GOST R 51271-99

Group L79

STATE STANDARD OF THE RUSSIAN FEDERATION

PYROTECHNIC GOODS

Methods of certification tests

OKS 71.100.30
OKSTU 7275

Effective since 2000-01-01

Preface

1 DEVELOPED AND INTRODUCED by the State Unitary Enterprise "Federal Research and Development Center "R&D Institute of Applied Chemistry" (GUP FNPC NIIPH)

2 APPROVED AND RELEASED by Resolution of Gosstandart of Russia no. 136 dated April 27, 1999

3 This standard incorporates the norms of the Law of the Russian Federation "On Protection of Consumer Rights"

4 FIRST RELEASE

5 EDITION (February of 2011) Revision 1 approved in June of 2010 (IUS 2-2011)

1 Scope

This standard covers pyrotechnic goods for household and technical use and establishes methods of testing to determine their parameters and characteristics, including verification of conformity.

Application of any of the methods established by this standard in the tests is to be included in the test program for a specific pyrotechnic article.

All testing and measuring instruments used for the test under any of the methods established hereby shall have documents (data sheet, testimonial, record book, user manual) with statement of validity. Any testing and measuring instruments mentioned in this standard may be changed to others with similar technical data.

When testing under any method established by this standard, a job log is to be kept to record he data of the pyrotechnic article (name, code, index, etc.), date of test, data on the measuring instruments used (name, type, measuring range, validity period, etc.), on the test conditions (if necessary), test results (if these can be obtained during the test) or information on the measurement data carriers (number of carriers, number of pyrotechnic articles tested, where the data carriers have been submitted for further processing, etc.), names of the test operator(s) and the test chief.

Measurement techniques are to be developed on the basis of the general methods explained in this standard in accordance GOST R 8.563 and approved in due manner stating the specific apparatuses and sequence of operations for measurements.

Section 1 (Revised edition, Rev. 1)

2 Normative references

This standard refers to the following norms:

GOST R 8.563-2009 State system for ensuring the uniformity of measurements. Procedures of measurements

GOST R 8.585-2001 State system for ensuring the uniformity of measurements. Thermocouples. Nominal static characteristics of conversion

GOST R 50342-92 (IEC 584-2-82) Thermoelectric converters. General specifications

GOST R 50810-95 Fire hazard of textiles. Decorative textiles. Flammability test method and classification

GOST R 51270-99 Pyrotechnic goods. General safety requirements

GOST R 53228-2008 Non-automatic weighing instruments. Part 1. Metrological and technical requirements. Tests

GOST 9.510-93 Unified system of corrosion and ageing protection. Aluminum and aluminum alloys semifinished products. General requirements for temporary anticorrosive protection, packing, transportation and storage

GOST 9.707-81 Unified system of corrosion and ageing protection. Polymeric materials. Methods of accelerated climatic ageing test

GOST 166-89 (ISO 3599-76) Vernier calipers. Specifications

GOST 334-73 Scale-coordinate paper. Specifications

GOST 380-2005 Common quality carbon steel. Grades

GOST 427-75 Measuring metal rulers. Specifications

GOST 2162-97 Adhesive rubberized tape. Specifications

GOST 4117-78 TMT for industrial explosives. Specifications

GOST 4514-78 Straps for electrical industry. Specifications

GOST 5462-72 Condenser exploder. General technical requirements

GOST 5496-78 Rubber technical tubes. Specifications

GOST 5679-91 Cotton wool for garments and furniture. Specifications

GOST 6445-74 News-print. Specifications

GOST 7164-78 SSI self-balancing servoinstruments. General specifications

GOST 7165-93 (IEC 564-77) D.C. bridges for measuring resistance

GOST 7502-98 Measuring metal tapes. Specifications

GOST 7721-89 Illuminants for color measurements. Types. Technical requirements. Marking

GOST 8240-97 Hot-rolled steel channels. Assortment

GOST 8291-83 Dead-weight pressure-gauge testers. General technical requirements

GOST 8509-93 Hot-rolled steel equal-leg angles. Dimensions

GOST 8711-93 (IEC 51-2-84) Direct acting indicating analogue electrical measuring instruments and their accessories. Part 2. Special requirements for ammeters and voltmeters

GOST 9089-75 Instantaneous electric detonators. Specifications

GOST 9416-83 Building levels. Technical requirements

GOST 9486-79 Alternating current measuring bridges. General requirements

GOST 9500-84 Standard portable dynamometers. General technical requirements

GOST 9829-81 Light-beam oscillographs. General technical specifications

GOST 10374-93 (IEC 51-7-84) Direct acting indicating analogue electrical measuring instruments and their accessories. Part 7. Special requirements for multi-function instruments

GOST 10529-96 Theodolites. General specifications

GOST 10771-82 Filament electric lamps for light measuring. Specifications

GOST 11109-90 Domestic cotton gauze. General specifications

GOST 13208-78 Pyrotechnic photoilluminating items. Photometering method

GOST 16350-80 Climate of the USSR. Regionalizing and statistical parameters of climatic factors for technical purposes

GOST 17168-82 Filters electrical octave and third-octave. General technical requirements and methods of testing

GOST 17187-81 Sound level meters. General technical requirements and methods of testing

GOST 17299-78 Technical ethyl alcohol. Specifications

GOST 17527-2003 Package. Terms and definitions

GOST 17616-82 Electric lamps. Measurements of electrical and luminous characteristics

GOST 17675-87 Flexible electrical insulating tubes. General specifications

GOST 18300-87 Technical rectified ethyl alcohol. Specifications

GOST 19034-82 Tubes of polyvinylchloride plastic. Specifications

GOST 19433-88 Dangerous goods. Classification and marking

GOST 20799-88 Industrial oils. Specifications

GOST 21631-76 Sheets of aluminum and aluminum alloys. Specifications

GOST 28498-90 Liquid-in-glass thermometers. General technical requirements. Methods of test, Rev. 1).

3 Definitions and acronyms

The following terms with their respective definitions and acronyms are used in this standard:

pyrotechnic article; PA: As per GOST R 51270;

pyrotechnic compound; PTC: As per GOST R 51270;

pyrotechnic element; PE: As per GOST R 51270;

pyrotechnic article hazard: As per GOST R 51270;

pyrotechnic article danger zone: As per GOST R 51270;

consumer package: Package as per GOST 17527 intended for handing over a pyrotechnic article to consumer;

igniting ability of pyrotechnic article: Ability to ignite/kindle flammable substances and materials through the effect of high-temperature combustion products (gaseous and condensed) or heated structural elements of a pyrotechnic article;

primary measuring transducer: As per [1];

intermediate measuring transducer: As per [1];

rig: Device intended for mounting and orienting a pyrotechnic article and transmitting the thrust (recoil force) from the said article to the primary measuring transducer;

stake: Post (rod) of a certain size used for scaling images on a monitor;

stability of pyrotechnic article to external effects: Ability of a pyrotechnic article to perform after exposure to external effects (mechanical or climatic).

Section 3 (Revised edition, Rev. 1).

4 Notations

The following notations are used in this standard.

For subsection 6.1:

K - scaling factor, mm/m

L - rod length, m

l - stake (rod) image length on a monitor or TV set (hereinafter a monitor), mm

$L_{\text{п}}$ - flame length, m

$l_{\text{п}}$ - flame/sparks image length on a monitor, mm

$D_{\text{п}}$ - flame/spark spread diameter, m

$h_{\text{п}}$ - flame/spark spread image width on a monitor, mm

For subsection 6.4:

h - difference of location levels of optical gauges and launch station, m

a - distance from optical gauge post to launch station, m

δ - angle between horizon and launch station bearing, ...°

H_A, H_B - PA flight trajectory point heights calculated by the data obtained at optical gauge posts A and B respectively, m

$Б$ - base: distance between optical gauge posts A and B, m

h_A, h_B - difference of location levels of launch station and optical gauges A and B respectively, m

R - danger zone radius, m

$R_{\text{дог}A}$, $R_{\text{дог}B}$ - PA post-combustion radii calculated by the data of optical gauge posts A and B respectively, m

l_0 - distance from optical gauge post A to projection of trajectory point onto horizontal plane, m

l_1 - distance from optical gauge post B to projection of trajectory point onto horizontal plane, m

l_2 - distance from optical gauge post A to launch station, m

l_3 - distance from optical gauge post B to launch station, m

θ - off-vertical deflection angle, ...°

α, β - angles in horizontal plane between the straight line connecting the optical gauge posts and the straight lines connecting each of the optical gauge posts with the projection of the PA triggering point respectively, ...°

α_1, β_1 - angles in horizontal plane between the straight line connecting the optical gauge posts and the straight lines connecting each of the optical gauge posts with the projection of the launch station respectively, ...°

σ, σ_1 - angles in vertical plane between horizontal plane and bearings from each optical gauge post to the PA triggering point respectively, ...°

For subsection 6.5:

$K_{1(2)}$ - scaling factor of video camera 1 or 2 image, mm^{-1}

$L_{1(2)\Pi} = \sqrt{(L_{\Pi}^2 - \Delta_{H_p}^2)}$ - scaled distance from video recorder 1 or 2 to launch point, m

$L_{1(2)B} = \sqrt{(L_B^2 - (\Delta_{H_p} - \Delta_{H_в})^2)}$ - scaled distance from video recorder 1 or 2 to stake base, m

Δ_{H_p} - altitude of recorder point above launch point, m

$\Delta_{H_в}$ - altitude of stake base over launch point, m

$\Delta_в$ - horizontal deflection of stake base from video recorder axis, m

H_p - PA burst height, m

H - elevation of a tested object above the launch point's horizontal plane, m

$H_в$ - stake height/length, m

$h_{1(2)}$ - vertical dimension/deflection of a tested point image on a monitor of video camera 1 or 2, mm

$\delta_{1(2)}$ - horizontal dimension/deflection of a tested point image on a monitor of video camera 1 or 2, mm

$\Delta_{1(2)}$ - deflection of the projection of a tested point onto the horizontal plane of the launch point determined by recording with video camera 1 or 2

R - deflection of the projection of a tested point onto the horizontal plane from the launch point (radius), m

V - velocity of motion in a given trajectory segment, m/s

E - kinetic energy, J

m - moving object mass, kg

g - free-fall acceleration, 9.8 m/s ^{2}

γ - off-vertical deflection of a given trajectory segment, ... °

$X_{1, 2, ..., n}$ - determinations of values of a tested parameter in a separate sample/group of observations

$X_{\text{ср}1, 2, ..., k}$ - sample mean value of a tested parameter in a separate sample

$X_{\text{рез}}$ - observation result of a tested parameter

$\sigma_{1, 2, ..., k}$ - sample variance of a tested parameter in a separate sample

$\sigma_{\text{рез}}$ - variance of a tested parameter

n - number of averaged observation values in a sample

k - number of parallel test groups/samples of an article in determination of a tested parameter

f - number of degrees of freedom in a variance

For subsection 6.6:

h_1, h_2, h_3 - radiometer indications during calibration, mm

$I_{\text{л}}$ - radiation intensity of a lamp, W/sr

$R_{\text{г}}$ - calibration base, m

$R_{\text{и}}$ - gauge length, m

$I_{\text{ном}}$ - rated expected radiation intensity, W/sr

$h_{\text{и max}}$ - maximum ordinate value in a radiation diagram, mm

$h_{\text{и}1}$, $h_{\text{и}2}$ - respectively first and second ordinates of a radiation diagram, or a working area of a radiation diagram if it is foreseen in the PA documentation

n - number of ordinates of a radiation diagram's working area

$h_{\max}$ - maximum radiation ordinate value, mm

E - threshold value of flux per unit area of thermal radiation according to GOST R 51270, W/m ^{2}

R - danger zone radius, m

For subsection 6.7:

v_i - shock wave propagation velocity at the i th portion between primary measuring transducers, m/s

R_i - distance between adjacent primary measuring transducers, m/s

t_i - time for the shock wave to go the distance R_i, s

$P_{\text{в}}$ - atmospheric pressure at the day of test, MPa

$T_{\text{в}}$ - Air temperature at the day of test, K

R - danger zone radius, m

For subsection 6.9:

$R_{\text{р}i}$ - burst radius of the i th PE dummy, m

n - number of PE dummies, pcs.

σ - mean square deviation of the PE dummy burst radius

$R_{\max}$ - maximum burst radius of PE dummies, m

For subsection 6.10:

L - distance from PA to the target frame, m

α - deflection angle of PA flight trajectory from the aiming line, ...°

$L_{\text{р}}$ - distance between target frames, m

$\tau_{\text{пр}}$ - time for PA to fly the distance $L_{\text{р}}$, s

$v_{\text{п}}$ - PA flying velocity, m/s

m - PA mass, kg

Q - PA energy, J

S - area of contact of PA with an obstacle at the time of collision, cm ^{2}

$Q_у$ - PA specific energy, J/cm ^{2}

For subsection 6.11:

I - PA candle power, cd

$t_г$ - eye closing time (equal to 0.2 s), or PA glowing time if it is less than eye closing time or PA working time, when needed to observe the light radiation, s

$H_{с.н}$ - light radiation level, J/m ^{2}

$R_{з.о}$ - danger zone size, m

For subsection 6.12:

J_r - measured value of sound level, dBA

r - microphone to PA distance, m

For subsection 7.1:

l - channel length, m

$f_{пр}$ - pressure variation process frequency, Hz

$\tau_д$ - minimum preset/expected time to reach the maximum pressure value, s

$\gamma_н$ - nonlinearity of calibration curve, %

$X_i - X_{i-1}$ - difference of neighboring calibration levels, mm

X_{max} - maximum calibration level, mm

n - number of calibration levels when loading/unloading a measuring transducer

i - index that designates the sequential number of a calibration level

χ - recorded output signal value, mm

y - calibration level value that corresponds to a recorded output signal value, MPa

P - pressure in a PA at an arbitrary moment of time τ, MPa

$t_н, t_к$ - moments of time of the start and the end of a PA working interval, s

$\tau_{зад}, \tau_{вых}, \tau_{p\,max}, \tau_{p\,min}, \tau_п$ - time of delay of a process start, conditioning, achieving a maximum or minimum parameter value, and full PA working time, respectively, s

P_{max}, P_{min} - maximum and minimum pressure in a PA respectively, MPa

For subsection 7.2:

$\tau_{дт}$ - tome to achieve a maximum or steady-state value of a measured parameter, s

$X_i - X_{i-1}$ - difference of neighboring calibration levels, mm

X_{max} - maximum calibration level, mm

n - number of calibration levels when loading/unloading a measuring transducer

$\gamma_{н}$ - nonlinearity of calibration curve, %

$t_{н}$, $t_{к}$ - moments of time of the start and the end of the PA working interval, s

$\tau_{зад}$, $\tau_{вых}$, $\tau_{реж}$, $\tau_{р}$ - time of delay of a process start, conditioning, PA working time, and achieving a typical parameter value, respectively, s

R_{max}, R_{min} - maximum and minimum thrust value respectively, N

R_{τ} - thrust value at an arbitrary moment of time τ, N

$J_{п}$ - full thrust impulse, N·s

F_{max} - maximum recoil force value, N

For subsection 7.3:

W_i - PA ignition energy, J

C - electric capacity of a capacitor, F

U - electrical voltage across a capacitor, V

n - number of measurements

For subsection 8.1:

D - total random-process variance in a respective frequency band, m^2/s^4

τ - doubled shock acceleration peak rise time, s

t - testing duration, s

L - length of haul, km

N - number of impacts per 1 km of the road

$f_{в}$, $f_{н}$ - respectively upper and lower frequencies of the vibration test band, Hz

$f_{ср}$ - mean frequency of the vibration test band, Hz

$t_{с}$ - reduced testing duration, s

$W_{с}$ - increased amplitude of a forced test, m/s^2

$W_{н}$ - vibration acceleration amplitude at normal test mode, m/s^2

k - exponent in a forced test

Section 4 (Revised edition, Rev. 1)

5 Sampling

5.1 Number of PA to be sampled and rules for PA sampling and preparation for testing should be established by a duly approved test program.

5.2 Where a test program does not specify the number of PA to be tested, for the purposes of confirming conformity 12 PA are to be sampled but in any case no fewer than two consumer packages.

5.1, 5.2 (Revised edition, Rev. 1)

6 Methods for determining hazard parameters

6.1 Flame size determination method

The method allows for determining the dimensions of flame and the burst radius of sparks (burning elements) flying out of the flame during operation of PA. The essence of the method is to make video recording of a working PA's flame and compare the flame dimensions with the reference image on a monitor or TV screen. Measurement error: no more than 10 %.

6.1.1 *Test means and auxiliaries*

6.1.1.1 Video camera: 2 pcs.

6.1.1.2 Pole whose length is 0.3 to 1.0 of the expected flame length or burst radius of burning fragments.

6.1.1.3 Ruler as per GOST 427 or tape measure as per GOST 7502.

6.1.1.4 Device of any type to fix a PA at the test site.

6.1.1.5 Video tape recorder whose format of play corresponds to the format of record of the image by video cameras as per 6.1.1.1.

6.1.1.6 Monitor or TV set.

6.1.2 *Procedure for preparing and conducting tests*

6.1.2.1 The tests are to be conducted in an open air at night or in darkened premises at least 6x6x3.5 m in size.

6.1.2.2 Mount the PA fixing device and video cameras so that the latter stand at least three expected flame sizes apart and the rays connecting each of the video cameras with the PA fixing device stand at angle of 90°±3°.

6.1.2.3 Mount the pole on the PA fixing device (hereinafter the device) vertically with the permitted deviation of maximum 3°.

6.1.2.4 Using the zoom lenses of the video cameras, set an image recording scale with which the recorded flame will fully fit in the field of view of each of the cameras.

6.1.2.5 Record the pole with each camera.

6.1.2.6 Fix the PA in the device so that the flame is directed upwards.

6.1.2.7 Kindle the PA in accordance with its instructions for use.

6.1.2.8 Record with the cameras the burning article over the whole time of its work.

6.1.3 *Procedure for processing test results*

6.1.3.1 Play the video footage of the test on a monitor or a TV set using a video tape recorder.

6.1.3.2 Determine the scaling factor as

$$K = \frac{L}{l} . (1)$$

6.1.3.3 Determine the flame length as

$$L_{\Pi} = K \cdot l_{\Pi} . (2)$$

6.1.3.4 Determine the flame width (spreading of sparks) as

$$D_{\Pi} = K \cdot h_{\Pi} . (2a)$$

If the flame is an axially symmetric figure, then the values mentioned in 6.3.3.3 and 6.1.3.4 are to be determined using formulae (2) and (2a). Out of the entire footage, the frame with the maximum width of flame (spread of sparks) is to be used for the processing, and a single video camera may be used for the testing.

If there is no symmetry in the flame, use footages from two cameras to determine the parameters of 6.1.3.3 and 6.1.3.4. Use the greatest value as the measurement results in this case.

Subsection 6.1 (Revised edition, Rev. 1)

6.2 Method for measuring flame sizes and pyrotechnic article surface temperature (method 1)

This method is used for making measurements and calculations to determine the distribution of brightness temperatures on surface of a radiating object visualized by an infrared camera. The object of determining brightness temperature fields are the thermal zones occurring with the burning PTC: flame and body of PA. The method is based on dependence of the thermal radiation of the object on its surface temperature.

A pyrovidicon infrared camera remotely makes contactless offline conversion of the measured thermal radiation in the infrared region into a video signal with scanning of the radiating object field in a television standard. The image brightness is translated into a temperature distribution by grading against a black body radiation using a set of image processing programs.

This method ensures measuring brightness temperature fields between 20°C and 2400°C on surface of heated objects.

The relative error of the method depends on the upper and lower boundaries of the brightness temperature range and on the measuring mode and is between ±10% (for the upper boundary of the temperature range) and ±35% (for the lower boundary) (appendix A).

The timing resolution in determination of brightness temperature fields is 40 ms.

The following conditions must be observed during testing:

Ambient temperature between 5°C and 30°C for pyrovidicon infrared camera; between 15°C and 35°C for all other equipment; maximum air humidity up to 80% at +25+1°C. Atmospheric pressure between $7.98 \cdot 10^{4}$ to $1.06 \cdot 10^{5}$ Pa.

Levels of vibration, electromagnetic and radio frequency interferences should be established in the documentation of the measuring instruments.

