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BSI Standards Publication

Pyrotechnic articles — Other pyrotechnic articles — Ignition devices

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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European foreword

This document (EN 16265:2015) has been prepared by Technical Committee CEN/TC 212 “Pyrotechnic articles”, the secretariat of which is held by NEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2016, and conflicting national standards shall be withdrawn at the latest by June 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This European standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential safety requirements of EU Directive 2007/23/EC and 2013/29/EU on the placing on the market of pyrotechnic articles.

For relationship with EU Directives 2007/23/EC and 2013/29/EU on the placing on the market of pyrotechnic articles, see informative Annexes ZA and ZB, which are an integral part of this document.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard defines the terms and specifies the requirements, means of categorization, test methods, minimum labelling requirements and instructions for use, for ignition devices (except ignition devices for pyrotechnic articles for vehicles) of the following generic types:

— igniters;

— components for pyrotechnic trains;

— pyrotechnic cords and fuses;

— delay fuses;

— fuzes.

NOTE Safety fuses are subject to Directive 93/15/EEC and therefore not considered in this European Standard.

This European Standard does not apply for articles containing pyrotechnic compositions that include any of the following substances:

— arsenic or arsenic compounds;

— polychlorobenzenes;

— mercury compounds;

— white phosphorus;

— picrates or picric acid.

This European Standard does not apply to pyrotechnic articles that contain detonative explosives other than black powder and/or flash composition, except igniters if these detonative explosives:

— can be easily extracted from the pyrotechnic article, or

— can initiate secondary explosives, or

— can function in a detonative manner, although the article is not designed to detonate and the article belongs to the category P2.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

ISO 2859-1, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 General terms

3.1.1
type
sample representative of the production envisaged

3.1.2
generic type
set of articles with common, very general, design features and/or with common characteristic effects

3.1.3
subtype
set of articles within a generic type with specific design features

3.1.4
individual item
article within a generic type and/or subtype for which every possible feature and characteristic has been fixed

Note 1 to entry: Each feature and characteristic will be specified in the technical name or a technical data sheet, as appropriate.

3.1.5
technical name
general description of an individual item

3.2 Technical terms

3.2.1
Acceptance Quality Limit
AQL
quality level that is the worst tolerable process average when a continuing series of lots is submitted for acceptance sampling

3.2.2
acceptor charge
acceptor component
charge of pyrotechnic composition or component receiving a stimulus from another charge (See "donor charge")

Note 1 to entry: The term acceptor charge is also known as acceptor component.

3.2.3
all-fire current
minimum current (generally expressed in Amperes DC) needed to ensure that an electric igniter is fired within a given time frame (See "All-fire level")

3.2.4
all-fire level
minimum level of the initiation input (e.g. electric current in Amperes, mechanical force in Newtons, optical power in Watts, etc.) needed to ensure that an igniter or an ignition device is fired within a given time frame

Note 1 to entry: All-fire level is a characteristic given in the instructions for use of every igniter. It is generally associated with a probability level (e.g. 99,9 % at 95 % confidence level) within a specified time frame (e.g. 50 ms).

3.2.5
ancillary equipment
any device which does not form part of a pyrotechnic article, but which is supplied with it and is required in order that the article functions safely and correctly when used in accordance with the instructions for use

3.2.6
batch test
test performed on one or more sample(s) of products taken at random from a production batch to check compliance with a given specification

Note 1 to entry: Batch testing needs all products in the production batch to comply with the characteristics the standard requires to ensure homogeneity of the whole batch. It aims at proving all products which are placed on the market are in conformity with the type which is described in the EC type-examination certificate and have been successfully submitted to type tests determined by the standard.

3.2.7
black powder
intimate mixture of charcoal and sodium nitrate or potassium nitrate with or without sulfur

3.2.8
booster
pyrotechnic device used as a donor charge to amplify the energy supplied to the acceptor charge

3.2.9
bridgewire
resistive element connecting the leading wires inside an electric igniter or primer

3.2.10
burning time
time in seconds for a defined mass or length of pyrotechnic composition to burn from its ignition to its consumption

3.2.11
critical nonconformity
nonconformity that judgement and experience indicate is likely to result in hazardous or unsafe conditions

Note 1 to entry: This type of nonconformity is referred to as a 'class A nonconformity' in ISO 2859-1.

3.2.12
critical nonconforming unit
nonconforming unit with one or more critical nonconformities, with or without major or minor nonconformities

3.2.13
deflagration
reaction of fast combustion through a pyrotechnic composition at subsonic velocity in the reacting explosive

3.2.14
delay fuse duration
time delay of a delay fuse

3.2.15
detonation
reaction which propagates through an explosive at supersonic velocity in the reacting explosive

3.2.16
detonative explosive
substance or mixture of substances which can undergo a fast internal decomposition reaction leading to a detonation in normal use

3.2.17
donor charge
charge of pyrotechnic composition supplying a stimulus to another charge (See “acceptor charge”)

3.2.18
electrostatic discharge
ESD
sudden and momentary electric current that flows between two objects at different electrical potentials

3.2.19
explosive
chemical substance or mixture of chemical substances as defined in Article 1 paragraph 2 of Directive 93/15/EEC

3.2.20
firework
pyrotechnic article intended for entertainment purposes, as defined by Art. 2 No. 3 of Directive 2007/23/EC

3.2.21
firing current
constant electrical direct current required to reliably initiate functioning of an electric igniter or primer

3.2.22
friction head
ignition head designed to be ignited by friction

3.2.23
fusehead
part of an electric igniter consisting of one or more pairs of metal conductors, bridged by fine resistance wire(s), and coated with a pyrotechnic composition which initiates when the firing current is passed through the bridgewire(s)

3.2.24
gross mass
total mass of a pyrotechnic article (not including any ancillary equipment)

3.2.25
ignition head
initial fuse consisting of pyrotechnic composition only

3.2.26
ignition tube
tube usually containing a thin pyrotechnic charge on the inner wall capable on activation of transmitting a deflagration effect from one end of the tube to the other at a subsonic velocity

3.2.27
incompatible substances
substances or materials that react together resulting in unsafe conditions

3.2.28
linear burning rate
length of pyrotechnic composition in millimetres or metres divided by the burning time in seconds

3.2.29
main charge
pyrotechnic composition which produces the principal effect

3.2.30
major nonconformity
nonconformity, other than a critical nonconformity, which is likely to result in failure, to reduce materially the usability of the pyrotechnic article, or to increase the potential hazard

Note 1 to entry: This type of nonconformity is referred to as a “class B nonconformity” in ISO 2859-1.

3.2.31
major nonconforming unit
nonconforming unit with one or more major nonconformities, with or without minor nonconformities, but with no critical nonconformities

3.2.32
minor nonconformity
nonconformity that is not likely to reduce materially the usability of the pyrotechnic article

Note 1 to entry: This type of nonconformity is referred to as a “class C nonconformity” in ISO 2859-1.

3.2.33
minor nonconforming unit
nonconforming unit with one or more minor nonconformities, but with no critical or major nonconformities

3.2.34
misfire
incomplete functioning or non-functioning of a pyrotechnic article after application of initiation stimulus

3.2.35
Net Explosive Content
NEC
total mass of explosive material in a pyrotechnic article

3.2.36
no-fire current
maximum current (generally expressed in Amperes DC) that can be applied without causing an electric igniter to function within a specified time period (See “No-fire level”)

3.2.37
no-fire level
maximum level of the initiation input (e.g. electric current in Amperes, mechanical force in Newtons, optical power in Watts, etc.) that can be applied without causing an igniter to function within a specified time period

Note 1 to entry: No-fire level is a characteristic given in the instructions for use of every igniter. It is generally associated with a probability level (e.g. 99,9 % at 95 % confidence level) within a specified time frame (e.g. 50 ms).

3.2.38
nonconforming unit
pyrotechnic article with one or more nonconformities

3.2.39
nonconformity
non-fulfilment of a requirement

3.2.40
other pyrotechnic article
pyrotechnic article other than fireworks, theatrical pyrotechnic articles and pyrotechnic articles for vehicles

3.2.41
“pin-to-case” configuration
configuration in which the ESD occurs between the two short-circuited leading wire ends and the igniter casing or between the pins and the casing of the connector of the igniter

3.2.42
“pin-to-pin” configuration
configuration in which the ESD occurs through the bridgewire of the igniter

3.2.43
primary pack
package of one or more pyrotechnic articles, offered for retail sale as a single unit

Note 1 to entry: A primary pack is neither necessarily the smallest piece of packaging nor a full enclosure: for instance, pyrotechnic cords and fuses are often delivered coiled around a reel as the smallest piece of retail sale.

3.2.44
principal effect
main effect a pyrotechnic article is designed to produce, as defined by the manufacturer

3.2.45
pyrotechnic component
any component of a pyrotechnic article which contains one or more pyrotechnic compositions

3.2.46
pyrotechnic composition
explosive substance or mixture of explosive substances which is designed, on ignition or initiation, to produce heat, light, sound, gas or smoke or a combination of such effects through self-sustained exothermic chemical reactions

3.2.47
pyrotechnic delay
pyrotechnic device designed in such a manner that it generates a delay in the transmission of ignition in a pyrotechnic train

Note 1 to entry: Delay fuses are specific examples of such pyrotechnic delays (see “Delay fuse”).

3.2.48
pyrotechnic device
any device containing pyrotechnic composition(s) which determine its principal effect

3.2.49
pyrotechnic operation
any operation which leads to the direct application of a mechanical, thermal and/or chemical stress on a pyrotechnic composition without intending to ignite or initiate the article at the time the stress is applied

3.2.50
pyrotechnic train
set of pyrotechnic components which are functionally linked and, after an initial input of energy, function in a designed sequence to transmit, enhance and/or distribute ignition to one or more other pyrotechnic components

3.2.51
relay
charge of pyrotechnic composition that is used to transmit ignition

3.2.52
safe test current
maximum electrical current (generally expressed in Amperes DC) that can be applied without causing an electric igniter to function regardless of the duration

3.2.53
safety friction tip
friction head that can only be ignited when rubbed against a striker component containing a chemical substance with which it reacts, such as red phosphorus, or a combination of such a chemical substance and an abrasive surface

3.2.54
safety fuse
article consisting of a core of fine-grained black powder surrounded by a flexible woven fabric with one or more protective coverings

Note 1 to entry Other names: safety cord, fuse cord, mine or mining fuse. This article is subject to Directive 93/15/EEC and to the corresponding European Standard EN 13630.

3.2.55
slag
condensed reaction products resulting from the combustion of pyrotechnic composition(s)

3.2.56
type test
test performed on a sample of products, representative of the production envisaged, in order to demonstrate their compliance with the essential safety requirements of Annex I and the relevant provisions of the Directive 2007/23/EC

Note 1 to entry: The successful submission to type tests leads to the attribution of a EC type-examination certificate.

3.2.57
use by date
latest date by which an article shall be used if it is to safely exhibit the performance characteristics described in the manufacturer's or importer's specifications

4 Categories and types of ignition devices

4.1 Generic types

The generic types are defined as follows:

4.1.1 Igniter: Article containing pyrotechnic composition(s) used to initiate combustion or deflagration. They may be actuated by chemical, electrical, optical or mechanical means.

NOTE Complex igniters (e.g. some integral rocket igniters) are not considered as subtypes of "igniters", but linked to "gas generators" or "heaters" (see EN 16263–1, EN 16263–2, EN 16263–3, EN 16263–4 and EN 16263–5).

4.1.2 Component for pyrotechnic trains: Article, excluding the other generic types containing pyrotechnic composition(s) designed to transmit a pyrotechnic reaction or effect within a pyrotechnic train. They can include bursting charges and lift charges.

4.1.3 Pyrotechnic cord and fuse: Article consisting of black powder or other pyrotechnic composition(s) either coated on a supporting medium and/or inside a tube with or without a protective covering.

4.1.4 Delay fuse: Article consisting of a casing with a core of compacted pyrotechnic composition. Designed to transmit ignition over a time period.

4.1.5 Fuse: Device which incorporates mechanical, electrical, chemical or hydrostatic components and one or more pyrotechnic composition(s) to initiate a pyrotechnic train.

4.2 Subtypes

The generic types can include the following subtypes:

4.2.1 Black match: *Pyrotechnic cord and fuse* consisting of textile yarns covered with black powder or another fast burning pyrotechnic composition. It burns progressively along its length with an external flame and is used to transmit ignition.

4.2.2 Cord igniter: *Pyrotechnic cord and fuse* consisting of a core of pyrotechnic composition surrounded by a flexible woven fabric, plastic or similar close fitting sheath. It burns progressively along its length with an external flame and is used to transmit ignition.

4.2.3 Delay element: *Delay fuse* consisting of a core of fine grained black powder surrounded by a flexible woven fabric with or without one or more protective outer coverings.

NOTE Frequently, when used as a component of fireworks, it is axially inserted into a solid rigid part.

4.2.4 Delay igniter: *Igniter* with a delay unit designed to transmit ignition over a time period.

NOTE The delay unit may be either pyrotechnic – a *delay fuse* – or non-pyrotechnic (e.g. electronic).

4.2.5 Electric igniter: Electrically actuated *igniter*. Electric current is used to heat a resistive element (e.g. bridge wire). The sensitive pyrotechnic composition in contact with the resistive element is ignited by heat transfer. The article initiates a pyrotechnic train or component by the deflagration that is generated.

4.2.6 Ignition cartridge: See “squib”.

4.2.7 Ignition tube: *Pyrotechnic cord and fuse* as defined in 3.2.27.

4.2.8 Mechanical igniter: Mechanically actuated *igniter.* A mechanical signal (e.g. percussion, friction) is used to ignite a pyrotechnic composition sensitive to the mechanical signal. The article initiates a pyrotechnic train or component by the deflagration of the pyrotechnic composition.

