INTERNATIONAL STANDARD

ISO 26261-3

First edition
2017-02

Fireworks — Category 4 —

Part 3:
Test methods

Artifices de divertissement — Catégorie 4 —

Partie 3: Méthodes d'essai

Reference number
ISO 26261-3:2017(E)

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 264, *Fireworks*.

A list of all the parts in the ISO 26261 series can be found on the ISO website.

Fireworks — Category 4 —

Part 3: Test methods

1 Scope

This document specifies test methods for fireworks of Category 4.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13385-1, *Geometrical product specifications (GPS) — Dimensional measuring equipment — Part 1: Callipers; Design and metrological characteristics*

ISO 26261-1, *Fireworks — Category 4 — Part 1: Terminology*

ISO 26261-2:2017, *Fireworks — Category 4 — Part 2: Requirements*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 26261-1 apply.

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

4 Test environment for functioning test

4.1 General

The test environment shall be a large unobstructed area, which shall be wide open. The measuring points shall be positioned appropriately for the type of measurement being carried out.

For aquatic fireworks, a water test area shall be available for testing the resistance to moisture and functioning in the expected manner.

4.2 Wind measurement

The wind speed at a height of 1,50 m above the ground shall be measured and recorded using a wind speed meter (see 5.5). No performance testing shall be carried out if the wind speed exceeds 5,0 m/s.

5 Apparatus

Any equivalent apparatus with the same accuracy or better may be used.

5.1 Timing device, capable of being read to the nearest 0,1 s.

5.2 Calliper, flat faced vernier calliper reading to 0,1 mm, conforming to ISO 13385-1.

5.3 Ruler, with a scale resolution of 1,0 mm or better.

5.4 Measuring tape, with a scale resolution of 10 mm or better.

5.5 Wind speed meter, accurate to at least 0,5 m/s.

5.6 Balance, with an accuracy of ±0,01 g or better.

5.7 Temperature chamber.

5.7.1 Up to (50 ± 2,5) °C.

5.7.2 Up to (75 ± 2,5) °C.

5.8 Sound level meter of class 1 conforming to IEC 61672-1 with a free-field microphone.

5.9 Shock apparatus, providing a deceleration of 490 m/s^2 (-50/+100) m/s^2 (when measured at the centre of an unloaded platform) and the shock impulse duration (time elapsed from the starting of the machine's deceleration to the time in which the deceleration reaches its maximum value during each first shock pulse) shall be 2 ms ± 1 ms working at a frequency of 1 Hz ± 0,1 Hz.

An example of an apparatus is shown in Annex A.

5.10 Devices for measuring heights.

Heights shall be measured using universal surveying instruments (USI) such as theodolites, electronic spirit levels or video (visible and/or infrared) systems.

Examples of measuring methods and the calculation of the height are given in Annex B.

5.11 Goniometer, reading to 1° or better.

5.12 Mortar.

The rising height of shells depends particularly on the clearance of the shell in the mortar [ratio of the maximum cross section area of the shell (A_{shell}) to the inner cross section area of the mortar (A_{mortar})], also designated as "Q". Q is the ratio of the outer diameter of the shell ($d_{\mathrm{o,shell}}$, including the fuse to the lifting charge) squared over the inner diameter of the mortar ($d_{\mathrm{i,mortar}}$) squared. The outer diameter of the shell shall be measured horizontally at the place of largest diameter including the fuse to the lifting charge. The conditions given in Formula (1) and Formula (2) shall be achieved:

$$0,9 \le Q = \frac{A_{\mathrm{shell}}}{A_{\mathrm{mortar}}} = \frac{d^2{}_{\mathrm{o,shell}}}{d^2{}_{\mathrm{i,mortar}}} \le 0,98 \tag{1}$$

$$\sqrt{1,02 \cdot d^2_{\text{o,shell}}} \leq d_{\text{i,mortar}} \leq \sqrt{1,1 \cdot d^2_{\text{o,shell}}} \tag{2}$$

For calibre ≤100 mm, a wider tolerance can be accepted. The conditions given in Formula (3) and Formula (4) shall be achieved:

$$0,83 \leq Q^*_{\leq 100} \leq 0,98 \tag{3}$$

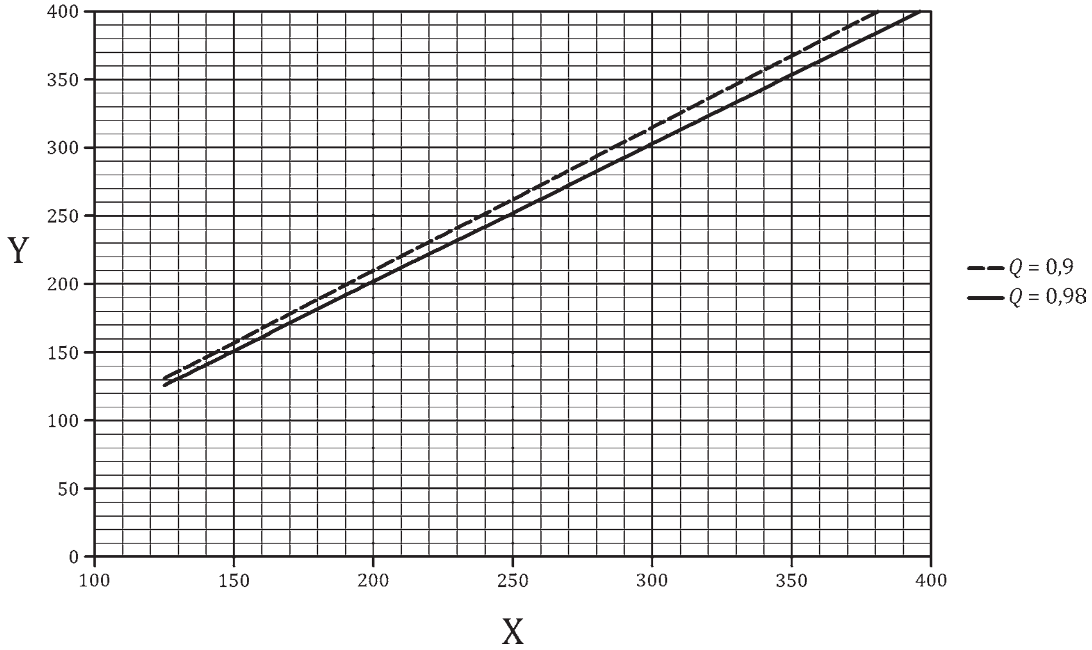
$$\sqrt{1,02 \cdot d^2_{\text{o,shell}}} \leq d^*_{\text{i,mortar}} \leq \sqrt{1,2 \cdot d^2_{\text{o,shell}}} \tag{4}$$

