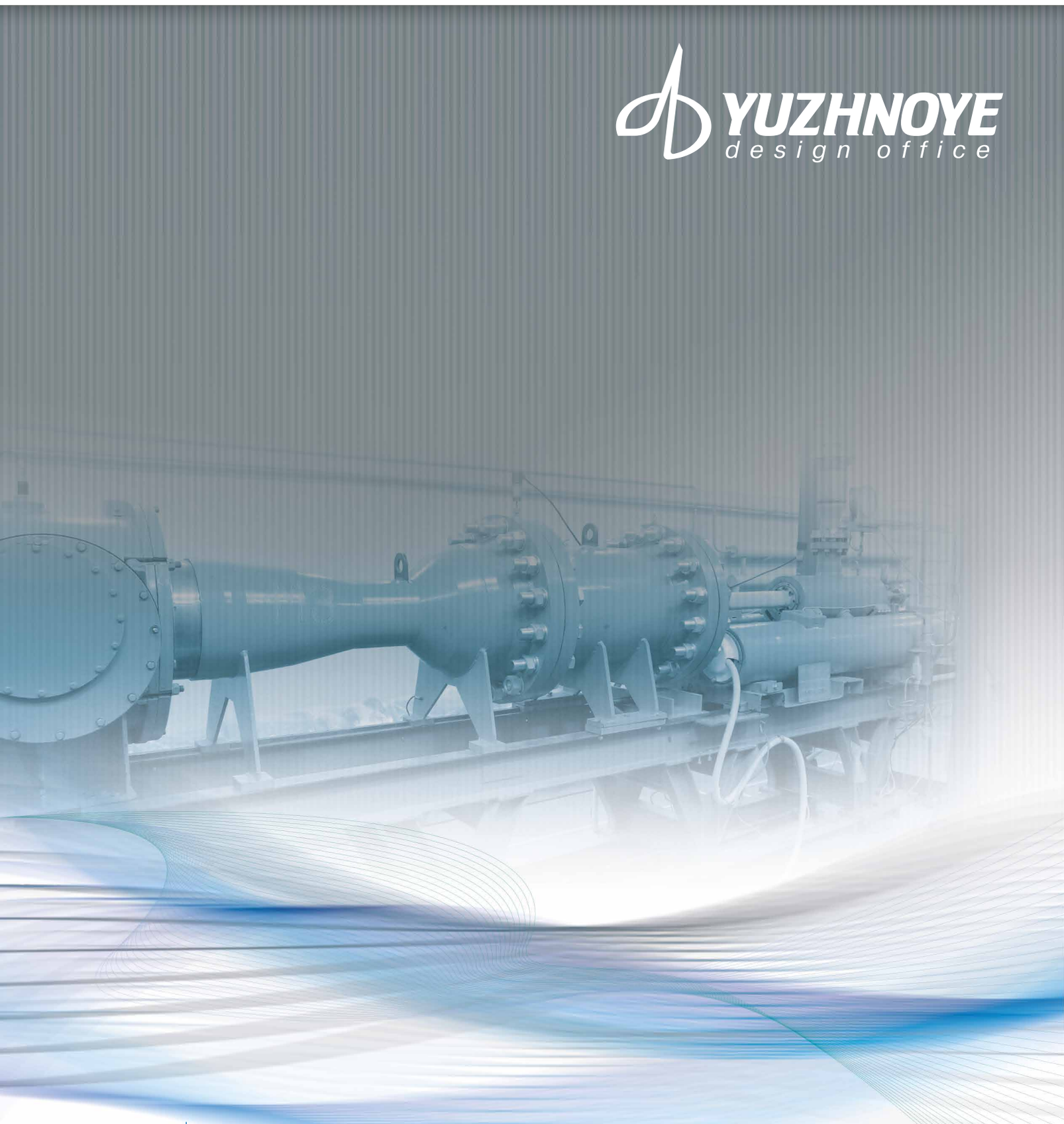
YUZHNOYE
design office



EXPERIMENTAL TESTS

Yuzhnoye State Design Office performs Ground development tests of rocket-space systems and products from other industries at own test facilities.

The test facilities represent a unique multifunctional complex comprised of special-purpose facilities and test benches that support fire, hydrostatic, pneumatic, strength and functional tests, and simulate various environmental conditions.

Tests are supported by optical and telemetry measurements and the use of reference equipment.

If required, the tested articles and chemicals (products) used in the tests are subjected to environmentally safe neutralization.

Yuzhnoye's specialists have many years of experience in testing as well as developing test stand equipment and solving a wide range of technical, scientific and applied tasks related to functional demonstration and certification tests.

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FIRING TESTS

Fire tests are functional tests of products, involving combustion and ignition. Product performances are determined and main specifications are measured in the process of fire tests .

Tests are performed on jet engines (liquid mono- and bipropellant, solid-propellant), liquid-propellant jet systems, rocket combustion chambers, gas generators, burners, etc.