6.2.1 *Test means and auxiliaries*

6.2.1.1 Pyrovidicon infrared camera of Video Term 92 type with germanium lens (hereinafter infrared camera). Infrared camera characteristics: image standard: 625 lines, 25 frames per second; video output 1 V/75 Ohm; spectral sensitivity range 3-14 μm; lens angle 18°.

6.2.1.2 Optical filters whose bandwidth and center wavelength are situated in atmospheric transmission bands 3-5 and 8-14 mm respectively.

6.2.1.3 Videorecorder of VO-7630 type with a control monitor (hereinafter the monitor) providing a video output 1+0.2 V/75 Ohm and signal-to-noise ratio over 46 dB.

6.2.1.4 Personal computer (PC) of IBM PC type with a color graphic printer and an operating system of MS-DOS type of version 5.0 or above.

6.2.1.5 PITMIN and WORKIMA image processing software packages and an image printing program.

6.2.1.6 PITER-500 interface unit for transmission of images from the video recorder to the PC. Operating frequency 10 MHz, video memory space 512 Kbyte, number of analog-to-digital converter (ADC) 8 bits.

6.2.1.7 Stand rod for an infrared camera of any type.

6.2.1.8 AC mains/generator with voltage 220+22 V, frequency 50+1 Hz, and power no lower than 300 VA.

6.2.1.9 Tape measure as per GOST 7502 at least 1 m long.

6.2.2 *Procedure for preparation of tests*

6.2.2.1 Locate the infrared camera at the defined distance (gauge length) from the PA mounting place. Select the specific distance L depending on the expected sizes of the d thermal zone and the angle of view of the γinfrared camera lens: $L \geq d/(2\,\mathrm{tg}\,(\gamma/2))$. Protect the infrared camera from the possible mechanical damage with a shock wave and fragments upon triggering of PA. Place the infrared camera on the strand rod if necessary.

6.2.2.2 Connect the instruments to the AC mains/generator with power cables in accordance with the user manual.

6.2.2.3 Switch on and set up the infrared camera and the video recorder as specified by their user manuals. Connect the said camera's output to the video recorder's input with a coaxial cable in parallel with the monitor.

6.2.2.4 Before mounting the PA to be tested, determine the scale of the resulting image by recording with the infrared camera the sources of radiation located at the PA mounting place at a known distance from each other.

In test field conditions, the sources of radiation in the infrared band may be, for example, white flares. For the scaling purposes it is allowed to use any inert body of known geometry heated up above the background level.

Select the distance between the scaling radiation sources depending on the base so that the distance between the images of the sources on the monitor is a t least 10 mm.

6.2.2.5 Observing the thermal picture of the scaled image through the infrared camera's viewfinder, set up the camera by adjusting the lens to get sharp image. Record it with the video recorder for at least 30 s.

6.2.2.6 Set the infrared filter foreseen by the test program onto the infrared camera lens.

6.2.2.7 Set the camera lens aperture using the calibration chart (appendix B) according to the expected maximum brightness temperature of the thermal zone of the PA combustion products or the required temperature range.

6.2.2.8 Switch the video recorder into the record mode 30-40 s before initiating the PA.

6.2.2.9 Control the PA thermal zone image recording process on the monitor as the PA burns.

6.2.2.10 As the PA is finished, switch off the video recorder 30-60 s later.

6.2.3 *Rules for processing test results*

6.2.3.1 Connect the video recorder output to the PC interface unit and the interface unit to the monitor input with proper cables. Connect the graphic printer to a parallel interface of the PC.

6.2.3.2 Switch on the video recorder, the monitor, the printer, and the PC and set them up as required in accordance with their user manuals.

6.2.3.3 Boot the PC's operating system and execute the PITMIN.BAT command file to initiate the image processing software.

6.2.3.4 Using the still picture mode of the video recorder, select on the monitor a suitable image frame that corresponds to a certain moment of evolution of the thermal zone.

6.2.3.5 Bring the selected image frame into the PC RAM and write it as a data file into the PC memory using the PITMIN software package. Repeat the same operation for all image frames to be processed.

6.2.3.6 Find the scaling factor from the ratio of the actual object size to its size in the image.

6.2.3.7 Process each data file with the WORKIMA software for displaying the image on the PC screen. Enter initial data for processing such as ambient temperature, image scale, gauge length, lens f-number during measurement, frame number and filter number. Temperature grades on the object image in its different parts are coded with colors, each color being assigned its own temperature range obtained from calibration of the camera (appendix B).

6.2.3.8 Write the object's resulting thermograms into files. Print every image frame processed and saved in 6.2.3.6 and 6.2.3.7 on the color printer to get a hard copy.

6.2.3.9 Make a report of the test results so processed. Enclose the set of hard copies of image frames to the report.

6.2.3.10 Find the actual size of a whole thermal zone or any part thereof by multiplying the measured size on the image by the scaling factor.

6.3 Method for measuring flame sizes and pyrotechnic article surface temperature (method 2)

This method allows for measuring PA flame or body temperature when testing the PA using thermocouples.

The measurement error does not exceed 10%.

6.3.1 *Test means and auxiliaries*

6.3.1.1 Time marker of any type with accuracy within 0.5%.

6.3.1.2 Thermoelectric converter (hereinafter thermal converter) as per GOST R 50342.

6.3.1.3 Thermocouples L as per GOST R 8.585.

6.3.1.4 Light-beam oscilloscope as per GOST 9829.

6.3.1.5 Self-balancing servoinstrument as per GOST 7164.

6.3.1.6 Universal measuring instrument R4833 as per [2].

6.3.1.7 Temperature measuring device including all of the following features:

6.3.1.7.1 PA fixing assembly that keeps the PA securely in place during testing.

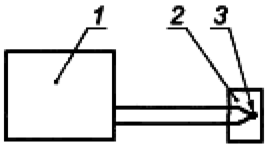
6.3.1.7.2 Fastening assembly for thermocouples that allows for varying their position between 20 and 500 mm radially and between 20 and 1500 mm axially.

6.3.1.8 Technical ethyl alcohol as per GOST 17299 or rectified ethyl alcohol as per GOST 18300.

6.3.1.9 Thermocouple cable of any type (specific resistance from $0.33 \cdot 10^{-6}$ to $0.68 \cdot 10^{-6}$ Ohm·m, insulation resistance no lower than 10000 Ohm) with wire cross-section no smaller than 0.5 mm^2.

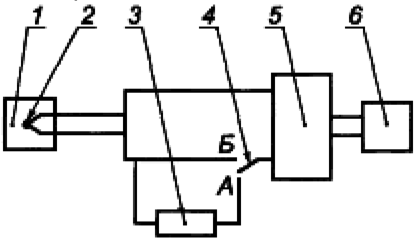
6.3.2 *Procedure for preparing tests*

6.3.2.1 Assemble the measurement setup according to figure 1 or 2.



1 - KSP-type potentiometer; *2* - PA under test; *3* - thermal converter

Figure 1 - Structural diagram for temperature measurement without measuring circuit calibration



1 - PA under test; *2* - thermal converter; *3* - R4833 universal measuring instrument; *4* - switch; *5* - oscilloscope; *6* - time marker

Figure 2 - Structural diagram for temperature measurement with measuring circuit calibration

6.3.2.2 The diagram shown in figure 1 allows for measuring temperature in PA action processes at least 1 s in duration without pre-calibrating the measuring circuit.

6.3.2.3 The diagram shown in figure 2 allows for measuring temperature in PA action processes at least 0.1 s in duration with pre-calibration of the measuring circuit.

6.3.2.3.1 Turn switch *4* into position A (figure 2).

6.3.2.3.2 Break down the expected range of the measured thermal electromotive force (t-emf) into 5 or 6 equal intervals considering the thermocouple type and the maximum expected temperature (subject to the cold junction temperature) in accordance with the nominal static characteristics of the thermocouples stated in GOST R 8.585.

6.3.2.3.3 Set the selected t-emf level on the potentiometer.

6.3.2.3.4 Turn on the oscilloscope and record the calibration value of t-emf.

6.3.2.3.5 Calibrate the test setup at least 1 time every month and also each time any of the setup elements are changed.

6.3.2.4 Use metal or wire clamps to fasten a thermocouple on PA body.

6.3.2.5 Mount the PA into the fastener's seat.

6.3.2.6 Locate the thermocouples in the temperature measurement points. Specify the positions and the number of thermocouples in the test program.

(Revised edition, Rev. 1)

6.3.3 *Procedure for testing*

6.3.3.1 Set an oscillograph photopaper/paper tape travel speed and a time marking frequency sufficient for deciphering the PA action process record in time.

6.3.3.2 Turn on the recording instrument, i.e. an oscilloscope or a plotter. Turn switch *4* into position *Б* (see figure 2).

6.3.3.3 Activate the PA.

6.3.3.4 Record the temperature for the length of time set by the test program.

6.3.3.5 Once the tests are over, turn off the recording equipment.

6.3.3.6 Dismantle the thermocouples.

6.3.4 *Procedure for processing test results*

6.3.4.1 When making measurements with a setup shown in figure 1, read the temperature values and write them down in the test report.

6.3.4.2 When making measurements with a setup shown in figure 2, plot the calibration curve.

6.3.4.3 Measure the ordinates of deviation of the galvanometer light spot from zero position at reference voltage values on the calibrating oscillogram with absolute error of ±0.5 mm.

6.3.4.4 Plot the calibration graph as a t-emf value vs. galvanometer light spot off-zero deviation curve.

6.3.4.5 Measure the galvanometer light spot deviation on the working oscillogram with absolute error ±0.5 mm.

6.3.4.6 Determine by the calibration curve the t-emf value that corresponds to each deviation.

6.3.4.7 Add to the measured t-emf value the t-emf value corresponding to the cold junction temperature and determine the temperature value for the total t-emf as per GOST R 8.585.

6.3.4.8 Register the processed results in the test report.

6.4 Method for determination of trajectory characteristic points (method 1)

This method determines the rise height, the burst height, the post-combustion height, the angle of divergence from the firing direction, and the burst radius of glowing PA elements (signals and fireworks).

The essence of the method is that optical instruments (e.g. theodolites) are applied to intersect the point of activation of a PA on its trajectory by any light effect and then to calculate the point's coordinated by formulae.

The error of this method does not exceed 10%.

It is not recommended to use this method if the slewing velocity of a flying PA or a PA element during measurements is more than 0.5 rad/s.

Meteorological conditions at which the testing is not allowed:

a) thunderous state of the atmosphere, intensive evolution of thunderclouds, approaching storm;

b) quickly changing weather with squally wind near the ground;

c) ground wind speed above 5 m/s unless specified otherwise in the test program;

d) fog, mist and precipitations that hinder intersecting trajectory points.

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6.4.1 *Test means and auxiliaries*

6.4.1.1 Optical gauge of any type with which it is possible to determine the spatial position of an object:

- horizontally ±75° from the initial position,

- vertically 0° to 60°,

- angle change rate in both planes up to 0.5 rad/s.

An example of such an optical device can be:

- theodolite as per GOST 10529 equipped with a collimator sight;

- aiming circle.

At least two optical gauges are to be used at the same time to determine every parameter during test.

6.4.1.2 Weather station of any type or a set of instruments for measuring air temperature, wind speed and direction.

6.4.1.3 Test site that includes the following:

- control station,

- shelter for operators,

- launch station,

- optical gauge posts.

6.4.1.3.1 Select a place for the launch station so as to ensure distribution of all trajectory points foreseen by the test sight during the shooting.

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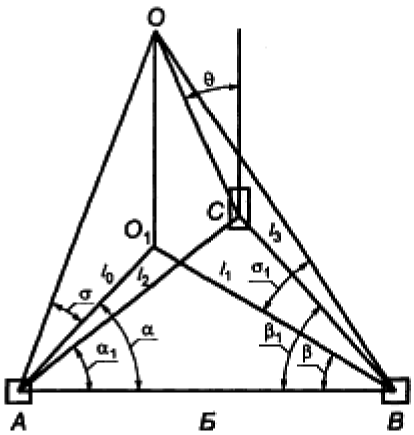
6.4.1.3.2 Select a place for the optical gauge posts so as to ensure direct visibility between the points, and in respect to the launch station the optical gauges should be arranged so that the horizontal angles of intersection from the points to the launch station are within 30°-150°.

Vertical angles of intersection should be no less than 10° but no greater than those permitted for this type of optical gauge. The recommended arrangement of the optical gauges and the launch station is shown in figure 3.



A and B - optical gauge posts; C - launch station; O - PA activation point; O_1 - projection of PA activation point onto horizontal plane

Figure 3 - Recommended arrangement of optical gauge posts and launch station

6.4.1.3.3 The optical gauge posts and the launch station are to be located on the same level. It allowed to locate the optical gauge posts and the launch station in different levels and take the difference into account if it exceeds ±1% of the height of the recorded trajectory point.

6.4.1.4 Radio or telephone communication between the optical gauge posts and the control station.

6.4.1.5 Optical coincidence rangefinder with root-mean-square error of measurement no higher than 8 cm per 100 m.

6.4.2 *Procedure for preparation of tests*

6.4.2.1 Select a place for the optical gauge posts according to 6.4.1.3.2 and 6.4.1.3.3.

6.4.2.2 Check that the launch station and the radio or telephone communication system are ready for the test.

6.4.2.3 Mutually orient the optical gauges by aiming them towards each other and setting zero indications on the horizontal scales or by recording the scale indications and assuming them to be the reference (conventional 0). Determine the horizontal angles of intersection to the launch station from each optical gauge post.

6.4.2.4 Use the rangefinder to measure the distance between the optical gauges, between each optical gauge and the launch station. It is allowed to measure the distances by any other method with error within 1%.

6.4.2.5 Determine the difference of location levels of the optical gauges and the launch station as

$$h = a \times \sin\delta . \quad (3)$$

6.4.2.6 Where theodolites with collimator sights are used as the optical gauges, adjust them mutually by any remote point.

6.4.2.7 Aim the optical gauges onto the expected PA activation point and inform the station post that the test is ready.

6.4.3 *Procedure for testing*

6.4.3.1 Upon the ready signal from the optical gauge posts, launch the PA.

6.4.3.2 Intersect the PA flight trajectory points mentioned in the test program.

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6.4.3.3 Read the angles by the scales of the optical meters.

6.4.3.4 To exclude possible subjective errors in the test, it is recommended to intersect the PA flight trajectory points from every optical gauge post with several optical gauges simultaneously.

6.4.4 *Rules for processing test results*

6.4.4.1 Using the measurement data on each optical gauge post (A and B), calculate the height of each of the PA flight trajectory point specified in the test program, the danger zone radius, the angle of divergence from the firing direction (when shooting straight up), and the PA post-combustion height.

Determine the danger zone radius as the distance from the launch station to the projection of the remotest glowing point of the working PA onto horizontal plane.

The test program may include determination of other trajectory characteristics, too.

6.4.4.2 Determine the height of each of the flight trajectory points specified in the test program from each optical gauge post using the formulae:

$$H_A = E\frac{\sin\beta \cdot \mathrm{tg}\,\delta}{\sin(\alpha+\beta)} \pm h_A ; \quad (4)$$

$$H_B = E\frac{\sin\alpha \cdot \mathrm{tg}\,\delta}{\sin(\alpha+\beta)} \pm h_B . \quad (5)$$

Use the 'plus' sign in formulae (4) and (5) where the optical gauges stand higher than the launch unit, or the 'minus' sign if lower than the launch unit.

Where the flight trajectory point heights are determined by one theodolite from each post and the distance between the calculated values of H_A and H_B is more than 20%, the smallest value being taken as 100%, the test should be considered unsuccessful.

With the difference between H_A and H_B less than 20%, all tests are to be considered successful, and the evaluation is to be made by the average H_{cp} value of H_A and H_B:

$$H_{cp} = \frac{H_A + H_B}{2}. \quad (6)$$

6.4.4.1, 6.4.4.2 (Revised edition, Rev. 1)

6.4.4.3 Determine the danger zone radius as

$$R = \frac{R_{\text{пор}\,A} + R_{\text{пор}\,B}}{2}, \quad (7)$$

where

$$R_{\text{пор}\,A} = \sqrt{l_0^2 + l_2^2 - 2 l_0 l_2 \cos(\alpha - \alpha_1)}; \quad (8)$$

$$R_{\text{пор}\,B} = \sqrt{l_1^2 + l_3^2 - 2 l_1 l_3 \cos(\beta_1 - \beta)}; \quad (9)$$

$$l_0 = B \frac{\sin \beta}{\sin(\alpha + \beta)}; \quad (10)$$

$$l_1 = B \frac{\sin \alpha}{\sin(\alpha + \beta)}. \quad (11)$$

Distances l_2 and l_3 may be measured in the field according to 6.4.2.4.

6.4.4.4 Determine the off-verticality angle with the shooting vertically up as

$$\theta = \operatorname{arctg} \frac{R}{H_{cp}}. \quad (12)$$

Determine R using formula (7).

6.5 Method for determination of trajectory characteristics

This method determines the coordinates of the points of activation/burst, rising, and post-combustion, the angle of divergence from the firing direction, the motion speed of a PA equipped with a tracer or a working propeller, and the burst radius of burning/glowing elements. The method can also be used to determine the boundaries and sizes of colorful or glowing aerosol forms (smokes). The sizes in this case are determined by the coordinates of boundary points of the form under study.

The essence of the method is to visualize the PA flight trajectory by video recording and writing down the observation results and processing the image by a preset algorithm. The error of this method does not exceed 10%.

6.5.1 *Test means and auxiliaries*

6.5.1.1 Video camera: 2 pcs.

6.5.1.2 Stationary or portable stake 20-50 cm tall (5-20 m for a portable stake).

6.5.1.3 Tape measure as per GOST 7502.

6.5.1.4 Test site with launch units (LU) equipped in the central area for launching PA. The size of each side of the site should be at least three times the danger zone radius. Adjoined to the site in two mutually perpendicular directions should be corridors passing through the central area, their widths and lengths to be sufficient for video shooting the entire flight trajectory of the observed elements from the launch station to the point where the burning elements fade out or fall to the ground.

6.5.1.5 Ruler as per GOST 427.

6.5.1.6 Devices for uninterruptible two-way communication between the LU operators and the video cameras.

6.5.2 *Procedure for preparation of tests*

6.5.2.1 Install/check he stakes vertically with deflection not exceeding 3°.

6.5.2.2 Place the LU in the center of the test site.

6.5.2.3 Install and align the video cameras about the LU horizontal plane in two mutually perpendicular directions so that both cameras could see the whole trajectory of flight and positions of the stakes and the launching point is displayed in the middle of the bottom part of the viewfinder screen of each camera.

6.5.2.4 Zoom the cameras so that the aperture of each camera accommodate all the studied trajectory points with 20% to 30% margin and the stake's image be as large as possible but in any case no smaller than 20% of the frame height. If the said requirements cannot be combined, change locations of the cameras or the stakes. Make a short record of the image of the test site and later the position of the cameras and the stakes. Avoid changing the focal distance of camera lenses unless absolutely necessary.

6.5.2.5 Check the sample and prepare it for testing. Enter the sample data and any remarks to its condition into the job log.

6.5.2.6 Measure and report in the job log the distances from each video camera to the launch station and the stakes, height of the stakes, altitudes of the video cameras and the stake bases above the LU location, and also the list and data of the instruments and equipment, weather conditions and the test code.

6.5.3 *Procedure for testing*

6.5.3.1 Arm the launch system with the PA to be tested.

6.5.3.2 Prepare the video cameras for recording and communicate a ready-to-register signal to the launch system. When commanded to start, the operators should confirm the command and turn on their cameras.

6.5.3.3 Launch the PA.

6.5.3.4 Make video recording until all images of the objects under study vanish completely. During registration, use the audio channel (or the job log) to coordinate with the launch system operator and register the code of this footage/test, the camera's number, and any possible comments of visual observations. Transmit a recording-is-over signal to the launch station and turn off the cameras.

6.5.3.5 The option to show the date and time should be activated in the video cameras during setup and recording.

6.5.3.6 If any violation of 6.5.2.3 or 6.5.2.4 is found, stop the test and readjust the recording system according to 6.5.2.3 and 6.5.2.4 and repeat the test.