For calibre >400 mm, the clearances shall be determined according to the safety standard of manufacturer.

Another determining factor influencing the rising height is the length of the mortar (l_{mortar}) – length from the mortar muzzle to the mortar ground.

The dimensions of the mortar may also be determined from Figure 1, Figure 2 and Figure 3.

Dimensions in millimetres



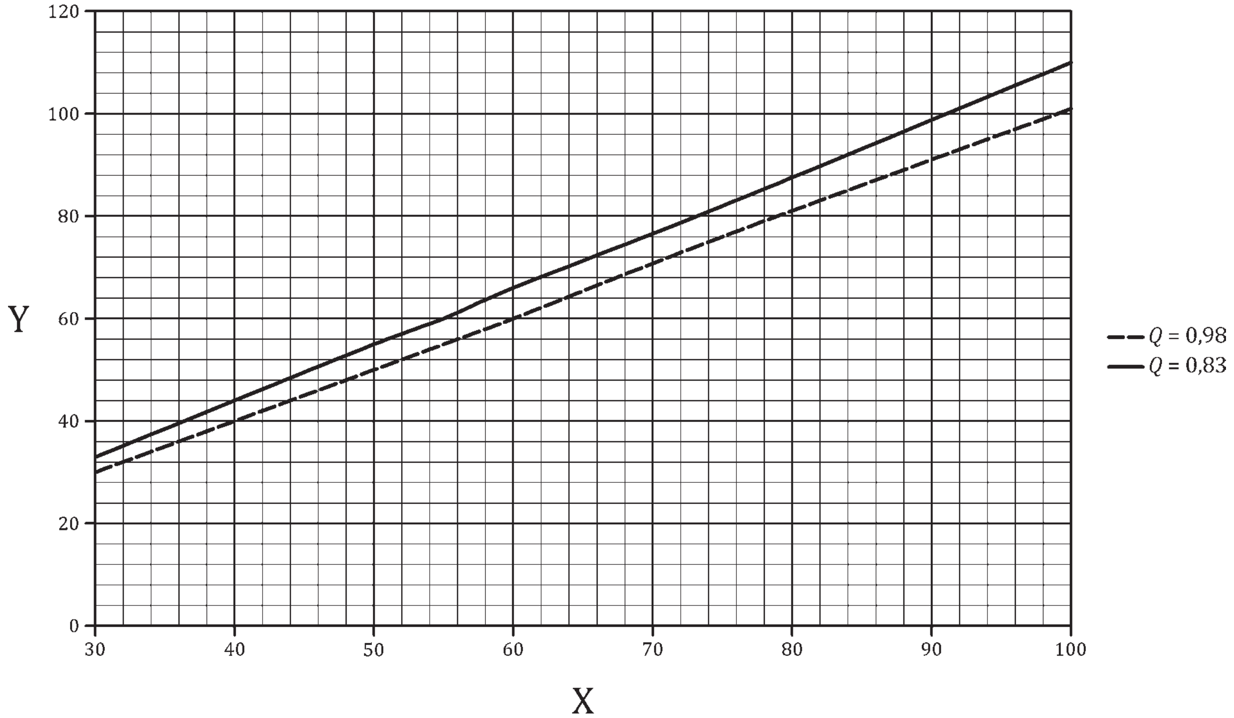
Key

X calibre of the shell

Y internal diameter of the mortar

Figure 1 — Dimensions of the mortars for spherical shells — Calibre above 100 mm

Dimensions in millimetres



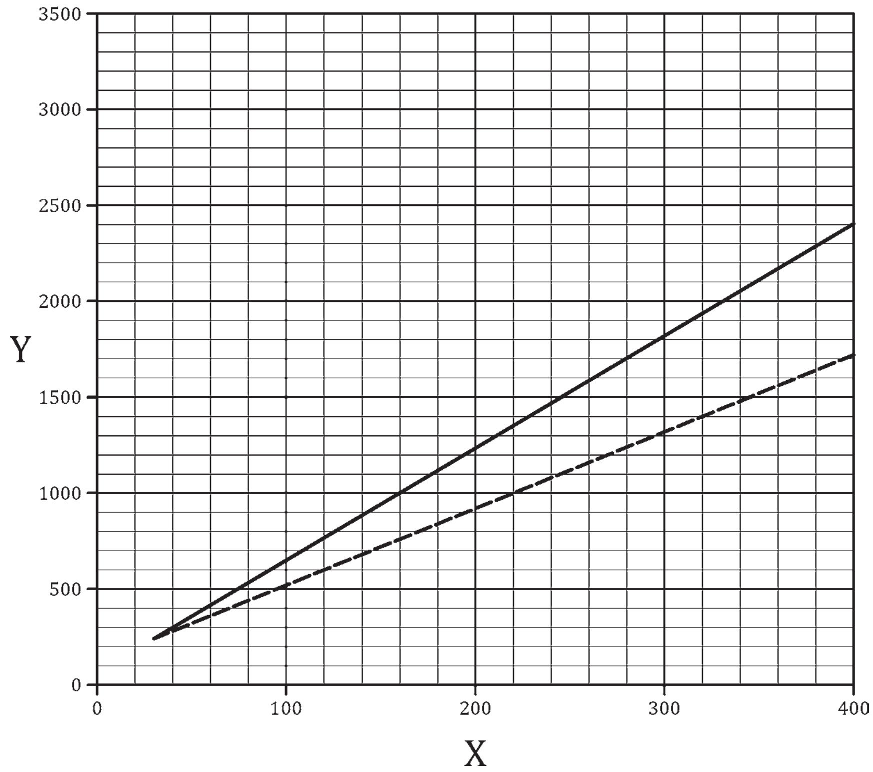
Key

X calibre of the shell

Y internal diameter of the mortar

Figure 2 — Dimensions of the mortars for spherical shells — Calibre up to 100 mm

Dimensions in millimetres



Key

X calibre of the shell

Y inside length of the mortar

— $l_{\text{mortar}} = 6 \times d_{\text{n}} + 70$

--- $l_{\text{mortar}} = 4 \times d_{\text{n}} + 120$

d_n nominal calibre

NOTE $4 \times d_{\text{n}} + 120 \leq l_{\text{mortar}}$ (mm) $\leq 6 \times d_{\text{n}} + 70$.

Figure 3 — Range of the mortar length for spherical shells

6 Test methods

NOTE Any equivalent method with the same sensitivity and the same accuracy or better might be used.

6.1 Construction and stability

6.1.1 Outer dimension of item

6.1.1.1 Apparatus

6.1.1.1.1 Ruler (see 5.3).

6.1.1.2 Procedure

Use the ruler to measure the outer dimensions of the tested article to the nearest of 1,0 mm and record the results.

6.1.2 Determination of calibre

6.1.2.1 Apparatus

6.1.2.1.1 Calliper (see 5.2).

6.1.2.2 Procedure

Use the calliper (5.2) to measure the calibre of the tested article at least three times at different positions on the article and to the nearest 0,1 mm and record the results.

6.1.3 Determination of gross mass

Use the balance (5.6) to measure the gross mass of the tested article and record the results.