FIRING TESTS

- TESTS OF LIQUID-PROPELLANT ROCKET ENGINES, LIQUID-PROPELLANT JET SYSTEMS, ASSOCIATED SUBSYSTEMS AND ASSEMBLIES

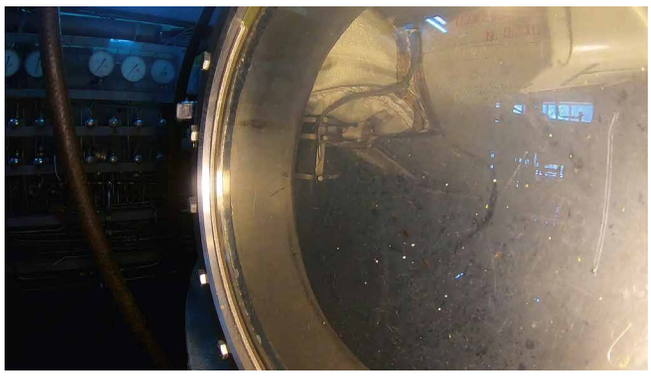
Tests are supported by continuous video surveillance, automated electronic measurements, test object parameter recording. If required, neutralization is performed after the tests.

Thrust, kgf	1 – 1000
Propellant flow rate, kg/s	0,015 – 3
Propellant supply pressure, kgf/cm^2	1 – 200
Propellants	
• fuel	kerosene or unsymmetrical dimethylhydrazine
• oxidizer	liquid oxygen or nitrogen tetroxide
Propellant thermal conditioning, °C	–5 to +45

FIRING TESTS

SOLID-PROPELLANT ROCKET MOTOR TESTS

During tests we simulate actual environment which corresponds to an altitude of up to 20 km above the Earth surface. In vacuum chambers, dynamic vacuum is achieved by using gas dynamic exhaust pipes and gas ejector setups.



Test article dimensions, m, not more than	Ø 3,1 × 1,6
Nozzle exit pressure, kgf/cm^2	0,00015 – 0,2
Number of measured parameters	538

GAS-DYNAMIC RESEARCH

The research is aimed at monitoring gas dynamic processes caused by blasting effects of launch vehicle engines to the ground infrastructure at liftoff. Gas dynamic parameters (pressure and temperature) are determined on test articles.

Distance from gas generator to model, m	0 – 10
Working fluid temperature at gas generator outlet, °C, not more than	330
Propellant flow rate	
• kerosene, kg/s, not more than	0,12
• air at P=53 kgf/cm^2, kg/s, not more than	5
Number of measured parameters	96
Sampling rate, kHz	0,5 – 5

FIRING TESTS

SOLID-PROPELLANT ROCKET MOTOR TESTS

Solid-propellant rocket motors and gas generators are tested in actual environmental conditions using measurement and recording equipment and special-purpose rigging equipment.

Thrust, tf, not more than	150
Diameter, mm	50 – 2400
Mass, kg	0,1 – 40000
Number of measured parameters	25

HYDROSTATIC AND PNEUMATIC TESTS

Hydrostatic and pneumatic tests are functional tests of products, control units and systems by liquid and gas working fluids. Tests are performed to check performances, demonstrate guarantee service lifetime, perform calibration, graduation, certification.

Tests are performed on centrifugal and piston fluid-flow pumps, gas turbines (including when integrated into an onboard power supply sources), control units and systems (reducers, valves, sensors, flow meters), vessels. Behavior of fluid in tanks under dynamic loads and local g-loads is investigated.

TESTING SUBSYSTEMS, ASSEMBLIES AND COMPONENTS BY LIQUID AND GAS

The following substances can be used as a working fluid:
• Liquids: water, liquid oxygen, oil products, technical oils, acids, alkaline solutions, etc.
• Gases: air, nitrogen, helium, oxygen, hydrogen, ammonia, argon, propane, carbon dioxide, etc.

Internal nominal diameter, mm	4 – 300
Gas flow rate, l/s	0.1 – 700
Liquid flow rate, l/s	0.0003 – 200
Liquid temperature, °C	5 – 90
Oxygen flow rate, l/s	0.001 – 3
Oxygen temperature, °C	from –183 to +400
Operating pressure, kgf/cm^2	0.1 – 600

HYDROSTATIC AND PNEUMATIC TESTS

- TESTING SUBSYSTEMS, ASSEMBLIES AND COMPONENTS BY AGGRESSIVE AND TOXIC FLUIDS, INCLUDING PROPELLANTS

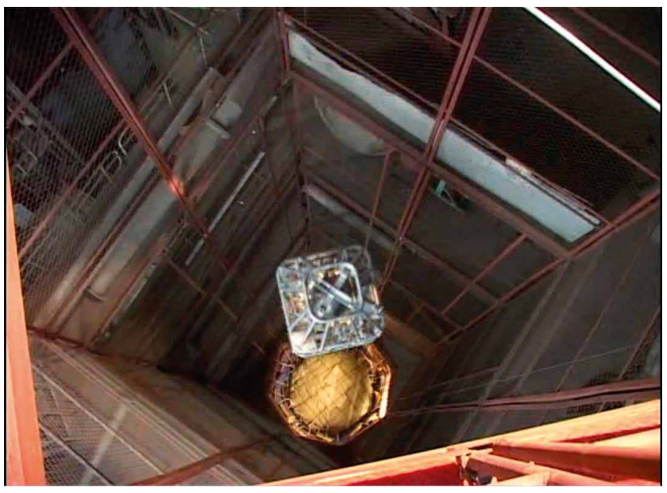
We ensure complete environmental safety of tests. We perform neutralization after tests.

