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Space systems — Liquid rocket engines and test stands — Terms and definitions

Systèmes spatiaux — Moteurs de fusée liquides et stands d'essai — Termes et définitions

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Foreword

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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 is intended to be applied for all types of rocket engines which use a liquid propellant.

The terms in this International Standard are specified in scope of design, testing, reliability analysis and quality control of liquid rocket engines.

The terms are intended to be required for use in all types of documentation and literature including in scope of standardization or using results of this activity.

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Space systems — Liquid rocket engines and test stands — Terms and definitions

1 Scope

The International Standard provides terms and definitions in scope of design, testing, reliability analysis and quality control of liquid rocket engines. The terms are required for use in all types of documentation and literature including in the scope of standardization or using the results of this activity.

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2 Terms and definitions

2.1 General

2.1.1
rocket engine
RE
reaction engine producing thrust for vehicle movement with the help of substances and energy sources contained within the vehicle being moved

2.1.2
liquid rocket engine
LRE
rocket engine (2.1.1) using propellants in liquid form

2.1.3
low-thrust engine
LTE
rocket engine (2.1.1) of a thrust not more than 5 000 N

2.1.4
liquid rocket propulsion system
propulsion system including engine, propellant tanks, avionics for control sub-systems, pressure vessels and control devices for pneumatic and hydraulic control sub-systems, propellant feed system, actuators for steering sub-systems, and auxiliary equipment

2.1.5
clustered engine
liquid rocket propulsion system (2.1.4) consisting of multiple *rocket engines* (2.1.1), common propellant tanks, and autonomous (independent) propellant feed systems

2.2 Engine units

2.2.1
chamber
engine assembly where propellant and/or gas generation products, as a result of chemical reactions, are converted into products of combustion, created at the expiration of the reactive force

2.2.2
turbo-pump
TP
engine component designed to pump propellant into the *chamber* (2.2.1), gas generator sets and automatic engine

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2.2.3
booster turbo-pump
BTP
turbo-pump (2.2.2) engine support designed to increase propellant pressure in the pipelines to *pump* (2.20.1)

2.2.4
gas generator
unit of engine wherein propellant, as a result of chemical reaction, is converted in gaseous products of reaction at relatively low temperature

2.2.5
automatic engine controller
engine assembly designed for automatic control, regulation or maintenance of engine

2.3 Engine types by way of work process

2.3.1
engine with afterburning
engine where gas generation products after their use are used to drive the *turbo-pump* (2.2.2) assembly

2.3.2
engine without afterburning
engine where gas generation products after their use to drive the *turbo-pump* (2.2.2) assembly are released into the environment

Note 1 to entry: Engine without afterburning have a *pump* (2.20.1) or a pressurized fuel supply.

2.3.3
single-mode engine
engine with one major mode

2.3.4
multimode engine
engine with several basic modes

2.4 Engine types by multiplicity of use and integration

2.4.1
expendable engine
engine intended for a specific purpose and used only one time

2.4.2
nonexpendable engine
engine intended for a specific purpose and used multiple times

2.4.3
single-start engine
engine started only once for a specific purpose

2.4.4
multi-start engine
restartable engine
engine started multiple times for one specific purpose

2.5 Engine types by purpose

2.5.1
main engine
engine intended to accelerate the space vehicle

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2.5.2
correction engine
engine intended to correct the speed during the correction of trajectory of the space vehicle

2.5.3
control engine
engine intended to control the correction of the vector of the space vehicle in the active phase of the trajectory of motion

2.5.4
retrorocket engine
engine intended to reduce the speed of the space vehicle

2.6 Low-thrust engine types by way of work process

2.6.1
catalytic engine
LTE (2.1.3) where the transformation of propellant into gaseous chemical reaction products is performed with the help of a catalyst

2.6.2
thermo-catalytic engine
catalytic LTE where the catalyst is heated by the external heat source

2.6.3
electro-thermo-catalytic engine
thermo-catalytic LTE using an electrical source of energy

2.6.4
radio-thermo-catalytic engine
thermo-catalytic LTE using a radioactive source of energy

2.6.5
thermal engine
LTE (2.1.3) where the conversion of propellant in the gaseous products of chemical reactions is affected by heating the fuel from an external source of energy which increases their rate of expiration

Note 1 to entry: Energy is fed to the propellant or products of chemical reactions.

2.6.6
electro-thermal engine
thermal LTE using an electrical energy source

2.6.7
radio-thermal engine
thermal LTE using a radioactive energy source

2.6.8
electrolytic engine
one-component of the *LTE* (2.1.3) where the electrolysis of the propellant is part of operating process

2.6.9
adjustable engine
low-thrust engine (2.1.3) that has a device to change the thrust

2.7 General parameters and performance of engine

2.7.1
rated performance
set of nominal values of the engine designated in the specifications

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2.7.2
mass flow rate
mass of fluid passing a specified line or gate in unit time

2.7.3
volume flow rate
volume of fluid passing a specified line or gate in unit time

2.7.4
pre-start consumption
propellant mass consumption during the time interval from the first start command until the thrust build-up to a specified value equal to 5 % of the nominal

2.7.5
mixture ratio
ratio of oxidizer *mass flow rate* (2.7.2) to the fuel mass flow rate

2.7.6
volume ratio
ratio of oxidizer *volume flow rate* (2.7.3) to the fuel volume rate

2.7.7
pressure
<in chamber> average static pressure of combustion products at the beginning of the *combustion chamber* (2.12.1) at the mixing system chamber