4.2.9 Optical igniter: Optically actuated *igniter.* Optical condensed light, transmitted through an optical fibre, is used to ignite a pyrotechnic composition by radiative heat transfer. The article initiates a pyrotechnic train or component by the deflagration of the pyrotechnic composition.

4.2.10 Pressed fuse: *Delay fuse* where pyrotechnic composition is pressed in a rigid case. Pyrotechnic composition burns progressively along the device length with an internal flame.

4.2.11 Primer: *Igniter* consisting of a cap containing pyrotechnic composition(s) for ignition, with or without an auxiliary charge, designed to ignite the propelling charge in a cartridge case.

4.2.12 Quick match: *Pyrotechnic cord and fuse* consisting of textile yarns covered with black powder or another fast burning pyrotechnic composition wrapped loosely in a paper or plasticised paper pipe or sheath. It burns progressively along its length with an external flame and a linear burning rate of several metres per second.

4.2.13 Squib: *Igniter* with a boosting charge, designed to amplify the pyrotechnic output of the igniter.

4.2.14 Touch paper: Paper impregnated with an oxidizing agent such as potassium nitrate and having self-sustaining combustion properties.

4.3 Conditions determining whether an article is P1 or P2

4.3.1 Igniters

When placed on the market as a separate article, igniters shall be categorized as P2 articles if they do not comply with at least one of the following requirements:

— they shall not exhibit bare pyrotechnic compositions except for friction igniters and electric igniters containing less than 10 mg of pyrotechnic composition. The presence of bare composition shall be verified by visual examination according to 6.3.23;

— the igniter is designed in such manner that its assembly with any other article does not require a pyrotechnic operation as defined in 3.2.49.

4.3.2 Components for pyrotechnic trains

When placed on the market as a separate article, components for pyrotechnic trains shall be categorized as P2 articles if they do not comply with at least one of the following requirements:

— they shall not exhibit bare pyrotechnic compositions or their design shall prevent any inadvertent or unintentional application of mechanical and/or thermal stimuli to bare pyrotechnic compositions. This characteristic shall be checked by visual examination according to 6.3.23;

— the article is designed in such manner that its assembly with any other article does not require a pyrotechnic operation as defined in 3.2.49;

— the NEC of the article shall not exceed 20 g, with any booster not exceeding 2 g.

4.3.3 Pyrotechnic cords and fuses

When placed on the market as a separate article, pyrotechnic cords and fuses shall be categorized as P2 articles except cord igniters and ignition tubes which shall be categorized as P1 if they comply with at least one of the following requirements:

— they do not exhibit bare pyrotechnic compositions, except at their ends; prior to use, the ends shall be protected by an appropriate removable cover;

— they are equipped at their ends with specific connecting parts which allow pure mechanical upstream and downstream connections with pyrotechnic articles.

All the above characteristics shall be checked by visual examination according to 6.3.23.

Touchpaper is submitted to the same requirements as *Pyrotechnic cord and fuse* and is categorized as a P1 article.

4.3.4 Delay fuses

When placed on the market as a separate article, delay fuses shall be categorized as P2 articles if they do not comply with at least one of the following requirements:

— they shall not exhibit bare pyrotechnic compositions or their design shall prevent any inadvertent or unintentional application of mechanical and/or thermal stimuli to bare pyrotechnic compositions. This characteristic shall be checked by visual examination according to 6.3.23;

— the article is designed in such manner that its assembly with any other article does not require a pyrotechnic operation as defined in 3.2.49;

— when they provide a final flash effect that burns in less than 1 s, the NEC of that flash effect shall not exceed 10,0 g of black powder or 4,0 g nitrate/metal based composition or 2,0 g of any other composition that produces a flash effect.

4.3.5 Fuzes

When placed on the market as a separate article, fuzes shall be categorized as P2 articles if they do not comply with at least one of the following requirements:

— they shall not exhibit bare pyrotechnic compositions or their design shall prevent any inadvertent or unintentional application of mechanical and/or thermal stimuli to bare pyrotechnic compositions;

— the article is designed in such manner that its assembly with any other article does not require a pyrotechnic operation as defined in 3.2.49.

— the NEC of the article shall not exceed 20 g, with any booster not exceeding 2 g;

— they shall be equipped with an easily detectable and understandable safe/arm element or safety pin which shall not be easily removable unintentionally during foreseeable conditions of handling and transportation.

All the above characteristics shall be checked by visual examination according to 6.3.23.

5 Requirements

5.1 Verification of construction and design

5.1.1 General

When tested in accordance with 6.3.1 and 6.3.2 the ignition device shall be in accordance with the manufacturer's documentation regarding construction, dimensions, permanent or removable protections, presence of safe/arm components or safety pins (where appropriate), protections against electrostatic discharges and electromagnetic fields (where appropriate).

The manufacturer's documentation shall show any relevant component, e.g. pyrotechnic unit, with its dimensions, with the mass and details of each pyrotechnic composition used in the article.

5.1.2 Incompatible substances

Pyrotechnic articles shall not contain incompatible substances as defined in 3.2.27 unless effective measures have been taken to permanently segregate incompatible substances one from the other and effective measures have been taken to stabilize mixtures of incompatible substances.

This requirement shall be verified by examination of the design and/or construction from the manufacturer's documentation.

5.1.3 Igniters

The following requirements apply to igniters.

— When a varnish is the only protective barrier for the pyrotechnic composition(s), it shall protect against electric and mechanical stresses. This shall be verified according to 6.3.11, 6.3.14 and 6.3.19;

— friction igniters (e.g. friction heads, safety friction tips…) shall be protected against mechanical crushing, shock and friction by removable protections until use. The presence of such protections shall be checked by visual examination according to 6.3.23 and verification of design according to 6.3.2;

— the net explosive content (NEC) of the pyrotechnic composition which is directly ignited by the stimulus shall not exceed 100 mg; this shall be verified from the manufacturer's documentation according to 6.3.2.2;

— in all cases, the NEC of the igniter shall not exceed 2,0 g; this shall be verified from the manufacturer's documentation according to 6.3.2.2.

When tested according to 6.3.22, igniters shall not have the capacity to initiate the detonation of the charge as defined in 6.3.22.2.

5.1.4 Delay fuses

When delay fuses are sensitive to mechanical crushing, shock and friction, they shall bear removable protections. It shall be checked by visual examination according to 6.3.23 and verification of construction and design according to 6.3.2.2.

5.1.5 Fuzes and components for pyrotechnic trains

The following requirements apply to fuzes and components for pyrotechnic trains.

— When they are sensitive to mechanical crushing, shock and friction, they shall bear removable protections until they are assembled to another article;

— where the main charge burns in less than 1 s, their NEC shall not exceed 10,0 g of black powder or equivalent; 4,0 g nitrate/metal based composition or equivalent; 2,0 g of any other composition.

All the above characteristics shall be checked by visual examination according to 6.3.23 and verification of construction and design according to 6.3.2.

5.2 Verification of labelling and instructions for use

When tested in accordance with 6.3.3 the labelling and instructions for use of the ignition device shall be in accordance with Clause 7.

5.3 Verification of specified functioning characteristics

5.3.1 General

Performance of the ignition device shall be checked by functioning tests as defined in the following 5.3.2 to 5.3.5 and shall be in accordance with the manufacturer's specifications which shall include performance characteristics.

Functioning tests shall be performed at (20 ± 5,0) °C and, after thermal conditioning according to 6.3.9, at the minimum and maximum operating temperatures specified by the manufacturer.

In every case, possible projections of any fragments, burning material and hot slag shall be checked and a decision whether they are acceptable shall be taken by comparison to manufacturer's specifications for the given ignition device (see safety distances, information on direction of effects in the instructions for use).

5.3.2 Igniters

When measured in accordance with 6.3.4, the initiation time of the igniter for the recommended electrical, mechanical or optical input shall comply with manufacturer's specifications which shall include performance characteristics.

When the peak pressure or the time pressure curve in a closed vessel is specified by the manufacturer, tests shall be performed in accordance with 6.3.5 and records shall comply with manufacturer's specifications which shall include performance characteristics, especially the functioning time.

In other cases, the visual aspect of the flame or flow of reacting species generated by the igniter shall be recorded in accordance with 6.3.6 and shall comply with manufacturer's specifications.

When an igniter is designed to initiate a specific component or a specific family of components, fire transmission tests shall be carried out in accordance with 6.3.7. Fire transmission times shall comply with manufacturer's specifications which shall include performance characteristics.

All recorded values shall be in accordance with the manufacturer's specifications including tolerances.

5.3.3 Components of pyrotechnic trains

The following tests shall be performed, if the following parameters are described in the manufacturer's specifications:

— the initiation time shall be measured in accordance with 6.3.4;

— the functioning time shall be measured in accordance with 6.3.5;

— the time pressure curve in a closed vessel for components containing compressed or compacted pellets and grains, tests shall be performed in accordance with 6.3.5;

— the peak pressure in a closed vessel for relays or boosters containing loose composition or granules shall be recorded in accordance with 6.3.5;

— the aspect of flame for relays or boosters containing loose composition or granules shall be recorded in accordance with 6.3.6.

All results shall comply with manufacturer's specifications.

Where the component is designed to initiate a specific component or a specific family of components, fire transmission tests shall be carried out in accordance with 6.3.7. Fire transmission times shall comply with manufacturer's specifications.

5.3.4 Delay fuses, pyrotechnic cords and fuses

When tested in accordance with 6.3.8, pyrotechnic cords and fuses and delay fuses shall initiate and exhibit continuous and stable burning. The linear burning rate or delay time shall comply with the value and tolerances defined by the manufacturer's specifications.

Ignition time shall comply with manufacturer's specifications when measured in accordance with 6.3.4.

The casing of delay fuses shall prevent all lateral emission of gases, flames or hot particles during functioning. It shall be checked after functioning by visual examination according to 6.3.23.

When designed to protect the surroundings against projection of burning particles and/or hot slag, the protective covering of pyrotechnic cords and fuses shall be intact and without holes after testing in accordance with 6.3.8. This shall be verified by visual examination according to 6.3.23.

When delay fuses include a boosting or fire-enhancing charge, they shall be additionally tested according to 5.3.3, including fire transmission tests according to 6.3.7 where appropriate.

5.3.5 Fuzes

Fuzes shall be tested in the "arm" position according to the manufacturer's specifications (including the means of application of the initiation stimulus). The functioning of their main charge shall comply with manufacturer's declarations when tested in accordance with 6.3.5, 6.3.6 or 6.3.7.

The "safe" mode shall be checked by verification of construction and design according to 6.3.2.2. Its effectiveness shall be verified in accordance with 6.3.10 (mechanical conditioning) and 6.3.11 (mechanical impact test). No initiation shall take place during these tests and the safety features shall remain in their "safe" position. This requirement shall be verified by function test on the samples submitted to 6.3.10 and 6.3.11 in accordance with 6.3.5, 6.3.6 or 6.3.7.

5.4 Thermal stability

When tested in accordance with 6.3.9, ignition devices shall neither ignite during the test nor exhibit degradation or mass changes (emission of gases, cracks or expansion of compacted compositions, migration of chemicals). This shall be checked by visual examination according to 6.3.23 and measurement of the gross mass after test in accordance with 6.3.1.3. After the thermal stability test the article shall still function properly at maximum or minimum use temperature according to 5.3.

The leading wires of electric igniters shall not show any cracking or degradation of their insulation after thermal conditioning.

5.5 Safety features

Ignition devices shall include or be equipped with:

— safety protections, e.g. primary pack or protective cover or any other mechanical element specified by the manufacturer to protect pyrotechnic compositions and/or the weakest parts of the article and/or the sensitive parts intended to be triggered to initiate normal functioning of the article;

— safety components, e.g. safe/arm switches, removable safety pins or plugs (where appropriate);

— protection against electromagnetic fields for electric igniters;

— protection against ESD.

The presence of the safety features shall be checked by visual examination and their effectiveness shall be verified in accordance with 5.6, 5.7, 5.8, 5.11 and/or 5.12.

Integral safety features shall be checked by verification of construction and design according to 5.1 and their effectiveness shall be verified in accordance with 5.6, 5.7, 5.8, 5.11 and/or 5.12.

For electrical igniters, when specified by the manufacturer, verification of the presence of a shunting device or application of a shunting method to the leading wires shall be made by visual examination.

Whenever bare composition is not protected, information on the safety characteristics of the composition (shock, friction, ESD) shall be supplied by the manufacturer and comply with 5.13.

5.6 Sensitivity to normal, foreseeable handling and transportation

When tested in accordance with 6.3.10 in their primary pack (if any) and fitted with their safety features (if any), ignition devices shall not ignite during the test and shall still function after this test in accordance with the manufacturers specifications. This shall be verified according to requirements of 5.3. Safety protections and safety components shall remain in place or in their normal "safe" position.

P1 articles shall not exhibit any loss of pyrotechnic composition from the article. It shall be checked by visual examination.

For P2 articles, when tested in accordance with 6.3.10, the loose pyrotechnic composition found outside the article after mechanical conditioning shall be weighed. The mass of loose pyrotechnic composition shall not exceed 2 % of the NEC or 0,5 g whichever is the smaller. If the pyrotechnic composition cannot be separated from the loose material, the same limits shall apply to the whole loose material.

For black match and quick match, this criterion is passed if during mechanical conditioning no functioning occurs and providing that, following mechanical conditioning (6.3.10), the black match and quick match function correctly (6.3.8.2).

A drop test according to 6.3.11 shall be performed on the following unpacked articles:

— articles which are designed to function at impact or shock or designed to arm on acceleration;

— ignition devices (except pyrotechnic cords and fuses) which exhibit bare composition or a protection of their pyrotechnic composition only by varnish or by a deformable or thin casing.

Articles shall not ignite or arm during the test. P1 articles shall still function properly after this drop test in accordance with the requirements of 5.3.