6.2 Design – Verification

Compare the actual article with the detailed manufacturer's drawing.

Observe and record any nonconformity.

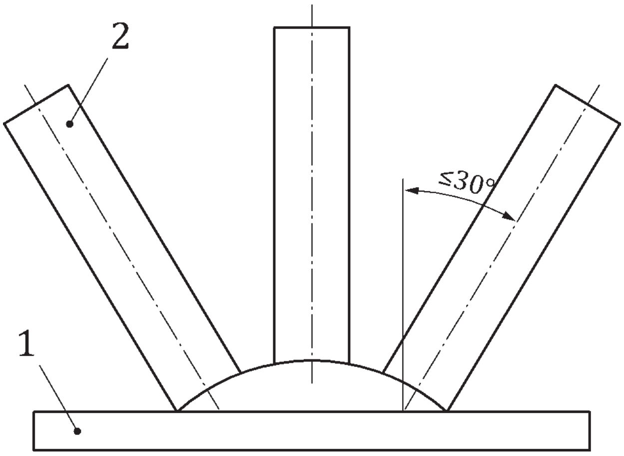
6.3 Determination of tube angle

6.3.1 Apparatus

6.3.1.1 Goniometer (see 5.11).

6.3.2 Procedure

For the determination of the tube angle, dismantle the functioned article (if necessary) in such a way that the angle of the tube against the vertical can be measured with the goniometer (see Figure 4) and record the results.



Key

1 base of firework

2 tube of mine, Roman candle or shot tube

Figure 4 — Determination of tube angle

6.4 Angle of ascent and burst height

6.4.1 General

The fireworks shall be fired vertically (firing device at 90° ± 2°).

The measurement of heights may be made according to one of the methods described in Annex B.

6.4.2 Dimensions of mortar

For type and batch tests, defined standard mortars (5.12) shall be used. Tables for the standardized inside diameter and inside length are given in 5.12.

When the height of a shell casing (excluding the lifting charge) is more than twice the calibre (for all shells with a calibre greater than 400 mm and for shells that are designed to be fired from a specific mortar), the mortar recommended by the manufacturer shall be used.

6.4.3 Support of mortar

The mortar shall be supported in such a way that it is not displaced by the firing of the tested article.

No deformable material shall be placed under the mortar.

6.5 Measurement of sound pressure level

6.5.1 Apparatus

6.5.1.1 Sound level meter (see 5.8).

6.5.1.2 Measuring tape (see 5.4).

6.5.2 Procedure

Set up the microphone of the sound level meter in the test area (see Clause 4) at a height of 1,0 m. The sound level meter shall be orientated to the firing point.

The distance between the measuring and firing point may be the same as for the measuring of the rising height according to 6.4.