6.5.4 *Rules for processing test results*

6.5.4.1 Analyze the test program and enter into the primary processing report/job log the test object data, the names of all parameters under study, the data foreseen by 6.5.2.5 and 6.5.2.6 (from the test log), the data of the information carriers and the instruments and tools used for the processing, the necessary comments (if any) and the current date.

6.5.4.2 Analyze the video records of both cameras and make a decision on that basis if one of them can be chosen as the main one.

6.5.4.3 For each camera, measure the sizes of images of all tested trajectory points and stakes on the monitor or TV set screen and enter their values into the report/job log.

6.5.4.4 For each camera, determine the scaled distances and elevations of launch points and stakes. For the cases where a scaled distance differs from the initial one by no more than 5%, it is allowed to use the initial values. Enter the values that will be used for further processing into the report/job log.

6.5.4.5 For each camera, calculate scaling factors

$$K_{1(2)} = \frac{H_в}{h_в \cdot L_в} \text{ or } K_{1(2)} = \frac{\Delta_в}{\delta_в \cdot L_в} . \quad (12a)$$

6.5.4.6 For the points under study, determine deflections of their projections to the LU plane from the centerlines of cameras

$$\Delta_1 = \frac{K_1 \cdot \delta_1 (L_{1П} + K_2 \cdot \delta_2 \cdot L_{2П})}{1 - K_1 \cdot K_2 \cdot \delta_1 \cdot \delta_2} \text{ and } \Delta_2 = \frac{K_2 \cdot \delta_2 (L_{2П} + K_1 \cdot \delta_1 \cdot L_{1П})}{1 - K_1 \cdot K_2 \cdot \delta_1 \cdot \delta_2} . \quad (12b)$$

6.5.4.7 If the projection of a point under study on the monitor screen lies to the right of the launching point, the respective deflection δ is considered positive, otherwise negative. If necessary, calculate deflections of projections (burst radius) of the points under study from the launching point

$$R = \sqrt{(\Delta_1^2 + \Delta_2^2)} . \quad (12c)$$

6.5.4.8 For the points under study, determine their deflections from the LU plane (height)

$$H_1 = K_1 \cdot h_1 \sqrt{(\Delta_1^2 + (L_{1П} + \Delta_2)^2)} \text{ and } H_2 = K_2 \cdot h_2 \sqrt{(\Delta_2^2 + (L_{2П} + \Delta_1)^2)} , \quad (12d)$$

$$H = \sqrt{(H_1^2 + H_2^2)} . \quad (12e)$$

6.5.4.9 Assume Δ_1, Δ_2 and H as coordinates of any visible trajectory point in the coordinates system with the origin in the launching point.

6.5.4.10 When determining the apex of trajectory, use the main camera's frame with the highest h_1, record the moment of time and determine deviations in the second camera's frame for the same moment of time. Use the relationships of (12d) and (12e) to find the height in question. If no main camera has been chosen, proceed as above for each camera and take the mean value as the result.

6.5.4.11 When determining the post-combustion height, use the main camera's frame with the lowest h_1, record the moment of time and determine deviations in the second camera's frame for the same moment of time. Use the relationships of (12d) and (12e) to find the height in question. If no main camera has been chosen, proceed as above for each camera and take the mean value as the result.

6.5.4.12 When determining the motion speed of a glowing object in a specific trajectory portion, select images of the two utmost points of that portion (1 and 2), determine the coordinates and the moments of time of passage for those points, the distance between them, and the speed of travel as the quotient of distance and time.

6.5.4.13 Obtain the kinetic energy value of the object motion from the results of determination of the motion speed in this trajectory portion and the mass of the object according to preliminary weighing.

It is allowed to evaluate the kinetic energy of a firework article motion from the results of determination of the burst height and its mass as

$$E = m \cdot g \cdot H_{\text{р}} . \quad (12f)$$

6.5.4.14 Determine directionality of the object's flight by using formulae (12a) and (12d) to determine the coordinates of two selected trajectory points (1 and 2) and the flight path angle as

$$\gamma = 90° - \text{arctg} \frac{(H_2 - H_1)}{(\Delta_2 - \Delta_1)} . \quad (12g)$$

6.5.4.15 If there is a large number of objects observed simultaneously that cannot be unambiguously identified, in the images of both cameras, to determine the post-combustion radius, select two objects with the greatest positive and negative horizontal deflections of the combustion point $|\delta_1|_{\max}$ in the image of the main camera (1) and record the indication of a timer at the moment when they vanish from screen. In the frames of the second camera that correspond to the recorded moments of time, highlight the objects with the greatest positive horizontal deflection $\delta_{2\max}$. For the selected values of δ_1 and δ_2 , using formulae (12b) and (12c), determine the deviations of post-combustion points and the post-combustion radius.

If the resulting values differ significantly, take the greatest value as the observation result. If the difference between the resulting values does not exceed 5%, take their mean value as the observation result.

If no main camera has been chosen, proceed as above for each camera.

6.5.4.16 If there is a large number of objects observed simultaneously that cannot be unambiguously identified, in the images of both cameras, to determine the post-combustion height, select the object with the smallest vertical deflection (h_1) of the combustion point in the image of the main camera and record the indication of a timer at the moment when it vanishes from screen. In the frame of the second camera that corresponds to the recorded moment of time, highlight the object with the greatest negative horizontal deflection. For the selected object of observation of the main camera, determine the height of the post-combustion point and its deflection from projection using formulae

$$H_1 = K_1 \cdot h_1 (L_{1\Pi} + \Delta_2) \text{ and } \Delta_2 = K_2 \cdot \delta_2 \cdot L_{2\Pi} . \quad (12h)$$

If no main camera has been chosen, proceed as above for each camera.

If the resulting values differ significantly, take the smallest value as the observation result. If the difference between the resulting values does not exceed 5%, take their mean value as the observation result.

6.5.4.17 When determining the burst radius and the post-combustion height of multi-element PA, for better precision of observation results it is recommended to select two groups, not a pair, of objects in the image of each of the main and the auxiliary cameras. A group may combine objects with deviations differing by no more than 10%. The number of objects in each group, the coordinates of selected objects and the calculation results should be recorded in the primary test report/job log.

Horizontal deflections of the auxiliary camera are to be averaged. Using the averaged value, determine the post-combustion heights of all selected objects of the main camera and make statistical processing of results with determination of the mean value, the root-mean-square deviation, and the number of degrees of freedom:

$$X_{\text{ср}} = \frac{1}{n} \cdot \sum X_i \ ; \ \sigma^2 = \frac{1}{f} \cdot \sum (X_i - X_{\text{ср}})^2 \ ; \ f = n - 1 , \quad (12i)$$

where i is between 1 and n .

If the tests have been duplicated k times, then the result to be recorded in the test report should be

$$X_{\text{рез}} = \frac{1}{k} \sum X_j \ ; \ \sigma^2_{\text{рез}} = \frac{1}{f} \sum \sigma^2_j \ ; \ f = \sum f_j , \quad (12j)$$

where j is between 1 and k .

Assess the conformity of the characteristic values received by testing with the preset requirements using the values of $X_{рез}$ averaged from all observation results considering its upper and lower values at the adopted confidence level P:

$$X_{верх (нижн)} = X_{рез} + (-) \sigma_{рез} \cdot t_{pf}, \quad (12k)$$

where t_{pf} are quantiles of Student's distribution (appendix L).

6.5.4.18 In the process of primary processing of video records, it is required to continuously check the stake image dimensions and if they match the reference record results as per 6.5.2.4. If this condition is found to be breached, stop any further processing and investigate. If it is positively determined that the breach is only caused by a change in the focal length (f-length) of a camera, recalculate the angle coefficients and use the recalculated values for further calculations henceforth. Otherwise the measurement results are to be canceled. All detected facts of detuning, their causes, time of detuning (in the frame) and recalculation results or cancellations are to be recorded in the primary processing report/job log.

6.5.4.19 In cases where the symmetry of an observation object about the vertical axis is undoubtful and the measured size is substantially smaller than the distance to the video recorder, using one camera is allowed.

Subsection 6.5 (Revised edition, Rev. 1)

6.6 Method for measuring radiation intensity in infrared band

This method allows for measuring PA radiation intensity in the 0.7 to 14.0 μm wavelength band.

The method is based on comparing the irradiances created by PA flame radiation and a standard radiator in source mode A as per GOST 7721.

The confidence boundary of error of the radiation intensity measurement result is $\Delta r \leq$ 20%.

6.6.1 *Test means and auxiliaries*

6.6.1.1 Radiometer matching the following:

6.6.1.1.1 Spectral response range between 0.7 and 14.0 μm.

6.6.1.1.2 Time constant max 0.2 s.

6.6.1.1.3 Energy characteristic off-linearity max ±5%.

6.6.1.1.4 Viewing angle min 30°.

6.6.1.1.5 Permissible limit of error ±10%.

6.6.1.2 Control bulbs of PZ (floodlight) type as per [3], of SIS (light metering) type as per GOST 10771, verified at the color temperature of the source A.

Electrical parameters of the bulbs are to be checked in accordance with the diagram given in GOST 17616.

6.6.1.3 Voltmeters of 0.5 or better accuracy class with 0-150 V scale range as per GOST 8711.

6.6.1.4 Ammeters of 0.5 or better accuracy class with 0-50 A scale range as per GOST 8711.

6.6.1.5 Tape measure as per GOST 7502.

6.6.1.6 Source of direct or stabilized alternating current (50 Hz) for powering the control bulbs.

6.6.2 *Required application conditions*

6.6.2.1 PA radiation intensity is to be determined round the clock both in test bench as well as test field conditions provided that the photometering route is free from rain, snow and fog.

6.6.2.2 When measuring in daytime, the background signal amplitude on the recording instrument should be no greater than 10% of the expected signal amplitude in measurement of PA radiation intensity.

6.6.2.3 The gauge length should be larger than 5 times the maximum linear dimension of the PA's radiating surface.

6.6.3 *Procedure for preparation of tests*

6.6.3.1 Prepare the radiometer for use according to its design documentation.

6.6.3.2 Calibrate the radiometer in laboratory conditions.

6.6.3.2.1 Calibrate the radiometer three or more times on a photometry bench of FS-M type equipped with screens to prevent the radiation receiver from exposure to reflected or stray light, determining the radiometer sensitivity as the arithmetic mean.

6.6.3.2.2 Connect a SIS or PZ bulb to an adjustable source of alternating or direct current. Check the voltage using an electrical metering instrument connected directly to the bulb's power supply cap.

6.6.3.2.3 Select a calibration base so that the radiometer's indication at the expected radiation intensity is between 30% and 50% of its scale.

6.6.3.2.4 Determine the radiometer's sensitivity $S_{\text{р}}$ as

$$S_{\text{р}} = \frac{h_1 + h_2 + h_3}{3 \cdot I_{\text{л}} / R_{\text{г}}^2} . \quad (20)$$

6.6.3.3 Calculate the gauge length (distance from the radiometer's entry window to the radiation source) $R_{\text{и}}$ of the PA flame radiation (hereinafter the gauge length) as

$$R_{\text{и}} = \sqrt{I_{\text{ном}} \cdot S_{\text{р}} / h_{\text{и}}} . \quad (21)$$

6.6.3.4 Set the radiometer's receiving head on the gauge length so that the expected PA flame center or another point of guidance mentioned in the test program and the radiometer's entry window center are on the same optical axis.

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6.6.4 *Procedure for testing*

6.6.4.1 Prepare the PA for testing as described in its design documentation.

6.6.4.2 Activate the PA and record its radiation intensity as described in the radiometer's design documentation.

6.6.4.3 Check that the recording instruments are functioning normally and evaluate the burning process recording quality visually.

6.6.4.4 If necessary, adjust the gauge length and the guidance points of the radiometer.

6.6.5 *Rules for processing test results*

This method suggests techniques for processing test results when determining mean radiation intensity, radiation intensity at any moment of time, and instantaneous radiation intensity values after known intervals of time. The specific processing technique is to be stated in the test program.

(Revised edition, Rev. 1)

6.6.5.1 *Processing test results to determine mean radiation intensity of PA*

6.6.5.1.1 Determine the ordinate $h_{\text{ном}}$ of the PA nominal radiation intensity as

$$h_{\text{ном}} = (I_{\text{ном}} \cdot S_{\text{р}}) / R_{\text{н}}^2 . \quad (22)$$

6.6.5.1.2 Break down the oscillogram into time intervals $\Delta\tau$. The value of interval $\Delta\tau$ and nominal radiation intensity are to be specified in the test program.

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6.6.5.1.3 Measure the ordinates $h_{\text{н}i}$ at the end of every i th time interval.

6.6.5.1.4 Determine the mean value of ordinate $h_{\text{ср}}$ as

$$h_{\text{ср}} = \left(\frac{h_{\text{н}1} + h_{\text{н}n}}{2} + \sum_{i=2}^{n-1} h_{\text{н}i} \right) / (n-1) . \quad (23)$$

6.6.5.1.5 Determine the radiation intensity $I_{\text{н}i}$ at any moment of time τ_i as

$$I_{\text{н}i} = (1 / S_{\text{р}}) R_{\text{н}}^2 h_{\text{н}i} . \quad (24)$$

6.6.5.1.6 Determine the mean radiation intensity value $I_{\text{ср}}$ as

$$I_{\text{ср}} = (1 / S_{\text{р}}) R_{\text{н}}^2 h_{\text{ср}} . \quad (25)$$

6.6.5.2 *Processing measurement results to determine instantaneous radiation intensity values after time intervals* $\Delta\tau$ *specified in the test program*

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6.6.5.2.1 Break down the radiation pattern into intervals $\Delta\tau$.

6.6.5.2.2 Measure the ordinates $h_{\text{н}i}$ of the radiation pattern.

6.6.5.2.3 Determine the radiation intensity $I_{\text{н}i}$ at any moment of time τ_i using formula (24).

6.6.5.2.4 Determine the maximum radiation intensity value $I_{\text{н max}}$ as

$$I_{\text{н max}} = (1 / S_{\text{р}}) R_{\text{н}}^2 h_{\text{н max}} . \quad (26)$$

6.6.5.3 Determine the danger zone radius by the thermal (infrared) radiation as

$$R = \sqrt{I_{\text{н max}} / E} . \quad (27)$$

6.7 Method for measuring pressure in air shock waves

The essence of the method is to determine the propagation velocity of an air shock wave and use the result to calculate the maximum pressure at the air shock wave front.

The error of this method does not exceed 10%.

6.7.1 *Test means and auxiliaries*

6.7.1.1 Instrument field 25x25 m^2 equipped with measuring rays in mutually perpendicular directions with primary measuring transducers (PMT) installed on them in shelters and damage-proofed measuring lines.

Set directions of the rays with error within ±3°.

Permissible ground variation in the instrument field is max 0.03 m.

Elevation or submersion of the PMT membrane relative to the ground level is max 0.01 m. In a radius of at least 0.5 m around the PMT the ground should be leveled, with permissible variation within ±5 mm.

A support no more than 0.1 m high should be installed in the center of the instrument field to fasten the PA.

6.7.1.2 Measuring lines manufactured from radiofrequency cable with grounded shield.

6.7.1.3 Primary measuring pressure transducers with upper range value no lower than the expected pressure in the shock wave and frequency band at least 20000 Hz and intermediate measuring transducers with working frequency band no smaller than that of the PMT.

6.7.1.4 Recording means that ensure recording the measured parameters in analog form in a frequency band no smaller than that of the PMT.

6.7.1.5 Universal coordinated time equipment with time interval setting accuracy within $\pm 5 \cdot 10^{-6}$ s.

6.7.1.6 Synchronization device for PA launch and measuring and recording equipment.

6.7.1.7 Weather station of any type or a set of instruments for measuring air temperature, atmospheric pressure, wind direction and speed.

6.7.1.8 Tape measure as per GOST 7502.

6.7.2 *Procedure for preparation of tests*

6.7.2.1 Prepare the instrument field in accordance with 6.7.1.1.

6.7.2.2 Install primary measuring transducers on the instrument field rays at distances from the center and in quantity specified in the test program and connect them to intermediate measuring transducers, recording means, universal coordinated time equipment, and PA launch synchronization device.

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6.7.2.3 Measure and record in the job log the values of air temperature, atmospheric pressure and wind speed. This method is allowed for making tests at a wind speed up to 5 m/s.

6.7.2.4 Place the PA on the support in the center of the instrument field and connect it to the launching unit.

6.7.3 *Procedure for testing*

6.7.3.1 Make the measuring and recording equipment ready by following the operating instructions for that equipment.

6.7.3.2 Check operability of the synchronization device for PA launch and measuring and recording equipment.

6.7.3.3 Connect the PA's electric squib to the power source.

6.7.3.4 Activate the PA.

6.7.4 *Rules for processing test results*

6.7.4.1 Determine the shock wave propagation velocity between primary measuring transducers as

$$v_i = \frac{R_i}{t_i} . \quad (28)$$

6.7.4.2 Determine the maximum gauge pressure value P_{max} of the shock wave as

$$P_{max} = \frac{7}{6} P_{в} \left[\frac{288}{T_{в}} \left(\frac{v_i}{340} \right)^2 - 1 \right] . \quad (29)$$

6.7.4.3 Plot the graph of the maximum shock wave pressure vs. the distance to PA and determine the danger zone radius that corresponds to the dangerous pressure level as per GOST R 51270.

6.7.5 If data is available on TNT equivalent values of the PTC α and mass of the PTC in the PA M, the danger zone radius can be determined from

$$R \geq 16 \sqrt[3]{\alpha M} . \quad (30)$$

6.8 Method for determining burst radius of fragments/ejected elements of pyrotechnic articles for household use

The method implies recording disintegration of screens from a fragile material by PA fragments produced when the PA is activated.

The error of this method does not exceed 10%.

6.8.1 *Test means and auxiliaries*

6.8.1.1 The target test unit consists of vertical screens made of paper as per GOST 6445. Fix the screens to the horizontal rods mounted on poles. Load the bottom of the screens with a distributed load of at least 20 N.

A screen should be max 2 m tall, and the poles should stand at least 100 mm away from the screen.

6.8.1.2 Tape measure as per GOST 7502 or other distance metering means with relative error within 0.5%.

6.8.2 *Procedure for preparation of tests*

6.8.2.1 Make the test site free from vegetation and/or snow. Remove all foreign objects bigger than 5 mm.

6.8.2.2 Install the screens at the distance from PA specified by the program, ensuring they are overlapped.

6.8.2.3 Fasten the PA so as to make sure it will not shift during testing.

6.8.3 *Procedure for testing*

6.8.3.1 Activate the PA.

6.8.3.2 Once the PA's action is finished, inspect the site bordered by the screens.

6.8.3.2.1 Find the locations of PA fragments and unburnt pieces of PTC and measure the distance to them. Register the measurement results in the test report.

6.8.3.2.2 Inspect the screens and report any holes in them.

6.8.4 *Procedure for processing test results*

6.8.4.1 Holes in a screen should be perceived as hazard – impact of a fragment on a person.

6.8.4.2 Establish the safe impact radius by the distance to the screen that has no holes.

6.9 Method for determining burst radius of pyrotechnic elements of high-flying firework pyrotechnic articles

The method consists in organoleptic assessment of the burst radius of burning PE of specially armed firework PA dummies.

The absolute measurement error does not exceed ±1 m.

6.9.1 *Test means and auxiliaries*

6.9.1.1 Wooden stakes 20-50 mm in diameter, at least 1200 mm tall.

6.9.1.2 Tape measure as per GOST 7502 or other distance metering means with relative error within 0.5%.

6.9.2 *Procedure for preparation of tests*

6.9.2.1 Manufacture PE dummies with certain overall dimensions and mass (hereinafter the dummies) containing a smoke tracer instead of basic compounds with working time at least 1 minute long.

6.9.2.2 Arm the PA to be tested, replacing 20% of regular PE (but in any case at least four pieces) with dummies.

6.9.2.3 Write down the number of PE used for the armament in the PA documentation.

6.9.2.4 Prepare a measuring field with the radius no smaller than the danger zone radius for the PA to be tested.

6.9.2.5 Mount the launch unit.

6.9.2.6 Measure the ambient temperature and the wind speed. Testing is allowed at ambient temperatures no lower than minus 20°C and wind speed no more than 5 m/s.

