tests of liquid rocket engines is be made by means of the same sensors if possible.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 15864:2004, *Space systems — General test methods for space craft, subsystems and units*

ISO 15865:2005, *Space systems — Qualification assessment*

ISO 24917:2010, *Space systems — General test requirements for launch vehicles*

3 Symbols and abbreviations

AVR	apparent velocity regulator
BTPU	booster turbo pump
CFC	components-flow controller

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CST	confirmatory sampling test
DD	design documentation
EV	electric valve
FCR	regulator of fuel components ratio in combustion chamber
IDT	interdepartmental tests
LV	launch vehicle
LRE	liquid rocket engine
LTE	low thrust engine
PA	pressure alarm
PS	propulsion system
PST	pressure stabilizer
SAT	sampling acceptance test
SST	special sampling test
SV	space vehicle
TDS	tank depletion system
TPU	turbopump
TT	technological test

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4 General

4.1 Classification of measured parameters

4.1.1 The main purpose of measurement at proof tests of serial LRE (firing stand and flight tests) is to provide information for reliability analysis and quality control of engines.

4.1.2 Parameters measured at firing stand and flight tests of LRE are subdivided into the following groups:

- a) parameters characterizing test operation conditions;
- b) main parameters;
- c) parameters characterizing the engine ability to operate without any degradation.

4.1.3 Parameters that characterize the actual test operation conditions are compared to required test operation conditions. These parameters include:

- a) environmental parameters before and during the tests,
- b) fuel components state before and during the tests, and
- c) LRE characteristics (thrust and specific impulse).

4.1.4 The main parameters characterize the ability of an engine to fulfill requirements determined by the technical documentation of the manufacturer.

4.1.5 Parameters characterizing the ability of an engine to operate without any degradation are used to control the loads imposed over the engine elements.

This group consists of parameters whose values cannot be determined directly with measurements made during the assembly production process. Among these parameters are ones characterizing strength and heat-resistance of the combustion chamber and gas generator and the stability of working process in these assemblies. In case of an emergency situation these parameters (together with the main parameters and parameters characterizing the conditions of test operation) are used for the reasons of emergency process analysis.

4.2 Firing stand and flight tests operation conditions

4.2.1 Qualification tests of LRE are carried out in order to verify a safety margin beyond the expected life in accordance with the manufacturer of LV (SV) in consideration of the environmental factors and engine operation modes.

4.2.2 Technological tests are carried out under values of the environmental factors and engine operation mode with operating time necessary for measurement of parameters.

4.2.3 Sampling acceptance tests are performed for checking lifetime which is agreed upon with the manufacturer of LV (SV) under values of the environmental factors and engine operation modes.

4.2.4 Confirmatory Sampling Test (CST) is carried out within the guarantee limits of the lifelength and operation conditions of LRE. It is allowed to carry out CST above guarantee limits one at a time or under any system of operation conditions of LRE.

4.2.5 Special tests of LRE are carried out in accordance with special programs defined by a designer or a manufacturer of LRE and ratified by both enterprises.

4.2.6 Flight tests of LRE are carried out in a LV (SV) at the real conditions of operation with the purpose of verifying conformance of LRE with specifications and determination of readiness of use.

4.2.7 Purposes and objectives of flight tests are presented in details in ISO 24917.

4.2.8 General methods of tests of spacecrafts, subsystems, and units are presented in ISO 15864.

4.2.9 Flight test analysis is performed according to the requirements of ISO 15865.

5 The measured parameters at tests of LRE

The measured parameters at firing stand and flight tests of LRE are presented in the respective tables.

LRE with afterburning (staged combustion cycle) and without afterburning (gas generator cycle/expander cycle/pressure fed cycle) used in launch vehicles and space vehicles are represented.

Parameters measured under tests of LRE are subdivided into the following groups:

- a) obligatory;
- b) supplemental, depending on situation;
- c) interchangeable, obligatory to be measured.