Place and ignite the test sample in accordance with the labelled instructions and instructions for use, and record the maximum A-weighted impulse sound pressure levels as measured by the sound level meter (5.8) and the distance from the firing point (5.4).

NOTE An example of the calculation method for safety/protection distance is given in Annex C. The measurement set-up for sound pressure level is illustrated in Figure C.1.

6.6 Extinguishing of flames

6.6.1 Apparatus

6.6.1.1 Timing device (see 5.1).

6.6.2 Procedure

At the moment the tested article ceases to function (see 6.10.2), immediately start the timing device (5.1) and record the time until all flames caused by the functioning of the fireworks have extinguished.

6.7 Visual and audible inspections

The visual inspection shall be done by naked eye.

The audible inspection shall be done by suitably protected ears at the relevant distance.

Record any anomalies.

6.8 Mechanical conditioning

6.8.1 Apparatus

6.8.1.1 Shock apparatus (see 5.9).

6.8.1.2 Balance (see 5.6).

6.8.1.3 Timing device (see 5.1).

6.8.2 Procedure

Place a sheet of paper on the platform of the mechanical shock apparatus and place the test samples on the top of the sheet of paper. For articles that are supplied in primary packs, condition the appropriate number of complete, unopened packs. Cover the test samples or packs and secure the covering to the platform around its edges. Run the shock apparatus (5.9) for 1 h.

At the end of the conditioning period, stop the shock apparatus (5.9) and remove the test samples or primary packs. For samples which have been conditioned in primary packs, carefully open the packs, remove the samples and empty any loose material on to the sheet of paper. Separate any pyrotechnic composition from the loose material and weigh this pyrotechnic composition with the balance.

Where the tested article contains sealing paper, ignition head(s) and/or friction head(s), record whether there was any of these damaged or loose after the mechanical conditioning.

6.9 Thermal conditioning

6.9.1 Apparatus

6.9.1.1 Temperature chamber (5.7).

6.9.2 Procedure

Store the fireworks for two days at a temperature of (75 ± 2,5) °C or four weeks at a temperature of (50 ± 2,5) °C in the temperature chamber (see 5.7) and then for at least two days at ambient temperature (20 ± 5,0) °C before testing. For fireworks which were supplied in primary packs, condition the fireworks by storing the appropriate number of complete unopened packs.

Record if any article presents sign of ignition or chemical reaction. If any signs are visible, the test is failed and no re-test is possible.

Record whether any articles are damaged to an extent that might affect their functioning.

6.10 Function test

6.10.1 Apparatus

6.10.1.1 Test area (see Clause 4).

6.10.1.2 Water test area, where applicable (see 4.1).

6.10.1.3 Mortar (see 5.12).

6.10.2 Procedure

Articles shall be fired vertically upwards, unless specified otherwise by the manufacturer. For waterfalls, the article shall be fired vertically downwards, unless specified otherwise by the manufacturer.

Place the test sample onto the testing site as specified in 4.1 and ignite test sample in accordance with the labelled instructions and the instructions for use. Aquatic fireworks shall be tested in accordance with the instructions for use; the test may be performed on the ground (see 4.1). For checking the resistance to moisture and functioning under wet conditions, aquatic fireworks shall be ignited in the water test area. Aquatic fireworks shall be wetted and ignited in a way which replicates its normal use. The measurement, visible and audible inspection (see 6.7) while functioning (if this is applicable for the tested article) shall observe and record the conformity:

— to the related principle effect (see ISO 26261-2:2017, 7.2.1);

— to check that no explosion or rupture occurs during function (except when explosion is intended or is the principal effect, ISO 26261-2:2017, 7.2.2);

— to check that the article remains in its initial position while functioning (if applicable, see ISO 26261-2:2017, 7.2.3);

— to the angle of ascent and burst or effect height (see ISO 26261-2:2017, 7.2.4);

— to the sound pressure level (see ISO 26261-2:2017, 7.2.5);

— to the extinguishing of flames (see ISO 26261-2:2017, 7.2.6);

— to the projected debris (see ISO 26261-2:2017, 7.2.7);

— to check that all pyrotechnic units function completely;

— to check that the elements of the tested article are securely attached;

— to the burning or incandescent matter (ISO 26261-2:2017, 7.2.8);

and possible nonconformities as listed in ISO 26261-2:2017, Annex B.

6.10.3 Monitoring of effect, rising/bursting and drop height

Two positions for monitoring the height of ascent and angle of flight shall be provided, at an adequate measured distance and at preferably 90° to each other or at a sufficient angle to ensure a good accuracy of the measuring (depending on the method of measurement and calculation of the heights). In order to achieve a reasonable accuracy, the distance between firing point and measurement location, referred to as “base length” here, has to be adjusted to the measurement device.

The vertical angle should not exceed 60°; optimal would be having angles between 30° and 50°. If the monitoring positions are not in the same horizontal plane, appropriate corrections should be made in the calculation of heights. Generally, the measuring distance should be adapted to the fireworks (anticipated rising/bursting height).

6.10.4 Monitoring of effect range and effect dimensions of aquatic fireworks

One position for monitoring the effect range and dimensions shall be provided at an adequate measuring distance.

In order to achieve reasonable accuracy, the distance between the firing point and the measurement location shall be adjusted to the measurement device.

The effect dimensions can also be measured during the ignition on the water test area.