5.7 Resistance to moisture

When the article is intended to be used in humid or wet conditions, thermal conditioning according to 5.4 shall be performed at the highest moisture level specified by the manufacturer. After conditioning the ignition device shall function properly in accordance with the requirements of 5.3.

Up to the point of use, articles that exhibit bare pyrotechnic composition shall be protected against moisture by a cover or primary pack.. When submitted to thermal tests according to 6.3.9, the relative humidity level shall be within the range from 40 % to 60 % and the articles shall be tested without their cover (if removable) or outside their primary pack.

When the article is intended to be used in or under water, the ignition device shall be tested in accordance with 6.3.21 and shall function properly afterwards in accordance with the requirements of 5.3.

5.8 Resistance to mechanical damage

5.8.1 Leading wires of electric igniters and electrically triggered fuzes

The following requirements apply to electric igniters and electrically triggered fuzes where the leading wires are not removable.

When tested in accordance with 6.3.12.2, the insulation shall resist at least one hundred cycles (arithmetic mean of the results of the tests) or, when tested in accordance with 6.3.12.3, no penetration of the insulation which lets the conductor appear shall occur.

When tested in accordance with 6.3.13, the leading wires shall not break, elongate or be pulled out of the igniter or fuze. Electrical resistance of the igniter shall be recorded after test according to 6.3.17 and shall remain within the tolerances specified by the manufacturer. After testing according to this paragraph, the electric igniters and electrically triggered fuzes shall still function according to the manufacturer's specifications. This shall be verified by testing according to 6.3.4.

5.8.2 Leading optical fibre of optical igniters and optically triggered fuzes

This requirement only applies to optical igniters or optically triggered fuzes where the leading optical fibre is not removable.

When tested in accordance with 6.3.13, the leading optical fibre shall not break, elongate or be pulled out of the igniter or fuze.

After testing according to 6.3.13, the optical igniters and optically triggered fuzes shall still function according to the manufacturer's specifications. This shall be verified by testing according to 6.3.4.

5.8.3 Crush test

When submitted to crush test according to 6.3.14, igniters and pyrotechnic cords and fuses shall not ignite or be damaged during the test and shall still function properly after test. This shall be verified by testing according to 6.3.4 or 6.3.8.

This test is not applicable to black match.

5.8.4 Pyrotechnic cords and fuses

When tested according to 6.3.15, pyrotechnic cords and fuses shall not break within 30 min under tension. They shall function properly after test. This shall be verified by testing according to 6.3.8.

This test is not applicable to black match.

5.9 All-Fire / No-Fire levels of igniters

All-fire / no-fire levels shall be determined for igniters by using either "Bruceton Method" as given in Annex A or "Dichotomic / Langlie method" as given in Annex B.

A minimum of 25 igniters shall be submitted to these sequential tests and the all-fire and no-fire levels shall be calculated from test results at a confidence level of 95 % as for the values claimed by the manufacturer. The calculated all-fire and no-fire levels shall be within the interval of values claimed by the manufacturer. In the case where the accuracy is not sufficient to prove this, the sequence of tests may be prolonged.

Functioning tests shall be performed in accordance with 6.3.4.

The type of stimulus which will be applied to the igniters shall be determined in accordance with the intended use of the article:

— electric current in Amperes DC for electric igniters;

— optical power in Watts for optical igniters;

— percussion energy in Joules for mechanical igniters which are triggered by percussion.

The test equipment which will deliver the appropriate stimulus shall be the one which is specified for functioning tests (see 5.3). It shall be capable of varying the stimulus in the range which is necessary to perform the sequential test.

The duration of the electric and optical stimuli shall be the duration which is recommended by the manufacturer in normal use.

A probability level of 99,9 % at 95 % confidence level shall be applied for the tests.

The calculated all-fire level from these tests shall not be greater than the value stated by the manufacturer. The calculated no-fire level from these tests shall not be lower than the value stated by the manufacturer.

Where the igniter is designed to be fired by means of specific ancillary equipment and this equipment has not been used for the tests, compliance of the calculated values from these tests with the characteristics of the stimulus delivered by the ancillary equipment shall be verified.

Igniters which are triggered by friction will not be submitted to such determination of all-fire / no-fire levels. However, the sensitivity level of the friction-sensitive composition shall be checked in accordance with 6.3.20.4 and shall comply with the manufacturer's specifications.

5.10 Series firings of electric igniters

Igniters which are designed or intended to be fired in series shall be tested in accordance with 6.3.16. The quantity of igniters in the series to be tested shall be the maximum number that is recommended by the manufacturer in the instructions for use.

There shall be no misfire of any igniter in the series firing test.

5.11 Electrical characteristics

The electrical resistance of electric igniters shall be tested in accordance with 6.3.17. All test results shall be within the limits stated by the manufacturer or, when no limits are claimed, a tolerance of ± 10 % of the nominal value stated by the manufacturer shall be applied.

For electric igniters with a metal casing, the insulation “pin-to-case” resistance of electric igniters shall be tested in accordance with 6.3.18. All test results shall be higher than the minimum value stated by the manufacturer.

For double-bridgewire igniters, the insulation “pin-to-pin” resistance between the two bridgewires and the insulation “pin-to-case” resistance between each bridgewire and the casing of the igniter shall be tested. All test results shall be higher than the minimum value stated by the manufacturer.

In every case, the measured values of insulation resistances shall not be lower than 100 MΩ for igniters.

5.12 Electrostatic discharge

Electric igniters shall be tested according to 6.3.19. No igniter shall function at a minimum impulse of 0,2 mJ/Ω “pin-to-pin” or 0,6 mJ/Ω “pin-to-case” (where the igniter is fitted with a case).

5.13 Sensitivity of pyrotechnic composition

P1 igniters exhibiting bare compositions shall, where not protected by effective safety features (see 5.5), comply with the following requirements:

— when the article is tested according to 6.3.20.2, its sensitivity to electrostatic discharge shall be higher than 100 mJ;

— when the composition is tested according to 6.3.20.3, its sensitivity to impact shall be higher than 8 J;

— when the composition is tested according to 6.3.20.4, its sensitivity to friction shall be higher than 80 N. This requirement does not apply to friction igniters where the sensitive element is protected by a covering device or an appropriate primary pack.

For electric igniters containing less than 10 mg of bare pyrotechnic composition, the self-ignition temperature of the composition shall be higher than 150 °C. This shall be verified by examination of the manufacturer’s documentation.

5.14 Type testing

5.14.1 General

Each ignition device to be type tested shall meet all requirements as stated in 5.1 to 5.13 (whenever appropriate).

5.14.2 Number of items to be tested

The number of ignition devices to be submitted to type test shall depend on the generic type, in accordance with Table 1.

Table 1 — Number of items to be tested

Requirements	Test methods	Number of items to be tested				
		Igniters	Components for pyrotechnic trains	Pyrotechnic Cords and fuses	Delay fuses	Fuzes[k]
5.1 Verification of construction and design [a]	6.3.1 and 6.3.2 6.3.22	12 3	12	12	12	12
5.2 Verification of labelling and instruction for use [a]	6.3.3	12	12	12	12	12
5.3 Verification of specified functioning characteristics [b]	6.3.4 6.3.5 or 6.3.6 or 6.3.7	12	12	—	—	12
	6.3.8	—	-	12	12	—
5.4 Thermal stability [c]	6.3.9	4 (+4)	4 (+4)	4 (+4)	4 (+4)	4 (+4)
5.5 Safety features [a]	Visual examination	12	12	12	12	12
5.6 Sensitivity to normal, foreseeable handling and transportation [d]	6.3.10 6.3.11 or 6.3.20	6 (+6)	6 (+6)	6 (+6)	6 (+6)	6 (+6)
5.7 Resistance to moisture [e]	6.3.9 or 6.3.21	(4)	(4)	(4)	(4)	(4)
5.8 Resistance to mechanical damage	—	—	—	—	—	—
5.8.1 Leading wires (electric igniters)	6.3.12 6.3.13	20	-—	—	—	—
5.8.2 Leading fibre (optical igniters)	6.3.13	20	—	—	—	—
5.8.3 Crush test	6.3.14	10	—	—	—	—
5.8.4 Pyrotechnic cords and fuses [f]	6.3.14 6.3.15	—	—	10 + 5	—	—
5.9 All-fire / no-fire levels	6.3.4 and A.1 or A.2 or equivalent	≥ 25	—	—	—	—
5.10 Series firings of electric igniters [g]	6.3.16	30 + 5xN	—	—	—	—
5.11 Electrical characteristics [h]	6.3.17 6.3.18	(25)	—	—	—	—
5.12 Electrostatic discharge [j]	6.3.19	2 × 12	—	—	—	—
5.13 Sensitivity of pyrotechnic composition	6.3.20.1 or 6.3.20.2 or 6.3.20.3	See note [m]	-—	—	—	—

[a] The 12 items are the same as those submitted to 5.3.

[b] 4 at (20 ± 5) °C, 4 at the minimum and 4 at maximum temperatures specified by the manufacturer.

[c] 4 at high temperature (+4 at low temperature where appropriate).

[d] 6 for mechanical conditioning (+6 for drop tests where appropriate); mechanical conditioning tests being carried out in packaging, the number of items shall depend on the quantity which is usually present in the packaging adopted by the manufacturer, with a minimum of 6.

[e] The same 4 articles as for thermal conditioning (high temperature).

[f] 10 for crush test and 5 for resistance to tension.

[g] 30 for determination of current break time and 5 times N where N is the maximum number of igniters to be connected in series which is authorized by the manufacturer.

[h] The same 25 igniters as for determination of all-fire and no-fire levels.

[j] 12 only in the case of primers with a sole central pin.

[k] In the case of complex fuzes associated to small series, the number of articles to be submitted to type tests may be reduced by taking into consideration the results of development tests carried out previously by manufacturers.

[m] For the purpose of sensitivity testing the manufacturer will supply 15 igniters and 10 g of composition.

5.14.3 Test report

The test report shall include at least the following information:

— a reference to this European Standard (i.e. EN 16265);

— the complete identification of the sample under test;

— the date of completion of testing;

— the relevant observations concerning the applicable type test requirements for the ignition devices under tests given in Table 1;

The test report shall include information about:

— labelling;

— the chosen protections of the sensitive parts (where appropriate);

— whether the primary pack is used for labelling.

The assessment whether the sample meets the requirements of this European Standard shall be done by a Notified Body.

5.15 Batch testing

5.15.1 General

For the purposes of batch testing, acceptance sampling in accordance with 5.15.2 and 5.15.3 shall be applied.

5.15.2 Sampling plans

Sampling shall be in accordance with ISO 2859-1 using double sampling plans and applying the switching procedures for normal, tightened and reduced inspection. Inspection level S-4 shall apply.

The following tests shall be performed in batch testing:

— verification of design (5.1) and visual examination: 100 % of the sample;

— verification of labelling and instruction for use (5.2): 100 % of the sample;

— verification of proper functioning at (20 ± 5,0) °C (5.3):

- — igniters: 50 % of the sample with a maximum of 25 at the recommended electrical, mechanical or optical input by the manufacturer, 50 % of the sample with a maximum of 25 at the No-Fire level claimed by the manufacturer;
- — components of pyrotechnic trains: 100 % of the sample;
- — pyrotechnic cords and fuses, Delay fuses: 100 % of the sample;
- — fuzes: 50 % of the sample in “arm” position, 50 % of the sample in “safe” position;

— safety features (5.5): 100 % of the sample;

— electrical characteristics (5.11): 100 % of the sample;

— method of ignition (7.2.10): 100 % of the sample;

— for igniters, all-fire / no-fire levels shall be determined according to 5.9 on 25 items which can require additional test items to the sample size determined by the inspection level S4.

5.15.3 Sample size for small batches (destructive tests)

For small batches (≤ 35 000), the sampling plan (5.15.2) is not applicable for the Acceptance Quality Levels specified in 5.15.7. The following Table 2 lists the altered sample sizes which are required and the number of acceptable minor nonconformities:

Table 2 — Distribution of test for small batch sizes

Batch size	Minimum sample for functioning tests	Acceptable minor nonconformities
2 to 15	1	0
16 to 25	2	0
26 to90	3	0
91 to 150	5	1
151 to 500	8	2
501 to 1200	13	3
1201 to 10000	32	7
10001 to 35000	80	14

If Table 2 is applied, no critical or major nonconformities as defined in Table 3 are acceptable.

5.15.4 Nonconformities

Nonconformities shall be classed in accordance with Table 3.

Table 3 — Nonconformities

Requirement	Generic type	Type of nonconformity
Verification of construction and design (5.1) and visual examination (6.3.23)	All	Outer dimensions: Critical (defects of mechanical and electrical interfaces), Major (other defects) Calibre: Critical Gross mass: Minor (<2 %), Major (2 % to 5 %), Critical (>5 %) [a] Visual defects: Critical (integrity and abnormal shape or aspects such as cracks, bulges, deformations, pollution by pyrotechnic compositions, local changes of colours…), Minor (other defects)
Verification of specified functioning characteristics at (20 ± 5,0) °C (5.3)	All	Performances: Critical (>10 %) [a] Major (5 % to 10 %) [a] Minor (<5 %) [a] Quick match: critical if incorrect functioning
	Igniters	Critical (ignition at no-fire level)
	Fuzes	Critical (functioning in "safe" position)
Safety features (5.5)	All	Critical
Electrical characteristics (5.11)	Igniters and electrically triggered articles	Critical (>10 %) [a] Major (5 % to 10 %) [a] Minor (<5 %) [a]
Method of ignition (7.2.10)	All	Major
All-fire / no-fire levels (5.9)	Igniters	Critical
Verification of labelling and instructions for use (5.2)	All	Critical when the information on the label or in the instructions for use changes the meaning of the text, making it misleading or incomplete EXAMPLE: — wrong or incomplete type; — wrong or incomplete performance data which could lead to an incorrect safety distance being determined.