6.9.3 *Procedure for testing*

6.9.3.1 Arm the PA into the launch unit and do the launching in accordance with the instructions for use.

6.9.3.2 Using the stakes, mark the position of the falling points of the PE dummies.

6.9.3.3 Measure the distance from the PA center to the points of falling of the dummies.

6.9.4 *Rules for processing test results*

6.9.4.1 Calculate the mean burst radius of the PE dummies for the series of tests $\overline{R}$:

$$\overline{R} = \frac{\sum_{i=1}^{n} R_{pi}}{n}. \quad (31)$$

6.9.4.2 Calculate the mean square deviation of the PE dummy burst radius:

$$\sigma = \left[\frac{\sum_{i=1}^{n} (\overline{R} - R_{pi})^2}{n-1} \right]^{1/2}. \quad (32)$$

6.9.4.3 Determine the maximum possible value of the PE burst radius

$$R_{max} = \overline{R} + 3\sigma. \quad (33)$$

6.10 Method for determining flight velocity and motion energy of pyrotechnic articles

The method consists in recording the time of flight of a pyrotechnic article (or a pyrotechnic element) over a gauge length bordered by target frames and determining the flight velocity and the motion energy using a specified algorithm.

The error of determination is 5% for flight velocity and 10% for energy.

6.10.1 *Test means and auxiliaries*

6.10.1.1 Target frame – an electronic, mechatronic, optical or other device that makes it possible to record the passage of a PA or any flying object through the frame and generates an electric signal at the time of the passage – 2 pcs.

The inner size of a l target frame should be no smaller than the one determined as

$$l = L \operatorname{tg} \alpha . \quad (34)$$

A target frame can be round or rectangular.

6.10.1.2 Support(s) for the target frame – of an arbitrary design.

6.10.1.3 Electronic time-interval meter capable of metering the time of flight of a PA between two target frames with accuracy within 2%.

6.10.1.4 Ruler as per GOST 427 or tape measure as per GOST 7502.

6.10.1.5 Power supply for connecting the target frame in accordance with its design documentation.

6.10.1.6 Rig for the fastening of a PA or a launch unit.

6.10.1.7 Weighing instrument capable of weighing PA or ejectable PE with accuracy within ±1%.

6.10.2 *Procedure for preparation of tests*

6.10.2.1 Arrange the target frames and the rig on the test site so that the centers of the target frames are on the PA axis and the planes of the target frames are perpendicular to the PA axis.

The distance between the PA and the target frame nearest to it and between the target frames should be 0.5 m, unless specified otherwise in the certification test program.

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6.10.2.2 Weigh the PA or the ejectable PE. Where impossible to weigh the ejectable PE before shooting, find and weigh it after the shooting or determine its mass from the design documentation.

6.10.2.3 Connect the target frames to the power supply and the time meter as prescribed by their user manuals.

6.10.2.4 Fix the PA on the rig.

6.10.3 *Procedure for testing*

6.10.3.1 Set the time-interval meter's indication to zero.

6.10.3.2 Activate the PA.

6.10.3.3 Write down the time of flight of the PA between the target frames.

6.10.4 *Rules for processing test results*

6.10.4.1 Determine the PA flying speed as

$$v_{п} = \frac{L_{р}}{\tau_{пр}} . (35)$$

6.10.4.2 Determine the flying PA energy as

$$Q = \frac{m v_{п}^2}{2} . (36)$$

6.10.4.3 Determine the specific energy of the flying PA when it meets the obstacle

$$Q_{у} = \frac{Q}{S} . (37)$$

6.11 Method for measuring luminous intensity

The method allows for determining the sizes of safety, danger, and extreme danger zones of PA flame light radiation.

The method's application conditions should satisfy GOST 13208 for measurements in test field environment.

The measuring error does not exceed 13% for luminous intensity and 7% for PA action time.

6.11.1 *Test means and auxiliaries*

Measuring instruments and auxiliary equipment for luminous intensity measurement as per GOST 13208.

6.11.2 *Procedure for preparation of tests*

When preparing and carrying out measurements, proceed in the sequence specified in GOST 13208. Particular test conditions are to be mentioned in the PA design documentation or in the test program.

(Revised edition, Rev. 1)

6.11.3 *Rules for processing test results*

6.11.3.1 Process the test results in accordance with GOST 13208, having determined the PA's luminous intensity and glowing time.

6.11.3.2 Determine the danger zone sizes as

$$R_{з.о} = \sqrt{I \cdot t_{г} /(50,7 \cdot H_{с.н})} , (38)$$

where $H_{с.н}$ is light radiation level for safety, danger, and extreme danger zones according to appendix C, J/m ^{2};

50.7 is lumen equivalent of the radiant flux, lm/W.

The 50.7 coefficient is calculated on the condition that the PA radiation is assumed to be 3000°C black body radiation.

(Revised edition, Rev. 1)

6.12 Method for measuring sound level

The method consists in measuring sound wave pressure with noise meters.

The measurement error is ±5 dBA.

6.12.1 *Test means and auxiliaries*

6.12.1.1 Noise meters of class 1 or 2 as per GOST 17187 with octave ($\frac{1}{3}$-octave) electric filters as per GOST 17168.

6.12.1.2 Tape measure as per GOST 7502.

6.12.1.3 Fastening device for the PA under test.

6.12.1.4 All equipment used for the measurements should have state verification certificates.

6.12.2 *Procedure for preparation of tests*

6.12.2.1 Mount the PA fastening device (hereinafter the device).

6.12.2.2 Install the PA under test using the device. Deviation of the distance between the PA and the microphone from the one specified in the test program should not exceed ±10 cm.

(Revised edition, Rev. 1)

6.12.2.3 Install microphones in accordance with GOST 17187 and the noise meter's user manual:

6.12.2.3.1 The microphones should be installed at a height of 1.5 m above the floor or the platform.

6.12.2.3.2 Indoors, the microphone should be located at a distance of at least 1 m from walls or other reflective surfaces.

6.12.2.3.3 The test platform should be horizontal (with no irregularities over 0.2 m) and have no reflective surfaces (walls, etc.) around the microphone in a radius no shorter than the distance from the microphone to the PA under test.

6.12.2.4 Prepare the noise meter for measurement according to its user manual.

6.12.2.4.1 Check the zero point position on the noise meter scale and adjust the indicator needle if necessary.

6.12.2.4.2 Calibrate the noise meter.

6.12.2.4.3 Turn the frequency reduction switch to A mode.

6.12.2.4.4 Turn the time reduction switch to the impulse hold position.

6.12.2.5 Location of microphones and PA fastening method are to be specified in the test program.

(Revised edition, Rev. 1)

6.12.3 *Procedure for testing*

6.12.3.1 Activate the PA.

6.12.3.2 Make measurements throughout the PA action time.

6.12.3.3 After the PA action is over, record the sound level value in the job log.

6.12.4 *Rules for processing test results*

6.12.4.1 Choose the maximum value from the measured sound levels and take it as the characteristic value.

6.12.4.2 If necessary, recalculate the sound level to an arbitrary distance $R(J_R)$ as

$$J_R = J_r - 20\lg\frac{R}{r}. \quad (39)$$

6.13 Method for evaluating fire hazard of pyrotechnic articles

The method allows for determining the danger zone sizes for PA intended for use indoors or in hands and having no other hazards but flame and flying sparks.

The method consists in organoleptic registration of kindling of an indicator substance (cotton wool) in cells located on a coordinate area.

The error of this method does not exceed 20%.

6.13.1 *Test means and auxiliaries*

6.13.1.1 PA fixing assembly that keeps the PA securely in place during testing.

6.13.1.2 Ruler as per GOST 427.

6.13.1.3 Set of cuvettes from steel of an arbitrary grade 50 mm in diameter, at least 10 mm high and with wall thickness 0.8-1.0 mm.

6.13.1.4 Tape measure as per GOST 7502.

6.13.1.5 Cotton wool for garments and furniture as per GOST 5679.

6.13.1.6 Drying cupboard.

6.13.2 *Procedure for preparation of tests*

6.13.2.1 Lay the cotton wool into the cuvettes so that the surface layer is uniform and does not elevate more than 3 mm above the cuvette edge.

The number of cuvettes per test and their distance to PA during testing are to be stated in the test program.

(Revised edition, Rev. 1)

6.13.2.2 Hold the cotton wool in cuvettes as per 6.13.2.1 in the drying cupboard at least 30 minutes at 40°C.

6.13.2.3 Install the PA into the fastening assembly and secure it so as to exclude any shifting during the test.

6.13.2.4 Place the cuvettes on the test site around the PA fastening assembly.

6.13.3 *Procedure for testing*

6.13.3.1 Make the tests at ambient temperature no lower than minus 20°C, wind speed no more than 5 m/s, air humidity no higher than 80%, and when there is no precipitation.

6.13.3.2 Activate the PA.

6.13.3.3 Inspect the test site after the PA action is finished.

6.13.3.4 Measure the distance from the PA canter to the center of the cuvettes in which the cotton wool is kindled (glowing).

6.13.3.5 After the test is complete, clean the unit from slag and remove all foreign materials out of the cuvettes. Cuvettes in which the cotton wool was not kindled can be reused.

6.13.4 *Rules for processing test results*

6.13.4.1 Record into the job log the results of measurement of the distances to the cuvettes in which the cotton wool was kindled/glowing.

6.13.4.2 From all of the tests, choose the maximum distance to the cuvette following the one in which the cotton wool was kindled and designate it as R – danger zone radius.

6.13.4.3 The space beyond the hemisphere with radius R should be considered fire safe zone.

6.14 Method for evaluating fire and explosion safety of pyrotechnic articles (campfire test)

This method is based on the ability of packaged or unpackaged PA to catch fire or explode when exposed to open flame.

(Revised edition, Rev. 1)

6.14.1 *Test means and auxiliaries*

6.14.1.1 Device for arrangement of PA under test in the form of a stand with its surface made as a rectangular mesh. The stand should be tall enough to accommodate fuel underneath. The mesh size should be bigger than the PA under test.

6.14.1.2 Wood fuel or liquid fuel in a vessel made as a dish with dimensions equal to the mesh size. The height of the dish should be chosen so that the layer of fuel poured into it would be enough for 10-15 minutes of burning.

The wood fuel should be shaped as square planks no bigger than 30-50 mm in section and with their length equal to the mesh size.

6.14.1.3 Stopwatch or clock of any type.

6.14.1.4 Cine or video camera.

6.14.1.5 Screen of an arbitrary design to protect the campfire from wind.

6.14.1.6 Device of an arbitrary design to kindle the fuel remotely (electrical, gas, pyrotechnic, etc.)

6.14.1.7 Three sheets 2000x2000x2 mm from aluminum 11000-0 (Brinell hardness 23, tensile strength 90 MPa) or an equivalent type to be used as control screens together with respective supports to keep them vertical. The control screens are to be fastened rigidly in their frames.

(Revised edition, Rev. 1)

6.14.2 *Procedure for preparation of tests*

6.14.2.1 Install the stand at the test location.

6.14.2.2 Pile up the wood fuel or install the liquid fuel vessel beneath the mesh. Pile the wood cage-like in rows with gaps approximately 50-100 mm between the planks in each row. It is allowed to wet the wood with liquid fuel.

6.14.2.3 Install remote kindlers on two sides from the prepared fuel.

6.14.2.4 Install a cine or video camera at a safe distance and prepare it for work.

6.14.2.5 Put the PA under test packaged or unpackaged in the center of the stand so that no part of the PA stands out beyond the campfire boundary.

Prepare the pressure measuring equipment for work according to 6.7.

6.14.2.6 Put up the vertical control screens in each of the three quadrants 4 m away from the edge of the packages or unpacked articles. Do not install screens in the downwind direction because long exposure to flames may alter the resistance of aluminum to the impact of fragments. Install the sheets so that their centers are in level with the center of the packages or unpackaged articles or – if this level is less than 1 m above the ground – touching the ground. If any holes or jags are found in the control screens before testing, these should be properly marked to avoid confusing them with the holes or jags obtained in the test.

(Added, Rev. 1)

6.14.3 *Procedure for testing*

6.14.3.1 Turn on the cine or video camera, the stopwatch, and the pressure measuring equipment.

6.14.3.2 Turn on the remote kindlers.

6.14.3.3 Observe the process and record it until the PA is burnt down or explodes.

6.14.3.4 Turn off the cine or video camera and the pressure measuring equipment and stop the watch.

6.14.3.5 If the PA has failed to activate (catch fire or explode), repeat the test with more fuel, but no sooner than 0.5 h after the campfire is fully extinct.

6.14.4 *Rules for processing test results*

6.14.4.1 Determine the air shock wave pressure or state there is no shock wave in accordance with 6.7.

6.14.4.2 If the PA is activated with explosion (throwing out the campfire, ejecting PA fragments, forming a shock wave) during the test, the PA is fire-and-explosion hazardous and, if necessary, should be submitted to testing to determine its hazard class by a duly established procedure.

6.14.4.3 If during the test the PA has burnt down without producing any fragments or shock wave, that PA is not explosion-hazardous.

6.14.4.4 If an explosion in bulk occurs, the article belongs to subclass 1.1. It is considered that explosion in bulk occurred if a considerable part of the package contents has worked, so the practical danger should be assessed by reference to simultaneous activation of the whole PTC mass contained in the packages or in all unpackaged articles.

If a hole has been punched in any of the control screens, that article belongs to subclass 1.2 as per GOST 19433.

If a fireball or a flame jet occurs reaching out beyond any of the control screens, the article belongs to subclass 1.3 as per GOST 19433.

If metal fragments are scattered to more than 1 m outside the control screens or jags of more than 4 mm appear on any of the control screens, the article belongs to subclass 1.4 and to a compatibility group other than compatibility group S.

If none of the events requiring the article to be classified as subclass 1.1, 1.2, 1.3 or 1.4, other than compatibility group S, but there are scattered fragments, thermal effect or PE scattering effect that do not hinder firefighting or taking other urgent measures in close vicinity, the article belongs to subclass 1.4 and compatibility group S.

(Added, Rev. 1)

6.14.5 *Method for testing easily flammable solid PTC and PA containing them*

Ability of a substance to propagate fire is checked by kindling it and determining the time of burning.

6.14.5.1 *Instruments and materials*

To prepare a sample for burning speed test, use a tray of triangular cross-section 250 mm long, 10 mm high inside and 20 mm wide. On both sides of the tray along its length, install two metal plates as side limiters protruding 2 mm beyond the top edge of the triangular cross-section. To keep the sample in place, use a stiff nonflammable plate with low thermal conductivity.

6.14.5.2 *Preliminary checking test*

Pour a sample of PTC (its certain ingredients) in a line or a strip 250 mm long, 20 mm wide and 10 mm high onto an impregnation-proof plate with low thermal conductivity and of the room temperature. Bring to the sample end a hot flame (at least 1000°C) from a gas torch (minimum diameter 5 mm) and keep the flame in contact with the sample until it catches fire but no longer than 2 minutes (or 5 minutes if powders of metals or metal alloys are used). Notice whether the burning zone has spread 200 mm lengthwise over the time of test 2 minutes long (or 20 minutes if metal powders are used). If the sample has not caught fire, and there is no propagation of the burning zone with or without flame to 200 mm lengthwise during the test that lasted 2 minutes (or 20 minutes, as the case may be), the substance (PTC and the containing article) should neither be classified as highly flammable nor subjected to any further tests. If in less than 2 minutes, or respectively in less than 20 minutes in the case of metal powders, the burning propagates to 200 mm of the sample, continue with the testing.

6.14.5.3 *Burning speed test*

Pour the PTC (its ingredient) as powder or granules (in its marketable form) into the tray without ramming. After that, drop the mold three times from 20 mm high onto a hard surface. Then remove the side plates and lay a plate of a non-impregnable non-combustible material of low thermal conductivity on top of the mold; then topple the mold over and take it off. Put the paste-like substance onto the non-combustible surface in a line about 250 mm long and with a cross-section area about 100 mm^2. If moisture-sensitive substances are used, make the test immediately as soon as the substance is taken out of the tray. Put the sample into the air stream circulating in the fume hood. The air stream velocity that should be enough to prevent the smoke leakage should remain constant throughout the test. A protective screen can be installed around the cupboard.

If substances other than metal powders are used, moisten the sample drop-wise by one millimeter of moisturizing solution 30-40 mm away from the 100-millimeter measurement zone. The solution should moisten the sample across ins whole section, without rolling down off the edges. Try to moisturize the sample on its smallest length, avoiding any loss of liquid from the sides. For pure water it is typical to flow down on the sides of a molded substance without penetrating into it; in such case, adding moisturizers may be necessary. The moisturizers should be free from flammable thinners, and the total active substance content of the moisturizing solution should not exceed 1%. The liquid can be added into a groove 3 mm deep and 5 mm in diameter made in the top of the mold.

Using a proper technique, with a small flame or a wire heated up to 1000°C, kindle the sample on one end. Once 80 mm of the sample have been burnt, measure the burning speed on the next portion 100 mm long. For substances other than metal powders, notice whether the moistened zone was holding back the propagation of flame for at least 4 minutes. Repeat the test six times on a cooled down and cleaned plate unless a positive outcome is received before the end of the test series.

6.14.5.4 *Test criteria and evaluation method*

A PTC (or its ingredients) will belong to subclass 4.1 if the time of burning recorded in one or more tests made in accordance with the method stated in 6.14.5.3 is less than 45 s (burning speed exceeds 2.2 mm/s). Powders of metals or metal alloys will belong to subclass 4.1 if ignition occurs and if the reaction propagates to the whole length of the sample in 10 (or less) minutes.

Easily combustible PTC or its components (other than metal powders) will belong to subclass 4.1 (ADR package group II) if the time of burning is less than 45 s and the flame comes through the moistened zone. Powders of metals or metal alloys will belong to subclass 4.1 (package group II) if the reaction zone propagates to the whole length of the sample in 5 (or less) minutes.

Easily combustible PTC or its components (other than metal powders) will belong to subclass 4.1 (ADR package group III) if the time of burning is less than 45 s and the moistened zone holds back the propagation of flame for at least 4 minutes. Metal powders will belong to subclass 4.1 (package group III) if the reaction propagates to the whole length of the sample in more than 5 minutes but less than 10 minutes.

6.14.5, 6.14.5.1-6.14.5.4 (Added, Rev. 1).

6.15 Methods for controlling specific factors

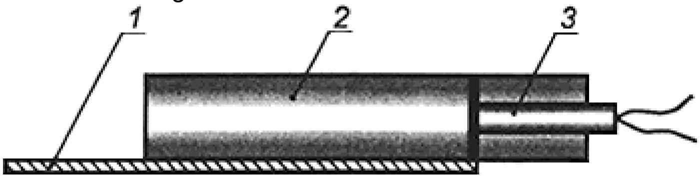
6.15.1 Sizes of the danger zones of an aerosol cloud of combustion or dispersion products, specific influence of combustion products on humans and environment, and fragment distribution of class V PA are to be determined using the methods described in the PA's normative documentation.

6.15.2 It is allowed to use conclusions of competent expert and scientific organizations and hygiene certificates as documents that confirm the level of danger by specific factors.

6.16 Method for evaluating susceptibility of pyrotechnic articles to detonation pulse

The detonation pulse susceptibility evaluation method is based on visually checking the deformation of a metal "witness" plate exposed to the products of explosive conversion of PA (charge) initiated by an electric detonator with or without an additional explosive charge.

Figure 3a shows a schematic diagram of the test.



1 - witness plate; *2* - charge; *3* - electric detonator
Fig. 3a – Detonation pulse susceptibility test diagram

6.16.1 *Test means and auxiliaries*

6.16.1.1 PA or PTC sample to be initiated by electric detonator ED-8 as per GOST 9089.

6.16.1.2 Witness plates made of aluminum as per GOST 9.510 and GOST 21631 or St3 grade steel as per GOST 380 3 to 10 mm thick, with width and length equal to or greater than the sizes of the article under test.

6.16.1.3 Exploder of KPM-3 type as per GOST 5462 or any other power source generating a current of at least 2 A and voltage between 20 and 36 V.

6.16.1.4 Photoelectric indicator Yu-140 as per [4] or linear direct-current bridge of R343 type as per GOST 7165.

6.16.1.5 Voltmeter of any type as per GOST 8711.

6.16.1.6 St3 steel slab as per GOST 380 50 mm thick, 800 mm wide and 1000 mm long.

6.16.1.7 Twin conductor wire in rubber or vinyl chloride insulation of MGShV type as per [5].

6.16.1.8 Insulating tape as per GOST 2162.

6.16.2 *Procedure for preparation of tests*

6.16.2.1 Prepare the test sample by ensuring close contact of PA (PTC weighed sample) with ED-8 electric detonator. Locate the electric detonator so that the pulse is directed to the most sensitive part of the pyrotechnic charge (initiator). The ED-8 conductors should be short-circuited.