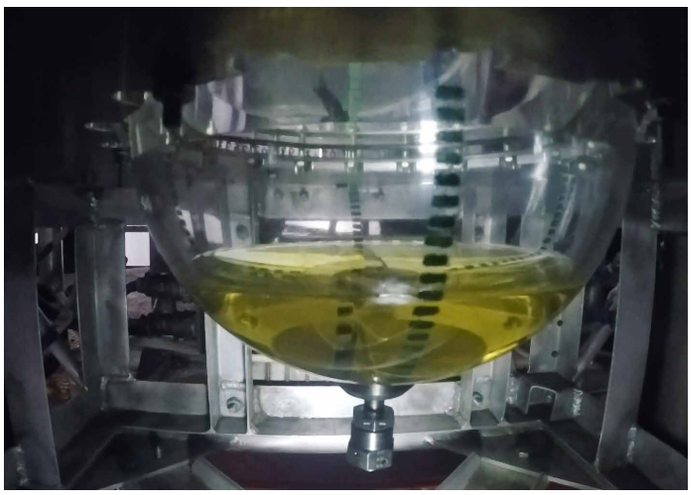
Test article dimensions, m, not more than	Ø 3 × 10
Internal nominal diameter, mm	4 – 300
Flow rate, l/s	0,2 – 25
Supply pressure, kgf/cm^2	1 – 200

HYDROSTATIC AND PNEUMATIC TESTS

RESEARCH OF FLUID BEHAVIOR IN TANKS EXPOSED TO AN IMPULSE

The research allows determining behavior of fluid in transparent tank models at zero gravity when simulating an impulse of various magnitudes. Tank model mass is not more than 180 kg.





TANKS, SUBSYSTEMS, ASSEMBLIES AND COMPONENTS LEAK TESTS

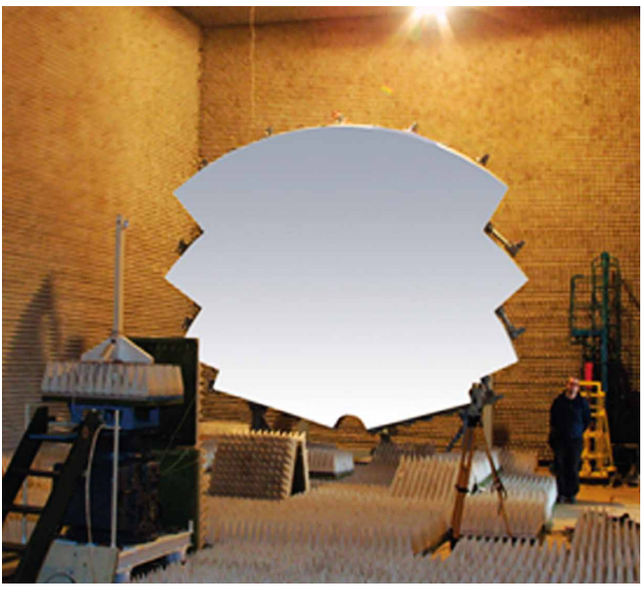
Leak tests are performed to monitor pressure integrity and detect leaks. Helium is used for leak testing.

Parameter name	Vacuum mode	Probe mode
Lowest detectable helium leak rate, kgf•l/(cm^2•s)	$5 \cdot 10^{-15}$	$1 \cdot 10^{-10}$

ELECTRONIC SYSTEM TESTS

Functional tests of electronic systems are performed in simulated actual environment.

ANTENNA FEEDER DEVICE TESTS



Tests are performed to measure radiation characteristics of antennas installed in spacecraft, launch vehicles, and other radio emitting objects.

Tests are performed in an anechoic chamber. A parabolic collimating mirror is used for the measurements.

Operating frequency band, GHz	1 – 20
Mirror aperture (width × height), m	6 × 5
Focal length, m	3,5
Number of mirror segments	67
Deviation of mirror segment parabolic surfaces, mm, not more than	0,5

ELECTRONIC SYSTEM TESTS

AVIONICS TESTS

Inertial instruments and optical equipment are tested with reproduction of high-precision positioning under high dynamic loading simultaneously along three axes.