[a] (X %) means the percentage by which a measured value V exceeds the tolerance specified by the manufacturer.

$$\left|\frac{V-M}{M}\right| - \frac{m}{M} < X\ \%$$

Requirement	Generic type	Type of nonconformity
where M is the mean and m is the absolute tolerance for the given parameter. Example: M = 150 ms m = 10 ms V = 178 ms $\left\|\frac{178-150}{150}\right\| - \frac{10}{150} = 12\ \% < X\ \%$ which means a critical failure.		

5.15.5 Labelling and instructions for use

When identical labels are used throughout a batch, the text of one label shall be examined.

For batches containing different variants, the number of different labels used in the batch shall be determined and the text of one label of each kind should be examined.

The label and instructions for use shall be examined in accordance with the requirements for minimum labelling and instructions for use in Clause 7.

5.15.6 Test report

The test report shall include at least:

— a reference to this European Standard,

— the complete identification of the sample under test,

— the date of completion of testing and the relevant observations concerning the applicable batch test requirements for the ignition devices under tests given in 5.15.2.

The test report shall include information about:

— the observations concerning the labelling,

— the instructions for use,

— the chosen protections of the sensitive parts

— whether the primary pack is used for labelling.

5.15.7 Acceptance or rejection of a batch

5.15.7.1 Nonconforming units

Acceptance or rejection of the batch shall be determined by the number of nonconforming units of each type, in accordance with 5.15.7.2 to 5.15.7.4 for normal sampling or Table 2 for small batch size.

NOTE Acceptance or rejection of the batch is determined by the number of nonconforming units of each type and not necessarily by the number of nonconformities found.

5.15.7.2 Critical nonconforming units

For critical nonconforming units an Acceptance Quality Limit (AQL) of 0,65 % shall apply.

If the batch fails to meet this criterion, it shall be rejected. Any critical nonconforming units shall not also be counted as major nonconforming units or minor nonconforming units.

5.15.7.3 Major nonconforming units

For major nonconforming units an AQL of 2,5 % shall apply. If the batch fails to meet this criterion, it shall be rejected. Any major nonconforming units shall not also be counted as minor nonconforming units.

5.15.7.4 Minor nonconforming units

For minor nonconforming units an AQL of 10 % shall apply. If the batch fails to meet this criterion, it shall be rejected.

6 Test methods

6.1 General

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

6.2 Apparatus

6.2.1 Calliper

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

6.2.2 Ruler

Ruler, reading to 1,0 mm.

6.2.3 Balance

6.2.3.1 Balance, read to 0,1 g.

6.2.3.2 Balance, read to 0,01 g.

6.2.3.3 Balance, read to 0,001 g.

6.2.3.4 Balance, read to 0,1 mg.

6.2.4 Climatic chamber

Up to 75 °C or 1,25 times the maximum use temperature of the tested article in degrees Celsius (if higher than 60 °C). Where appropriate, down to 10 °C lower than the minimum use temperature.

Tolerance on temperature shall be ± 2,5 °C.

Where required, capability of storing the test sample at 95 % of relative humidity.

Different climatic chambers may be used for different temperatures and relative humidity situations.

6.2.5 Sound level meter

Sound level meter to class 1 of EN 61672-1 with free-field microphone.

6.2.6 Electric firing sources

Regulated current sources capable of producing square current pulses with adjustable amplitude (Amperes) and time period. The rise and fall times shall not be greater than 50 μs, the accuracy of the amplitude shall be ± 1 % with a current overshoot of no more than 10 % on pure resistive load.

6.2.7 Time-measuring equipment

6.2.7.1 Timing device

An electronic device to determine time intervals with a resolution of 10 µs.

6.2.7.2 Stopwatch

Stopwatch, accurate to 0,1 s.

6.2.8 Optical sensors

Photomultiplier or similar device having its maximum performance in the visible and near-infrared ranges of the electromagnetic spectrum with a response time faster than 10 μs.

6.2.9 Pressure sensors

Piezoelectric pressure gauges with a response time faster than 2 µs.

6.2.10 Video camera

High speed video camera with a minimum capacity of at least 1 000 frames per second.

6.2.11 Stills photographic camera

Stills photographic camera having the possibility to function in *T* (Time) mode which keeps the shutter open until the shutter release is pressed again.

6.2.12 Microphone

Unidirectional microphone with a linear frequency response covering the range 40 Hz to 20 kHz (±3 dB).

6.2.13 Shock apparatus

The apparatus shall provide 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 ± 1) ms working at a frequency of (1 ± 0,1) Hz

An example of an apparatus is shown in Annex C.

6.2.14 Drop-test apparatus

The apparatus shall be capable of allowing a drop from a height of 1,2 m above a steel plate. Thickness of plate shall be higher than 10 mm.

An example of an apparatus is shown in Annex D.

6.2.15 Ohmmeters

— Ohmmeter capable of measuring to an accuracy of ± 0,01 Ω. Maximum current ≤ 15 mA;

— megohmmeter capable of measuring to an accuracy of 2 % in the range from 0 MΩ to 100 MΩ with a maximum test current lower than the no-fire current.

6.2.16 ESD generator

Electrostatic discharge generator with capacitance ranging from 500 pF to 3500 pF and sufficient voltage to give the required impulse.

6.2.17 Magnifying equipment

Magnifying lens or electronic magnifier or microscope, with suitable power for the dimensions of the tested article or the details of its design that need to be checked.

6.2.18 Transparent type size sheet

Transparent sheet with the characters shown in Figure 1 printed on it in 2,8 mm and 2,1 mm text. Height of text determined by height of capital X in each case.

2,8 mm : ABC abc XYZ xyz 123

2,1 mm : ABC abc XYZ xyz 123

Figure 1 — Type sizes of print

6.3 Test methods

6.3.1 Construction

6.3.1.1 Outer dimension of item

Ruler (see 6.2.2) or calliper (see 6.2.1) according to the size and shape of the tested article and the expected value of its dimensions.

6.3.1.2 Determination of calibre

Calliper (see 6.2.1)

6.3.1.3 Determination of gross mass

Using the balance (6.2.3), measure and record the gross mass of the item.

The choice of the appropriate balance (see 6.2.3.1 to 6.2.3.4) shall depend on the expected value of the gross mass of the tested article.

6.3.2 Verification of design

6.3.2.1 General

These tests shall be done for type testing to verify that the tested item is in accordance with the requirements of 5.1.

6.3.2.2 Conformity to drawings and part lists

The tested item shall be inspected and compared with the relevant manufacturing drawing(s) by visual examination according to 6.3.23.

Observe and record any nonconformity.

6.3.3 Verification of labelling and instructions for use

6.3.3.1 General

Observe and record any nonconformity with respect to the requirements of Clause 7.

Information about setting, use, storage and disposal of the ignition device shall be checked in relation with the categorization of the ignition device which has been done by the manufacturer (see 4.3).

6.3.3.2 Measurement of labelling

6.3.3.2.1 Apparatus

— Calliper (6.2.1);

— transparent type size sheet (6.2.18).

6.3.3.2.2 Procedure

Using the calliper (6.2.1) or the transparent type size sheet (6.2.18), record whether the type sizes are correct and the printing legible.

6.3.4 Initiation (or reaction) time

6.3.4.1 Apparatus

This test shall be performed in a dark area or a dark closed chamber.

The tested article shall be initiated by application of the nominal value of the electrical, mechanical or optical stimulus which is specified by the manufacturer.

Electrically triggered igniters shall be fired by means of an electric firing source in compliance with 6.2.6, except when otherwise specified by the manufacturer.

Mechanical and optical igniters shall be fired by means of the triggering device which is specified by the manufacturer.

Initiation (or reaction) time is determined as the time period between the commencement of the triggering stimulus and the appearance of a flame from the tested article. An optical sensor (see 6.2.8) shall be used to detect the appearance of a flame in association with a timing device (see 6.2.7.1). Figure 2 gives the principle of such a measurement chain.

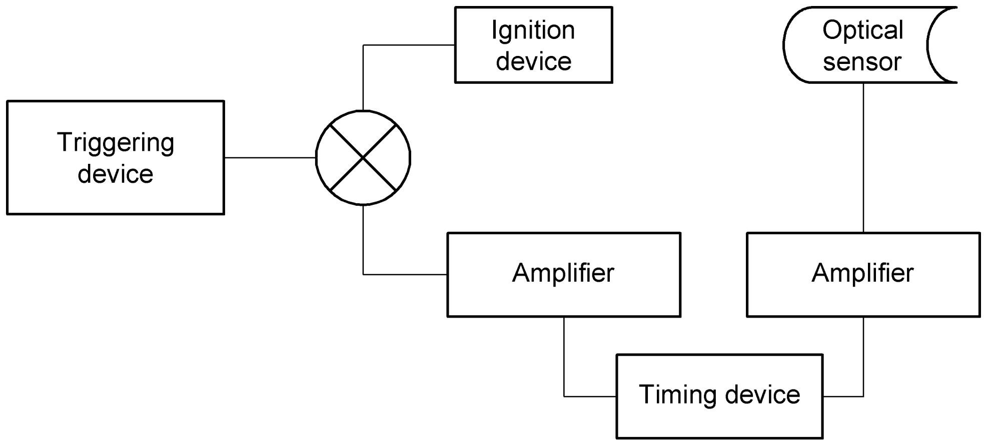


Figure 2 — Measurement of the initiation (or reaction) time

6.3.4.2 Procedure

The following procedure shall be applied:

— select the required number of articles as indicated in Table 1 (type test) or 5.15.2 (batch test);

— for electric and optical igniters:

  — firmly secure the tested article to prevent erratic motions or misalignment with the optical sensor;

  — verify that the triggering device is in the "safe" position and then connect the tested article to it;

— for mechanical igniters, verify that the triggering device is in the "safe" position and then firmly secure the tested article to it, to prevent erratic motions or misalignment with the optical sensor as well as with the mechanical striker;

— for pyrotechnic cords, fuses and delay fuses, initiation shall be made by means of the ignition device recommended by the manufacturer;

— activate the optical sensor;

— reset the timing device to zero;

— set the triggering device to the "arm" position;

— start the triggering device;

— fire the test,

— record the initiation time from the display of the timing device.

6.3.5 Closed vessel test

6.3.5.1 General

This test aims to measure the time pressure curve generated by igniters or components of pyrotechnic trains in a fixed closed volume.

6.3.5.2 Apparatus

The tested igniters or components of pyrotechnic trains shall be fired in the closed vessel with an internal volume adapted to the mass of the pyrotechnic composition of the tested item in order to obtain a sufficiently high peak pressure and optimal accuracy and discrimination of the time pressure results.

It is recommended that:

— the internal chamber of the vessel is cylindrical, with a ratio of the length to the diameter between 0,75 and 1,5;

— the pressure pick-up is located laterally at mid-length of the internal chamber;

— the seal of the closed vessel is ensured by means of reliable techniques (e.g. O-rings or better according to the expected values of the pressure peaks);

— an optical flame detector is located opposite the tested item to verify its effective initiation.

Pressure evolution shall be measured by means of a pressure sensor according to 6.2.9.

The tested item shall be initiated by application of the nominal value of the electrical, mechanical, optical or thermal stimulus which is specified by the manufacturer.

Electrically triggered igniters shall be fired by means of an electric firing source in compliance with 6.2.6, except when otherwise specified by the manufacturer.

6.3.5.3 Procedure

The following procedure shall be applied:

— select the required number of articles as indicated in Table 1 (type test) or 5.15.2 (batch test);

— firmly secure the tested item in the closed vessel;

— for electric and optical igniters, verify that the triggering device is in its “safe” position and then connect the tested igniter to it;

— for mechanical igniters, verify that the triggering device is in its “safe” position and then firmly secure it to the closed vessel, so that it is correctly aligned with the tested igniter;

— for components of pyrotechnic trains, fit the recommended igniter to the tested item and follow the corresponding manufacturer’s instructions for use;

— activate the optical sensor (if any);

— reset the pressure sensor amplifier and start recording;

— set the triggering device to the “arm” position;

— start the triggering device;

— fire the test;

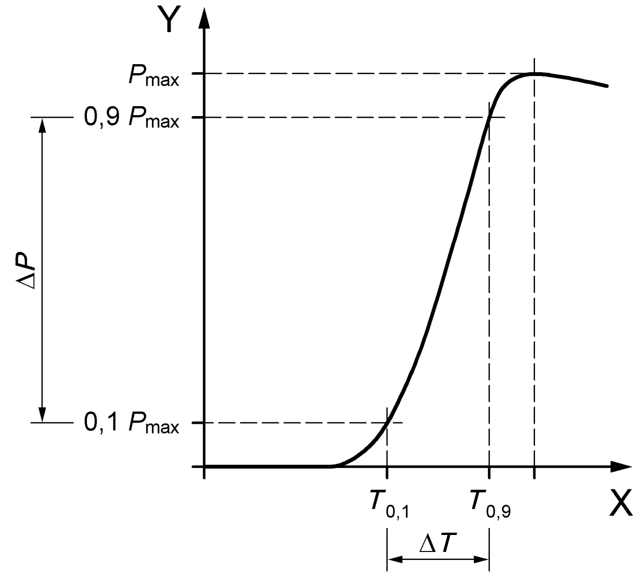
— verify the correct initiation of the tested item from the display of the optical sensor (if any);

— stop the time pressure recording after the specified time interval by the manufacturer.

The internal chamber of the closed vessel shall be cleaned between each firing, to prevent the build-up of slag or unburnt pyrotechnic composition. Special attention shall be paid to the cleanness of the aperture for the pressure gauge.

The functioning time ΔT shall be determined according to Figure 3.