2.7.8
pressure
<in gas generator> average static pressure of gas generation at the beginning of the *combustion chamber* (2.12.2) at the mixing system gas generator

2.7.9
combustion temperature
<in chamber> stagnation temperature of combustion products at the exit from the *combustion chamber* (2.12.1)

2.7.10
combustion temperature
<in gas generator> stagnation temperature of gas generation at the exit from the *gas generator* (2.2.4)

2.7.11
exhaust velocity
velocity of exhaust stream through the *nozzle* (2.12.16) or a reaction engine, relative to the nozzle

2.7.12
engine reactive force
gas and fluid flow resultant force acting on the thrust chamber internal surfaces resulting from the combustion gases

2.7.13
engine thrust
resultant of the *engine reactive force* (2.7.12) and the environment pressure forces acting on the engine external surfaces (excluding external aerodynamic drag forces)

2.7.14
engine impulse
time integral of engine thrust

2.7.15
cut-off impulse
impulse (2.9.5) of engine thrust for the time interval defining the engine tail-off

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2.7.16
specific impulse

ratio of engine thrust to the mass flow of propellant $\left(I_s = \frac{R}{\dot{m}}\right)$

Note 1 to entry: Thrust engine (chamber) specific impulse is converted in a vacuum and at sea level.

Note 2 to entry: Thrust engine (chamber) specific impulse is also an equalled derivative from the thrust engine (chamber) impulse by weight or volume of propellant consumed.

Note 3 to entry: For *LTE* (2.1.3), the term "specific impulse" is used for steady-state continuous mode, single inclusions mode and the steady-state impulse mode.

2.7.17
volume specific impulse

ratio of engine thrust to the propellant volume flow rate $\left(I_{s,v} = \frac{R}{\dot{v}}\right)$

2.7.18
thrust coefficient
ratio of chamber thrust to the product of the nozzle stagnation pressure (or chamber total pressure at nozzle inlet) and the area of nozzle throat

2.7.19
coefficient of specific impulse
ratio of actual specific impulse to the theoretical value that is defined by the same values of *mixture ratio* (2.7.5), the nozzle stagnation pressure or chamber total pressure at nozzle inlet

2.7.20
total coefficient of specific impulse
coefficient of *specific impulse* (2.7.16) defined at the *mixture ratio* (2.7.5) to be the maximum ideal value

2.7.21
consumable complex of chamber
consumable complex
product of the combustion pressure in a given section of the *chamber* (2.2.1) to a nozzle throat area, referred to the mass flow of the propellant in chamber

Note 1 to entry: Given section of the *chamber* (2.2.1) is in analysis of camera characteristics stability during serial production [initial section of *combustion chamber* (2.12.1) at (near) *mixing system* (2.12.3)] and in analysis of multiphase flows (2.19.4) [initial section of *nozzle* (2.12.16)].

2.7.22
thrust complex
ratio of engine thrust chamber pressure and the product of combustion products in a given section of the *chamber* (2.2.1) for an area of minimum section of the *nozzle* (2.12.16)

Note 1 to entry: Thrust complex is also equal to the ratio of camera-specific impulse to *consumable complex* (2.7.19).

2.7.23
coefficient of consumable complex
ratio of the actual spending of the complex chamber rocket engine to the ideal that defined the same values of the ratio components fuel pressure in the *chamber* (2.2.1)

2.7.24
coefficient of nozzle flow
coefficient of flow
ratio of the actual flow of gas through the rocket engine nozzle to the theoretical value, as defined under the same temperature and total pressure in the nozzle throat, under the conditions for the gas constant and the local adiabatic exponent

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2.7.25
nozzle coefficient
ratio of the actual thrust coefficient in a vacuum to the ideal that defined the same values of the *mixture ratio* (2.7.5) and combustion pressure in the *chamber* (2.2.1) and the geometric expansion ratio nozzle

2.7.26
chamber coefficient
ratio of the real characteristic velocity in the *chamber* (2.2.1) to the ideal defined by the same values of the *mixture ratio* (2.7.5) and the combustion chamber pressure

2.7.27
characteristic velocity
product of the nozzle stagnation pressure and nozzle throat area, referred to the mass consumption of propellant in chamber

2.7.28
ideal parameter value
<of chamber> parameter value of *chamber* (2.2.1), corresponding to the equilibrium flow of combustion products in the absence outlet heat and friction

2.7.29
ideal parameter value
<of gas generator> parameter value of *gas generator* (2.2.4), corresponding to the equilibrium flow of products gas generation in the absence outlet heat and friction

2.7.30
wet mass
mass of engine designed with propellants and other consumption articles filling its pipelines and aggregates

2.7.31
relative mass
ratio of the *wet mass* (2.7.30) to the maximum thrust on the main steady-state operation

2.7.32
engine altitude characteristic
dependence of the thrust rocket engine on the environment pressure at constant values of the ratio of the propellant components and the pressure in the *chamber* (2.2.1)

2.7.33
engine throttle characteristic
dependence of the engine thrust from the chamber pressure at constant values of the *mixture ratio* (2.7.5) of propellants and the ambient pressure

2.8 Engine time characteristics, types of operating and resources

2.8.1
period of propellant flow
time interval from the moment of complete opening of the solenoid valve until it is completely closed

2.8.2
designed operating life
period of time during which the engine is expected to operate within its specified design parameters

2.8.3
engine operating time
operation duration and/or operation cycle number of the engine

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2.8.4
engine verification time
mean time engine specified in the request for the proposal

2.8.5
engine specified resource
engine operating time (2.8.3) specified in the request for the proposal

2.8.6
engine working resource
total running time of engine during a specified period of service, used as directed

2.8.7
engine single working resource
work resource of engines, or part thereof, during one cycle operation

2.8.8
engine designated resource
total operating time after the expiry of which the use of the engine should be stopped

2.8.9
LTE total designated resource
operation duration assigned for continuous and pulse modes

Note 1 to entry: In addition to total designated resourse, for *LTE* (2.1.3), it is also determined designated resource according to the following:

— number of *inclusions* (2.9.8);

— duration at impulse mode;

— duration at continuous mode;

— total propellant consumption for catalytic LTE.