Annex A
(informative)

Mechanical conditioning (shock apparatus)

The mechanical shock apparatus is illustrated in Figure A.1, Figure A.2 and Figure A.3 and is comprised of the following elements:

a) **a flat horizontal platform** made of steel, 800 mm × 600 mm, 2 mm to 3 mm thick, with a 3 mm thick rim having a height of 15 mm; the platform is reinforced with eight steel ribs, 5 mm thick with a height of 30 mm, which are welded to the underside and run from the centre to each of the four corners and to the middle of each edge;

b) **a 20 mm thick plate of fibreboard**, firmly attached to the platform by screws;

c) **a cylindrical steel boss**, diameter 125 mm and height 35 mm, located under the centre of the platform;

d) **a 284 mm long shaft**, with diameter of 20 mm, fixed to the centre of the boss;

e) **a restraining peg**, to prevent the platform from rotating; the mass of the platform assembly [items a) to e)] is 23 kg ± 1 kg;

f) **an annular, elastomeric pressure spring**, with a Shore A hardness, when determined in accordance with ISO 868, of 68, outside diameter 125 mm, inside diameter 27 mm and height 32 mm, on which the cylindrical boss will rest;

g) **a shallow steel cylinder**, inside diameter 126 mm, wall thickness 5 mm, outside height 30 mm, with a base 8 mm thick which has a 25 mm diameter hole drilled through the centre, to contain the elastomeric spring;

h) **a supporting steel cylinder**, outside diameter 80 mm, inside diameter 60,1 mm and height 92,4 mm, to which the shallow cylinder is screwed;

i) **a PVC liner**, outside diameter 60 mm, inside diameter 20,2 mm and height 92,4 mm, located inside the supporting cylinder and attached by a screw;

j) **a steel mounting plate**, thickness 12 mm with a 25 mm hole drilled through the centre, to which the supporting steel cylinder is screwed;

k) **a steel base plate,** thickness 12 mm;

l) **four supporting pillars**, height 260 mm and diameter 32 mm, screwed to the mounting plate and to the base plate;

m) **a framework** to support the based plate so that the complete assembly is at a convenient height;

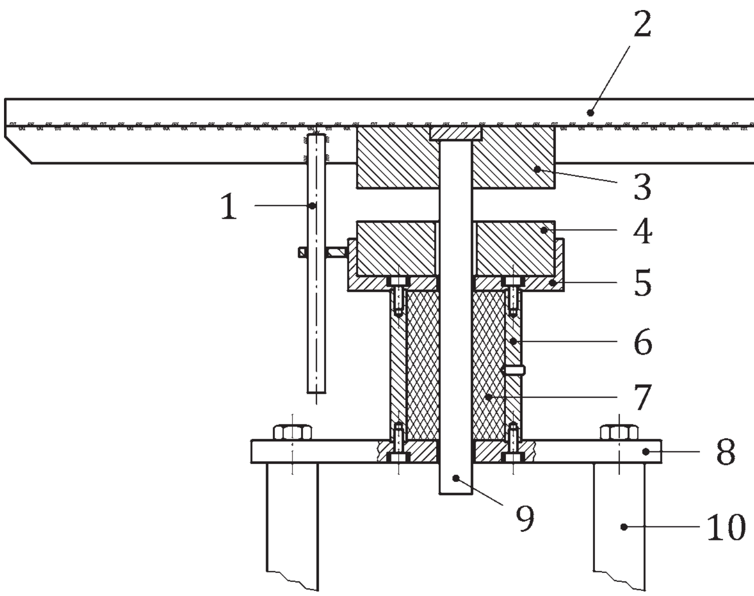
n) **an attachment to the shaft**, allowing adjustment to the overall length, fitted with a cam wheel, outside diameter 30,0 mm, with a contact surface 8,0 mm wide;

o) **a cylindrical cam**, outside diameter 120 mm, inside diameter 100 mm, wall thickness 10 mm, with a “vertical drop” of 50,0 mm between the high point and the low point;

p) **a collar**, outside diameter 50 mm, height 4,0 mm;

q) **an electric motor and suitable gearing**, to rotate the cam at a rotational frequency of 1 Hz;

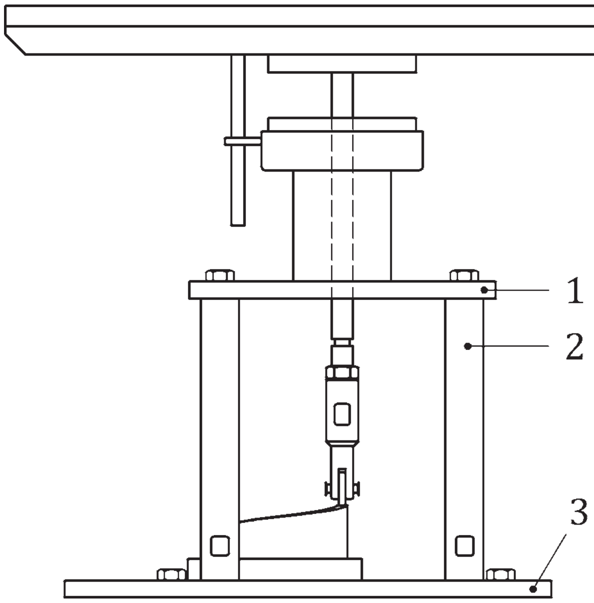
r) **cellular rubber sheet**, 100 mm thick. The material used should have an apparent density when determined in accordance with ISO 845, of 35 kg/m^3 and an indention hardness check, when determined in accordance with ISO 2439 of 215 N.