NOTE Depending on the performance claimed by the manufacturer, time pressure curves may lead to the determination of the characteristics P_{max} and $\Delta P/\Delta t$ (e.g. for statistical evaluation):



Key

Y pressure

X time

Figure 3 — Time Pressure characteristics

6.3.6 Aspect of flame or flow of reacting species

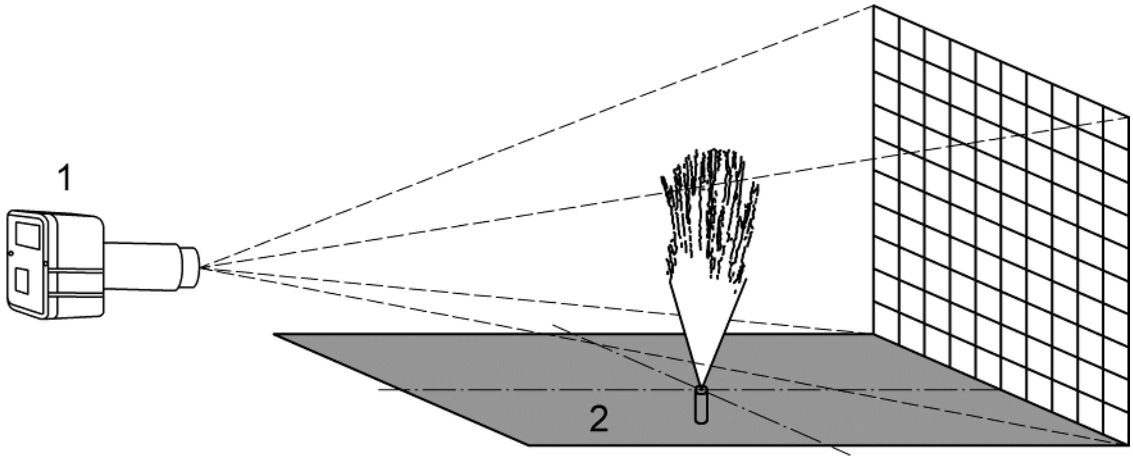
6.3.6.1 General

This test aims to observe the visual aspect of the flame or flow of reacting species generated by the article when the direction of the flame or the flow of species is not erratic and when the duration of the pyrotechnic effect is sufficient to be reliably recorded by the photo camera.

6.3.6.2 Apparatus

The tested item shall be fired in a dark room or a dark chamber before a grid of white lines on a black and flat surface to quantify the spreading of its flame during its functioning.

A high speed video camera (see 6.2.10) or a stills photographic camera (see 6.2.11) equipped with an internal timing device or a separate timing device (see 6.2.7.1) shall be used to record the image(s) of this spreading in the free space of the dark room or chamber.



Key

1 camera

2 ignition device

Figure 4 — Recording the flame or flow of reacting species

6.3.6.3 Procedure

The following procedure applies to aspect of flame or flow of reacting species test:

- select the required number of articles as in Table 1 (type test) or 5.15.2 (batch test);
- for electric and optical igniters, firmly secure the igniter under test to its firing tool; verify that the triggering device is in its "safe" position and then connect the igniter to it ;
- for mechanical igniters, verify that this device is in its "safe" mode and then firmly secure the igniter under test to its triggering device;
- for components of pyrotechnic trains, fit the recommended igniter to the tested item and follow the corresponding manufacturer's instructions for use;
- start the video camera in "record" mode or set the photo camera in T mode and press the shutter open;
- set the triggering device to its "arm" position;
- start the triggering device;
- fire the test;
- stop the video recording or close the shutter of the stills photographic camera after the flame has disappeared;
- record whether the spreading of the flame or flow of burning species is within the area specified by the manufacturer.

6.3.7 Fire transmission

6.3.7.1 General

The purpose of this test is to verify that igniters or components of pyrotechnic trains which have been designed to initiate a specific component or a specific family of components transmit fire within the transmission times specified by their manufacturer.

6.3.7.2 Apparatus

Fire transmission tests shall be carried out in the configuration described in the instructions for use provided by the manufacturer.

Electrically triggered igniters shall be fired by means of an electric firing source in compliance with 6.2.6, except when otherwise specified by the manufacturer.

Mechanical and optical igniters shall be fired by means of the triggering device which is specified by the manufacturer.

Transmission time is determined as the time period between the appearance of a flame from the donor charge and the main effect of the acceptor component. An optical sensor (see 6.2.8) or a pressure sensor (see 6.2.9) shall be used to detect the appearance of a flame. The method to verify the correct functioning of the acceptor component shall be specified by the manufacturer.

Figure 5 gives the principle of such a measurement chain.

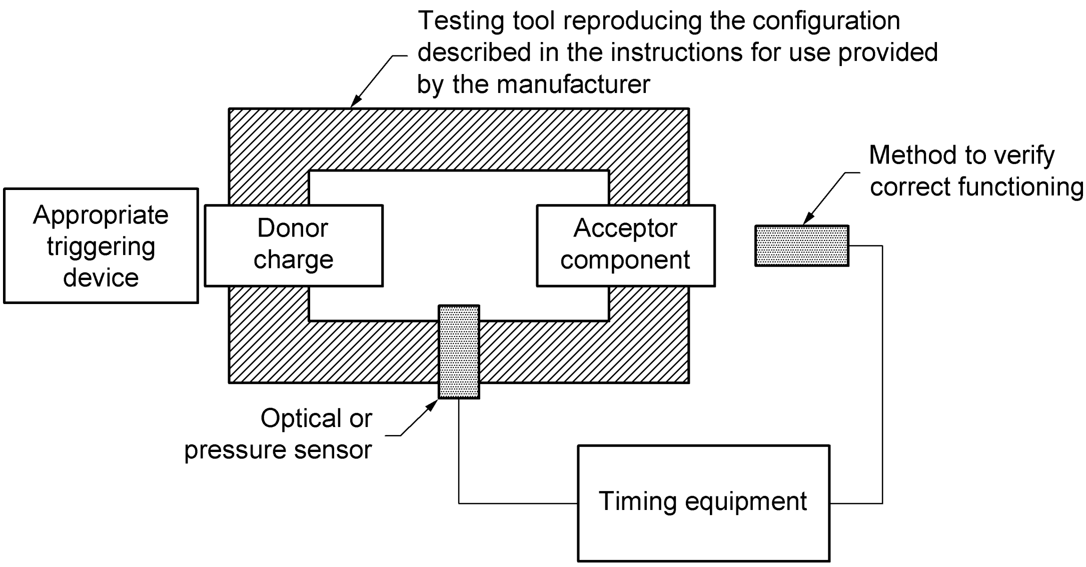


Figure 5 — Measurement of the transmission time

Where practicable, timing equipment (see 6.2.7.1) should be used to directly determine the transmission time during the test. In some cases, it may be necessary to determine the transmission time indirectly from other performance parameter (e.g. pressure or temperature).

6.3.7.3 Procedure

The following procedure applies to fire transmission tests:

— select the required number of igniters or components of pyrotechnic trains as donor charges as in Table 1 (type test) or 5.15.2 (batch test). The same number of specific components shall also be used as acceptor charges according to manufacturer’s specifications;

— firmly secure the donor charge under test to prevent erratic motions or misplacement with regard to the acceptor component;

— verify that the triggering device is in its “safe” position and then connect the tested donor charge to it;

— activate the optical or pressure sensor;

— reset the timing device to zero;

— set the triggering device in its “arm” position;

— start the triggering device;

— fire the test;

— record the transmission time from the display of the timing equipment.

6.3.8 Linear burning rate or delay time

6.3.8.1 General

The purpose of this test is to verify that pyrotechnic cords and fuses and delay fuses initiate correctly and exhibit continuous and stable burning and to measure their linear burning rate or delay time.

Pyrotechnic cords which are likely to be coiled or folded either when they are placed on the market, when incorporated into or attached to an article, or otherwise during use shall function properly

6.3.8.2 Slow burning cords and fuses

6.3.8.2.1 General

The following test method applies to:

— pyrotechnic cords and fuses, which burn at less than 0,5 m/s;

— delay fuses, with a delay time higher than 2 s.

6.3.8.2.2 Apparatus

— A supporting device, for example a V shaped steel gutter, at least 1 m long, positioned horizontally;

— a stopwatch (see 6.2.7.2);

— an appropriate means of reliably igniting the article under test: matches, lighter, electric lighter or any suitable device. The time at which ignition occurs shall be known with an accuracy that is compatible with the verification of compliance with the performance criteria.

6.3.8.2.3 Procedure

The following procedure applies to slow burning cords and fuses:

— select the required number of articles as in Table 1 (type test) or 5.15.2 (batch test). For pyrotechnic cords and fuses, these pieces shall be (1 000 ± 5) mm long; for touch paper, strips of length and width determined by the manufacturer shall be tested;

— place the test piece horizontally in the supporting device without creating confinement;

— light the test piece at one end and measure the time *t* that the flame takes to reach or appear at the other end using a stopwatch;

— record this time or, if the test piece, fails to burn along its complete length, record the result as “failed”;

— the linear burning rate is given by the formula: v (m/s) = L/t, where L is the length of pyrotechnic composition in meters and t is expressed in seconds.

6.3.8.3 Fast burning cords and fuses

6.3.8.3.1 General

The following test method applies to:

— pyrotechnic cords and fuses, which burn at a linear burning rate ≥ 0,5 m/s;

— delay fuses, with a time delay ≤ 2 s.

This test method does not apply to quick match in batch testing: for such product correct functioning shall be determined visually.

6.3.8.3.2 Apparatus

— A supporting device, for example a V shaped steel gutter, at least 1 m long, positioned horizontally;

— a dark box equipped with an optical sensor (see 6.2.8) at one end of the supporting device;

— an electric igniter with or without a fire-enhancing charge as recommended by the manufacturer of the tested article. The igniter shall emit a sharp report when it functions;

— a microphone (see 6.2.12);

— a timing device (see 6.2.7.1).

Figure 6 gives the principle of such a measurement chain.

Burning time is calculated as the time period between the detection of the sharp noise or optical signal which is emitted by the igniter as it functions and the appearance of a flame in the dark box.

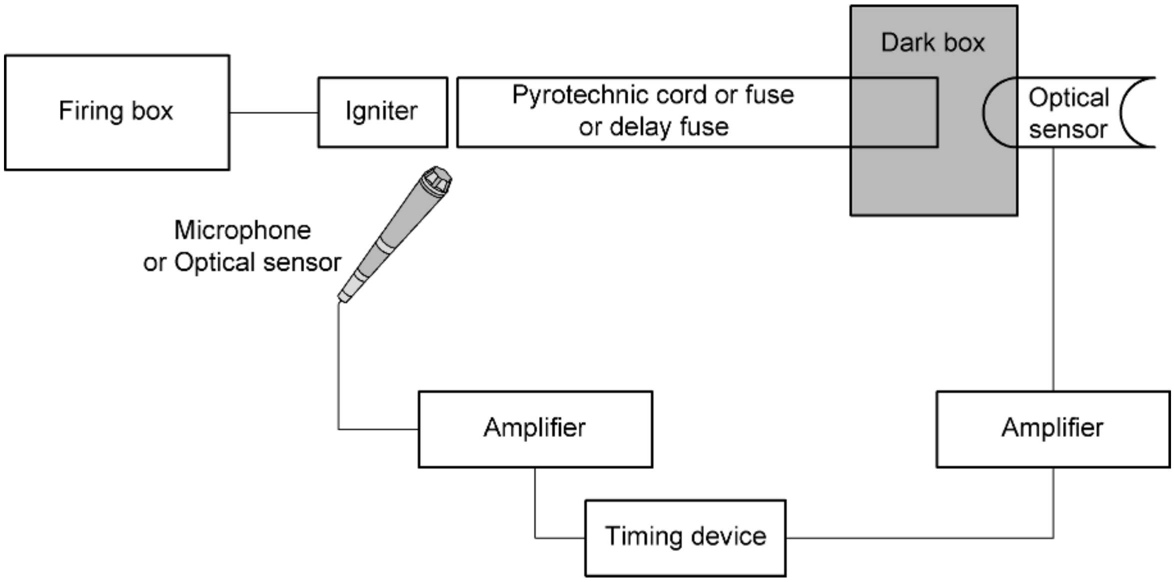


Figure 6 — Measurement of the burning time

6.3.8.3.3 Procedure

The following procedure applies to:

- fast burning pyrotechnic cords and fuses:
  - select the required number of pieces of (1 000 ± 5) mm length as in Table 1 (type test) or 5.15.2 (batch test);
  - place the test piece horizontally in the supporting device without creating confinement and insert one of its ends in the dark box and align it with the optical sensor;
  - firmly secure the electric igniter with its booster (if any) to the other end of the pyrotechnic cord or fuse and to the supporting device;
- fast burning delay fuses:
  - select the required number of delays as in Table 1 (type test) or 5.15.2 (batch test);
  - firmly secure the delay under test to the dark box with its output facing the optical sensor;
  - firmly secure the electric igniter with its booster (if any) to the input of the delay fuse;
- verify that the firing device is in its “safe” position and then connect the igniter to it ;
- activate the microphone and the optical sensor;
- reset the timing device to zero;
- set the firing box to its “arm” position;
- fire the igniter;
- record the burning time from the display of the timing device;

— the linear burning rate is given by the formula: "v (m/s) = L/t, where L is the length of pyrotechnic composition in meters and t is the burning time expressed in seconds.

6.3.9 Thermal conditioning

6.3.9.1 Apparatus

Climatic chamber (see 6.2.4).

6.3.9.2 Procedure

6.3.9.2.1 General

Test samples shall be supported on grids so that all areas are exposed to the prescribed atmospheric conditions at all times during the test.

The number of articles to be submitted to thermal conditioning is given in 5.14.2 – Table 1.

For articles which are intended to be used at temperature between 0 °C and 60 °C, normal thermal conditioning according to 6.3.9.2.2 is applicable. In other cases, high and/or low temperature conditioning according to 6.3.9.2.3 and 6.3.9.2.4 are applied.

6.3.9.2.2 Normal thermal conditioning

Place the items in a temperature chamber at 75 °C for 48 h (in the primary pack if any).

