



**International  
Standard**

**ISO 16694**

**Space systems — 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*

**Second edition  
2024-09**

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Published in Switzerland

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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 document 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](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

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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](http://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 16694:2015), which has been technically revised.

The main changes are as follows:

- [ISO 16694:2024](https://standards.iteh.ai/catalog/standards/iso/b31f9edce-4de2-4351-8ec2-eb90bdfc277/iso-16694-2024)  
<https://standards.iteh.ai/catalog/standards/iso/b31f9edce-4de2-4351-8ec2-eb90bdfc277/iso-16694-2024>  
— [Clauses 4](#) and [5](#) are amended;
- the list of measured parameters is expanded;
- in [Tables 1](#) and [3](#), the parameter “...pressure pulsation...” is split into two parameters: “...vibration amplitude...” and “...vibration frequency...”; the parameter “vibro-overloads...” is split into “vibration acceleration amplitude...” and “vibration acceleration frequency...”;
- certain parameters are moved from the category “mandatory parameters” to the category “optional”;
- superscripts and subscripts of parameter “Letter symbols” are corrected.

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](http://www.iso.org/members.html).

## Introduction

The document provides users, designers, and manufacturers of liquid rocket engines with requirements and guidance for parameters, measured during firing bench and flight tests. Parameters to be measured are used for reliability analysis and quality control of liquid rocket engines.

The parameters listed in the document characterize performance of liquid rocket engines and they are used to evaluate the technical condition of engines (operable, inoperable), their conformity with the specified requirements and whether engines are available to be delivered to a user and put into operation. ISO 15865 is used to assess conformity of liquid rocket engines to the specified requirements.

Uniform requirements for the parameters, measured during firing bench and flight tests of liquid rocket engines, ensure the following:

- quality and reliability of developed and operated liquid rocket engines;
- comparison of liquid rocket engine test results;
- end product safety and environmental protection.

The engine developer may identify an additional list of measured parameters for specific items, taking into account their design features.

This document makes it possible to develop uniform criteria for performance evaluation and comparison of liquid rocket engines, created by different countries, based on firing bench and flight tests results.

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# Space systems — Measured parameters at firing bench and flight tests of liquid rocket engines

## 1 Scope

This document specifies requirements for the list of parameters, measured during firing bench and flight tests. The requirements of the document apply to all the types of expendable liquid rocket engines supplied to the user:

- a) operating on all types of propellant (including cryogenic);
- b) with afterburning (with gradual burning) and without afterburning (without gradual burning);
- c) low-thrust engines: one component (monopropellant) and two-component (bipropellant);
- d) with a single firing or multiple firings.

The document doesn't specify firing bench test preparation and testing procedure, methods of test results processing and analysis, or requirements to measurement accuracy.

The document specifies mandatory and optional parameters.

## 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 15864, *Space systems — General test methods for spacecraft, subsystems and units*

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

## 3 Terms and definitions

No terms and definitions are listed in this document.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

## 4 Abbreviated terms

AVR	apparent velocity regulator
BTP	booster turbo pump
CFC	component-flow controller
CPT	certification periodic test
DD	design documentation

EV	electric valve
FCR	controller of the propellants ratio in a combustion chamber
IpCT	in-process control test
LV	launch vehicle
LRE	liquid rocket engine
LTE	low thrust engine
PA	pressure alarm
QT	qualification test
R&D	research and development
SC	spacecraft
SPT	special periodic test
TDS	tank depletion system
TP	turbopump

## 5 General

**5.1** The main purpose of LRE and LTLRE parameters measurement while performing ground and flight tests is to obtain information for assessment of parameter conformity to DD requirements, reliability and quality analysis of supplied engines.

**5.2** Parameters, which should be measured during fire bench and flight tests of LRE, and to which requirements of this document are applied, fall into the following groups:

- a) parameters, characterizing test environment ([5.3](#), [5.4](#));
- b) main parameters ([5.5](#));
- c) key performance parameters ([5.6](#));
- d) parameters, characterizing the engine ability to operate without any degradation ([5.7](#)).

**5.3** Parameters, characterizing test environment, include:

- a) parameters of natural and artificial environmental impacts;
- b) propellants status before and during tests.

**5.4** Parameters, characterizing test environment, are used to evaluate conformity of physical environment and propellants status before and during tests to the requirements of the test specification, and ensure that the corrected characteristics of an engine (thrust, specific impulse) are identified.

**5.5** Main parameters define how the engine performs the specified functions; and they are set by technical documentation requirements of the engine developer.

**5.6** Key performance parameters characterize the engine performance and define whether a test is passed or not. Key performance parameters may be obtained either directly from measurements or from calculations. The parameters shall comply with DD requirements of the engine developer.



**5.7** Parameters, characterizing the engine ability to operate without any degradation, are used to control the engine health by estimating values of loads, which act on the engine's assemblies.