Test article dimensions, mm, not more than	450 × 450 × 400
Test article mass, kg, not more than	50
Angular freedom in axes, °	Full
Positioning accuracy, "	1,5
Minimum angular rate, °/s	0,001
Peak angular rate (in axes), °/s	500 / 500 / 400
Peak angular acceleration (in axes), °/s^2	700 / 600 / 400

Microelectromechanical systems for inertial devices, quartz sensors, silicon sensors, ring-laser and fiber-optic gyroscopes, safety devices are tested for linear g-loads.

Test article dimensions, mm, not more than	450 × 450 × 400
Test article mass, kg, not more than	50
Linear g-load range, g	0 – 45
Angular rate resolution, °/s	0,0001

STRENGTH TESTS

Strength tests are performed to collect information on the condition of products when exposed to external loads. Test articles can be subjected to static and dynamic loading, with test parameters recorded and processed.

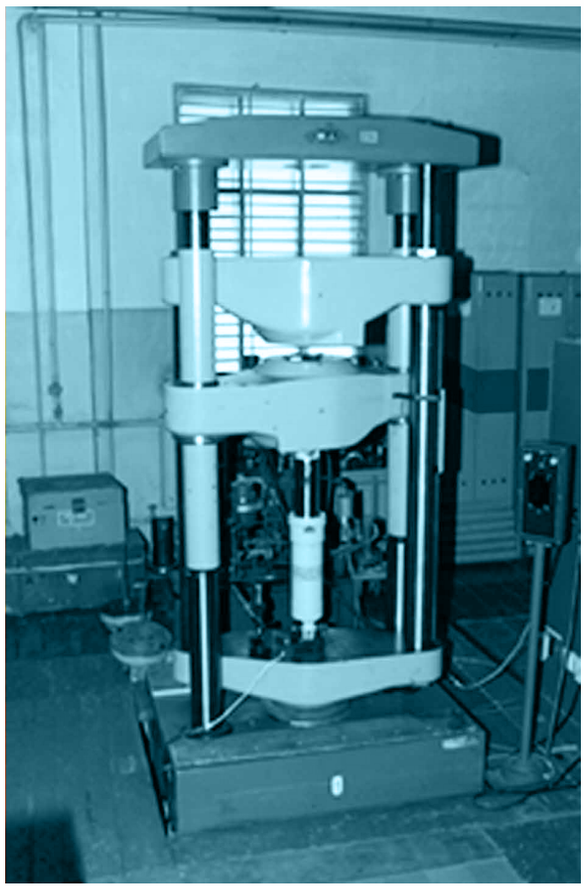
Tests are performed on aerospace hardware, engineering products, electric power industry equipment, engineering structures, models, hardware fragments, etc.

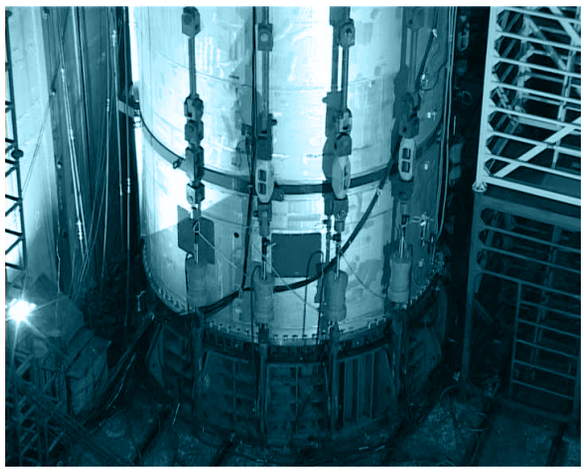
Models of loading equivalent to actual operational loading are developed.

STRENGTH TESTS

STATIC TESTS

Hardware is tested for strength and stability when exposed to concentrated and distributed loads, with any necessary combination of forces applied.

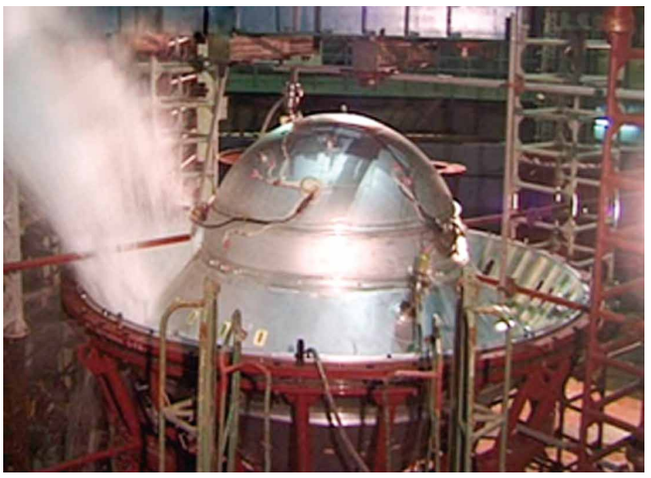




Local loading force, tf	1 – 150
Overall axially symmetric loading force, tf	1 – 1200
Measurement error, %	±1