At the end of the thermal conditioning, verify and record any ignition, degradation or mass changes (emission of gas, cracks or expansion of compacted compositions, migration of chemicals, etc.).

6.3.9.2.3 High temperature conditioning

Store the ignition devices in the climatic chamber for 2 days at a temperature of 1,25 times the maximum use temperature ± 2,5°C and then for at least one day at (20 ± 5,0) °C. Then test according to 6.3.4 and 6.3.5 or 6.3.6 or 6.3.7 or 6.3.8 depending on the generic type of the article.

When a manufacturer has designed or described an article as being suitable for use in humid conditions, the climatic chamber shall be maintained at 95 % relative humidity (RH).

6.3.9.2.4 Low temperature conditioning

Store the ignition devices in the climatic chamber for 2 days at a (10 ± 2,5) °C below the minimum use temperature and then for at least two days at (20 ± 5,0) °C. Then test according to 6.3.4 and 6.3.5 or 6.3.6 or 6.3.7 or 6.3.8 depending on the generic type of the article.

6.3.9.2.5 Verification of the "use by" date

When the manufacturer is required to demonstrate correct functioning of the article at the "use by" date by extension of the thermal conditioning test, the procedure described in 6.3.9.2.2 and 6.3.9.2.3 shall be applied over a period of time that can be calculated by application of accelerated ageing method such as described in Annex G.

6.3.10 Mechanical conditioning

6.3.10.1 Apparatus

Shock apparatus (see 6.2.13).

Balance (see 6.2.3).

6.3.10.2 Procedure

The number of articles to be submitted to mechanical conditioning is given in 5.14.2 – Table 1.

Place a sheet of paper on the platform of the mechanical shock apparatus (6.2.13) and place the test samples onto 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 them to the platform around its edges. Run the machine for 1 h.

At the end of the conditioning period stop the machine 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 onto the sheet of paper. Separate any pyrotechnic composition from the loose material and weigh this pyrotechnic composition on the balance.

Record the mass of loose pyrotechnic composition.

Verify and record whether the test sample and / or any primary pack exhibit any visible damage. Verify and record whether any safety features are still in the "safe" position or state.

6.3.11 Mechanical impact (drop test)

6.3.11.1 Apparatus

Drop-test apparatus (see 6.2.14).

6.3.11.2 Procedure

Six items are selected for the drop test.

Fix the article to a suitable release mechanism (see Annex D for details) and place at a height of 1,2 m above a steel plate.

The article shall be positioned for the first test in such a way that it can fall "nose up" along a main geometrical axis of symmetry. In a second test a new article is positioned "nose down" along the same main axis. In a third test a new article is positioned in a perpendicular orientation. The same sequence is performed on the remaining three items.

After triggering the release mechanism and after observing a safety period, record the following observations as "positive results":

— functioning of the article (including partial functioning);

— loss of pyrotechnic composition from the article;

— visible damages such as deformation, ruptures or cracks.

Very small deformations which do not alter the shape of the article or expose its contents are reported as a "negative" result. When the article includes a safe/arm device, the safe position shall be checked by X-ray, after the test if not directly visible.

This test is performed until one of the 'positive results' described below is obtained. In such a case the test does not have to be continued with the remaining articles. If a "negative result" is obtained the test is continued until all articles have been tested or a "positive result" is observed.

For P1 articles only: If no "positive result" is observed, further functioning tests shall be performed according to 6.3.4 and 6.3.5 or 6.3.6 or 6.3.7 or 6.3.8 depending on the generic type of the article.

6.3.12 Resistance of leading wires to abrasion

6.3.12.1 General

One of the following equivalent methods may be used.

6.3.12.2 Test method 1

6.3.12.2.1 Apparatus

The abrasion test apparatus (see Figures 7 and 8) shall consist of a device designed to abrade the surface of the insulation parallel to the leading wire axis, over a length of at least 10 mm at a frequency of (55 ± 5) cycles per minute.

The test device shall be provided with a counter and an automatic stop, controlled by a current leakage detector between the moveable blade and the conductor.

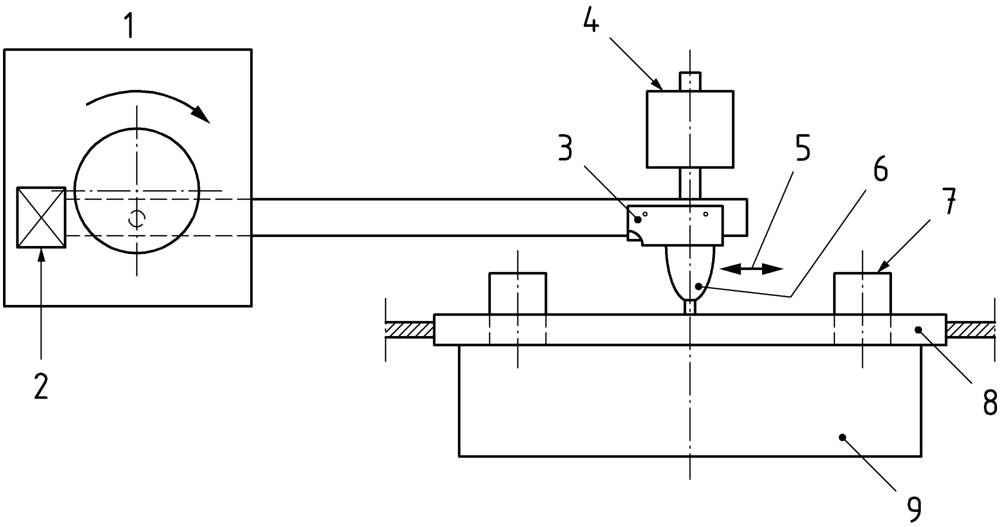
The needle holder shall be subjected to a load between 400 g and 1 000 g, according to the following Table 4.

Table 4 — Cross section and load of the apparatus

Area of the cross section of the conductor *S* (mm²)	**Load** (g)
$S \leq 0{,}35$	400
$0{,}35 < S \leq 1{,}4$	700
$S > 1{,}4$	1 000

The needle diameter shall be (0,45 ± 0,01) mm.

The needle shall be changed at least every 3 000 cycles.



Key

1	mechanism	6	needle holder
2	counter mass	7	cable clamp
3	electrical insulation	8	leading wire on test
4	mass	9	anvil (low thermal mass)
5	travel (10 ± 1) mm	10	needle

Figure 7 — Resistance of leading wires to abrasion

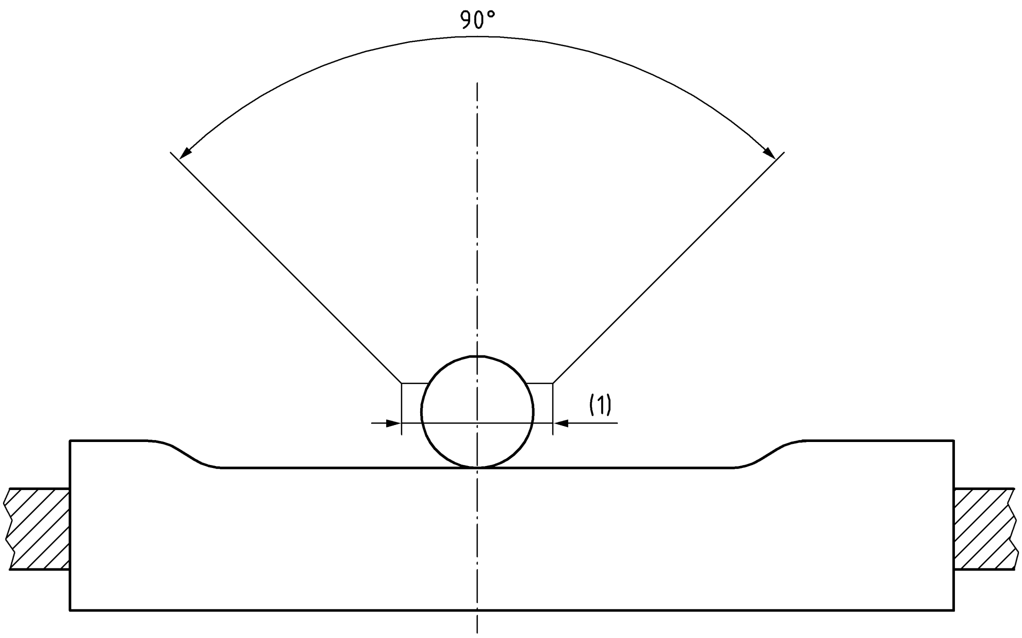


Figure 8 — Needle description (diameter (0,45 ± 0,01) mm)

6.3.12.2.2 Procedure

— This test shall be performed at temperature of (23 ± 5) °C;

— select the required number of specimens of the leading wire (see Table 1) that have a length of at least 750 mm;

— the leading wire shall be firmly fixed to the support by means of a cable clamp;

— each specimen shall undergo six tests and be moved 100 mm between each test and turned at an angle of 90°, always in the same direction;

— one cycle is defined by a backward and forward movement of the needle;

— scrape abrasion resistance shall be defined as the number of complete cycles required for the needle to completely wear through the insulation and to stop the equipment according to the load applied on the needle.

6.3.12.3 Test method 2

6.3.12.3.1 Apparatus

— Abrasion test apparatus as shown in Figure 9, composed of the following main parts:

  — steel or brass rotor, as shown in Figure 10, with a perimeter of (453 ± 2) mm to which three abrasive strips (see below) are attached by means of glue or double-sided adhesive tape. The abrasive strips might need to be previously bent carefully with a suitable tool in order to fit properly against the surface of the rotor. It shall be ensured that electrical contact between the abrasive strips and the rotor is made, e.g. at the slits on the rotor where the ends of the abrasive strips are inserted (see Figure 9). The rotor shall rotate at a speed of (9,96 ± 0,18) rpm, producing a mean peripheral speed of (0,075 ± 0,001) m/s;

  — three abrasive strips approximately 10 mm × 145 mm each, made of grinding steel as specified in Annex F;

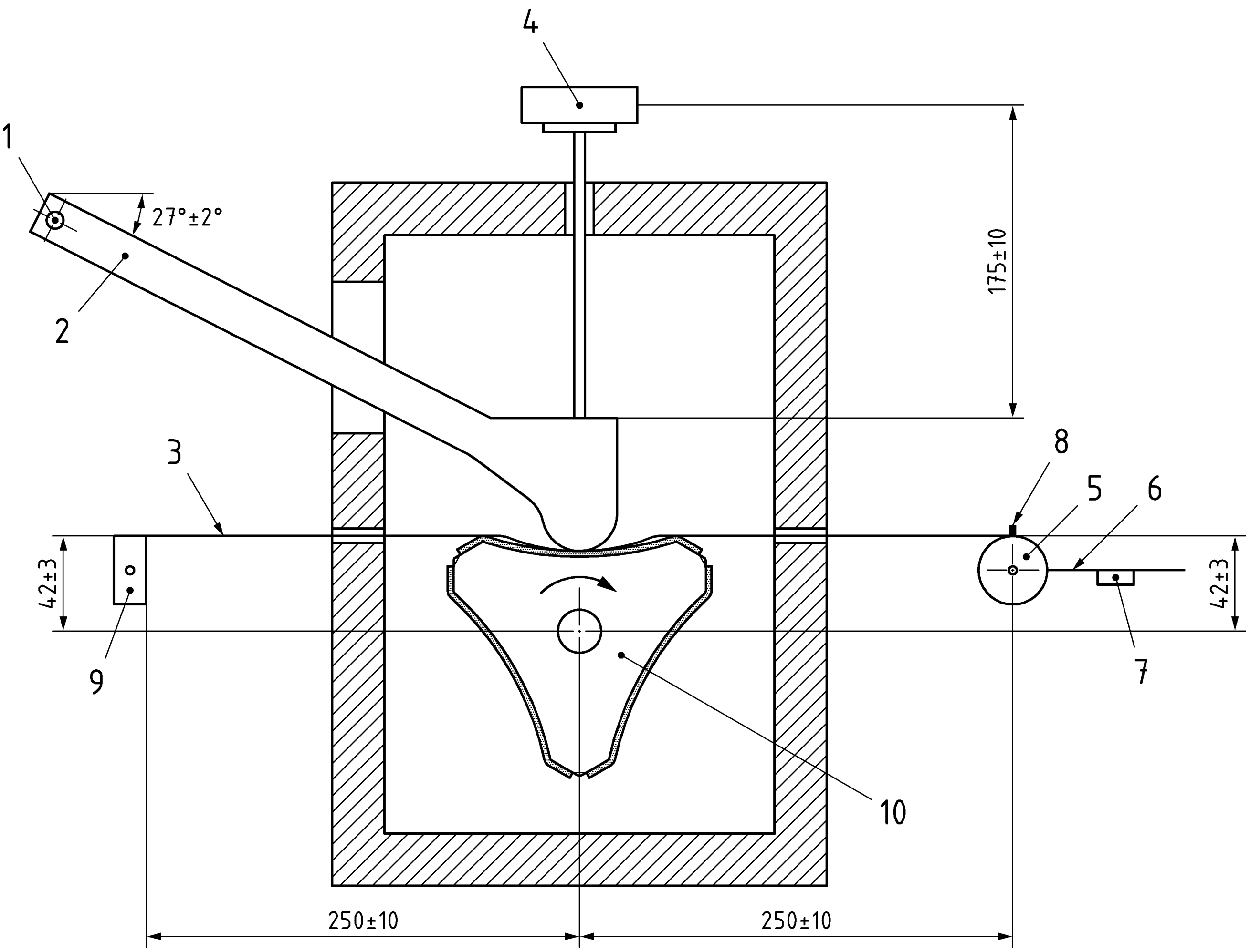
  — load, to be applied to the test piece through the hinged arm (see below);

  — hinged arm, made of steel or brass as shown in Figure 11; in the starting position, it shall apply a load of (8,35 ± 0,05) N to the test piece;

  — pulley of diameter (70 ± 1) mm, for applying a tensile load of (8,1 ± 0,5) N to the test piece, by means of a rod and a weight;

  — motor capable of maintaining a constant speed of rotation whatever load is applied to the rotor. A DC motor with an output power of at least 500 W and with a separate speed control may be used. The motor shall reach its specified speed of rotation 0,6 s after starting.