2.9 Low-thrust engine performance

2.9.1
full thruster impulse
thruster impulse of *LTE* (2.1.3) at which the mean integrated value of thrust, or chamber pressure, is more or equal to 0,9 of the steady-state value of the thrust, or chamber pressure, for the firing

2.9.2
part-thrust impulse
thruster impulse of *LTE* (2.1.3) at which the average integral value of thrust, or *pressure* (2.7.7) in the *chamber* (2.2.1), is less than 0,9 the steady-thrust, or pressure in the chamber, at a switch

2.9.3
unit impulse
thruster impulse of *LTE* (2.1.3) or one firing (*on-time* (2.9.10)) in the pulse or single firing operation mode

2.9.4
total impulse
thruster impulse of *LTE* (2.1.3) over the operating duration

2.9.5
impulse
forceful impact of *LTE* (2.1.3) characterized by changes in traction or *pressure* (2.7.7) in the *chamber* (2.2.1) at the time of a switch

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2.9.6
rated thrust
designed thrust level in a steady-state condition mode under nominal working conditions

2.9.7
conditional rated thrust
rated thrust of *LTE* (2.1.3) in a vacuum at an initial temperature of 288 K where structures and the geometric expansion ratio of the nozzle is equal to 50

2.9.8
inclusion
on-time
time interval from the moment of voltage being applied to the thruster electric valve up to the moment of reenergizing the *LTE* (2.1.3)

2.9.9
aftereffect
thruster electric valve reenergizing up to the moment when the thrust of the chamber pressure fall to a value equal to 0,1 of the thrust of the chamber pressure in the steady-state continuous operation mode

2.9.10
off-time
pause between inclusions
time interval from the moment of the thruster electric valve reenergizing up to the moment of the next voltage being applied

2.9.11
cycle period
on-time (2.9.8) and *off-time* (2.9.10) sum

2.9.12
inclusion frequency
reciprocal of *cycle period* (2.9.11)

2.9.13
cycle period to on-time ratio
duty cycle
reciprocal of duty cycle

2.9.14
coefficient of fill cycle operation
inclusion relation of *LTE* (2.1.3) to switching cycles

2.9.15
thrust build-up time
time interval from the ignition signal to the moment when the thrust or chamber pressure reaches a value of 90 % of the steady-state thrust or the chamber pressure

2.9.16
thrust delay
time interval from the cut-off signal until the thrust or chamber pressure decreases to 10 % of steady-state thrust or chamber pressure

2.9.17
propellant expansion delay
interval time from the start entry of the second component of propellant cell *LTE* (2.1.3) until the *pressure* (2.7.7) in the *chamber* (2.2.1) reaches a value equal to the pressure in the absence of fuel decomposition

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2.9.18
propellant ignition delay
time interval from the moment the second propellant enters the *chamber* (2.2.1) up to ignition

2.9.19
average mass flow of propellant
ratio of the mass flow of propellant (fuel, oxidizer) *LTE* (2.1.3) for one *inclusion* (2.9.8) to the next

2.10 Engine operation modes

2.10.1
engine operation
engine operating for thrust creating or changing its value and/or for providing the operation conditions of the vehicle components in accordance with the engine requirements

2.10.2
engine operation mode
set of the engine parameter values defined by the processes occurring in the engine

2.10.3
engine main mode
mode engine is in when a major problem is carried

2.10.4
engine firing
engine operation (2.10.1) from the firing command up to when the specified mode is reached

2.10.5
engine steady-state mode
engine operation mode (2.10.2) where the mean thrust and mixture ratio values remain constant

2.10.6
engine unsteady mode
engine operating mode where the average thrust or the ratio of propellant components varies in time

2.10.7
engine preview mode
setting of the engine thrust with less traction on the main mode

Note 1 to entry: Advance regime is part of the launching engine.

2.10.8
engine cut-off
engine operation (2.10.1) from the cut-off command up to when the thrust disappears

2.10.9
engine final mode
setting of the engine before stopping with a thrust with less traction on the main mode

2.10.10
break between engine inclusions
time interval from the engine stop multiple power-up to the first team for the subsequent *inclusion* (2.9.8)

2.10.11
engine emergency cut-off
engine cut-off caused by a failure of the engine, the propulsion system, the test stand systems or the vehicle systems

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2.11 Low-thrust engine operation modes

2.11.1
continuous operation mode
LTE operation mode of one firing with the specific impulse value constant in time

2.11.2
pulse mode
LTE operation mode of many firing (*on-times* (2.9.8)) where the *specific impulse* (2.7.16) depends on each firing (*on-time*)

Note 1 to entry: Minimum duration of the pulses is limited by the time taken for the thruster valves to open and close, since this limits the repeatability of the process.