STRENGTH TESTS

■ IMPLOSIVE AND BURST TESTS



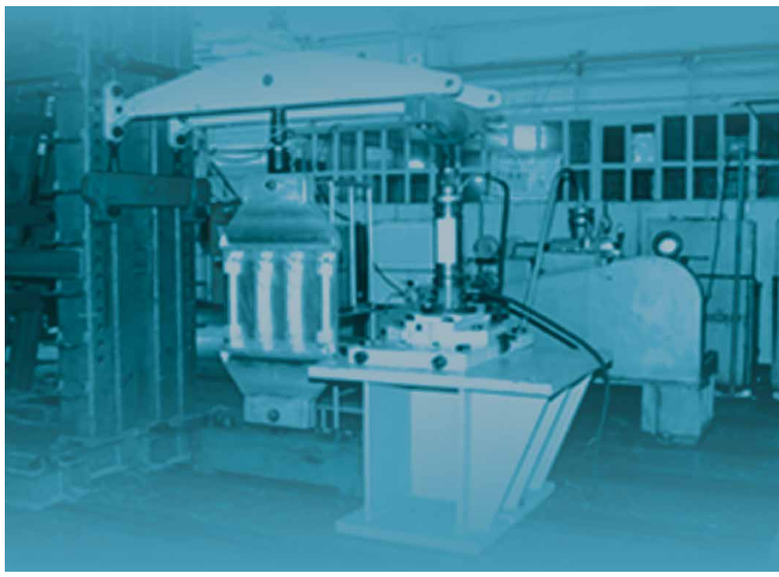
Implosive (in special chambers) and burst tests are performed using air or a liquid working fluid such as water or hydraulic oil.

Parameters	Water	Hydraulic oil	Air
Test article dimensions, m, not more than		Ø 4 × 20	
Test article mass, t, not more than		80	
Pressure, kgf/cm^2	5 – 500	1 – 400	0,5 – 15

STRENGTH TESTS

■ DYNAMIC TESTS

Fatigue tests simulate long duration high-cycle loading by symmetric and asymmetric bending, torsion and tension-compression.



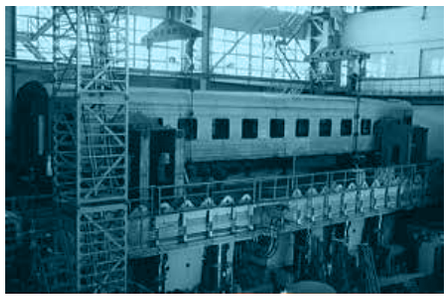
Dynamic force, kgf, not more than	500
Static force, kgf, not more than	800
Total cyclic load, tf, not more than	100
Frequency, Hz, not more than	24

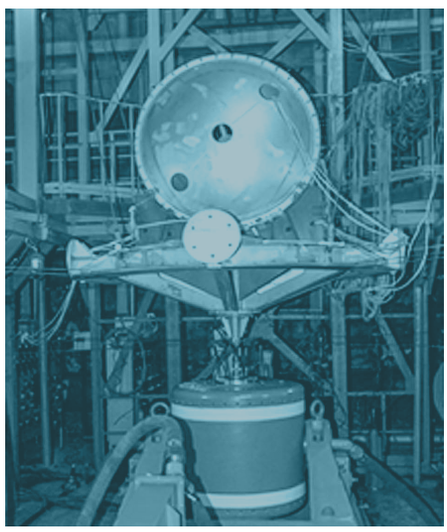
Tests are performed using special-purpose equipment in chambers with reinforced walls, reinforced floors and a protective/ reinforced transformable ceiling. The chambers are equipped with bridge cranes.

Workspace size (length x width x height), m	25 × 16 × 20 18 × 11 × 32
Allowable force per one linear meter of a wall or floor span, tf, not more than	50
Allowable bending moment per a wall or floor span, tf•m, not more than	300
Bridge crane capacity, t, not more than	80

STRENGTH TESTS

DYNAMIC TESTS





Strength tests with harmonic and random vibration loads are supported by a frequency-response analysis.