Key

1 restraining peg
2 platform
3 boss
4 pressure spring
5 cup
6 supporting cylinder
7 PVC liner
8 mounting plate
9 shaft
10 supporting pillar

Figure A.1 — Detail of the top section of the mechanical shock apparatus



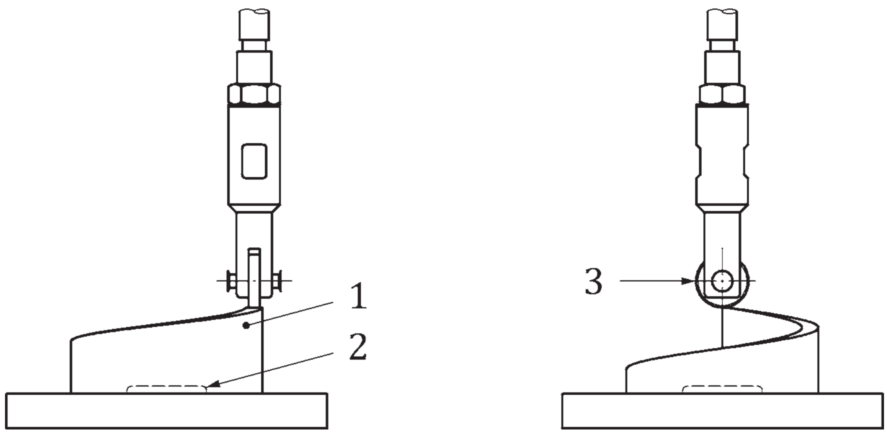
Key

1 mounting plate

2 supporting pillar

3 base plate

Figure A.2 — General assembly of the mechanical shock apparatus



Key

1 cam

2 collar

3 cam wheel

Figure A.3 — Detail of the shaft attachment and cam assembly of the mechanical shock apparatus

Annex B
(informative)

Procedures for calculation of heights

B.1 General

The following methods may be used for the calculation of heights.

B.2 Method 1

This procedure allows performing measurements with equipment that is not located at the same height as the firing point and at 90° to each other.

Firing takes place only in vertical direction (90° from the horizontal plane at the place of firing) and measurements shall only take place with a wind velocity of less than 5 m/s.

Measurement requires two locations (T1 and T2) which should be preferably, but not necessarily, located at 90° to each other with respect to the firing point (see Figure B.1).

Suitable equipment for height measurement is any kind of regular device for measuring two angles at the same time, specifically the elevation angles α_1 and α_2 (0° to 90°, 1° steps) and the azimuth angles β_1 and β_2 (0° to 180°, 1° steps) of the bursting point B (or maximum point of effect) of the firework seen from T1 and T2.

Differences in height of the measurement locations T1 and T2 have to be taken into account, corresponding to h_1 and h_2 in Figure B.1.

The effect height (or rising height, or drop height) H is determined from the angles α_1 and α_2, β_1 and β_2, and the horizontal distance $D_{1,2}$ between T1 and T2 through Formula (B.1), Formula (B.2) and Formula (B.3):

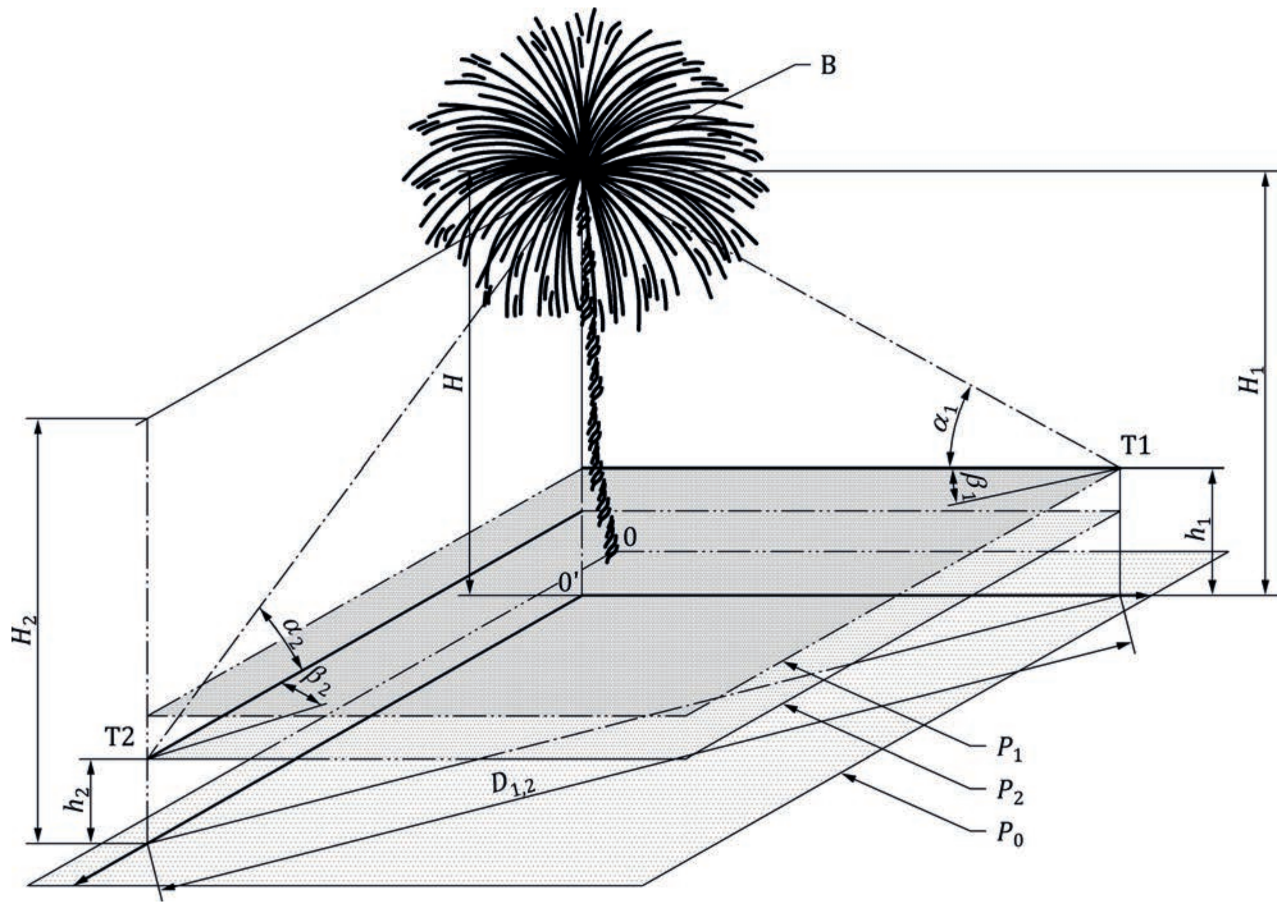
$$H_1 = \frac{D_{1,2}\sin\beta_2}{\sin\left(\beta_1 + \beta_2\right)}\tan\alpha_1 + h_1 \tag{B.1}$$