2.11.3
steady-state pulse mode
LTE pulse mode where the pulse shape is stabilized with a constant value of the on-time frequency

2.11.4
operation mode with connected pulses
LTE pulse mode where, during the *off-time* (2.9.10), the thrust or the chamber pressure falls to a value higher than 0,1 of the thrust or the chamber pressure of the steady-state continuous mode

2.11.5
cyclic mode
LTE mode consisting of repeating combinations of continuous and *pulsed modes* (2.11.2) or combinations of *inclusion* (2.9.8) and repetitive pauses of varying lengths

2.11.6
separate firing mode
isolated firing mode
LTE operation mode where the engine returns to the initial state during the *off-time* (2.9.10)

2.12 Chamber (gas generator) components

2.12.1
combustion chamber
<for chamber> part of the *chamber* (2.2.1) between the internal bottom of the *mixing system* (2.12.3) and the initial section of the *nozzle* (2.12.16), which is intended for *mixture generation* (2.14.3) and propellant combustion

2.12.2
combustion chamber
<for gas generator> part of the *gas generator* (2.2.4) intended for *mixture generation* (2.14.4) and propellant components transformation into gas generation products

2.12.3
mixing system
<for chamber> part of the *chamber* (2.2.1) representing the device for propellant components and/or gas generation products input into the *combustion chamber* (2.12.1) and their initial mixing

2.12.4
mixing system
<for gas generator> part of the *gas generator* (2.2.4) representing the device for propellant components input into the *combustion chamber* (2.12.2) and their initial mixing

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2.12.5
mixing system bottom
<for chamber> item of the engine chamber mixing system, dividing cavities of propellant components or gas generation products among themselves, or separating them from fire space and the external environment

2.12.6
mixing system bottom
<for gas generator> item of the gas generator mixing system, dividing cavities of propellant components among themselves, or separating them from fire space and external environment

Note 1 to entry: Distinguish the external, average and internal bottoms.

Note 2 to entry: External bottom function in the engine chamber, with reburning, can perform gas passage.

2.12.7
injector
device for propellant components or gas generation products that input into the *combustion chamber* (2.12.1) of *chamber* (2.2.1) and/or *gas generator* (2.2.4)

2.12.8
jet injector
engine injector whereby liquid or gas escapes in the form of one or several streams

2.12.9
centrifugal injector
engine injector whereby liquid or gas escape in the form of a veil generated as result of liquid or gas rotating in a vortex chamber

2.12.10
gas-distributing grid
item of the *chamber* (2.2.1) or gas generator mixing system that provides gas distribution in areas of the *mixing system* (2.12.3) and increases the operating process stability in the chamber or *gas generator* (2.2.4)

2.12.11
anti-pulsating partition
partition established in the *combustion chamber* (2.12.1) of the engine chamber or *gas generator* (2.2.4) for cross-section fluctuations suppression

2.12.12
chamber gas generator case
wall of engine chamber (gas generator) without *mixing system* (2.12.4)

2.12.13
gas generator chamber cooling tract
set of channels in the case and chamber (gas generator) mixing system with *one-through* (2.25.2) (direct-flow) or *transpiration cooling* (2.25.7)

2.12.14
veil belt zone
<for chamber> item of engine chamber intended for one of the propellant components or gas generation products to input into the wall area of the fire space for the creation of a liquid or gas protective layer

2.12.15
veil belt zone
<for gas generator> item of the engine *gas generator* (2.2.4) intended for one of the propellant components to input into the wall area of fire space for the creation of a liquid or gas protective layer

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2.12.16
nozzle
part of the engine that converts the thermal energy of the combustion gases into the kinetic energy of the exhaust plume

Note 1 to entry: The engine nozzle may be stationary and rotational, relative to the stationary parts of the *chamber* (2.2.1), and also have a rotational section for performance control.

2.13 Gas generator types

2.13.1
one-zone gas generator
gas generator (2.2.4) where all phases of the operating process are provided with items of the mixture generation constructional units placed on the internal bottom of the *mixing system* (2.12.4)

2.13.2
multizone gas generator
gas generator (2.2.4) where some phases of the operating process are provided with items of the mixture generation constructional units placed on the internal bottom of *mixing system* (2.12.4)

2.14 Operating process in chamber (gas generator)

2.14.1
operating process
<in chamber> set of processes in the *combustion chamber* (2.12.1) of an engine chamber for the transformation of propellant components and/or gas generation products to combustion products

2.14.2
operating process
<in gas generator> set of processes in the *combustion chamber* (2.12.2) of an engine gas generator for the transformation of propellant components to gas generation products

2.14.3
mixture generation
<in chamber> dispersion and mixing of propellant components or gas generation products

2.14.4
mixture generation
<in gas generator> dispersion and mixing of propellant components

2.14.5
wall layer in chamber
<gas generator> part of the propellant flow in a *chamber* (2.2.1) (gas generator) that adjoins to the combustion chamber walls but different in terms of the chemical composition, thermophysical characteristics and speed

2.14.6
propellant flow core
central part of propellant flow and/or gas generation products in the *chamber* (2.2.1) or *gas generator* (2.2.4) where combustion chamber walls and wall layer do not influence the operating process

2.14.7
flow rate tension
<in chamber> ratio of combustion products mass flow to the area of the chamber cross-section at the *mixing system* (2.12.3)

2.14.8
flow rate tension
<in gas generator> ratio of gas generation products mass flow to the area of the gas generator cross-section at the *mixing system* (2.12.4)