The number of articles needed for the test should be specified in the test program.

6.16.2.2 Fix the PA with the insulating tape (or put the PTC in a strip) on the witness plate so that the front edge of the electric detonator is on the end of the witness plate.

6.16.2.3 Install the steel slab on a flat spot of the test site. Put the plate with the PA on the slab.

6.16.2.4 Check there is no voltage in the blasting circuit, connect the electric detonator to the blasting circuit and retreat to the shelter.

6.16.2.5 Check the blasting circuit continuity using a photoelectric indicator or other device.

6.16.3 *Procedure for testing*

6.16.3.1 Activate the electric detonator.

6.16.3.2 Once the process is finished, inspect the test site, find the witness plate, remove foreign inclusions from its surface, and check the plate's condition.

6.16.4 *Processing test results*

6.16.4.1 Determine the presence of absence of the sample's detonation from the deformation of the witness plate.

If there is detonation, the witness plate will demonstrate a clear indent (bend) over the whole length of the article.

If there is no detonation, the witness plate will have a detonation trace visible in the detonation area only.

If the detonation is of fading nature, the detonation trace will only be seen on the fading area.

No deformation of the witness plate means the PA/PTC is unsusceptible to the detonation pulse.

Subsection 6.16 (Added, Rev. 1)

6.17 Method for determining TNT equivalent

6.17.1 *General requirements*

6.17.1.1 The method for determining TNT equivalents is based on reconciling the operability results of the explosive conversion products of pyrotechnic and reference samples (compounds or articles) by the time of flight of a load ejected from a blasting chamber (effect meter/impulse meter).

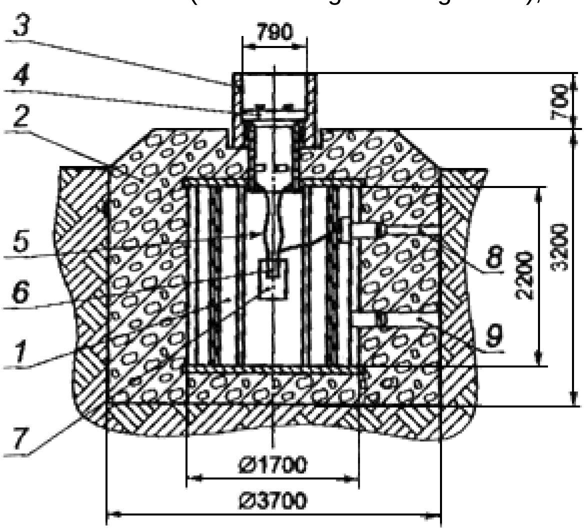
6.17.1.2 Determine TNT equivalents in accordance with the test program.

6.17.2 *Equipment, tools and materials*

Use the following equipment and materials for determining TNT equivalents of PTC:

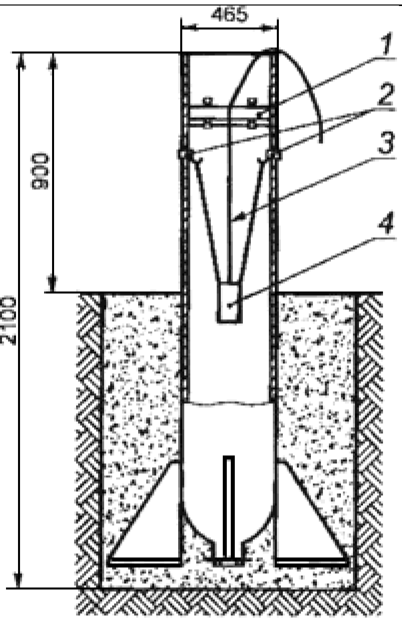
- effect meter with 5 m^3 chamber (see the diagram in figure 3b);

- impulse meter with 0.1 m^3 chamber (see the diagram in figure 3c);



1 - steel housing; *2* - reinforced concrete shroud; *3* - guiding cylinder; *4* - ejectable load up to 200 kg in weight; *5* - flexible suspension, *6* - additional detonator with ED-8 electric detonator; *7* - charge; *8* - electrical inlet; *9* - ventilation inlet

Figure 3b – 5 m^3 effect meter schematic diagram



1 - ejectable load; *2* - charge suspending hooks; *3* - electrical input; *4* - charge

Figure 3c – 0.1 m^3 impulse meter schematic diagram

- electrical winch with a force of at least 1 tf;

- theodolite VEGA Teo 5 or other type, 2 pcs.;

- direct current switched mode power supply of any type;

- ejectable load lifting device of any type, with lifting capacity no less than 1500 kgf;

- stopwatch of any type as per [6], 2 pcs.

6.17.3 *Test execution*

6.17.3.1 *Testing to determine TNT equivalent in a 5 m^3 effect meter*

Carry out the tests for determining TNT equivalent in a 5 m^3 effect meter in the following sequence:

a) put the charge under test in the geometrical center of the effect meter chamber, suspending it by two cotton ribbons LE-12-7-h/b or LE-12-9-h/b, or LE-12-10-h/b as per GOST 4514, 90 cm each;

b) use the winch and the load lowering device to close the effect meter chamber;

c) initiate the charge under test;

d) after each test, ventilate the effect meter chamber at least ten times using any ventilation unit;

e) make three or more parallel tests;

f) when testing with two stopwatches in parallel, measure the load flight time from the moment of ejection from the guiding cylinder until the load falls to the ground. If foreseen by the test program, additionally measure the maximum height of flight of the load using two theodolites;

g) process the test results in accordance with 6.17.4.

6.17.3.2 *Testing to determine TNT equivalent in an impulse meter*

Carry out the tests for determining TNT equivalent in an impulse meter in the following sequence:

a) put the charge under test in the geometrical center of the impulse meter chamber, suspending it by two cotton ribbons LE-12-7-h/b or LE-12-9-h/b, or LE-12-10-h/b as per GOST 4514, 40 cm each;

b) using special hooks, close the impulse meter chamber with the ejectable load;

c) initiate the charge under test;

d) make three or more parallel tests;

e) when testing with two stopwatches in parallel, measure the load flight time from the moment of ejection from the guiding cylinder until the load falls to the ground. If foreseen by the test program, additionally measure the maximum height of flight of the load using two theodolites;

f) process the test results in accordance with 6.17.4.

6.17.3.3 All test results and calculations should be recorded in the test area's job log.

6.17.4 *Treatment of results*

6.17.4.1 Parameters to be measured additionally using theodolites:

a) load flight time T_1, T_2 of first and second stopwatch respectively, s;

b) angle φ of load rising to maximum height H (m) using a theodolite;

c) distance ΔL from the guiding cylinder center to the load falling point, m;

d) ambient θ air temperature, K.

6.17.4.2 *Processing results of additional tests with theodolites*

Do the processing of results of additional tests with theodolites in the sequence specified below:

a) load rising height H_1 calculated from indications of the first theodolite, according to appendix K, m:

$$H_1 = \left[S_1 \cdot \cos(\beta_1) + \sqrt{\Delta L^2 - S_1^2(1-(\cos\beta_1)^2)}\right]\mathrm{tg}(\alpha_1) + h_1, \quad (39a)$$

where S_1 is distance from guiding cylinder to first theodolite, m;
ΔL is distance from guiding cylinder to load falling point, m;

α_1 and β_1 are indications of the first theodolite, ... °;

h_1 is height difference between load position before shooting and first theodolite position, m.

b) load rising height H_2 calculated from indications of the second theodolite, according to appendix A, m:

$$H_2 = \left[S_2 \cdot \cos(\beta_2) + \sqrt{\Delta L^2 - S_2^2(1-(\cos\beta_2)^2)}\right]\mathrm{tg}(\alpha_2) + h_2, \quad (39b)*$$

where S_2 is distance from guiding cylinder to second theodolite, m;
ΔL is distance from guiding cylinder to load falling point, m;

α_1 and β_1 * are indications of the second theodolite, deg;

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* The formula and its legend correspond to the original document. - Database maker's note

h_2 is height difference between load position before shooting and second theodolite position, m.

c) mean load rising height $\overline{H}$ calculated from indications of the first and the second theodolites, m:

$$\overline{H} = \frac{(H_1 + H_2)}{2}, \quad (39c)$$

where H_1 is load rising height H_1 calculated from indications of the first theodolite, m;

H_2 is load rising height H_1 * calculated from indications of the second theodolite, m;

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* According to the original document. - Database maker's note

d) estimated time of flight of the load T_p, s:

$$T_p = \sqrt{\frac{8\overline{H}}{g}}, \quad (39d)$$

where $\overline{H}$ is mean load rising height, m;

g is acceleration of gravity, 9.81 m/s^2;

e) mean time of flight of the load calculated from measurements with stopwatches $\overline{T}_c$, s:

$$\overline{T}_c = \frac{(T_1 + T_2)}{2}, \quad (39e)$$

where T_1 is indication of first stopwatch, s;

T_2 is indication of second stopwatch, s;

f) mean calculated time of flight of the load calculated from the measurements of the load rising height by theodolites $\overline{T}_{P_T}$, s:

$$\overline{T}_{P_T} = \frac{(T_{T_1} + T_{T_2})}{2}, \quad (39f)$$

where T_{T_1} is mean calculated time of flight of the load calculated from the measurements of the first theodolite, s;

T_{T_2} is mean calculated time of flight of the load calculated from the measurements of the second theodolite, s;

g) mean time of flight of the load $\overline{T}$, s:

$$\overline{T} = \frac{(\overline{T}_c + \overline{T}_{P_T})}{2}; \quad (39g)$$

h)* ballistic coefficient A of the ejectable load, m^{-1};

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* Numbering is according to the original document. - Database maker's note

$$A = K\frac{158}{M}\frac{288}{\theta}, \quad (39h)$$

where K is coefficient depending on the load ejection speed (for load ejection speed up to 200 m/s K = 0.001357);

158 is standard mass of the ejectable load, kg;

M is mass of the ejectable load, kg;

288 is standard ambient air temperature, K;

θ is absolute ambient air temperature, K;

i) load rising time T_+ to full time of flight ratio:

$$\frac{T_+}{\overline{T}} = 0{,}5 - \frac{A \cdot g \cdot \overline{T}^2}{96}, \quad (39i)$$

where $\overline{T}$ is full (averaged) time of flight of the load, s;

j) calculate the speed V_0 at the exit from the guiding cylinder of the effect meter/impulse meter as:

$$V_0 = \mathrm{tg}(T_+\sqrt{A \cdot g})\sqrt{\frac{g}{A}}, \quad (39j)$$

where T_+ is load rising time, s;

k) kinetic energy of the ejectable load E, J:

$$E = \frac{M \cdot V_0^2}{2}, \quad (39k)$$

where V_0 is starting speed of the load ejection, m/s;

l) specific energy of the charge under test e, J/kg:

$$e = \frac{E}{m}, \quad (39l)$$

where m is charge mass, kg;

m*) Determine TNT equivalent of the charge as:

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* Numbering is according to the original document. - Database maker's note

$$\alpha = \frac{e}{e_{\mathrm{THT}}}, \quad (39m)$$

where e_{THT} is TNT blast specific energy, J/kg.

6.17.4.3 *Processing results without additional measurements*

Do the processing of results without additional measurements in the sequence specified below:

a) mean time of flight of the load $\overline{T}$, s:

$$\overline{T} = \frac{(T_1 + T_2)}{2}, \quad (39n)$$

where T_1 is indication of first stopwatch, s;

T_2 is indication of second stopwatch, s;

b) load ejection speed at the exit from the guiding cylinder of the effect meter/impulse meter V_0, m/s:

$$V_0 = \frac{g \cdot \overline{T}}{2}; \quad (39o)$$

c) kinetic energy of the ejectable load, J:

$$E = \frac{M \cdot V_0^2}{2}, \quad (39p)$$

where M is mass of the ejectable load, kg;

d) specific energy of the charge under test e, J/kg:

$$e = \frac{E}{m}, \quad (39q)$$

where m is charge mass, kg.

6.17.4.4 The TNT equivalent of the charge will be

$$\alpha = \frac{e}{e_{THT}}, \quad (39r)$$

where e_{THT} is TNT blast specific energy, J/kg.

6.17.4.5 The measurement method error is ±17%.

6.17.4.6 Present the test results in a test report, stating: compound formula, compaction ratio, mean time of flight of the load, instruments and tools, and TNT equivalent value.

6.17.4.7 It is allowed to determine the load speed and rising height as per 6.5.

Subsection 6.17 (Added, Rev. 1)

6.18 Method for evaluating force and thermal actions of active pyrotechnic article on passive one

The method is based on checking the results of force effects and thermal actions of combustion products of an active PA on a passive one.

6.18.1 *Test means and auxiliaries*

6.18.1.1 The active pyrotechnic article (APA) can be a PA under study if it is insusceptible to detonation impulse or a sample as per 6.16.2.1 for a PA susceptible to detonation impulse.

6.18.1.2 The passive pyrotechnic article (PPA) is an article under study painted in some bright color for its subsequent identification.

6.18.1.3 Exploder of KPM-3 type as per GOST 5462 or any other source generating a current of at least 2 A and voltage between 20 and 36 V.

6.18.1.4 Photoelectric indicator Yu-140 [4] or direct-current bridge of R343 type as per GOST 7165.

6.18.1.5 AC or DC voltmeter as per GOST 8711.

6.18.1.6 Witness plate as per 6.16.1.2.

6.18.1.7 St3 steel slab as per GOST 38*, 50 mm thick, 800 mm wide and 1000 mm long.

* Probably an error in the original document. Should be read as GOST 380. – Database maker's note.

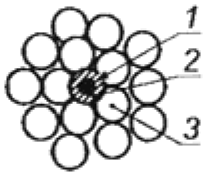
6.18.1.8 Twin conductor wire in rubber or vinyl chloride insulation of MGShV type as per [5].

6.18.1.9 Insulating tape as per GOST 2162.

6.18.2 *Procedure for preparing tests*

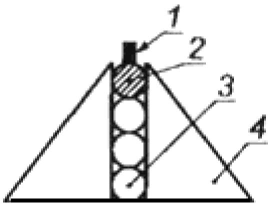
6.18.2.1 Prepare assemblies of active and passive PA and secure them with insulating tape to prevent detachment of the articles. Diagrams of APA and PPA arrangement in assemblies are shown in figure 3d.

Arrangement of articles in scheme 1 (front view)



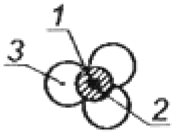
1 - initiator, *2* - active article, *3* - passive article

Arrangement of articles in scheme 2



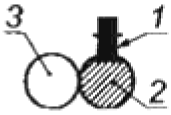
1 - initiator, *2* - active article, *3* - passive article, *4* - holding frame

Arrangement of articles in scheme 3 (top view)



1 - initiator, *2* - active article, *3* - passive article

Arrangement of articles in scheme 4



1 - initiator, *2* - active article, *3* - passive article

Figure 3d – Arrangement diagrams for tests of transition of detonation from active to passive PA

6.18.2.2 Install the steel slab on a flat spot of the test site and place the witness plate and the APA and PPA assembly on it.

6.18.2.3 Prepare the instruments and equipment for determining the danger zone sizes upon activation of the assemblies as per 6.5.

6.18.2.4 Use the voltmeter to check there is no voltage in the blasting line circuit, connect the electric detonator leads to the blasting circuit and retreat to the shelter.

6.18.2.5 Use Yu-140 photoelectric indicator or other instrument to check continuity of the blasting line.

6.18.3 *Procedure for testing*

6.18.3.1 Test the assemblies according to 6.5. Continue video recording until the PE quit burning.

6.18.3.2 After 20 minutes upon the assembly was triggered, check the witness plate and the site for any burning or glowing parts or items, collect PPA or their fragments, inspect them and do the video recording.

6.18.4 *Processing test results*

6.18.4.1 Analyze the witness plate condition. If the witness plate has dents over the whole assembly area, the article under test will be classified as exploding in bulk, otherwise it will be classified as unable to detonate under the effect from a neighbor article in the package and as non-exploding in bulk.

6.18.4.2 Absence of a passive PA or its fragments means that the PA is susceptible to force and thermal effects of an active PA onto the passive one and a high probability of explosion in bulk in the package.

6.18.4.3 Presence of unexploded passive PA or unburnt PE means the passive PA is unsusceptible to force and thermal effects of the active PA.

6.18.4.4 Determine the burst radius of burning PE of the assembly as per 6.5.

If the burst radius for an assembly is greater than the burst radius of burning PE of the PA under test by more than 10%, the activation of the passive PA should be considered abnormal. Otherwise the action of the passive PA will be recognized as normal.

Subsection 6.18 (Added, Rev. 1)

6.19 Method for evaluating safety of amorce ring caps for toy guns in arming

The essence of the method is to squeeze the amorce caps between a platform and a rod and to determine the pressure level at which the amorce will bang.

6.19.1 *Test means and auxiliaries*

6.19.1.1 Spring testing machine MIP-100-2.

6.19.1.2 Metal rod with flat end faces of the same diameter as the inner diameter of the amorce.

6.19.1.3 Holder for keeping the rod vertical.

6.19.2 *Procedure for preparation of tests*

6.19.2.1 Fix the rod in the holder vertically.

6.19.2.2 Put the amorce onto the rod.

6.19.2.3 Place the assembly onto the machine.

6.19.3 *Procedure for testing*

6.19.3.1 Load the assembly using the machine until the amorce bangs (the value stated in the program) and determine the activation force F, kgf.

Subsection 6.19 (Added, Rev. 1)

6.20 Method for checking fireproof treatment of shipping containers for household pyrotechnic articles

6.20.1 This practice covers the material – fireproofed packing cardboard (hereinafter the sample) intended for shipping containers for household PA.

6.20.2 The studies are aimed at determining stability of the sample to open flame.

6.20.3 The practice is a method for inspecting the sample's quality.

6.20.4 The method implemented in this practice is based on visual observation of the ignition and burning-through samples in an open flame of a gas torch after 3 seconds of contact with the flame.

6.20.5 Use three samples 220x170 mm or bigger in size, fixing them perpendicular to the torch axis.

6.20.6 *Test equipment*

6.20.6.1 Open flame test unit as per GOST R 50810. The unit is so designed as to allow bringing the torch to the sample's center excluding any unwanted movements.

6.20.6.2 Torch as per GOST R 50810 to ignite the sample, working on liquefied propane-butane gas.

6.20.6.3 Stopwatch with measurement error within 5 s per hour.

6.20.7 *Test preparation*

6.20.7.1 The exterior side of the sample is to be tested. Fix the sample vertically on poles at a height of 110 mm.

6.20.7.2 Heat up the gas torch for 2 minutes before testing. Adjust the flame height (40±2 mm) with the valve.

6.20.8 *Test execution*

Fix the sample of the frame so that its bottom edge stands out 5 mm beyond the lower stud.

Install the torch horizontally 40 mm of the bottom edge of the sample* and move toward it to a distance of 17 mm. Turn on the stopwatch. The time of exposure of the sample to the flame is 3 seconds.

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* As in the original document. - Database maker's note

After the open flame exposure, move the torch away from the sample.

After the sample and the fasteners are cooled down, change the sample for another one.

6.20.9 *Measurements*

6.20.9.1 Notice the sample ignition visually while exposed to the flame.

6.20.9.2 After the exposure to flame, record the sample's destruction and burning-through.

Report the findings.

6.20.10 *Test results evaluation*

A shipping container for household PA is fireproof if all three samples of the fireproofed packing material (cardboard) of which it is made are not burnt through during the test.

Subsection 6.20 (Added, Rev. 1)

6.21 Method for measuring maximum pressure exerted by firework article (FA) in mortar

The method allows for determining the maximum pressure level created by FA in a mortar. The essence of the method is to measure the pressure when testing PA sample according to subsection 7.1 using a pressure tap built in the (measuring) mortar and located at a distance from the bottom no more than half the outer diameter (caliber) of the FA.