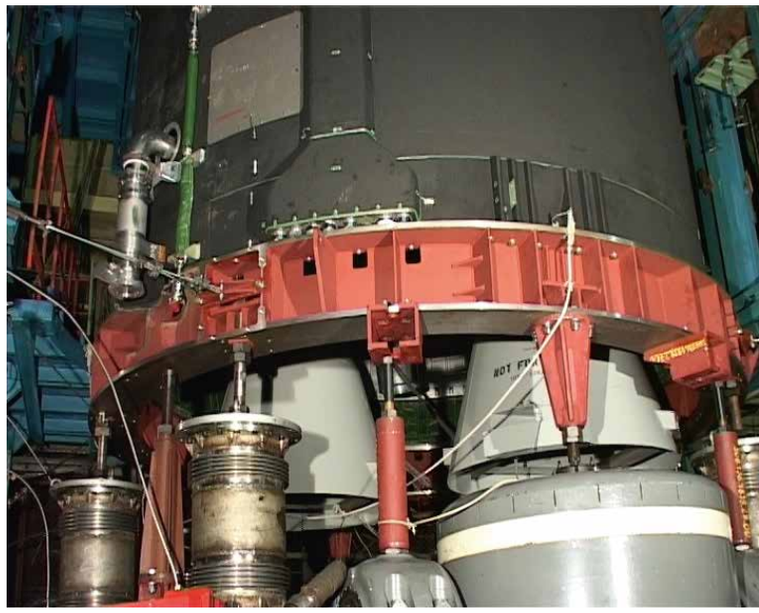
Test signal waveforms: sinusoidal, triangular, single pulse, pulse strings, random oscillations, seismic vibrations spectrum, etc.

Test article mass, kg	0,1 – 20000
Dynamic force, tf, not more than	9
Frequency, Hz	5 – 3000

STRENGTH TESTS

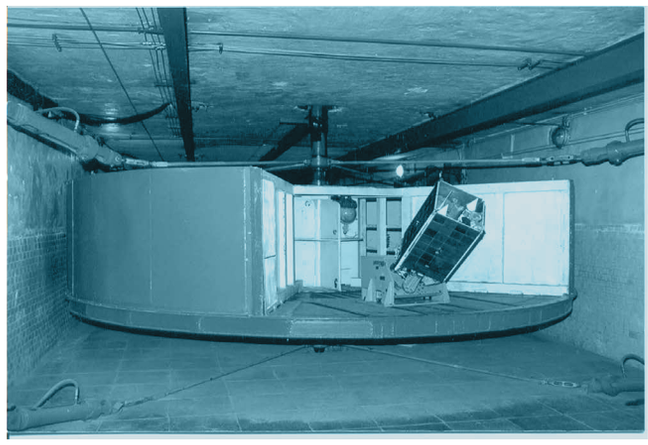
DYNAMIC TESTS

Tests for transportation or other dynamic loads are performed in operational and/or forced loading conditions.



Test article mass, t, not more than	160
Dynamic force of a single force actuator, tf, not more than	250
Force actuator rod displacement amplitude, mm, not more than	±135
Force actuator rod vibration acceleration, m/s^2, not more than	11g
Frequency, Hz	1 – 100
Operation	Continuous

Spacecraft, components of propellant systems and other products are tested for linear g-loads.



Test article dimensions, m, not more than	1 × 1 × 1
Test article mass, t, not more than	1
Linear g-load range, g	1 – 20

ENVIRONMENTAL TESTS

Environmental tests are performed to determine performances, specifications, and acceptable storage time of products in abnormal environmental conditions.

Hot and cold temperature tests and high humidity tests are performed according to an accelerated aging method, which was proven effective by many years of products operation in different climates. Functional checks of test articles are performed during or after the tests.

Test article dimensions, m, not more than	4 × 4 × 20
Test article mass, kg, not more than	5000
Test temperature, °C	–70 to +150
Test relative humidity at 19 to 30 °C, %	60 – 100
Network voltage, V	380 / 220 / 36
Pneumatic supply pressure, kgf/cm^2	6 – 230

ENVIRONMENTAL TESTS

TEMPERATURE, HUMIDITY, SALT-SPRAY TESTS

Salt-spray tests determine products resistance and performances under extreme concentrations of sodium chloride in an environment. Salt concentration in test chamber is constant or varies according to a preset test plan.

Test article dimensions, m, not more than	0,5 × 0,5 × 0,5
Test article mass, kg, not more than	25
Relative humidity at 15 to 35 °C, %	45 – 80
Pressure, kgf/cm^2	0,85 – 1,08
Sodium chloride concentration, ml/l	10 – 50

ENVIRONMENTAL TESTS

ZERO-GRAVITY TESTS

Articles are tested in free fall. A test article is placed in an aerodynamic container, which minimizes aerodynamic forces during the fall. At the end of the fall, the container with the article is caught by a special-purpose system.

Free fall distance, m	40
Free fall duration, s	~ 2,9
Container + article mass, kg, not more than	500
Deceleration load, g, not more than	25

VACUUM TESTS

Tests are performed in a vacuum chamber to support development of small ion-plasma engines and other spacecraft engines, functional tests of spacecraft transformable elements and launch vehicles upper stage assemblies.

Chamber volume, m^3	32
Test article dimensions, m, not more than	Ø 2,5 × 2
Chamber pressure, kgf/cm^2, not less than	$4{,}8 \cdot 10^{-5}$

ENVIRONMENTAL TESTS

WIND TUNNEL TESTS

Ground experiments to determine aerodynamic performances of aerial vehicles at supersonic and hypersonic speeds are performed in an impulse wind tunnel.

Discrete change in gas flow velocity is provided by replacing nozzle extensions. Tests at hypersonic gas flow velocities are performed with heating of the working gas.