Dimensions in millimetres

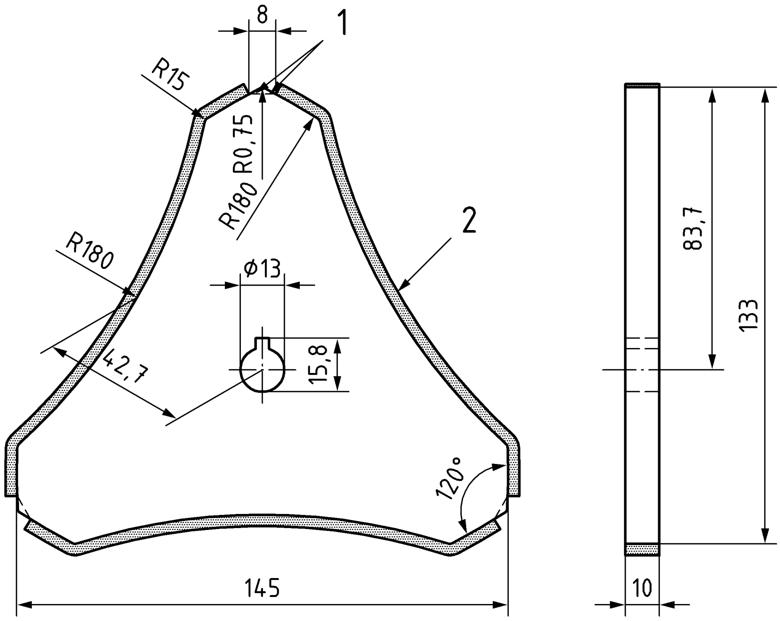


Key

1	pivot	6	rod
2	hinged arm	7	weight
3	leading wires	8	clamp screw for attaching the test piece
4	weight	9	clamp screw for attaching the test piece
5	pulley	10	rotor

Figure 9 — Abrasion test apparatus

Dimensions in millimetres



Key

1 slit for the end of the abrasive strip

2 abrasive strip

Figure 10 — Rotor

Dimensions in millimetres

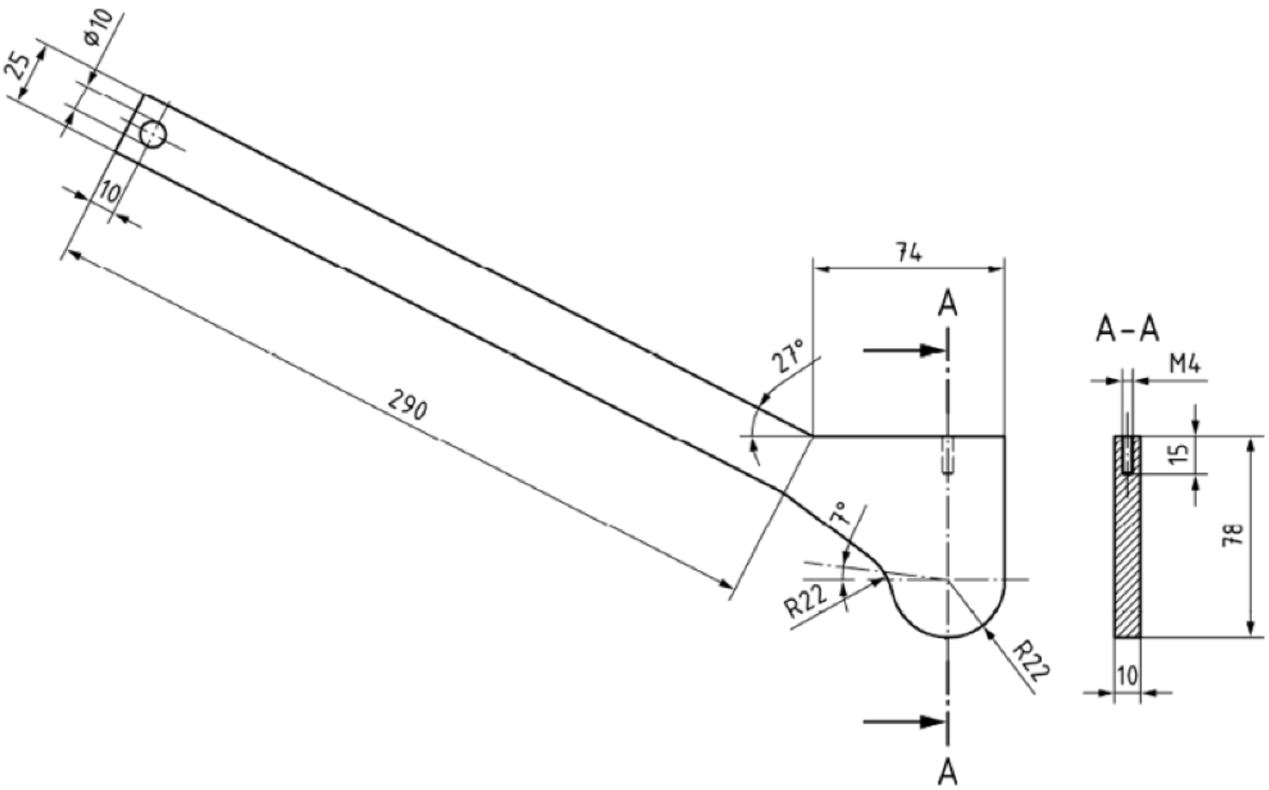


Figure 11 — Hinged arm

— Digital timer with relay output, capable of:

 — being set to a predetermined time in the range of 0 sto (10 ± 0,1) s;

 — being started when the hinged arm is lifted by the test piece;

 — automatically stopping the rotor when the predetermined time has elapsed;

 — automatically stopping the rotor when electrical contact is made between the leading wire and the abrasive strip or the rotor (only required for leading wire testing).

6.3.12.3.2 Procedure

The following procedure applies to the resistance of leading wires to abrasion test:

— select the required number of igniters with suitable length of leading wires as in Table 1;

— attach each test piece to the attachment points as shown in Figure 8, e.g. by suitable clamping in order to prevent the test piece from damage at the attachment points;

— position the rotor as shown in Figure 8, which shows the starting position;

— lift up the hinged arm (72 ± 2) mm above the centre of the rotor and fix it in that position using a retaining pin or similar arrangement;

— adjust the tensile load to 8,1 N;

— load the hinged arm with (4,00 ± 0,02) N (excluding the adjusted load due the hinged arm itself);

— carry out the test at the upper temperature limit stated by the manufacturer ± 2 °C;

— start the motor;

— the timing mechanism shall be started automatically as the hinged arm is lifted by the test piece;

— remove the retaining pin;

— the rotor shall be stopped automatically by the timing mechanism after (5,00 ± 0,05) s;

— record whether penetration of the insulation has occurred (detected by electrical contact being made between the leading wire conductor and the abrasive strip or the rotor).

After each test the abrasive strip shall be cleaned: for example, by using a brush with plastic bristles. The abrasive strip may be used for several tests but shall be changed at suitable intervals based on practical experience of the degradation of the strip.

The degradation of the strip can be monitored during routine testing by periodically testing a new set of 10 electric wires known to give a mean time at failure of approximately 5 s with a new abrasive strip. Then it should be ensured that the mean time at failure for each subsequent set of these wires has not increased by more than 5 % of the mean time at failure for the original set of wires (used with the new abrasive strip).

6.3.13 Resistance of leading wires or fibres to traction

6.3.13.1 General

This test aims at verifying that pulling forces which might be applied to the leading wires of electric igniters and the leading fibres of optical igniters do not cause an elongation or breakage or pullout of internal components of the igniters and an untimely initiation of the igniter.

6.3.13.2 Apparatus

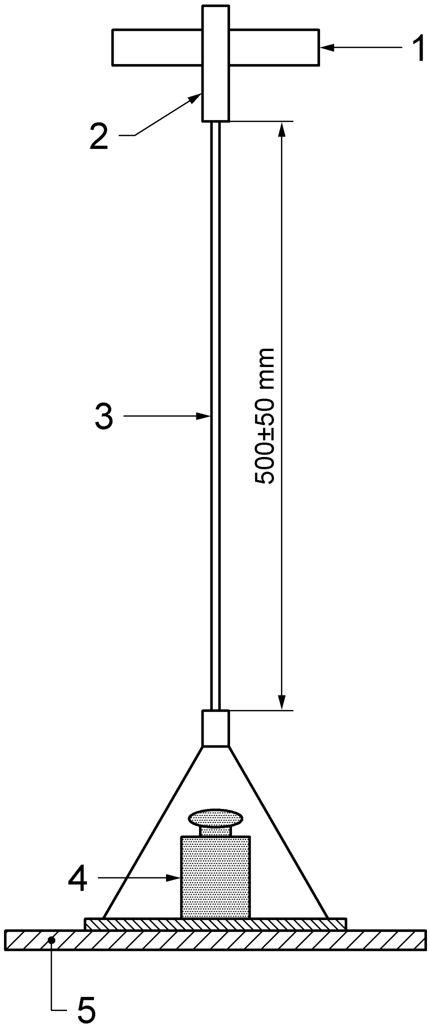
The apparatus comprises the following components as shown in Figure 12.

— Fixing point for the igniter:

It shall be determined on a case by case basis according to the external shape of the igniter or its fitting parts (if any).

— Weights to be attached to the leading wires or fibres, suitable for applying forces of 40 N or 100 N.

— Moveable support table.



Key

1 fixing point
2 igniter
3 leading wires
4 weights
5 movable support table

Figure 12 — Traction apparatus

6.3.13.3 Procedure

6.3.13.3.1 General

The tests shall be carried out at the highest operating temperature claimed by the manufacturer ± 2 °C.

Select the required number – as in Table 1 – of igniters that have dimensions, casing material, fitting parts (if any), leading wires or fibres, construction and initiating composition of the same design.

6.3.13.3.2 Sudden release test

Test the required number of igniters as in Table 1:

— attach the igniter to the fixing point and attach the leading wires or fibres to weights of total mass corresponding to a force of (40 ± 0,1) N;

— let the weights rest on the supporting table in such a manner that a slight tension of about 5 N is applied and so that the distance between the igniter and the attachment to the weights is (500 ± 50) mm;

— release the weights vertically so that the full load is applied instantly and maintain the load for (120 ± 5) s;

— record whether or not the igniter initiates during the test or whether the leading wires or fibres elongate or break and/or a pullout has occurred;

— fire the igniter according to 6.3.4 and record the initiation time.

6.3.13.3.3 Slow release test

Test the required number of igniters as in Table 1:

— attach the igniter to the fixing point and attach the leading wires or fibres to weights of total mass corresponding to a force of (100 ± 0,1) N;

— let the weights rest on the supporting table in such a manner that a slight tension of about 5 N is applied and so that the distance between the igniter and the attachment to the weights is (500 ± 50) mm;

— carefully release the weights vertically until the full load is applied and maintain that load for 10 s;

— record whether or not the igniter initiates during the test or whether the leading wires or fibres elongate or break and/or a pullout has occurred;

— if the leading wires or fibres are intact and no visible pullout has occurred, fire the igniter according to 6.3.4 and record the initiation time.

6.3.14 Crush test

6.3.14.1 General

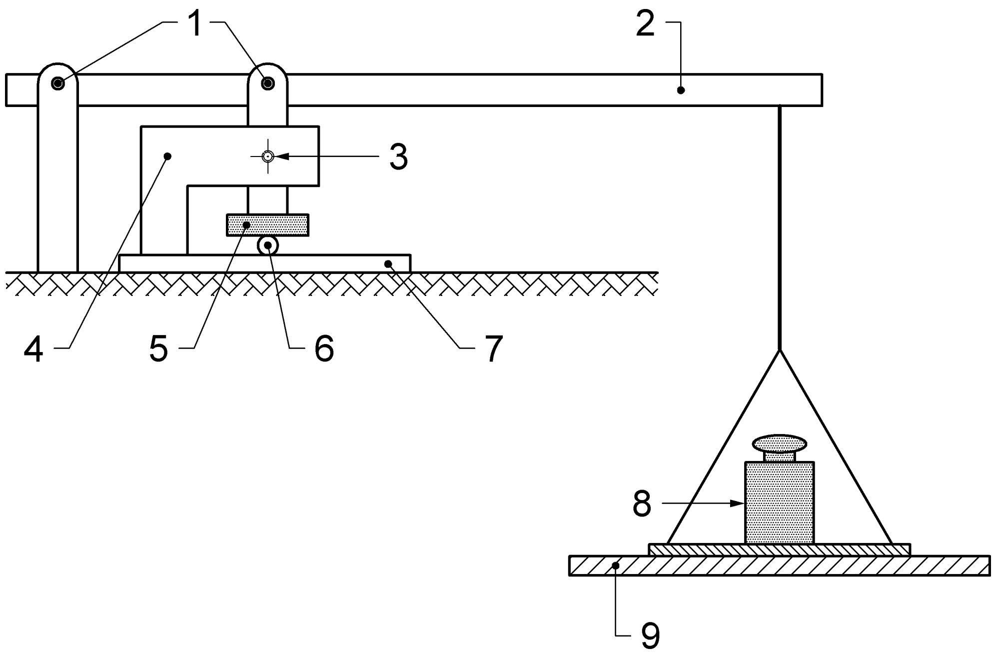
The test aims to check the sensitivity and resistance of igniters, pyrotechnic cords and fuses to damage which could result from being inadvertently crushed, e.g. a person walking on them.