6.21.1 *Procedure for preparation of tests*

6.21.1.1 Prepare the FA dummy according to the test program (modify the FA sample under study) to exclude the delay time of transmitting the firing impulse from the expelling charge to the igniting and bursting charge.

6.21.1.2 Hold the prepared FA dummies in thermal and humidity conditions specified by the test program.

6.21.1.3 Prepare the measuring mortar and the measuring instruments for work as per 7.1.

6.21.1.4 Arm the measuring mortar with the FA dummy and launch it in accordance with the operating documentation (extract from the user manual) for the article.

6.21.2 Record and process the results according to 7.1.

Subsection 6.21 (Added, Rev. 1)

7 Methods for indirectly determining hazard parameters

7.1 Pressure measuring method

This method allows for measuring the pressure and the temporal characteristics during the work of PA in bench tests using measuring and recording equipment.

The error of measurement is within 2% for temporal characteristics and 3% for pressure.

7.1.1 *Test means and auxiliaries*

7.1.1.1 Primary measuring transducers (PMT) for pressure of strain gauge, potentiometric or other type consistent with the following requirements:

- PMT measuring range should be such that the expected maximum value of the measured pressure is no lower than 60% of the upper measuring limit of the PMT;

- PMT frequency band should be higher than the frequency of the pressure variation process.

7.1.1.2 Pressure tap, consisting of a drain hole, a pressure tapping unit, and an interconnecting pipeline (if required).

The diameter of the drain hole and the internal channel of the tapping unit (hereinafter the channel) should be 4 mm or bigger.

Length of the channel for a specific PA should be calculated as

$$l \leq \frac{350}{20 f_{\text{пр}}} \quad (40)$$

or

$$l \leq \frac{350 \tau_{\text{д}}}{20}, \quad (41)$$

where 350 is speed of sound in the air, m/s.
The maximum channel length should be 60 mm.

The maximum free volume of the pressure tap connected to the PA should be no bigger than 10% of the internal free volume of the PA under test.

For protection of PMT from high-temperature combustion products, it is allowed, while testing PA with long action time (over 0.2 s), to apply interconnecting pipelines (hereinafter the pipelines) filled with industrial oil as per GOST 20799.

The oil filling method should preclude any possibility of air bubbles to remain in the pipeline.

7.1.1.3 Intermediate measuring transducers with working frequency band no lower than that of the PMT and main error within 1%.

7.1.1.4 Means of registration that enable recording the measured parameters in digital (coded) and/or analog form in a frequency band no smaller than the working frequency band of the PMT. As the means of registration, it is possible to use an automatic instrument of KSP type as per GOST 7164, a light-beam oscilloscope as per GOST 9829, etc.

7.1.1.5 Universal coordinated time equipment with time stamp setting accuracy within 0.5%.

7.1.1.6 Dead-weight pressure gauge of accuracy class 0.2 or better as per GOST 8291.

7.1.1.7 Caliper gauge as per GOST 166 for manual processing of the measurement results or an automated test result processing system.

7.1.1.8 The frequency bands of the measuring instruments for specific PA should be selected from the condition:

$$f_{\text{пр}} \gg \frac{1}{\tau_{\text{д}}}. \quad (42)$$

7.1.1.9 The working conditions of the measuring instruments should satisfy their respective user manuals.

7.1.1.10 A specific set of measuring instruments used for testing should be indicated in the certification test program.

(Revised edition, Rev. 1)

7.1.2 *Procedure for preparation of measurements*

7.1.2.1 Choose measuring instruments and check that their datasheets (certificates, record books) and user manuals are available.

7.1.2.2 Mount the measuring instruments according to their user manuals.

Communication lines of the measuring instruments should be made of a cable with individual and common screening of wires (hereinafter the cable lines).

When mounting electric circuits of PA initiation, always make sure to include interlocks to prevent unauthorized launching of PA.

7.1.2.3 Make graduation and/or calibration of the measuring instruments.

While making graduations and/or calibrations, check the zero level of such graduations and/or calibrations with no load on the PMT.

The numerical value of the maximum graduation level in respective engineering units should be between 1.0 and 1.3 of the maximum expected value of the measured parameter.

While recording parameters in analog form, the ordinate of the maximum graduation level should be no lower than 60 mm.

The number of graduation levels in loading/unloading PMT should be five or more.

Nonlinearity of graduation characteristic $\gamma_{\text{н}}$ at each graduation level in loading and unloading PMT should be within ±3% in relation to the maximum graduation level.

$$\gamma_{\text{н}} = \frac{(X_i - X_{i-1}) - X_{\max} / n}{X_{\max}} \cdot 100 \quad . (43)$$

7.1.2.4 Before and after graduation of measuring instruments, calibrate the instruments and record the calibration levels.

The difference of the calibration levels before and after graduation should be no greater than ±3% in relation to the arithmetic mean of those levels.

7.1.3 *Procedure for measurements*

7.1.3.1 Check the cable lines for continuity.

7.1.3.2 Calibrate the measuring instruments within 15 minutes prior to the start of the measurements/PA operation.

7.1.3.3 Activate the PA and record the pressure variation during the PA operation.

7.1.3.4 Calibrate the measuring instruments within 5 minutes after the end of the measurements/PA operation.

7.1.3.5 The difference of the calibration levels before and after measurement should be no greater than ±3% in relation to the arithmetic mean of those levels.

7.1.3.6 The drift of the graduation/calibration zero levels from the initial position throughout the pressure recording time should be no more than ±1% in relation to the maximum graduation/calibration level.

7.1.4 *Rules for processing measurement results*

7.1.4.1 Process the measurement results using the measurement information contained on data carriers depending on the recording format, i.e. digital or analog.

7.1.4.2 In addition to measurement information, the data carriers should contain the following:

- PA data (index or designation, title or name);

- PA number(s);

- measuring instruments data;

- measuring instrument graduation data;

- measurement/test date;

- sequential number of a test in a series of measurements;

- name and signature of the person who made the measurements.

Apply the additional information directly to the measurement data carrier or enter it into an accompanying document.

7.1.4.3 The graduation characteristics of measuring instruments should be determined depending on the graduation/calibration technique.

Graduation/calibration signals should be counted from the zero level of graduations/calibrations.

7.1.4.4 When making graduation over the whole PMT measuring range, the graduation characteristic should be represented by the ratio

$$\chi = f(y). \quad (44)$$

The value of χ is equal to arithmetic mean of the output when loading and unloading the PMT.

7.1.4.5 Depending on the test program requirements, the following main characteristics of the PA operation process can be determined:

- process start delay time $(\tau_{зад})$;

- setup time $(\tau_{вых})$;

- time to a parameter's characteristic value (maximum, minimum, etc.) $(\tau_{p\,max}, \tau_{p\,min})$;

- total time of PA's operation $(\tau_{п})$;

- maximum and minimum pressure (P_{max}, P_{min});

- mean integral value of pressure over the whole time of operation of PA or in characteristic sections of operation $(\overline{P})$;

- maximum value of pressure variation gradient (ΔP).

The listed characteristics should be determined in accordance with 7.1.4.5.1-7.1.4.5.5, unless specified otherwise in the test program or other document.

(Revised edition, Rev. 1)

7.1.4.5.1 The process start delay time should be determined from the moment of initiation to the start of pressure rise with PA in operation.

7.1.4.5.2 The setup time $\tau_{вых}$ should be determined as the time from the pressure rising start to the moment when $2/3$ reaches the maximum pressure with PA in operation.

7.1.4.5.3 The time to reach the characteristic pressure value should be counted from the start of pressure rise and until the characteristic value.

7.1.4.5.4 The total time of operation $\tau_{п}$ should be determined from the moment of PA initiation until the pressure reduces to zero.

7.1.4.5.5 The mean integral value of pressure should be determined as

$$\overline{P} = \frac{\int_{t_н}^{t_к} P(\tau)\,d\tau}{t_к - t_н}. \quad (45)$$

7.1.4.6 Measurement/test results are to be represented in a form prescribed by the test program or other document.

(Revised edition, Rev. 1)

7.2 Method for measuring reactive force and recoil force

This method allows for measuring the reactive thrust force (hereinafter the thrust), the recoil force, and the temporal characteristics during the work of PA in bench tests using measuring and recording equipment.

The error of measurement is within 2% for temporal characteristics and 3% for thrust.

7.2.1 *Test means and auxiliaries*

7.2.1.1 Force primary measuring transducers.

Measurement ranges of primary measuring transducers (hereinafter the PMT) for specific PA should be selected so that the expected maximum value of a measured parameter is no lower than 60% of the upper measurement limit of the PMT.

The PMT working frequency should be no lower than 25 Hz for thrust measurement and no lower than 2000 Hz for recoil force measurement.

Where PA documentation specifies a time to reach the maximum or steady-state value of controllable parameters $\tau_{ДТ}$, select PMT working frequency f from the condition

$$f >> \frac{1}{\tau_{ДТ}}. \quad (46)$$

7.2.1.2 Intermediate measuring transducers (IMT) with working frequency band no smaller than that of the PMT.

7.2.1.3 Means of registration that enable recording the measured parameters in digital (coded) and/or analog form.

When recording parameters in digital form, the increment Δt should be assured by reference to the condition

$$\Delta t \leq 0,2\,\tau_{ДТ}. \quad (47)$$

7.2.1.4 Universal coordinated time equipment with time stamp setting accuracy within ±0.2%.

7.2.1.5 Class III dynamometers as per GOST 9500.

7.2.1.6 Rig that ensures obedience with the following PA fastening conditions:

- angle α between the PA nozzle axis (PA axis, thrust vector) and PMT axis no more than 2°;

- axial misalignment of the nozzle axis (PA axis, thrust vector) in relation to the PMT axis no more than 1 mm;

- out-of-squareness of the PMT axis to the rig's supporting plate surface no more than 3°;

- no gap between the links of the force-measuring chain - PA-PMT - supporting plate of the rig.

The relative error introduced by the rig into the measurement result due to resistance to the axial displacement of PA on the rig within elastic strains of the PMT should be no greater than ±2%.

7.2.2 *Procedure for preparing measurements*

7.2.2.1 Measuring instruments and auxiliaries should be mounted so as to measure during the tests/measurements the thrust, time intervals, zero levels of the measured magnitude, moment of energization of the electric squib, or moment of ignition of the fuse cord.

7.2.2.2 Mount the measuring instruments, bench equipment and auxiliaries in compliance with their user manuals.

7.2.2.3 Mount PA onto the rig in accordance with the PA's instructions for use or the test program.

(Revised edition, Rev. 1)

7.2.2.4 Communication lines of the measuring instruments should be made of a cable with individual and common screening of wires (hereinafter the cable lines).

7.2.2.5 Electrical lines of initiation should have interlocks to prevent unauthorized launching of PA.

7.2.2.6 Install the PA on the rig and load the PMT with a force between 0.1 and 0.2 of the mean expected thrust value during the PA operation and consider this PMT load level as zero calibration level before and after measurement and zero thrust registration level.

7.2.2.7 Graduate the PMT.

The numerical value of the maximum graduation level in respective engineering units should be between 1.0 and 1.3 of the maximum expected value of the thrust/recoil force.

While recording parameters in analog form, the ordinate of the maximum graduation level should be no lower than 60 mm.

The number of graduation levels in loading/unloading PMT should be five or more.

Nonlinearity of graduation characteristic at each graduation level in loading and unloading PMT should be within ±3% in relation to the maximum graduation level:

$$\gamma_{н} = \frac{(X_i - X_{i-1}) - X_{\max}/n}{X_{\max}} \cdot 100 \quad (48)$$

Before and after graduation of measuring channels, calibrate these channels and record the calibration levels.

The difference of the calibration levels before and after graduation should be no greater than ±1% in relation to the arithmetic mean of those levels.

When recording the measured parameters in analog form, the ordinates of graduation and calibration levels and of the measured parameter should be measured with accuracy within ±0.5 mm.

7.2.3 *Procedure for measurements*

7.2.3.1 Check the cable lines for continuity and operability.

7.2.3.2 Record the calibration levels of the measuring instruments within 15 minutes prior to the start of the measurements/PA operation.

7.2.3.3 Record the measured parameters of PA during its operation.

7.2.3.4 Record the calibration levels of the measuring instruments within 15 minutes after the end of the measurements/PA operation.

7.2.3.5 The drift of the graduation/calibration zero levels from the initial position throughout the time of recording of the measured parameters should be no more than ±1% in relation to the maximum graduation/calibration level.

7.2.4 *Procedure for processing measurement results*

7.2.4.1 Process the measurement/test results using the measurement information contained on data carriers depending on the recording format, i.e. digital or analog.

7.2.4.2 In addition to measurement information, the data carriers should contain the following:

- PA data (index or designation, title or name, number);

- measuring instruments data (type, number, measuring limit);

- measurement/test date;

- sequential number of a test in a series of measurements/tests.

7.2.4.3 Determine the graduation characteristics of measuring instruments, which should be represented by ratio (44).

7.2.4.4 Depending on the test program requirements, the following characteristics can be determined:

- process start delay time $(\tau_{зад})$;
- setup time $(\tau_{вых})$;
- PA operation time $(\tau_{реж})$;
- time to reach the characteristic value of a parameter $(\tau_{р})$;
- maximum and minimum values of thrust (R_{max}, R_{min});
- mean integral value of thrust over the PA operation time;
- full thrust impulse $(J_{п})$;
- maximum recoil force value (F_{max}).

The listed characteristics should be determined in accordance with 7.2.4.4.1-7.2.4.4.7, unless specified otherwise in the test program or other accompanying documents.

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7.2.4.4.1 The process start delay time $\tau_{зад}$ should be determined from the moment of PA initiation to the start of thrust rise with PA in operation.

7.2.4.4.2 Setup time $\tau_{вых}$ is time from the moment when thrust appears and until $2/3$ reaching the maximum thrust, unless specified otherwise in the test program or other accompanying document.

7.2.4.4.3 PA operation time $\tau_{реж}$ is time during which the thrust remains no lower than the value specified by the test program or other accompanying document.

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7.2.4.4.4 Time to reach the characteristic value of a parameter should be counted from the moment when thrust appears and until the characteristic value appears.

7.2.4.4.5 The maximum or minimum thrust value should be determined in the interval $\tau_{реж}$.

7.2.4.4.6 The mean integral value of thrust $R_{ср}$ should be determined as

$$R_{ср} = \frac{\int_{t_н}^{t_к} R_{\tau}(\tau)\,d\tau}{t_к - t_н}. \quad (49)$$

7.2.4.4.7 The total thrust pulse should be determined as

$$J_{п} = \int_{t_н}^{t_к} R_{\tau}(\tau)\,d\tau. \quad (50)$$

7.2.4.5 Measurement data carriers or tables and/or graphs with current values of the measured parameter may be enclosed to the test report.

7.3 Method for evaluating sensitivity of pyrotechnic articles to static electricity

The method consists in measuring the energy of electrical discharge of a capacitor whose spark may trigger a PA.

The error of this method does not exceed 7%.

7.3.1 *Test means and auxiliaries*

7.3.1.1 Electrostatic kilovoltmeter of accuracy class 1.5, measurement limit 30 kV, as per GOST 8711.

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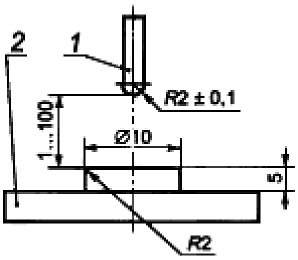
7.3.1.2 Direct current bridge of accuracy class 0.2 as per GOST 7165.

7.3.1.3 Set of capacitors with total electrical capacity 200 pF for operational electrical voltage 30 kV.

7.3.1.4 Direct electrical current source that ensures gradual variation of electrical voltage between 0 and 30 kV supplied to a capacitor, with current no higher than 5 mA.

7.3.1.5 Discharge electrodes according to figure 4.



1, *2* - brass discharge electrodes

Figure 4 - Discharge electrode arrangement diagram

7.3.1.6 Hygrometer of any type capable of measuring the air humidity indoors.

7.3.1.7 Liquid-in-glass (no mercury) thermometers as per GOST 28498, measurement limit between minus 20°C and plus 100°C.

7.3.1.8 High-voltage wires able to withstand up to 30 kV.

7.3.1.9 Flexible electrical insulating tube of type III, 10 mm in diameter as per GOST 17675 or tube 3.31 TV-40,10 as per GOST 19034.

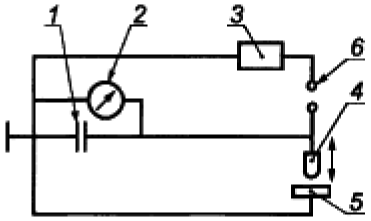
7.3.1.10 Chamber ensuring safe conduct of work and possibility to observe the course of tests.

7.3.1.11 Technical ethyl alcohol as per GOST 17299 or GOST 18300.

7.3.1.12 Domestic cotton gauze as per GOST 11109.

7.3.2 *Procedure for preparation of tests*

7.3.2.1 Assemble the unit for determining the sensitivity of PA to an electrical spark as shown in figure 5.



1 - electrical power source; *2* - kilovoltmeter; *3* - capacitor block; *4*, *5* - discharge electrodes; *6* - switch

Figure 5 – Schematic diagram of unit for determination of PA sensitivity to static electricity

7.3.2.2 Check the discharge circuit's inductance, which should not exceed 0.1 mH.

7.3.2.3 Check the discharge circuit's electrical resistance, which should not exceed 0.3 Ohm.

7.3.2.4 Check the voltage drop on the capacitors, which should not exceed 5% in 10 seconds after shutting off the high voltage source.

7.3.2.5 Place the PA to be tested in the chamber.

7.3.2.6 Make the test at relative air humidity no higher than 65% and temperature between 15°C and 35°C.

7.3.2.7 When determining sensitivity to static electricity, the PA should be connected in each case individually depending on the initiation scheme subject to the high-voltage installations code.

7.3.2.7.1 When initiating PA from an external source of heat (matches, thermomatches), put the PA onto discharge electrode *5*, and make a discharge to the ignitable part of the PA from electrode *4* (see figure 5).

7.3.2.7.2 When initiating PA from a friction cap, put the article on flat electrode *5*, and make a discharge from electrode *4* to that part of the PA where the cap is located.

7.3.2.7.3 When initiating PA from an electric squib, connect one lead to electrode *5*, and make a discharge to the other one from electrode *4*.

7.3.3 *Procedure for testing*

7.3.3.1 Install a 200 pF capacitor and measure the capacitance of capacitor *3*, kilovoltmeter *2*, and discharge circuit (see figure 5).

7.3.3.2 Charge capacitor *3* from power source *1* up th a voltage of 30 kV and cut off the direct current source.

7.3.3.3 Lower the electrode until it touches the PA, which will cause an electric discharge onto the PA.

7.3.3.4 If the PA ignites, it is allowed to make further tests with lower electrical discharge energy levels.

7.3.3.5 Each time a PA is triggered, clean the electrodes from slags with a gauze swab wetted in alcohol.

7.3.4 *Procedure for processing test results*

7.3.4.1 Calculate the PA ignition energy as

$$W_i = \frac{CU^2}{2}. \quad (51)$$

7.3.4.2 Determine the mean PA ignition energy $\overline{W}$ as

$$\overline{W} = \frac{\sum_{i=1}^{n} W_i}{n}. \quad (52)$$

7.4 Methods for measuring temporal characteristics

7.4.1 Temporal characteristics of the PA operation process can be determined by methods of 6.6, 6.11, 7.1, 7.2.

7.4.2 In other cases the process start delay time and the PA operation time (see 7.1.4.5) should be determined by a stopwatch with division value no less than 0.1 s. For measuring every temporal parameter, use at least two stopwatches and find the mean value of their indications.

7.5 Method for determining directionality of flight

The method consists in visually observing the PA flight through a limited annular space.

7.5.1 *Measurement means and auxiliaries*

7.5.1.1 Test bench (hereinafter the bench) including:

- flat steel slab 1x1 m or bigger;

- strong poles 3±0.01 m tall rigidly fixed to the slab on its diagonals at a distance of 50±20 mm from the edges;

- ring with inner diameter 800±2 mm rigidly fixed to the poles parallel to the slab;

- device (mark) located on the slab to mount a PA coaxially with the ring.