Tests provide:
- Optical observation of a model airflow structure;
- Measurement of a model center-of-mass displacement, velocity and acceleration in X, Y, Z axes and aerodynamic drag at any time.

Supported gas flow velocities, Mach	1,5; 2; 3; 4; 5; 6; 7; 8
Working gas	High-pressure air
Working gas pressure, kgf/cm^2	205
Working gas heating temperature, ^oC	20 – 500
Throat diameter, m	0,505
Throat length, m	0,98
Run time, s	0,3 – 0,6

MATERIAL STUDIES

Material studies are performed to determine characteristics of materials in a structure of off-the-shelf products or technology samples.

A destructive method is used for determination of material tensile, compression, bending, interlaminar shear, shear and bearing strength, and tensile strength of individual fibers.

Force measurement range, tf	1 – 10
Allowable force measurement error, %	±1
Active beam displacement velocity range, mm/m	1 – 500
Beam maximum travel distance, mm	1000
Beam displacement indicator resolution, mm	±0,01
Longitudinal and transverse strain indicator resolution, mm	0,01
Tensile load on individual fibers, kgf, not more than	150

MATERIAL STUDIES

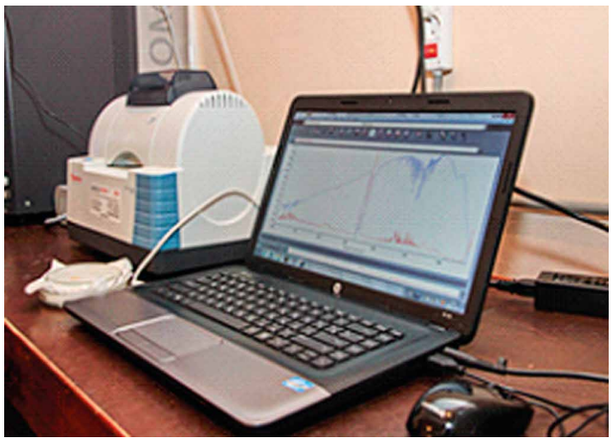
POLYMERIC COMPOSITE MATERIAL STUDIES

Thermal and physics characteristics of polymeric and synthetic materials are measured on samples in conditions that prevent bias due to extraneous thermal processes. Thermal conductivity is measured by a continuous heat flux method, and specific heat is measured in a multicellular calorimeter.

Thermal conductivity measurement range, W/(m °C)	0,02 – 1,5
Specific heat measurement range, J/(kg•°C)	300 – 3000
Operating temperature, °C	20 – 200
Numbers of simultaneously tested articles	5
Test article dimensions, mm, not more than	Ø 29 × 5

MATERIAL STUDIES

CHEMICAL COMPOSITION STUDY



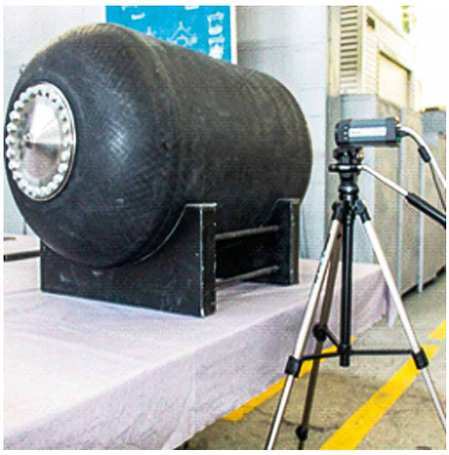
Chemical analysis of material samples is performed by collecting data of reflected radiation in mid-infrared band, using different modules, including consoles to measure transmission of infrared radiation, attenuated total reflection, diffused and direct reflections.

Spectral band, cm^{-1}	7800 – 350
Spectral resolution, cm^{-1}	0,8
Wave number scale error, cm^{-1}	0,2
Signal-to-noise ratio, not less than	22000 / 1
Pseudo-diffused light, %	0,7

MATERIAL STUDIES

NONDESTRUCTIVE QUALITY CONTROL

Quality control by thermal methods is based on recording the distribution of thermal fields as a test article heats up or cools down. Near a defect area, distribution of thermal fields is uneven, which is seen from infrared camera images displayed on a monitor.