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2.14.9
relative flow rate tension of chamber
<gas generator> ratio of *flow rate tension* (2.14.7) to the *pressure* (2.7.8) in the *chamber* (2.2.1) (gas generator)

2.14.10
average time of propellant being
time interval defined by ratio of product weight in the *combustion chamber* (2.12.1) to the propellant mass flow by the *chamber* (2.2.1)

2.14.11
high-frequency oscillation
pressure oscillation in the *combustion chamber* (2.12.1) with frequencies that are equal to or exceeding the minimum natural acoustic frequency

2.14.12
high-frequency self-oscillation
pressure self-oscillation in the *combustion chamber* (2.12.1) with a frequency that is similar to one of the natural acoustic frequencies

2.14.13
longitudinal oscillation
pressure high-frequency self-oscillation in *combustion chamber* (2.12.1) along combustion chamber axis

2.14.14
transverse oscillation
pressure high-frequency self-oscillation in *combustion chamber* (2.12.1) in a plane that is perpendicular to the combustion chamber axis

Note 1 to entry: Distinguish the tangential, radial and mixed cross-section oscillations depending on the oscillatory motion direction.

2.14.15
low-frequency oscillation
pressure oscillation in the *chamber* (2.2.1) (gas generator) with frequencies that are smaller than the minimum natural acoustic frequency

2.14.16
nozzle impedance
complex value in which the module is the ratio of pressure oscillations amplitude to the speed in the nozzle's initial section and the phase is the displacement between *pressure* (2.7.7) and speed oscillations

2.14.17
mixing system impedance
complex value in which the module is the ratio of pressure oscillations amplitude to the speed at the chamber (gas generator) mixing system and the phase is the displacement between *pressure* (2.7.8) and speed oscillations

2.14.18
soft excitation of self-oscillation
appearance of pressure self-oscillation in the *combustion chamber* (2.12.1) from small disturbances

2.14.19
hard excitation of self-oscillation
appearance of pressure self-oscillation in the *combustion chamber* (2.12.1) from disturbances that exceed critical value

2.14.20
stable operating process
operating process in the chamber (gas generator) without pressure self-oscillations

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2.14.21
unstable operating process
operating process in the chamber (gas generator) with pressure self-oscillations

2.14.22
frequencies identification
identification of pressure oscillation frequencies in the *chamber* (2.2.1) (gas generator) corresponding to maximum of amplitude spectrum with natural frequencies

2.14.23
stability range of operating process
values range (area) of the chamber (gas generator) operating mode parameters that provide a stable process

2.14.24
stability boundary of operating process
set of chamber (gas generator) operating mode parameter values that divide the operating process stability and instability ranges (areas)

2.15 Nozzle types

2.15.1
axisymmetric nozzle
engine nozzle in which the surface, from the side where combustion products flow, is symmetric relative to its axis

2.15.2
round nozzle
axisymmetric nozzle (2.15.1) in which any combustion products flow section perpendicular to symmetry axis is a circle

2.15.3
conical nozzle
round nozzle (2.15.2) in which the expanding part from the similar to the nominal section has a rectilinear contour

2.15.4
shaped nozzle
engine nozzle in which the expanding part has a curvilinear contour shaped for increasing nozzle efficiency

2.15.5
ring nozzle
axisymmetric nozzle (2.15.1) in which some or all perpendicular symmetry axes of the combustion products flow section are rings

2.15.6
pin nozzle
nozzle with external expansion
ring nozzle (2.15.5) in which the external zone is almost or completely absent at the expanding part contour

2.15.7
disk nozzle
nozzle with internal expansion
ring nozzle (2.15.5) in which the internal zone is almost or completely absent at the expanding part contour

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2.15.8
sliding nozzle
extending nozzle
nozzle (2.12.16) with one or several sliding attachments which are nozzle expanding part continuation in extended position

2.15.9
nozzle with oblique cut
nozzle (2.12.16) whose cut is inclined to nozzle axis, different from right angle

Note 1 to entry: A nozzle with an oblique cut consists of a major axisymmetric part and small non-axisymmetric part.

2.15.10
adjustable nozzle
nozzle (2.12.16) whose expansion ratio can be changed in the process of operation

2.16 Nozzle items

2.16.1
nozzle contour
intercepting line of the nozzle surface with the plane passing through central axis

2.16.2
extremal nozzle contour
shaped *nozzle contour* (2.16.1) whose expanding part is determined by various methods

2.16.3
nozzle contour with uniform characteristic
shaped *nozzle contour* (2.16.1) whose expanding part provides parallel flow at the *nozzle exit section* (2.16.10) with constant speed at any point of the section

2.16.4
shorter contour nozzle
shaped *nozzle contour* (2.16.1) whose extending part represents the initial site of the nozzle contour extending part with uniform characteristic

2.16.5
nozzle contour with corner point
nozzle contour (2.16.1) that has a break (turn)

2.16.6
nozzle exit section contour
closed line drawn through exit endpoints of all *nozzle contours* (2.16.1)

2.16.7
nozzle inlet section
engine chamber flow section behind where the sharp reduction of flow section area begins

2.16.8
nozzle throat section
nozzle flow section with minimum area

2.16.9
nozzle critical section
nozzle flow section where combustion product speed is equal to the local sound speed

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2.16.10
nozzle exit section
end of *nozzle* (2.12.16) of the divergent, bell-shaped part of a rocket exhaust nozzle that converts the thermal energy of the combustion gases to the kinetic energy of the exhaust plume and controls the expansion of the plume

Note 1 to entry: The nozzle exit section is perpendicular to the central axis and passes through endpoint of the *nozzle contour* (2.16.1).