This group comprises parameters, whose values cannot be determined directly by measurements, taken during assembly manufacturing process. Among these parameters are particularly ones, characterizing vibration strength and heat-resistance of the combustion chamber and the gas generator and stability of the assemblies operating process. In case of emergency, these parameters (together with the main parameters and parameters, characterizing test conditions) are used to analyse causes of emergency.

**5.8** It is recommended to use sensors of the same type to measure similar parameters during static fire and flight tests.

## **6 List of parameters, measured during LRE tests**

### **6.1 General**

Parameters, measured during firing bench and flight tests of the engine, are summarized in the corresponding tables.

Static fire tests of launch vehicles shall be conducted in accordance with the general requirements in ISO 24917.

Goals and objectives of flight tests shall be as specified in ISO 15864.

Depending on their importance, parameters, measured during an engine test, fall into the following groups:

- a) mandatory;
- b) optional;
- c) interchangeable.

The term "optional parameter" means (in cases, when a corresponding assembly or a unit is a part of the engine) that, according to the approved decision of a liquid engine developer, its measurement is not mandatory, as opposed to a mandatory parameter, which shall be measured and recorded.

Additions may be made to the set of parameters, which are measured during LRE QT, in accordance to the QT program, agreed upon with the engine developer.

The "Comment" column provides required clarifications and additions to certain parameters.

### **6.2 List of parameters, measured during LRE firing bench test**

The list of optional and mandatory parameters to be measured during in-process control test, certification periodic test and special periodic test (IpCT, CPT and SPT) of LRE is provided in [Table 1](#).

Table 1 — Parameters, measured during IpCT, CPT, SPT

	LRE type						Comment
	Letter symbol	Measurement unit	Without afterburning		With afterburning		
			For LV	For SC	For LV	For SC	
<b>1 Parameters, characterizing test environment</b>							
1.1 Ambient pressure	$P_{amb}$	kPa	0	0	0	0	
1.2 Ambient temperature	$T_{amb}$	K (°C)	0	0	0	0	
1.3 Ambient humidity	$H_{amb}$	%	Δ	Δ	Δ	Δ	
1.4 Air flows direction and speed	$W$	m/s	Δ	Δ	Δ	Δ	
1.5 Propellants temperature at flow sensor locations and at the engine inlet	$t_{inlet}^p$	K (°C)	0	0	0	0	
1.6 Propellants density (except cryogenic)	$\rho$	kg/m <sup>3</sup>	0	0	0	0	
1.7 Dissolved gases content in propellants when performing tests with forced gas saturation	$v_p^{gas}$	%	0	0	0	0	
1.8 Propellants pressure at the engine inlet	$p_{inlet}^{ox}$ $p_{inlet}^{fuel}$	mPa (kgf/cm <sup>2</sup> )	X <sub>4.10</sub>	X <sub>4.10</sub>	X <sub>4.10</sub>	X <sub>4.10</sub>	Sensors are used, which make it possible to measure pressure during transient processes: at start and during the change of the engine operating mode
<b>2 Main parameters</b>							
2.1 LRE thrust	$R$	N (kgf)	0	0	0	0	
2.2 Mass outflow of oxidizer and fuel through the engine per second	$\dot{m}_{ox}$ $\dot{m}_f$	kg/s	0	0	0	0	
2.3 Mass outflow of oxidizer and fuel through the engine chamber nozzle per second	$\dot{m}_{ox,n}$ $\dot{m}_{f,n}$	kg/s	0	0	0	0	
2.4 Fuel pressure upstream of the chamber injectors	$P_{f,A}$	mPa (kgf/cm <sup>2</sup> )	0	0	0	0	Sensors are used, which make it possible to measure pressure for parameters 2.4 to 2.7 during transient processes: at start and during the change of the engine operating mode
2.5 Oxidizer pressure upstream of the chamber injectors	$P_{ox,A}$	mPa (kgf/cm <sup>2</sup> )	0	0	0	0	For LRE without afterburning
<p><b>Key</b></p> <p>0 — mandatory parameter</p> <p>• — parameter measurement is not regulated by the document</p> <p>Δ — optional parameter</p> <p><math>X_m</math> — interchangeable parameter subject to mandatory measurement, where <math>m</math> is the numerical order of a parameter in the corresponding table, which can be used instead of the parameter, specified in parameter <math>m</math> in this table</p> <p>Parameters, which characterize test environment, shall be measured before the engine is fired.</p> <p>NOTE 1 Certain parameters, specified in the parameter table, can be controlled by measuring other parameters, specified in DD, if the customer is satisfied with control accuracy.</p> <p>NOTE 2 Such parameters as pressure upstream(downstream) of PA, FCR, CFC, TDS are to be measured if the specified parameters are necessary to determine the estimated values of the main (specified) LRE characteristics.</p> <p>NOTE 3 When performing test of cryogenic engines, in addition parameters are measured, which characterize the aggregate state of propellants (temperature, pressure).</p>							