7.5.1.2 Level as per GOST 9416.

7.5.2 *Procedure for preparing and conducting tests*

7.5.2.1 Install the bench on a flat site with deviation of the ring axis from verticality no more than 3°.

7.5.2.2 Install the PA under test or the launch unit at the slab mark.

7.5.2.3 Launch the PA and observe its flight.

7.5.3 *Rules for processing results*

7.5.3.1 If the PA or the ejected PE have flown through the ring, the directionality of flight satisfies the safety requirements.

7.6 Methods for verifying/confirming shelf lives

7.6.1 In order to verify/confirm and extend the shelf lives/guarantee periods of PA it is possible to use test results after long storage (LS) and/or accelerated climatic tests (ACT) as well as expert appraisals on the basis of data analysis of similar articles.

7.6.2 LS is to be conducted in conditions regulated by normative documentation on the articles using a special program established in due manner.

7.6.3 ACT consist in making accelerated ageing of PA exposed to climatic factors in artificial conditions (elevated temperature, elevated humidity) using a special program established in due manner.

The recommended value of accelerated ageing temperature is: 60°C for positive, minus 50°C for negative (if the value is permitted by the normative documentation of the article).

7.6.4 Analog method is used where reliable documented information is available on articles that are sufficiently full analogs to the PA under study.

7.6.5 Accelerated ageing time is calculated according to GOST 9.707 or using the formula

$$\tau_y = H \cdot \sum_{i=1}^{n} \frac{\varphi_i \cdot \tau_i}{\varphi_y} e^{\frac{E}{R}\left(\frac{1}{T_y} - \frac{1}{T_i}\right)}, \quad (52a),$$

where τ_y, φ_y, T_y are duration (h), relative humidity (%) and temperature (K) of accelerated test;

τ_i is duration of combined relative air humidity in 5% intervals (φ_i) and temperature in 5°C intervals (T_i) over a year in real conditions of storage (according to GOST 16350 or specification of the customer);

E is temperature coefficient;

R is gas constant 8.314 J/mol·K;

n is number of gradations of φ_i, τ_i, T_i over 1 year of storage if used in real conditions;

H is number of years of the guarantee period or shelf life being verified or extended.

For cases where the temperature coefficient E is difficult to determine or it is not established, the duration of accelerated heat-and-humidity tests (τ_y) simulating 1 year of storage in different types of stocks at the values of T_y assumed to be 333 K (60°C), φ_y - 65%, E - 83.8 kJ/mol (expertly adopted minimum value) is reduced to table 1a.

Table 1a – Duration of accelerated heat-and-humidity tests

Climatic region	τ_y values (days)	
	Heated storage	Unheated storage
Hot, dry	5.4	3.8
Moderate	3.2	2.1
Moderately cold	3.5	1.2

Subsection 7.6 (Revised edition, Rev. 1)

7.7 Method for testing electric squibs for no activation by electrical signal with parameters ensuring control over electrical start circuit

The method consists in passing electric current 10% over the maximum control current through an electric squib.

7.7.1 *Test means and auxiliaries*

7.7.1.1 Contact device in accordance with technical documentation for a specific electric squib type.

Note – The contact device is only mandatory for squibs that have no flexible wire leads.

7.7.1.2 Electrical power supply ensuring the passage of stabilized direct current of a necessary magnitude through the squib.

7.7.1.3 Ammeter of accuracy class 1.5 or better as per GOST 8711. Select the ammeter's measurement limit so that the measured current value is in the second half of the scale.

7.7.1.4 Mechanical stopwatch as per [6].

7.7.1.5 Insulated wires of any type with copper conductor with cross-section area 0.5mm^2 or bigger.

7.7.2 *Procedure for preparation of tests*

7.7.2.1 Install the electrical squib into the contact device (if available).

7.7.2.2 Set the necessary current value on the power supply. The set current should be 10% higher than the maximum control current specified in the technical documentation of the squib.

7.7.3 *Procedure for testing*

7.7.3.1 Connect the electric squib to the power supply in series with the ammeter.

7.7.3.2 Pass the current through the squib for a time period specified in the technical documentation.

7.7.3.3 As the specified period expires, cut off the squib from power supply.

7.7.3.4 Record the test result.

The electric squib should not be triggered during the test.

Subsection 7.7 (Added, Rev. 1)

7.8 Methods for checking mortar strength

The methods consist in loading a mortar with internal pressure matching the FA launching conditions.

7.8.1 *Method for checking mortar strength by launching a test FA*

7.8.1.1 Prepare the mortar to be tested and the test FA according to the checking program.

7.8.1.2 Launch the test FA according to the operating documentation/checking program, taking additional safety measures.

7.8.1.3 Inspect the mortar and report its condition. If there are no signs of damage on the mortar or change in its geometry, the mortar should be deemed usable for another period.

7.8.2 *Method for checking mortar strength by internal pressurization*

7.8.2.1 Test means and auxiliaries

7.8.2.1.1 Test unit including a cover with a gasket that ensures tight sealing of the mortar at a pressure value chosen for the check.

7.8.2.1.2 Strength element that holds the cover during the test and excludes the likelihood of power impact on the mortar tube walls.

7.8.2.1.3 Pipelines and valves designed for a service pressure at least 20% higher than the maximum pressure of test.

7.8.2.1.4 Dead-weight pressure gauge as per GOST 8291 or other supercharger with a pressure meter of a respective accuracy class.

7.8.2.1.5 Means for video recording of indication of measuring instruments (electronic recording of the measured parameters).

7.8.2.1.6 Shelter ensuring safety of the operator in case of destruction of the mortar (breakage of the pipelines).

7.8.2.1.7 Device for filling the mortar and draining the working liquid.

7.8.2.1.8 It is allowed to use soft rubbers with a known Poisson's ratio instead of the hydraulic system, and a force gauge of a respective accuracy class instead of the power unit (press) supercharger.

7.8.2.2 *Test preparation and execution*

7.8.2.2.1 Prepare the test unit and the mortar for work according to the operating documentation and the test program. If required, graduate the measuring equipment.

7.8.2.2.2 Turn on the recording equipment, gradually load the mortar up to the specified level, hold at that load level for 1-5 s, relieve the load and turn off the recording equipment.

7.8.2.2.3 Report the measurement processing results in a log of the form adopted in the organization.

7.8.2.2.4 Inspect the mortar and report its condition. If there are no signs of damage on the mortar or change in its geometry, the mortar should be deemed usable for another period.

7.8.3 *Method for checking soundness of mortar walls (for mortars from laminated plastics)*

The method is intended for checking the mortal walls for flow-through pores.

7.8.3.1 Soundness of the walls is checked by monitoring the level of liquid inside the mortar. Fill the mortar with low-viscosity inert liquid to a mark made in advance at 20-50 mm from the upper edge of the mortar and monitor its level during the holding time. If an easily evaporating liquid is used (e.g. water), it should be topped with 5-10 mm of liquid oil (spindle, transformer, automobile oil).

7.8.3.2 If after 24 hours the decrease of the liquid level inside the mortar does not exceed 2% of its initial level, the mortar walls are deemed sound.

7.8.3.3 Report the check results in a statement. A mortar should be deemed suitable for arming FA if the visual inspection has revealed no signs of deterioration on the mortar's walls and bottom (chips, cracks, buckling) and its walls are found to be sound.

Subsection 7.8 (Added, Rev. 1)

7.9 Method for checking internal dimensions of mortars

The method is intended for determining actual geometric parameters of used mortars with application of special calibers.

7.9.1 To check fulfilment of conditions for arming FA into this mortar (minimum permissible gap), use custom-made cylindrical calibers (a piece of pipe with wall thickness at least 2 mm) with height-to-diameter ratio $L/D=0.5$. The caliber's outer diameter should be equal to the sum of the FA maximum diameter and the minimum permissible gap as per GOST R 51270. The caliber should have a marking including its outer diameter. Outer diameters of calibers are to be checked periodically and reported in the check log.

7.9.2 Height (depth) of the mortar's working part (if inserts are present) should be checked by a universal measuring tool with division value no greater than 1 mm.

7.9.3 Report the check results in a statement. A mortar will be found suitable for arming FA if the caliber can move effortlessly over the mortar's whole length.

Subsection 7.9 (Added, Rev. 1)

8 Methods for testing stability to external effects

8.1 Methods for testing stability to mechanical impacts

Bench test modes are established to simulate exposures of PA transported by road, by rail, by water, and by air transport of general use.

PA tests for transport loads consist in modeling the real transportation conditions using special test benches by reproducing the loads typical for a certain kind of transport and conditions of transportation.

Transport load tests are conducted in order to determine:

- strength of PA exposed to transport loads;

- operability of PA after exposure to transport loads;

- ability of regular shipping containers to keep PA secure in transportation.

The tests are to be conducted at the temperature in the room where the test bench is situated or at ±60°C, unless other conditions are specified in the test program.

PA carried by road, by rail, by water and by air can be tested for exposure to loads typical for only road and rail transport.

PA should be tested for transport loads in their regular containers. Installation, fixation and stowage of PA in a package for testing as well as for real shipping should be the same.

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8.1.1 *Test means and auxiliaries*

8.1.1.1 The test equipment is to ensure:

- obtaining test modes in accordance with this standard and the test program;

- remote control of the PA and monitoring of the tests from distanced fully safe for workers in case of emergency activation of the PA in the test;

- installing the PA under test so as to prevent them from falling from the test bench in any test mode.

A list of recommended test benches is given in appendix D.

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8.1.1.2 Equipment for measuring, analyzing, and recording vibration and impact parameters (hereinafter for measuring parameters) should meet the following requirements:

a) for measuring vibration parameters:

- to have a flat frequency response (FR) with the flat region's nonlinearity within ±1 dB in the operating frequency band;

- to have a dynamic range that ensures measuring and recording maximum values of a random variable up to $\pm 5\sqrt{D}$;

b) for measuring impact parameters:

- to have an upper frequency in the frequency spectrum no lower than $3/\tau$, a lower cutoff frequency no higher than 1 Hz, and a natural (resonance) frequency of the measuring transducer no lower than $20/\tau$;

- to have a flat FR in all the resulting frequency range with nonlinearity within ±1 dB.

Lists of recommended equipment used for measuring, analyzing and recording vibration and impact parameters are given in appendices E, F, G, H.

8.1.2 *Procedure for preparation of tests*

8.1.2.1 Preparation of tests includes:

- choosing a test method;

- determining test modes;

- preparing test means and auxiliaries.

8.1.2.2 *Choosing a test method*

Transport load tests are to be made by one of the following PA exposure methods:

a) wideband random vibration on shake tables and impacting on shock tables;

b) sweep-frequency sinusoidal vibration on shake tables and impacting on shock tables;

c) fixed-frequency sinusoidal vibration on shake tables and impacting on shock tables;

d) impact loading on shock tables;

e) vibration and impact effects on transportation simulation benches.

8.1.2.3 An orthogonal system is adopted for PA tests:

X - horizontal axis matching the direction of transport;

Y - vertical axis perpendicular to the direction of transport;

Z - horizontal axis perpendicular to the direction of transport.

The alphabetical symbols of vibration and impact load parameters are shown with an index that corresponds to the direction of a coordinate axis.

8.1.2.4 Test modes for random vibration and impact methods are stated in tables 1 to 4.

The time of PA testing by random vibration method is determined by the lengths of haul L specified in their specifications and by the most probable travel speeds of the vehicles. Example calculations are shown in appendix I.

Table 1 – Random vibration test modes that simulate transportation by road

Driving conditions	Total dispersion D_y of vibratory acceleration, m ^{2} /s ^{4} (g^2)	Frequency band, Hz	Distribution of dispersions by frequency bands, %
Speed:			
50 km/h on cobblestone road	34.6 (0.36)	1-10	35
	34.6 (0.36)	10-20	25
40-60 km/h on dirt road	24 (0.25)	20-40	25
60-80 km/h on asphalt-concrete highway	15.4 (0.16)	40-60	15

In tests according to table 1, dispersion values in the direction of axes X and Z (D_x and D_z) are from 0.5 to 2.0 of the values of D_y .

Time in separate tests in the direction of axes X and Z is to be assumed as $t_x = t_z = 0{,}5t_y$.

Table 2 – Impact test modes that simulate transportation by road

Driving conditions	Test mode characteristics			
	Test mode component designation	Shock acceleration peak value $W_{п}$, m/s ^{2} (g)	Shock acceleration rise time, s	Number of impacts per 1 mm* of the road

				N
Dirt road with cobblestone pavement	I	49.0 (5.0)	0.04-0.10	2
	II	29.4 (3.0)	0.02-0.03	20
Note – Here and in tables 4, 5, 6, 7 the Roman numerals indicate the test modes, summation of which enables simulation of the transportation in a respective table.				

* As written in the original document. - Database maker's note

Table 3 – Random vibration test modes that simulate transportation by rail

Driving conditions	Total dispersion D_y of vibratory acceleration, m^2/s^4 (g^2)	Frequency band, Hz	Distribution of dispersions by frequency bands, %
Four-axle flat wagon, car or gondola car, likeliest speed 50 km/h, maximum speed 105 km/h	19.2 (0.2)	2-10	45
		10-20	25
		20-40	20
		40-60	10

In tests according to table 3, dispersion values in the direction of axes X and Z (D_x and D_z) are from 0.5 to 1.0 of the values of D_y.

Time in separate tests in the direction of axes X and Z (t_x and t_z) is to be assumed as $t_x = t_z = 0{,}5 t_y$.

Table 4 – Impact test modes that simulate transportation by rail

Driving conditions	Test mode characteristics			
	Test mode component designation	Shock acceleration peak value W_x, m/s^2 (g)	Shock acceleration rise time, s	Number of impacts per 1 km of the track N
Impacts in maneuvering and making-up trains at 16-18 km/h	I	58.8 (6)	0.01-0.02	0.003
	II	49.0 (5.0)	0.01-0.02	0.003
	III	29.4 (3)	0.01-0.02	0.003

In tests according to table 4, shock acceleration peak value in the direction of axes Y and Z (W_y, W_z

) is to be assumed as $W_y = W_z = 0{,}7\,W_x$.

The number of impacts in the direction of axes Y and Z (N_y and N_z) is to be assumed as $N_y = N_z = N_x$.

Where no data is available on the length of haul by each kind of transport, assume it as transportation to 5000 km by road.

Test modes for sinusoidal vibration methods are stated in tables 5 to 8.

Table 5 – Sinusoidal vibration test modes that simulate transportation by road

Driving conditions	Test mode characteristics			
	Test mode component designation	Vibratory acceleration amplitude W_y, m/s^2 (g)	Frequency, Hz	Number of vibration periods per 1 km N
Speed below 40 km/h on cobblestone road	I	23.5 (2.4)	1-10	20
	II	17.6 (1.8)	10-20	100
	III	11.8 (1.2)	20-40	430
	IV	5.9 (0.6)	40-60	350
Speed 40-60 km/h on dirt road	I	19.6 (2)	1-10	20
	II	14.7 (1.5)	10-20	100
	III	9.8 (10)	20-40	430
	IV	4.9 (0.5)	40-60	350
Speed below 80 km/h on highway	I	15.7 (1.6)	1-10	20
	II	11.8 (1.2)	10-20	100
	III	7.8 (0.8)	20-40	430
	IV	3.9 (0.4)	40-60	350

In tests according to table 5, the vibratory acceleration values in the direction of axes X and Z (W_x, W_z) are between 0.5 and 0.7 of W_y for dirt roads and cobblestone roads and between 0.3 and 0.5 of W_y for asphalt-concrete highways.

The number of vibration periods per 1 km in separate reproduction of vibrations in the direction of axes X and Z is to be assumed as $N_x = N_z = 0{,}5\,N_y$.

Table 6 – Sinusoidal vibration test modes that simulate transportation by rail

Driving conditions	Test mode characteristics

	Test mode component designation	Vibratory acceleration amplitude W_y, m/s^2 (g)	Frequency, Hz	Number of vibration periods per 1 km N_y
In a four-axle flat wagon, car or gondola car at 105 km/h	I	12.8 (1.3)	2-10	10
	II	9.8 (1)	10-20	60
	III	7.8 (0.8)	20-40	220
	IV	3.9 (0.4)	40-60	190

In tests according to table 6, vibratory acceleration values in the direction of axes X and Z (W_x and W_z) are from 0.7 to 1.0W_y .

The number of vibration periods per 1 km in the direction of axes X and Z (N_x and N_z) is to be assumed as $N_x = 0$; $N_z = 0,5N_y$.

Table 7 – Test modes that simulate transportation by water

Driving conditions	Test mode characteristics			
	Test mode component designation	Vibratory acceleration amplitude W_y, m/s^2 (g)	Frequency, Hz	Number of vibration periods per 1 km N_y
Travel speed 50 km/h (30 knots)	I	4.9 (0.5)	10-20	640
	II	14.7 (1.5)	20-40	200

In tests according to table 7, vibratory acceleration values in the direction of axes X and Z (W_x and W_z) are to be assumed as $W_x = 0$; $W_z = 0,5W_y$.

The number of vibration periods per 1 km in the direction of axes X and Z (N_x and N_z) is to be assumed as $N_x = 0$; $N_z = 0,5N_y$.

Duration of tests on each coordinate axis should be $1/3$ of the total time, unless other conditions are stipulated in the test program.

If a PA is tested in one position, the duration of tests should be equal to the total duration of tests in three coordinate axes.

The sweep-frequency sinusoidal vibration tests are to be conducted with the vibration frequency ramping up and down in every band from the lower value to the upper one and back. The ramping should be made logarithmically at no more than one octave per minute.

The duration of testing t, s, in every band should be determined as

$$t = \frac{L\,N}{f_{в} - f_{н}} \cdot \ln \frac{f_{в}}{f_{н}} . \quad (53)$$

The fixed-frequency sinusoidal vibration tests are to be conducted on middle frequencies of the bands. The test duration in this case is determined as

$$t = \frac{L\,N}{f_{ср}} . \quad (54)$$

Table 8 – Test modes that simulate transportation by air

Frequency, Hz	Vibratory acceleration amplitude, m/s ^{2} (g)	Test duration, min
5	9.8 (1)	20
6.25	9.8 (1)	20
8	9.8 (1)	20
10	9.8 (1)	20
12.5	9.8 (1)	20
16.0	9.8 (1)	20
20.0	9.8 (1)	20
25.0	9.8 (1)	20
31.5	9.8 (1)	20
40.0	9.8 (1)	20
50.0	9.8 (1)	20
63.0	9.8 (1)	20
80.0	9.8 (1)	20
100.0	9.8 (1)	20
125.0	9.8 (1)	20
160.0	9.8 (1)	20
200.0	9.8 (1)	20
250.0	9.8 (1)	20
315.0	9.8 (1)	20
400.0	9.8 (1)	20
500.0	9.8 (1)	20
630.0	9.8 (1)	20
800.0	9.8 (1)	20
1000.0	9.8 (1)	20

1250.0	9.8 (1)	20
1600.0	9.8 (1)	20
2000.0	9.8 (1)	20

It is allowed to reduce the test duration if the vibration acceleration amplitude is increased. The test duration in this case t_c for a chosen acceleration level W_c will be calculated as

$$t_c = \left(\frac{W_н}{W_c}\right)^k t \quad (55)$$

Where no data is available on the permissible dynamic load limits, assume k = 2.5.

Increasing the vibration acceleration amplitude value is allowable as long as the nature of the acting vibrations is not distorted.

The impact loading tests on shock tables are to be conducted in the modes with parameters specified in table 9.

Table 9 – Modes of packaged pyrotechnic articles transportation testing on shock tables

PA mass, kg	Shock acceleration peak value, m/s ^{2} (g)	Shock acceleration action time, ms	Total number of impacts on three axes
Up to 50 incl.	740 (75)	1-5	2000
	147 (15)	5-20	20000
	98 (10)	5-20	88000
Over 50 up to 75 incl.	490 (75)	1-5	2000
	147 (15)	5-20	20000
	98 (10)	5-20	88000
Over 75 up to 200 incl.	196 (20)	1-5	2000
	147 (15)	5-20	20000
	98 (10)	5-20	88000

In tests under table 9, the rate of impacts should be no more than 200 per minute for impacts with peak acceleration up to 15 g and 80 impacts per minute with peak acceleration 20 g or higher.

Tests with peak acceleration of 740, 490, 196 m/s ^{2} (75 g, 50 g, 20 g) are not made on the PA package that is to be attached to the hull of a vehicle.