$$H_2 = \frac{D_{1,2}\sin\beta_1}{\sin\left(\beta_1 + \beta_2\right)}\tan\alpha_2 + h_2 \tag{B.2}$$

and

$$H = \frac{H_1 + H_2}{2} \tag{B.3}$$

With these formulae, it is not necessary to know the distances of the two measurement locations T1 and T2 from the firing point O, or their angle to each other from this point.



Key

P_0	horizontal plane passing through the firing point O
P_1	horizontal plane passing through the measurement location T1
P_2	horizontal plane passing through the measurement location T2
h_1, h_2	heights of the measurement locations T1 and T2 from plane P_0, respectively, measured and recorded by the suitable equipment located at points T1 and T2
O′	vertical projection of the bursting point B (or maximum point of effect) of the firework on plane P_0
$D_{1,2}$	horizontal distance between T1 and T2
α_1, α_2	elevation angles of the bursting point B (or maximum point of effect) of the firework measured and recorded by the suitable equipment located at T1 and T2
β_1, β_2	azimuth angles of the bursting point B (or maximum point of effect) of the firework measured and recorded by the suitable equipment located at T1 and T2
H	effect height to be calculated from $D_{1,2}$, h_1 and h_2, α_1 and α_2, β_1 and β_2

Figure B.1 — Measurement set-up for shells (Method 1)

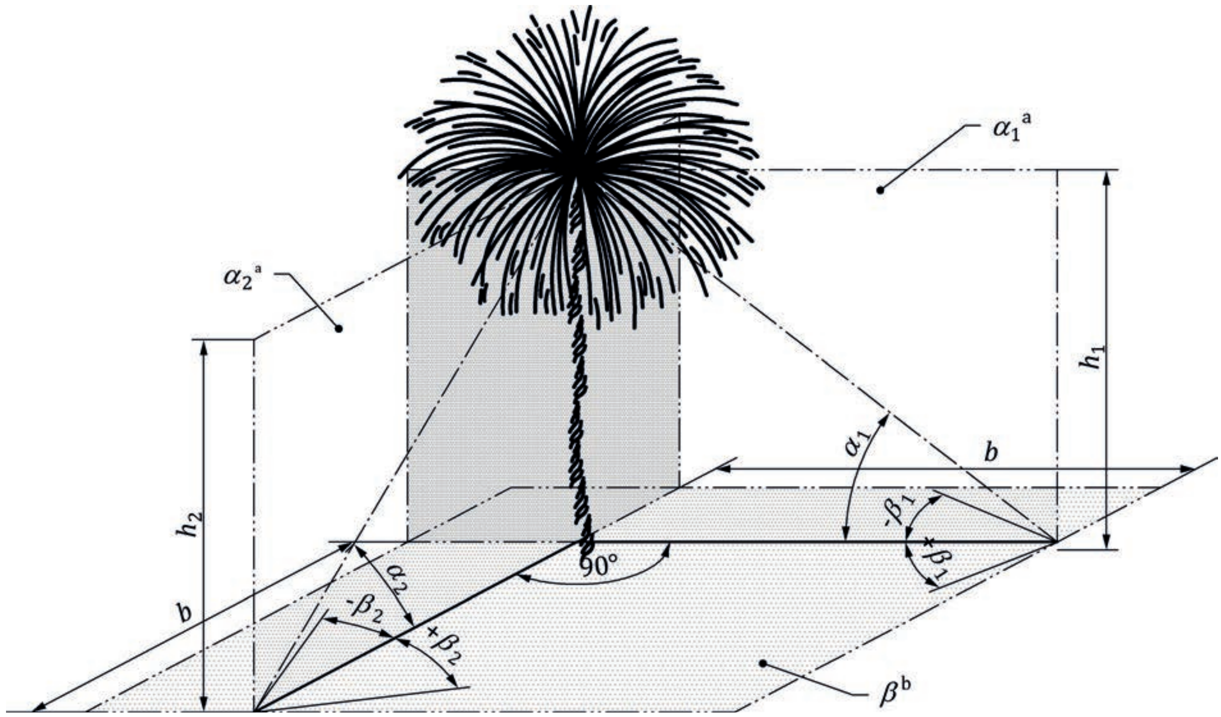
Measurement of the horizontal distance $D_{1,2}$ should take place with an accuracy of at least ±1 % of the distance.