Note 2 to entry: The exit section for a *ring nozzle* (2.15.5) is passed through endpoints of nozzle contour external site, while the exit section for a nozzle with an end cut is through the endpoint of the shortest contour.

2.16.11
nozzle tapering part
part of the *nozzle* (2.12.16) between the *nozzle inlet section* (2.16.7) and the *nozzle throat section* (2.16.8)

2.16.12
nozzle growing part
part of the *nozzle* (2.12.16) between the *nozzle throat section* (2.16.8) and the *nozzle exit section* (2.16.10)

2.17 Nozzle characteristics

2.17.1
geometric expansion ratio of nozzle
ratio of the nozzle exit section area to the minimum section area

2.17.2
gas expansion ratio in nozzle
ratio of the combustion product total pressure in the initial section to the static pressure at the exit section

2.18 Nozzle operation modes

2.18.1
rated operation mode
nozzle operating mode when gas pressure at the exit section is equal to the environment pressure

2.18.2
under-expansion
nozzle operating mode when gas pressure at the exit section is higher than the environment pressure

2.18.3
over-expansion
nozzle operating mode when gas pressure at the exit section is lower than the environment pressure

2.18.4
nozzle altitude
height above sea level where nozzle operating mode is rated in standard atmospheric conditions

Note 1 to entry: Instead of height above sea level, the height may be the applicable environment pressure corresponding to it.

2.19 Flow in nozzle

2.19.1
equilibrium flow
flow in the *nozzle* (2.12.16) characterized by power, chemical and phase balance of the combustion products

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2.19.2
non-equilibrium flow
flow in the *nozzle* (2.12.16) where there are no complied power, chemical and phase balance of combustion products or no presence of at least one of these kinds of balances

2.19.3
frozen flow
flow in the *nozzle* (2.12.16) characterized by constancy of combustion product chemical composition

2.19.4
multiphase flow
flow in the *nozzle* (2.12.16) characterized by the availability of gaseous, liquid and solid phases of combustion products

2.19.5
speed lag
speed difference of the condensed phase particle and the gaseous environment in a *nozzle* (2.12.16)

2.19.6
thermal lag
temperature difference of the condensed phase particle and the gaseous environment in a *nozzle* (2.12.16)

2.19.7
loss of specific impulse
deflection of real values from the ideal of the combustion product parameters in a *nozzle* (2.12.16)

2.20 Turbine pump components

2.20.1
pump
engine unit for an oxidizer or a fuel supply

2.20.2
pump auger
pump runner, with vanes, performed on helical surface

2.20.3
turbine
gas turbine intended for the pump drive of a turbine pump

2.20.4
booster turbine
gas or hydraulic turbine intended for pump drive of booster turbine pump

2.20.5
launch turbine
turbine (2.20.3) providing turbine pump rotor spin-up at engine launch

2.20.6
launch nozzle
nozzle (2.12.16) or group of nozzles in the turbine rotor providing turbine pump rotor spin-up at engine launch

2.20.7
axial unloading automat of turbine pump
booster turbine pump
device that unloads the turbine pump (booster turbine pump) bearings from axial forces by rotor automatic equilibration

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2.21 Pump characteristics

2.21.1
head
mechanical energy per unit mass flow

2.21.2
pump head
mechanical energy imparted to the fluid by the *pump* (2.20.1)

2.21.3
pump cavitation stall
sharp reduction of *pump head* (2.21.2) due to cavitation and stalling

2.21.4
pump stalling pressure
total pressure at the inlet of *pump* (2.20.1) which may cause cavitation stall

2.21.5
net positive suction head
NPSH
head (2.21.1) corresponding to the difference between the pump inlet pressure and the vapour pressure and the density of fluid and the gravitational acceleration

2.21.6
rated conditions of pump operation
set of conditions defined by standard value of the temperature, inlet pressure, flow rate, density of propellant and pump rotating speed that are specified in the design

2.21.7
pump cavitation characteristic
dependence of *pump head* (2.21.2) on the pressure input in the *pump* (2.20.1) at rated conditions

2.21.8
pump throttling cavitation characteristic
characteristic of pump stalling cavitation static suction head corresponding to the propellant flow rate

2.21.9
pump pressure characteristic
characteristic of total pressure corresponding to the flow rate at rated conditions

2.21.10
pump capacity characteristic
characteristic of pump capacity on the flow rate through the *pump* (2.20.1) at rated conditions

2.21.11
pump efficiency characteristic
characteristic of pump efficiency on flow rate through the *pump* (2.20.1) at rated conditions

2.22 Turbine pump general characteristics

2.22.1
specific weight of turbine pump
turbine pump weight per unit capacity that is increased by the *turbine* (2.20.3)

2.22.2
efficiency of turbine pump
ratio of the sum of pump available capacities to the sum of turbine adiabatic capacities

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2.22.3
efficiency of booster turbine pump
ratio of the sum of pump available capacities to the gas turbine adiabatic capacity or hydraulic turbine theoretical capacity

2.23 Automation units

2.23.1
solenoid
electrical valve
engine valve whose sluice activates by the electromagnet part of the valve

2.23.2
single-component solenoid
solenoid (2.23.1) having an oxidizer or a propellant cavity

2.23.3
two-component solenoid
solenoid (2.23.1) having an oxidizer and a propellant cavity

2.23.4
hydraulic solenoid
electrical hydraulic valve
valve whose sluice is activated by the electromagnet and hydraulic drive parts of the valve