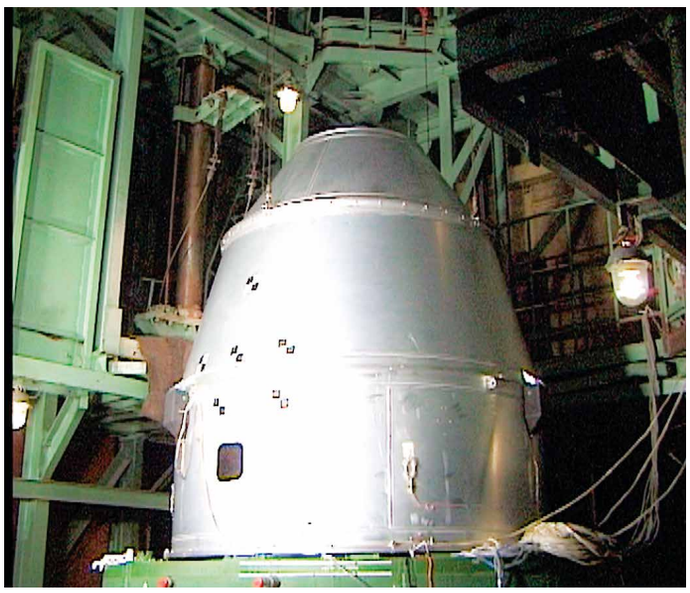
Quality control by ultrasonic methods is based on recording changes in parameters of an ultrasonic wave after it passes through a test article. In case of a defect, characteristics of the original and the received bands will differ significantly.

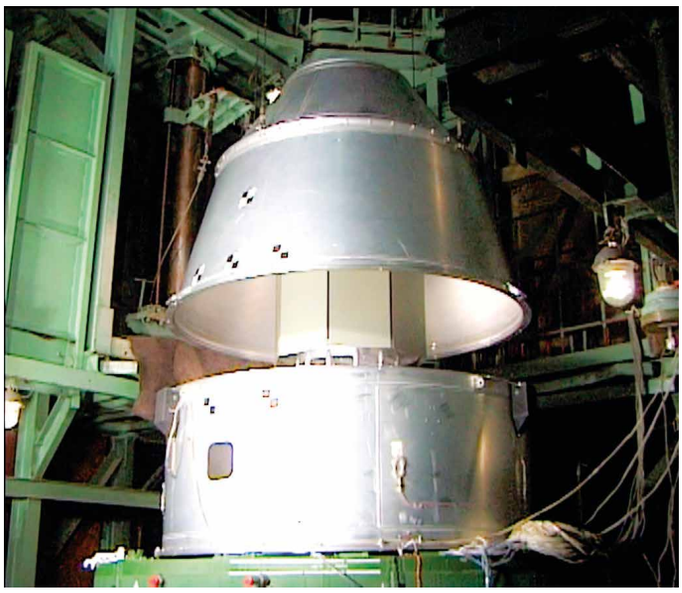
FUNCTIONAL TESTS

Functional tests of mechanical systems and mechanisms of different complexity are performed to determine performances and supported by measuring the motion of mobile or separating parts.

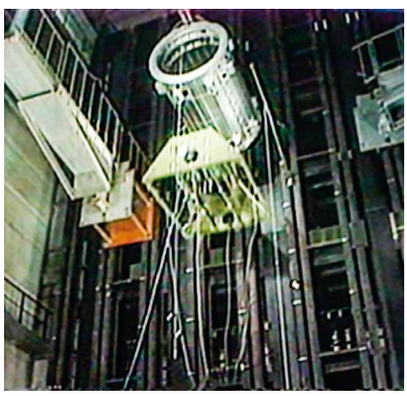
Tests are performed at dedicated test stands installed in buildings or chambers, equipped with bridge cranes and featuring reinforced walls, ceiling and floors.

FUNCTIONAL TESTS

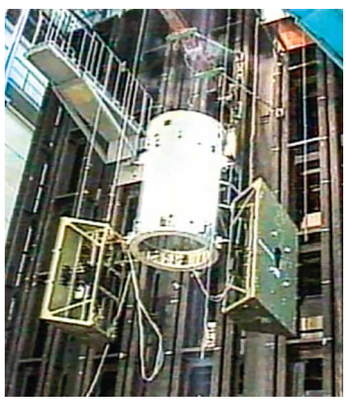




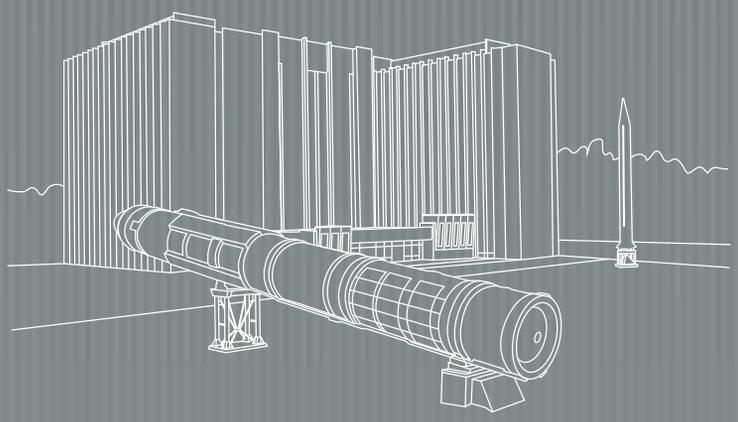
Gas dynamic shield separation test.



Spacecraft mockup – rigid dispenser separation tests.



Spacecraft mockup separation tests with zero-gravity simulation.



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