Tests for strength to mechanical factors typical for conditions of transportation of packaged PA by road and by rail using the method of vibration and impacts at transportation simulating benches should be conducted in accordance with the normative values stated in table 10.

Table 10 – Driving conditions and test modes on road and rail simulation benches

Kind of road	Travel speed, km/h	Root-mean-square acceleration, m/s^2 (g)	Testing time that corresponds to 1000 km of travel, h
Cobblestone road	up to 50	166.8±29.4 (17±3)	1.
Dirt road	up to 50	166.8±29.4 (17±3)	0.37
Asphalt-concrete highway	up to 80	166.8±29.4 (17±3)	0.21
Rail road	up to 105	83.4±14.7 (8.5±1)	0.1

(Revised edition, Rev. 1)

8.1.3 *Procedure for testing*

8.1.3.1 Bench tests of PA are to be made in the sequence:

- tests that simulate transportation by road;

- tests that simulate transportation by rail;

- tests that simulate transportation by air;

- tests that simulate transportation by water.

8.1.3.2 It is allowed to combine tests that simulate different methods of transportation. However, in this case the values of parameters of the rail, air and water transportation modes have to be recalculated in accordance with 8.1.2.4 into values of parameters of transportation by road.

8.1.3.3 The modes of impact and vibration tests are to be checked with measuring transducers installed on the test bench platform in places where a PA package is attached.

8.1.3.4 The test modes are to be set and maintained by indications of the operational measuring instruments with deviations not to exceed:

- ±3 dB for spectral density of random vibration acceleration;

- ±2 dB for total root-mean-square random vibration acceleration;

- vibration frequency of ±2 Hz at frequencies up to 50 Hz and ±5% at frequencies above 50 Hz;

- ±20% for amplitude of acceleration or shock acceleration peak value;

- ±5% for number of vibration periods or impacts;

- ±10% for temporal characteristics (test duration, shock acceleration rise time).

8.1.4 *Rules for processing test results*

8.1.4.1 After the tests are finished, check the PA visually for any external damages obtained by the PA during the testing. Report all changes in the PA appearance in the job log.

8.1.4.2 After inspection, hand over the PA for further tests according to the test program.

(Revised edition, Rev. 1)

8.2 Method for evaluating stability to climatic effects

The method is based on simulating real climatic effects using special chambers.

The main climatic tests include tests for:

- heat resistance

- cold resistance

- stability to temperature cycling

- stability to solar radiation

8.2.1 *Test means and auxiliaries*

8.2.1.1 Hot chamber capable of creating a temperature up to plus 60°C and maintaining it for a long time with deviation from the nominal value by no more than ±3°C.

8.2.1.2 Cold chamber capable of creating a temperature up to minus 60°C and maintaining it for a long time with deviation from the nominal value by no more than ±3°C.

8.2.1.3 Solar radiation simulation chamber characterized by upper values of the integral thermal flux density of 1125 W/m^2 [0.027 cal/(cm^2·s)], including the flux density of the ultraviolet spectrum range (wavelength 280 to 400 nm) 42 W/m^2 [0.0010 cal/(cm^2·s)].

8.2.1.4 Clock or any device for measuring long time intervals.

8.2.1.5 Temperature recorder in the climatic chamber, unless already included in its design.

8.2.2 *Procedure for preparation of tests*

8.2.2.1 Turn on the hot and/or the cold chambers.

8.2.2.2 Bring the chamber temperatures to the value specified in the test program.

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8.2.2.3 Check operability of the radiators in the solar radiation simulation chamber according to its instructions for use.

8.2.3 *Procedure for testing*

8.2.3.1 *Hot and cold tests*

8.2.3.1.1 Place the PA in the hot/cold chamber so as to ensure free circulation of air between the PA/the PA packages, the PA and the chamber walls.

8.2.3.1.2 Close the chambers and, if their temperatures have gone down/up during the loading time, hold them for as long as needed to reach the correct temperature.

8.2.3.1.3 The moment when the correct temperature is achieved in the chamber should be regarded the start of the test.

8.2.3.1.4 Hold the PA in the chamber for 2 hrs, unless specified differently in the test program.

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8.2.3.2 *Temperature cycling stability tests*

8.2.3.2.1 Put the PA into the hot chamber and proceed as per 8.2.2.2.

8.2.3.2.2 Hold the PA in the hot chamber for 3 hrs, unless a different time is specified in the test program.

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8.2.3.2.3 Take the PA from the hot chamber to the cold chamber and lay them down inside subject to 8.2.3.1.1.

8.2.3.2.4 Hold the PA in the cold chamber for 3 hrs, unless a different time is specified in the test program.

8.2.3.2.5 Return the PA to the hot chamber and repeat the exposures per 8.2.3.2.1 to 8.2.3.2.4 three times, unless specified otherwise in the test program.

8.2.3.2.6 The time of transfer of the PA from the hot chamber to the cold one or vice-versa should not exceed 5 minutes, unless specified otherwise in the test program.

8.2.3.2.4 to 8.2.3.2.6 (Revised edition, Rev. 1)

8.2.3.3 *Solar radiation stability tests*

8.2.3.3.1 Put the PA into the solar radiation simulation chamber, turn infrared and ultraviolet radiation on, and then set the air temperature inside the chamber to 55±2°C in the shade.

8.2.3.3.2 Radiate the PA in the chamber for 120 hrs continuously or discontinuously.

8.2.4 *Test results evaluation*

8.2.4.1 As the test is finished, take the PA out of the chamber and check visually and compare with PA that have not been subjected to hot, cold or solar radiation.

8.2.4.2 Report all changes in the PA appearance in the job log.

8.2.4.3 After inspection, hand over the PA for next tests according to the test program.

(Revised edition, Rev. 1)

8.3 Method for free fall testing

The method allows for determining the free fall strength when testing unsealed PA or PA in containers at ±60°C, unless a different temperature is specified in the test program.

(Revised edition, Rev. 1)

8.3.1 *Test means and auxiliaries*

8.3.1.1 Horizontal impact platform made of a steel slab at least 10 mm thick rigidly tied to a concrete foundation at least 200 mm thick. The sizes of the impact platform should be such that the PA or the container do not go outside its limits at the moment of contact with the platform.

Check horizontality of the platform using a level as per GOST 9416. The levels of two arbitrary points on the platform surface should not differ by more than 2 mm.

8.3.1.2 Lifting device equipped with clamps to hold the PA or package in the predefined position without damage and allowing for a free fall of the PA or package under test.

The lifting device should ensure the specify height of fall of the PA or package with ±2% tolerance.

When testing lightweight PA (up to 5 kg) for free falling from low heights (up to 2 m), it is allowed to replace the lifting device with a dropping device of a specified height meeting all requirements applicable to the lifting devices.

8.3.1.3 Tape measure as per GOST 7502.

8.3.1.4 Climatic chambers for thermal conditioning of PA consistent with 8.2.

8.3.2 *Procedure for preparing and conducting tests*

8.3.2.1 Lay the PA into a shipping container foreseen by the documentation of that PA. If the number of PA foreseen by the test program is insufficient to fill up the container, use fillers (such as waste paper, sand bags, etc.) so that the total mass of the PA and the filler does not exceed the value specified by the design documentation of the PA.

8.3.2.2 Condition the PA at the specified temperature for 30 minutes (without container) or 3 hours (in container). Fix the PA or the container in the lifting device clamps and lift to the specified height.

The height for dropping PA without package is 1.5 m, while the height for dropping a container with PA is 12 m, unless specified otherwise in the test program.

8.3.2.3 Check the lighting height by the distance:

- for falling on a corner – between the impact platform and the corner point;

- for falling on walls – between the impact platform and each of the corners of the wall under test;

- for falling on an edge – between the impact platform and the edge ends.

For non-rectangular PA, the distance to specific parts of the tested PA should be specified in the test program.

8.3.2.4 Drop the PA from the height and in the position (see 8.3.2.3) corresponding to the test program. If the test program does not specify a spatial position for PA during the test, drop the PA without orienting it, i.e. arbitrarily.

8.3.2.1 to 8.3.2.4 (Revised edition, Rev. 1)

8.3.3 *Procedure for processing test results*

8.3.3.1 Check the PA visually and note all changes in its appearance.

8.3.3.2 Destroyed container, damaged or destroyed PA and single (not in bulk) activations that do not lead to spreading PA are not reasons for rejection.

9 Safety requirements

9.1 Fire- and explosion-hazardous tests are to be conducted in strict adherence to the rules established for the pyrotechnic industry, in particular the rules for work with static electricity.

9.2 The tests may be carried out by trained and qualified specialists with knowledge of the design and rules of safe handling of the equipment used in the tests as well as the rules of using primary firefighting means and instructed on safe conduct of the tests.

9.1, 9.2 (Revised edition, Rev. 1)

9.3 During the tests it is prohibited to:

9.3.1 Launch any PA from hands (except party poppers).

9.3.2 Lean over PA during the launch.

9.3.3 Stay in the danger zone once the fuse/delay element has been kindled.

9.3.4 Aim or throw the PA under test toward people.

9.3.5 Carry any PA prepared for testing in garment pockets.

9.3.6 Test any PA with visible mechanical damages.

9.3.7 Apply high mechanical loads to PA.

9.3.8 Make tests in strong wind.

9.3.9 Work if no occupational health guidelines are in place.

Section 10 (Excluded, Rev. 1)

APPENDIX A
(mandatory)

Consistency of brightness temperature range and error of determination with lens aperture for pyrovidicon TV-9851 and filters N 1 and N 2

Table A.1

Aperture	Brightness temperature range, °C, of filters		Lower limit error, %	Constant A
	N 1	N 2		
0.8	300-500	19-50	8	810
1.	300-600	20-60	11	480
1.4	300-700	21-78	14	420
2	300-900	22-112	22	396
2.8	300-1200	25-174	34	243
4	325-1650	30-252	35	146
5.6	480-2100	35-342	35	223
8	650-2400	45-542	32	297
Note – The lower limit of the brightness temperature range is stated for a brightness signal of 16 relative units.				

APPENDIX B
(mandatory)

Calibration curves for pyrovidicon camera with filters N1 and N 2

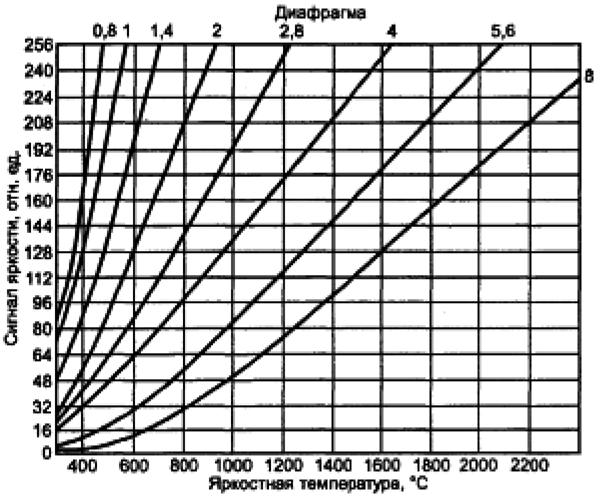

Figure B.1 – Calibration curve for pyrovidicon camera with filter N 1

Figure B.2 – Calibration curve for pyrovidicon camera with filter N 2

APPENDIX C
(mandatory)

Luminous radiation danger zone levels

Table C.1

Parameter, unit of measure	Danger level[1)]	
	Dangerous	Extremely dangerous
Radiation energy, J/m^2	10^5-$4 \cdot 10^5$	$>4 \cdot 10^5$

1) The danger levels for luminous radiation are assumed from data given in [9].

APPENDIX D
(recommended)

Main technical characteristics of benches for mechanical testing of pyrotechnic articles

Table D.1

Bench name	Bench type	Frequency band, Hz	Duration of impact, s	Maximum displacement amplitude, mm	Maximum acceleration, g	Lifting capacity, N
Shake table	EGV-10-100	0.05-100	-	100	30	10000
	EGV-20-200	1-200	-	75	30	20000
	VEDS-1500	5-5000	-	6	43	3000
	VEDS-400	5-5000	-	12.5	40	900
	VGS-3M	1-200	-	100	30	10000
	VEDS-200A	5-5000	-	12.5	40	450
	UVE-100/5-3000	5-3000	-	100	60	1000
	UVE-10/5000	5-5000	-	10	45	100
Transportation simulator bench	SIT	-	-	12	-	1000
	SIT M	-	-	12	-	3000
Impact bench	SU-1	-	0.001-0.030	-	150	500
	ChU-500/150	-	0.01-0.050	-	150	5000
Drop impact machine	K6-73-27	-	0.01-0.100	-	100	1500
	K6-79-68	-	0.006-0.200	-	200	15000

APPENDIX E
(recommended)

Equipment for measuring vibration parameters

Table E.1

Equipment type	Measuring transducer type	Measured parameter	Frequency band, Hz	Dynamic acceleration range	Error
VI-6-6TN	DU-5S inductive	Acceleration	0-200	39-850 m/s^2	±3%
ILV-67	D10, D11 piezoelectric		3-20000	30-130 dB	±15 dB
VA-2	D13, D14 piezoelectric		5-10000	10^{-2}-10^4 m/s^2	±15%

APPENDIX F
(recommended)

Equipment for measurement and control of random vibration

Table F.1

Equipment type	Frequency band, Hz	Dynamic range, dB	Number of filters	Filter bandwidth
SUVU-ShSV-1	5-2000	50	120	12.5; 25 Hz
SUVU-ShSV-2	5-3000	50	120	12.5; 25; 50 Hz
SUVU-ShSV-3	5-5000	50	120	12.5; 25; 100 Hz
DVC-500	1-10000	65	400	$1/400$ of upper frequency
SUAU	25-20000	50	30	$1/3$ of octave

APPENDIX G
(recommended)

Equipment for measuring impact parameters

Table G.1

Equipment type	Frequency band, Hz	Impulse duration, ms	Limits of measurement	Measurement accuracy
Udar-4	2-20000	0.04-100	1-20000 m/s	10%
PU-20c	1-20000	0.5-100	0-60 dB	10%
PU-30c	1-20000	0.5-100	1-2000 mV	5%
SMART	0-5000	0.2-5000	0.001-100 mV	4%
SM-311	2-15000	0.1-20	0,32-20000 m/s	17%
2607	2-20000	0.02-20	50 dB	±5 dB
15U7Y-6	1-2000	0.01-990	0.1-100000 m/s	6%

APPENDIX H
(recommended)

Equipment for recording mechanical effect parameters

Table H.1

Equipment name	Equipment type	Number of channels	Frequency band, Hz	Dynamic range, dB	Band travel speed, mm/s
Magnetograph	NO-62	7	0-20000	-	4.76-39.1
	LS-1832	16	0-20000	40	800
	7003	4	0-50000	50	38.1-381
Light-beam oscilloscope	K12-22	12	0-1000	-	3-1000
	K20-22	20	0-2000	-	1-2500
	N-115	12	0-5000	-	0.5-5000
	NO-30	12	0-5000	-	1-5000
	NO-43	12	0-5000	-	1-5000

APPENDIX I
(informative)

Calculation of sinusoidal vibration test time and impact test scope

I.1 Example of calculation of sinusoidal vibration test time from tables 5 to 7 is shown using the data from table 6.

From table 6 we find that each kilometer of the way corresponds to a sum of vibration periods N_y :

- 10 vibration periods with frequency from 2 to 10 Hz;

- 60 vibration periods with frequency from 10 to 20 Hz;

- 220 vibration periods with frequency from 20 to 40 Hz;

- 190 vibration periods with frequency from 40 to 60 Hz.

Calculate the arithmetic mean values of the above frequencies for each range and divide the number of vibration periods N_y corresponding to this frequency band by them.

Sum up the resulting quotients and then multiply by the simulated distance of haul. The result is the desired testing time in seconds.

I.2 Example of calculation of impact test scope from tables 2 and 4 is shown using the data from table 4.

It is seen from table 4 that there are 0.003 impacts per 1 km of travel in three ranges of peak shock acceleration on axis X .

Assume that the simulated distance of haul is 10000 km.

Then the simulated scope of testing with an impact acting in the direction of axis X (on the tested article it corresponds to the most dangerous direction of impact load) will be in total 30 impacts with peak shock accelerations $6g$, $5g$ and $3g$.

APPENDIX J
(informative)

References

[1] RMG 29-99 State system for ensuring the uniformity of measurements. Metrology. Basic terms and definitions

[2] TU 2504-3916-80* Universal measuring instrument R4833

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* The TU specifications mentioned here and hereafter are copyrighted. For more information use this link. – Database maker's note.

[3] TU 16-87 IFMP.675000.003 Filament electric floodlight lamps. Specifications

[4] TU 25-0425.069-83 Photoelectric indicator Yu-140. Specifications

[5] TU 16-505.437-82 Mounting wires with fibrous or film and polyvinylchloride insulation. Specifications

[6] TU 25-1894.003 Mechanical stopwatches. Specifications

[7] TU 25-1819.0021 Mechanical stopwatches Slava SDSpr-1-2-000, SDSpr-4b-2-000, SOSpr-6a-1-000

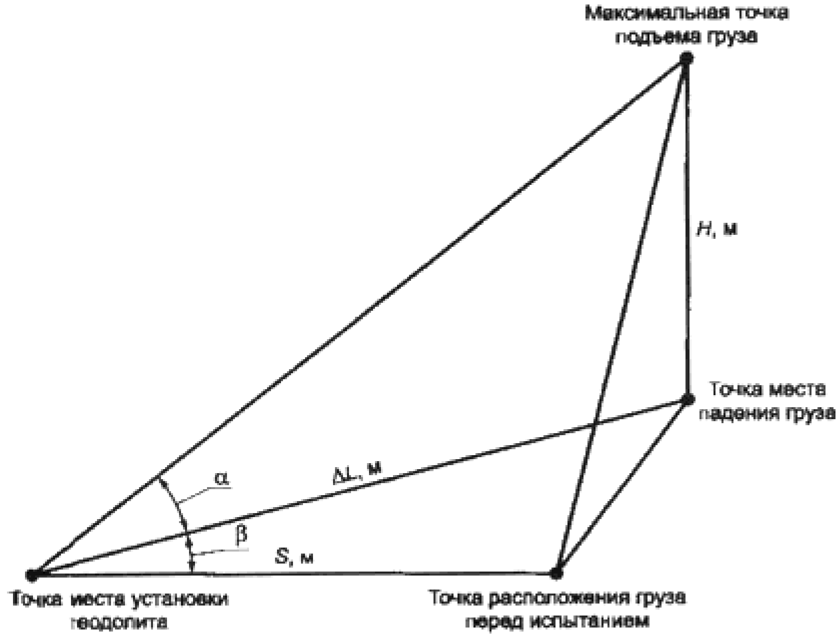
[8] Pyrotechnic goods certification rules

[9] Safety guidelines. - M.: Energia, 1982

Appendix J (Revised, Rev. 1)

APPENDIX K
(mandatory)

Diagram for calculating load lifting height with a theodolite



Appendix K (Added, Rev. 1)

APPENDIX L
(informative)

Student's coefficient values t_{α}

k	α *						
	0.80	0.90	0.95	0.98	0.99	0.995	0.999
2	1.886	2.920	4.303	6.965	9.925	14.09	31.60
3	1.638	2.353	3.182	4.541	5.841	7.453	12.92
4	1.533	2.132	2.776	3.747	4.604	5.598	8.610
5	1.476	2.015	2.571	3.365	4.032	4.773	6.869
6	1.440	1.943	2.447	3.143	3.707	4.317	5.959
7	1.415	1.895	2.365	2.998	3.500	4.029	5.408
8	1.397	1.860	2.306	2.897	3.355	3.883	5.041
9	1.383	1.833	2.262	2.821	3.250	3.690	4.781
10	1.372	1.813	2.228	2.764	3.169	3.581	4.587
11	1.363	1.796	2.201	2.718	3.106	3.497	4.437
13	1.356	1.782	2.179	2.681	3.055	3.428	4.318
14	1.350	1.771	2.160	2.650	3.012	3.373	4.221
15	1.345	1.761	2.145	2.625	2.977	3.326	4.141
12	1.341	1.753	2.131	2.603	2.947	3.286	4.073
16	1.337	1.746	2.120	2.584	2.921	3.252	4.015

Appendix L (Added, Rev. 1)

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