In the “Note” column in [Tables 1](#) to [3](#), some necessary clarifications and additions to the specific parameters are given.

5.1 The measured parameters at firing stand test of LRE

5.1.1 The measured parameters at commissioning and sampling tests (CTT, CST, and SST) of LRE are presented in [Table 1](#).

5.1.2 [Table 2](#) is additional to [Table 1](#) and contains parameters measured at qualification tests of LRE.

5.2 The measured parameters at flight tests of LRE

5.2.1 The measured parameters at flight tests of LRE are presented in [Table 3](#).

The following symbols are used in the tables:

- required parameter subjected to be obligatory measured;
- measuring of a parameter does not regulated by this International Standard;
- Δ supplemental, depending on situation;
- X_m interchangeable parameter to be measured where *m* is a serial number of a parameter in the respective table which can be used instead of the specified one in the clause.

Table 1 — The measured parameters at TT, SAT, CST, and SST

Description of a parameter	LRE type				Note
	without afterburning		with afterburning		
	for LV	for SV	for LV	for SV	
1. Parameters characterizing test operation conditions					
1.1 Ambient pressure	○	○	○	○	
1.2 Ambient temperature	○	○	○	○	
1.3 Ambient humidity	Δ	Δ	Δ	Δ	
1.4 Direction and speed of air	Δ	Δ	Δ	Δ	
1.5 Fuel components temperature in the place of flow rate meters installation and at the engine inlet	○	○	○	○	
1.6 Chemical composition of the fuel components	○	○	○	○	
1.7 Specific weight of the fuel components (except cryogenic)	○	○	○	○	
1.8 Content of solute gases in fuel components with a process of forced gassing	Δ	Δ	Δ	Δ	
2. Main parameters					
2.1 LRE thrust	○	○	○	○	
2.2 Mass outflow of fuel components through the engine (engine nozzle) per second	○	○	○	○	
2.3 Combustion chamber pressure	X _{3.8}	X _{3.8}	X _{3.8}	X _{3.8}	

Table 1 (continued)

Description of a parameter	LRE type				Note
	without afterburning		with afterburning		
	for LV	for SV	for LV	for SV	
1. Parameters characterizing test operation conditions					
2.4 Fuel components pressure at the engine inlet	○	○	○	○	
3. Parameters characterizing the ability of an engine to operate without any degradation					
3.1 Oxidizer pressure after the pump	○	○	○	○	Parameters 3.1 and 3.2 are subjected to be measured after final stage (for multi-stage pumps and after booster stage).
3.2 Fuel pressure after the pump	○	○	○	○	
3.3 Oxidizer pressure after the booster pump of oxidizer	Δ	Δ	Δ	Δ	Parameter 3.5 is measured by means of sensors allowing to measure pressure change under the transient process. Under sampling acceptance tests of engines without afterburning, parameter 3.5 is subjected to be measured if the engine construction provides the ability of the respective sensors installation.
3.4 Fuel pressure after the booster pump of fuel	Δ	Δ	Δ	Δ	
3.5 Gas pressure in the gas generator (at the turbine inlet)	Δ	Δ	Δ	Δ	
3.6 Igniter chamber pressure	Δ	Δ	Δ	Δ	
3.7 Propellant pressure at the input to steering actuators	Δ	Δ	Δ	Δ	
3.8 Propellant components pressure before the combustion chamber injectors	X _{2.3}	X _{2.3}	X _{2.3}	X _{2.3}	
3.9 Gas pressure after the turbine	Δ	Δ	Δ	Δ	
3.10 Gas pressure in gas generators of the pressurization system of tanks	Δ	Δ	Δ	Δ	Parameter 3.10 belongs to gas generator pressurization system of tanks.
3.11 Pressure drop on the flow regulator of a propellant	Δ	Δ	Δ	Δ	
3.12 Driving pressure in the regulator assembly	Δ	Δ	Δ	Δ	

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