B.3 Method 2

Suitable equipment for height measurement is any kind of regular device for measuring two angles at the same time, specifically the vertical angle (0° to 90°, 1° steps) and the horizontal angle (0° to 360°, 1° steps).

Measurement requires two locations which should be preferably located at 90° to each other with respect to the firing point (see Figure B.2).

When using a USI, (see 5.10) both angles, the vertical and the horizontal angle, have to be measured. Differences in height of the measurement locations have to be taken into account.



Key

h_1, h_2	calculated heights from vertical planes
b	horizontal distance between the measuring points and the firing point
α_1, α_2	measured elevation angles of the bursting point (or maximum point of effect)
β_1, β_2	measured azimuth angles of the bursting point (or maximum point of effect)
a	Vertical plane.
b	Horizontal plane.

Figure B.2 — Measurement set-up for shells (Method 2)

In the case of a vertical trajectory of the display shell (i.e. the horizontal angles are less than ±2°), the effect height, rising height, and drop height h is determined from the vertical angles α_1 and α_2 and the base length, b (distance between firing point and measurement location), through Formula (B.4):

$$h_{1,2} = b \times \tan\alpha_{1,2} \quad \text{(B.4)}$$

With this formula, it is possible to calculate the heights independently for each measurement location, thus making it possible to use different base lengths. Both values are averaged.

For a non-vertical trajectory, the actual height is calculated according to Formula (B.5) and Formula (B.6):

$$h_1 = b \times \tan\alpha_1 \times \frac{\cos\beta_2 - \sin\beta_2}{\cos\left(\beta_1 + \beta_2\right)} \tag{B.5}$$

and

$$h_2 = b \times \tan\alpha_2 \times \frac{\cos\beta_1 - \sin\beta_1}{\cos\left(\beta_1 + \beta_2\right)} \tag{B.6}$$

The angles β_1 and β_2 are the horizontal angles.

The effect height can be calculated as given in Formula (B.7):

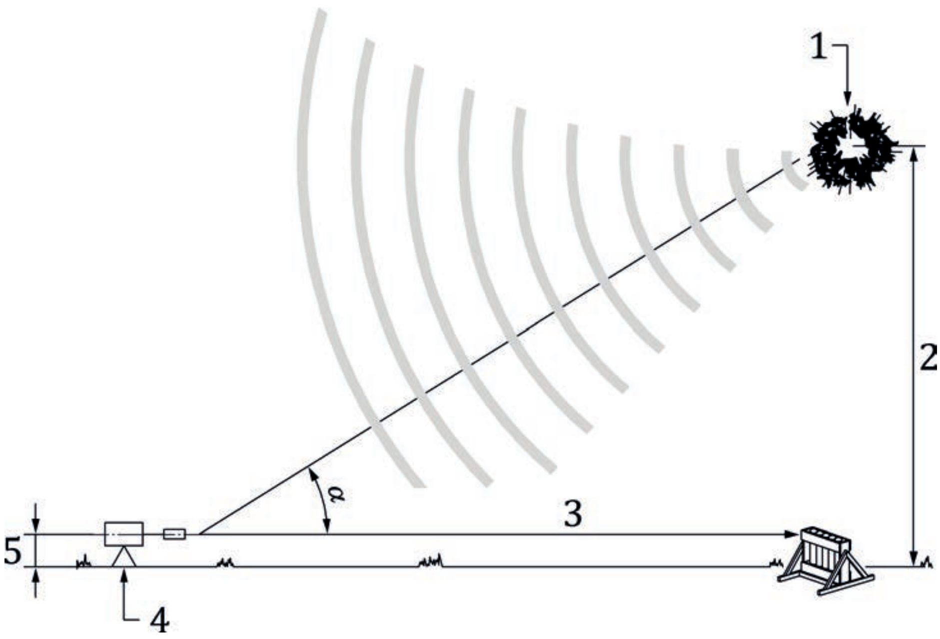
$$H = \frac{h_1 + h_2}{2} \tag{B.7}$$

In order to achieve a reasonable accuracy, the distance between firing point and measurement location, referred to as base length here, has to be adjusted to the measurement device. For an expected rising height of 300 m, the base length of at least 175 m is chosen, for example.

Measurement of the base length should take place with an accuracy of at least ±1 % of the distance.

Annex C
(informative)

Calculation method for safety/protection distance



Key

1 bursting point
2 rising and bursting height
3 measuring distance/safety distance
4 technician in measurement technology : audience
5 measuring height (1 m)

Figure C.1 — Measurement set-up for sound pressure level

In the case of an effect with a high sound pressure level, the safety/protection distance between the articles and the audience may be calculated as given in Formula (C.1):

$$R_S = 10^{\left(\log_{10} R_m - \frac{L_S - L_m}{20\ \mathrm{dB}}\right)} \qquad \text{(C.1)}$$

where

R_S is the minimum safety distance (depending of sound pressure);

R_m is the measuring distance;

L_S is the sound pressure limit;

L_m is the sound pressure level, measured at the measuring point.

Bibliography

[1] ISO 845, *Cellular plastics and rubbers — Determination of apparent density*

[2] ISO 868, *Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)*

[3] ISO 2439, *Flexible cellular polymeric materials — Determination of hardness (indentation technique)*

[4] ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ICS 71.100.30

Price based on 19 pages