2.23.5
indicator of pressure in chamber
device that is activated when the engine chamber pressure reaches a specified value

2.24 Devices and methods of control efforts creation in engines

2.24.1
control chamber
auxiliary chamber used for control efforts creation

2.24.2
control nozzle
auxiliary nozzle used for control efforts creation

2.24.3
jet vane
profiled rotary element mounted on the combustion product flow near the nozzle exit and have two working surfaces streamlined by the flow

2.24.4
control actuator
engine actuator that controls the position of devices creating control efforts

2.24.5
injection in nozzle
entering into the nozzle, the expanding part of the additional gas (liquid) flow leading to the emergence of an unbalanced lateral force

2.25 Engine cooling

2.25.1
external cooling
heat removal from engine design elements to cooler or environment

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2.25.2
one-through cooling
engine external cooling performed by a cooler flowing through a cooling channel in the wall of the *chamber* (2.2.1) and *gas generator* (2.2.4)

2.25.3
autonomous cooling
engine one-through cooling where removed heat is not transmitted to propellant components

2.25.4
regenerative cooling
engine one-through cooling where removed heat is transmitted to fuel components

2.25.5
radiation cooling
engine external cooling performed by heat emission to the environment

2.25.6
film cooling
reduction of heat flow, directed towards engine design elements, by creating a protective liquid or gas layer to their surface

2.25.7
transpiration cooling
engine internal cooling performed by injection into a gas or steam boundary layer through porous or perforated wall

2.25.8
capacitive cooling
prevention of engine design element overheating through heat absorption by a material without its mass entrapment

2.25.9
ablation cooling
prevention of engine design element overheating through heat absorption by a material with its mass entrapment

2.26 Engine thermal protection

2.26.1
thermal protection
set of measures implemented in the engine and rocket design that provides an acceptable thermal state

2.26.2
engine thermal state
engine condition characterized by a set of temperatures at its various points

2.26.3
LTE thermal bridge
LTE thermal protection item used as device with a thermal resistance and also used for a change of heat flow directed towards LTE construction

2.27 Engine tests: General

2.27.1
engine test
test for engine technical conditions assessment or its research processes

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2.27.2
engine experimental-design developing
experimental-design development that includes investigation tests of the engine and its component prototypes, design and technological documentation updating by test results, and *completing development tests* (2.34.3) and interagency tests of prototypes made of updated documentation

2.28 Types of engine tests: Thermal loads

2.28.1
firing test
engine test (2.27.1) with fuel combustion or decomposition

2.28.2
cold test
engine test (2.27.1) without fuel combustion or decomposition

2.29 Types of engine tests: Associate with rocket

2.29.1
integrated test
on-line test
engine test (2.27.1) in a propulsion system or rocket

2.29.2
independent test
off-line test
engine test (2.27.1) outside a propulsion system

2.30 Types of engine tests: Test site

2.30.1
ground test
engine firing test in an earthly environment

2.30.2
flight test
engine test (2.27.1) in a rocket in real operating conditions

2.31 Types of engine tests: Organizational factor and test site

2.31.1
flight-design test
developed or modernized engine test in a rocket in a real environment for the purpose of updating design and technological documentation

2.32 Types of engine tests: Test conditions

2.32.1
altitude test
engine firing test at high-altitude conditions

2.32.2
vacuum test
engine firing test in a vacuum chamber at a *pressure* (2.7.7) below 1 Pa

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2.33 Types of engine tests: Accelerated data accessing

2.33.1
forced test
engine accelerated test based on the intensification of processes that cause failures or defects

2.33.2
limit test
engine test (2.27.1) to the limiting state

2.34 Types of engine tests: Test purposes

2.34.1
research test
engine test (2.27.1) for the purpose of a parameter value area to determine where the engine is in working condition

2.34.2
development test
engine research test for the purpose of accessing data necessary for creating the final design

2.34.3
completing development test
engine development test of the final design for the purpose of confirming its performance to technical specification requirements and providing for acceptance test possibility

2.34.4
acceptance test
engine check test at acceptance inspection after which a decision is made about engine availability for delivery to operation

2.34.5
qualification test
engine firing test before start or renewal of a serial production for the purpose of confirming manufacturer availability to produce engines in compliance with the design documentation requirements

2.34.6
model test
produced engines check tests for the purpose of assessing the effectiveness and appropriateness of changes made in the product design or manufacturing process

2.34.7
technological test
check test of each sample engine for the purpose of checking the manufacture technological process

Note 1 to entry: The technological test may be firing or cold, with or without reassembly.

2.34.8
random test
check test of one engine selected from those made within a set time of production

Note 1 to entry: A random test may be acceptance or periodic (periodic confirmation, special periodic).

2.34.9
periodic confirmation test
engine periodic test for the purpose of making a decision perform an acceptance the inspection of each sample made within a set time of production

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2.34.10
special periodic test
engine periodic test for the purpose of a quality conformity assessment of the engines manufactured for delivery to operation at a level reached during development finishing

2.35 Types of tests specific for low-thrust engines

2.35.1
thermal test
thermocatalytic or thermal LTE test without fuel delivery, with heat supply from an external source

2.35.2
thermal-vacuum test
LTE vacuum test at a specified temperature of fuel components and design elements

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2.36 Test technology

2.36.1
test cyclogram
graphical representation and/or numerical description of the engine test condition changes program

2.36.2
engine adjustment
installation of engine regulatory elements for the purpose of a specified operating mode support

2.36.3
engine thermostating
reduction of the engine (fuel components) temperature to a specified value and its maintenance in that range for a set time interval

Note 1 to entry: The engine thermostating may be performed in combination with the fuel component thermostatic or separately.

2.36.4
engine blow
removal of combustion products, gas generation products, atmospheric air and engine internal cavity fuel by gas with excess pressure

2.36.5
engine neutralization
engine processing for the remaining fuel removal and/or clearance of unremoved remaining fuel

2.36.6
engine cavity passivation
engine cavity surface processing which results in the formation of a material film that does not act on fuel components and is inert to their aggressive action to engine cavities

2.36.7
engine fault detection
engine dismantling and technical condition research after test for the purpose of defect detection

2.37 Test conditions

2.37.1
test conditions
set of engine operating modes, external influencing factors and operating time during the test

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2.37.2
operating test conditions
engine test conditions are equal to the specified by design documentation for the intended use in operation

2.37.3
guarantee test conditions
expanded engine test condition (as compared to the *operating test conditions* (2.37.2))

Note 1 to entry: When a fault is identified during the test, there are actions to be taken to determine its causes, removal of the fault or confirming the impossibility of it appearing in operating conditions.

2.37.4
standard test conditions
engine test conditions where parameter values are implemented at random during initial nominal stand and *engine adjustment* (2.36.2)

2.37.5
special test conditions
engine test conditions which are provided by stand special adjustment and/or *engine adjustment* (2.36.2) and/or special requirements to exposure factors

2.37.6
high-altitude test conditions
engine test conditions providing complete gas expansion in the *nozzle* (2.12.16)

2.38 Test results

2.38.1
conclusive test result
test result on the basis of which conclusions can be drawn about engine technical condition, suitable for its reliability or quality analysis

2.38.2
inconclusive test result
test result on the basis of which conclusions cannot be drawn about engine technical condition, suitable for its reliability or quality analysis

Note 1 to entry: The same test result depending on the objectives specified at reliability analysis and quality control may be regarded as conclusive and inconclusive.

2.39 Engine reliability

2.39.1
engine reliability
engine property to maintain an *operable state* (2.39.2) under determined operational conditions

2.39.2
operable state
engine state when it can develop thrust of a specified value and direction, fulfil specified requirements for provision of a specific thrust impulse, fuel component ratio and rocket component operating conditions

Note 1 to entry: The specified customer requirements are provided in the process of development and delivery into operation.

2.39.3
non-operable state
engine state when it is not able to fulfil at least one of the requirements providing in an *operable state* (2.39.2)

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2.39.4
technical state qualification
identification of the type of engine operation condition

2.40 Engine defects

2.40.1
structural defect
engine defect caused by imperfect design documentation or set design rules and/or standards breach

Note 1 to entry: The design documentation is imperfect in the case where all its performance requirements' during engine manufacturing do not provide the engine operable state in operation.

2.40.2
manufacturing defect
engine defect caused by non-performance of the design documentation, non-fulfilment or non-performance of technological documentation requirements during its manufacturing and/or maintenance

2.40.3
operating defect
engine defect caused by a specified operating conditions breach

2.40.4
test defect
non-conformity of engine testing conditions to the design documentation requirements

2.41 Engine failure modes

2.41.1
engine failure
event based on the breach of engine operable state or its *non-operable state* (2.39.3) detection during test or operation

2.41.2
engine structural failure
engine failure (2.41.1) based on *structural defect* (2.40.1)

2.41.3
engine manufacturing failure
engine failure (2.41.1) based on *manufacturing defect* (2.40.2)

2.41.4
engine operating failure
engine failure (2.41.1) based on *operating defect* (2.40.3)

2.42 Engine operation

2.42.1
engine operating conditions
set of conditions specified by the design documentation for engine operating

2.42.2
operation cycle
in-service live
operating periodically of a recurrent part from its beginning to the end of engine intended use or to the end of it or its return after intended use for the purpose of maintenance

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2.42.3
failure-free operation
operating when the engine keeps its *operable state* (2.39.2) during its storing, transportation and intended use

Note 1 to entry: Failure-free operation of reusable engines includes the recovery of an engine operable state during period of time between its fights not exceeding the specified time.

2.43 Analysis of engine technical status

2.43.1
capacity for work parameter
engine parameter used for its reliability analysis for the purpose of identifying which one of its properties definition provides its *operable state* (2.39.2)

2.43.2
critical value of capacity for work parameter
engine capacity for work parameter value, at which when exceeded the engine will be at a *non-operable state* (2.39.3)

2.43.3
reserve of capacity for work parameter
difference between the capacity for work parameter value and its critical value during *engine test* (2.27.1) or operation

2.43.4
operational reserve of capacity for work parameter
reserve of capacity for work parameter (2.43.3) at operating conditions

2.43.5
guarantee reserve of capacity for work parameter
reserve of capacity for work parameter (2.43.3) at guarantee conditions

2.44 Engine reliability index

2.44.1
probability of failure-free work
probability of an engine operable state during work at operating conditions

2.44.2
probability of failure-free operation
probability of an engine operable state when operated at all operational stages at specified operating conditions

2.45 Engine quality control

2.45.1
preliminary acceptance testing
quality control of each engine specimen before acceptance testing

2.45.2
between-flights control
turnaround control
control of a reusable engine before regular intended use

2.45.3
control plan
plan that includes control type and structure, testing engine number, test periodicity and conditions, and decision rules

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