6.3.14.2 Apparatus

The apparatus is shown in Figure 13. Dimensions of the crusher and the steel plate shall be determined in relation with the size of the article to be tested; for pyrotechnic cord and fuses, the steel crusher shall be a disk of 10 cm in diameter A guiding device shall ensure a vertical motion of the crusher. Weight shall be determined according to the dimensions of the hinged arm and the distance between the two pivots in such a way a vertical force of (20 ± 1) N is applied to the tested article.

NOTE An appropriate device, such as moveable support table, may be used in order to apply safely the vertical force to the tested article.

The distance between the lower face of the crusher and its pivot shall be simply and easily adjustable so that it is possible to reduce the gap between this lower face and the tested article to a minimum without damaging the article. A safety pin may be used to prevent an inadvertent application of the force to the article in presence of the test operator.



Key

1	pivot	6	tested article
2	hinger arm	7	steel plate
3	safety pin	8	weights
4	guiding device	9	moveable support table
5	steel crusher		

Figure 13 — Crush test apparatus

6.3.14.3 Procedure

The following procedure applies to the crush test:

— select the required number of articles as in Table 1; for pyrotechnic cord and fuses, select 1m-long straight samples;

— place the tested article on the steel plate where the steel crusher will apply its force evenly;

— carefully adjust the gap between the crusher and the article to a minimum;

— place the weights on the scale pan while it rests on the supporting table;

— remove the safety pin from a safe distance;

— carefully release the weights vertically until the full load is applied and maintain that load for 10 s;

— record whether or not the article initiates during the test or whether it exhibits visual damages after test;

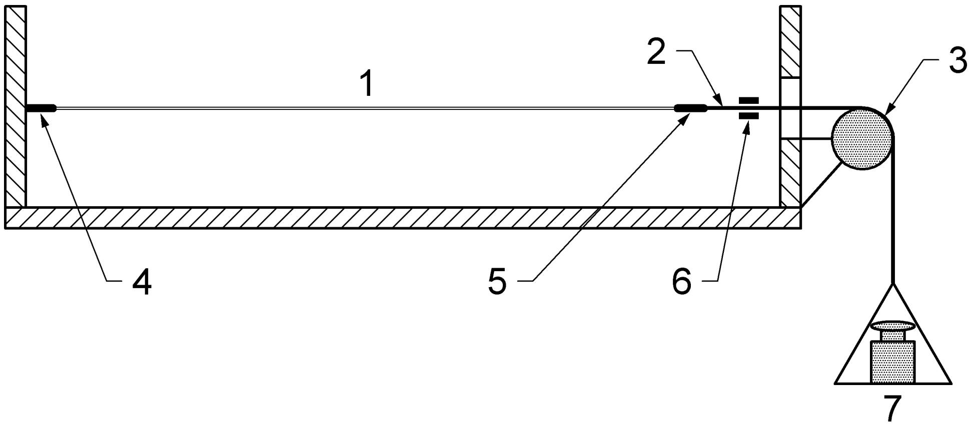
— fire the article according to 6.3.4 (igniters) or 6.3.8 (pyrotechnic cords and fuses) and record the initiation/burning time.

6.3.15 Resistance of cords and fuses to tension

6.3.15.1 Apparatus

The apparatus is shown in Figure 14. Suitable means shall be provided for fixing the test piece at one end and attaching it to a cable supporting weights at the other end. A blocking device shall be provided on the attachment between the test piece and the cable or on the cable itself so that the test piece can be held taut without applying the main force. The same result can be obtained by a moveable table on which the weights rest before test.

NOTE A similar apparatus to the one which is recommended for testing the resistance of leading wires or fibres of igniters to traction (see 6.3.13.1 – Figure 12) may also be used.



Key

1	test piece	5	mobile attachment
2	cable	6	blocking device
3	guiding pulley	7	weights
4	fixed attachment		

Figure 14 — Tension apparatus

6.3.15.2 Procedure

The following procedure applies to resistance of cords and fuses to tension test.

The required number of test pieces as in Table 1 shall be tested:

— fix the test piece in the apparatus and maintain it under slight tension sufficient to keep the test piece straight;

— apply a tension of (100 ± 5) N, unless otherwise specified by the manufacturer in its instructions for use, by removing instantaneously (rapid tension) the blocking device;

— if the test piece does not break, maintain the load for 30 min;

— then, remove the test piece from the apparatus and function it in accordance with 6.3.7 or 6.3.8.

6.3.16 Series firing of electric igniters

6.3.16.1 Apparatus

— Regulated current source (see 6.2.6);

— time measuring device (see 6.2.7.1).

6.3.16.2 Procedure

The following procedure applies to serial firing of electric igniters test:

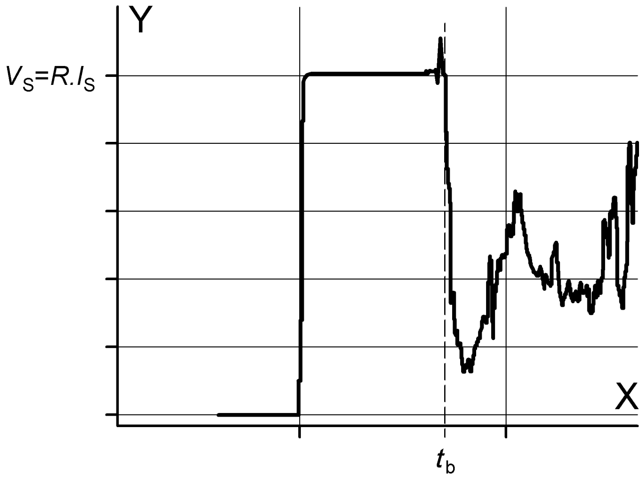
— current breakage time:

 — select 30 igniters;

 — adjust the current amplitude and the pulse duration time to the series firing current I_S and the pulse duration time t_S which are stated by the manufacturer for series firings;

 — connect an igniter to the current source and apply the current I_S for the time t_S;

 — record the current breakage time t_b;



Key

Y voltage (V)

X time (ms)

Figure 15 — Measurement of the current breakage time

 — repeat the two previous steps for each of the remaining igniters;

 — determine the minimum value of the current breakage time $t_{b,min}$ and, for instantaneous igniters, calculate the mean μ (t_b) and standard deviation σ (t_b);

— series firing test:

 — select 5 sets of N igniters, N being the maximum number which is authorized by the manufacturer;

— adjust the current amplitude to the series firing current I_S which is stated by the manufacturer for series firings and select the pulse duration time t_F given by:

$t_F = \min [t_{b,min}, \mu (t_b) - 3 \sigma (t_b)]$ for instantaneous igniters

and: $t_F = 0{,}8\ t_{b,min}$ for delay igniters

— connect N igniters in series to the current source IS and apply the current for the time t_F;

— record the number of igniters which fail to initiate;

— repeat the three previous steps for each of the four remaining sets of N igniters.

6.3.17 Electrical resistance of electric igniters

6.3.17.1 Apparatus

— Ohmmeter (see 6.2.15).

6.3.17.2 Procedure

The following procedure applies to electrical resistance of electric igniters test:

— select 25 electric igniters, having the same design and construction of the fusehead and the leading wires or connector; in the case of leading wires, they shall have the same length (±0,05 m);

— immediately prior to testing, condition the igniters for 2 h at (20 ± 2) °C and then carry out the test at (20 ± 2) °C;

— place the igniter in a protective container and measure the electrical resistance at the stripped end of the leading wires or using a connector which matches the connector of the igniter, using the ohmmeter;

— record the electrical resistance in ohms (Ω) for each tested igniter;

— calculate the mean μ and standard deviation σ of the results and compare the values $\mu \pm 3\sigma$ to the range of variation of resistance which is claimed by the manufacturer.

6.3.18 Insulation resistance of electric igniters

6.3.18.1 Apparatus

— Megohmmeter (see 6.2.15).

6.3.18.2 Procedure

The following procedure applies to:

Single-bridgewire igniters:

— select 25 electric igniters, having the same design and construction of the fusehead and the leading wires or connector; in the case of leading wires, they shall have the same length (±0,05m);

— short the igniter by twisting the bared ends of the two leading wires together (if any);

— immediately prior to testing, condition the igniters for 2 h at (20 ± 2) °C and then carry out the test at (20 ± 2) °C;

— place the igniter in a protective container and measure the insulation "pin-to-case" resistance between the twisted ends of the leading wires or one of the two pins of the connector of the igniter and the metallic casing of the igniter, using the megohmmeter;

— record the insulation resistance in megohms (M*Ω*) for each tested igniter;

— calculate the mean μ and standard deviation σ of the results and compare the values $\mu - 3\sigma$ to the minimum value of insulation "pin-to-case" resistance which is claimed by the manufacturer.

Double-bridgewire igniters:

— select 25 electric igniters, having the same design and construction of the fusehead and the leading wires or connector; in the case of leading wires, they shall have the same length (±0,05 m);

— short the igniters by twisting the bared ends of each pair of leading wires together (if any);

— immediately prior to testing, condition the igniters for 2 h at (20 ± 2) °C and carry out the test at (20 ± 2) °C;

— place the igniter in a protective container and measure the insulation "pin-to-case" resistance for each bridgewire:

  — between the shorted ends of the corresponding leading wires and the casing of the ignite;

  — between one of the corresponding pins of the connector of the igniter and the casing of the igniter, using the megohmmeter;

— measure the insulation "pin-to-pin" resistance:

  — between the shorted ends of the two bridgewires;

  — between two closest pins of the connector corresponding to each bridgewire of the ignite, using the megohmmeter;

— record the insulation resistances in megohms (M*Ω*) for each tested igniter;

— calculate the means μ and standard deviations σ of the results for each insulation resistance and compare the values $\mu - 3\sigma$ to the minimum values of insulation resistances which are claimed by the manufacturer.

6.3.19 Electrostatic discharge

6.3.19.1 General

This test aims at determining whether electric igniters can withstand an electrostatic discharge (ESD) without initiating. This test should not be undertaken on magnetically-coupled igniters.

For electric igniters with a sole central pin and a casing which acts as second pin, only the "pin-to-pin" configuration shall be taken into consideration.

For electric igniters where the sensitive element is only protected by a varnish or by a non-metallic protection, the "pin-to-case" configuration corresponds to the application of ESD between the two short-circuited leading wires and a conductive electrode through the protection.

For double-bridgewire igniters, the "pin-to-case" ESD test should be carried out for each bridgewire.

6.3.19.2 Apparatus

— ESD generator (see 6.2.16);

— equipment to record the ESD current and calculate the ESD impulse delivered to the igniter.

6.3.19.3 Procedure

The following procedure applies to Electrostatic discharge test.

Preparation of the test:

— select the required number of electric igniters as in Table 1, having the same design and construction of the fusehead and the leading wires or connector; in the case of leading wires, they shall have the same length (±0,05 m);

NOTE 1 Protective elements added to the bridgewire to increase resistance to mechanical, electrostatic or electromagnetic stress, such as a plastic sleeve on the fusehead, are regarded as part of the fusehead.

NOTE 2 In the case of primers with a sole central pin, only 12 items are selected.

— adjust the ESD generator according to Annex E. Then ensure that the leading wires and all measuring equipment are kept in the same position as they were when adjusting the ESD generator;

— the ESD impulse to be applied to the igniter shall be in accordance with the following table:

Table 5 — Minimum ESD impulse

No-fire current (A) [a]	$0{,}15 \le I_{NF} < 0{,}25$	$0{,}25 \le I_{NF} < 0{,}45$	$0{,}45 \le I_{NF} < 1{,}20$	$1{,}20 \le I_{NF} < 4{,}00$	$4{,}00 \le I_{NF}$
Minimum ESD impulse for the “pin-to-pin” configuration (mJ/Ω)	0,2	0,3	6	60	300
Minimum ESD impulse for the “pin-to-case” configuration (mJ/Ω)	0,6	0,6	12	120	600
[a] Value stated by the manufacturer.					

— carry out the test at (20 ± 5,0) °C and at a relative humidity not greater than 60 %;

— ensure that the leading wires and cables (if any) are kept at a distance of at least 100 mm from the ground and from any conductive objects that might cause leakage paths to earth;

— the leading wires (if any) shall be coiled as produced by the manufacturer.

Application of the ESD:

— monitor the ESD impulse applied each time. If it deviates from the specified value, adjust it again as described in Annex E before continuing with the test;

— pin-to-pin configuration: 12 igniters:

  — apply the ESD between the two separate ends of the leading wires or between the two pins (or between the pin and the casing);

  — observe whether the igniter initiates;

— repeat the operation 5 times successively for each igniter, allowing at least 10 s between each pulse;

— pin-to-case configuration: 12 igniters:

— twist together the ends of the two leading wires (if any);

— apply the ESD between the twisted ends of the leading wires or between one of the two pins and the casing of the igniter (this test is not applicable in the case of primers with a sole central pin);

— observe whether the igniter initiates;

— repeat the operation 5 times successively for each igniter, allowing at least 10 s between each pulse.

In the case of electric igniters with a sole central pin and a metallic casing which acts as the second pin, there is no difference between the “pin-to-pin” and “pin-to-case” configuration. The ESD impulse to be applied to the igniter shall be the value which is required for “pin-to-pin” configuration in the above table.

In the case of double-bridgewire igniters, a second “pin-to-pin” test shall be carried out between the two twisted ends of each pair of leading wires corresponding to each bridgewire or between one pin of the first bridgewire and one pin of the second bridgewire. The ESD impulse to be applied to the igniter shall be the value which is required for “pin-to-case” configuration in the above table.

6.3.20 Sensitivity testing

6.3.20.1 General

This test shall be applied to electric igniters which exhibit bare pyrotechnic substances, other ignition devices whenever bare compositions are not protected by safety features,

6.3.20.2 Electrostatic discharge

6.3.20.2.1 Apparatus

The ESD test circuit is described in Figure 16 hereunder.

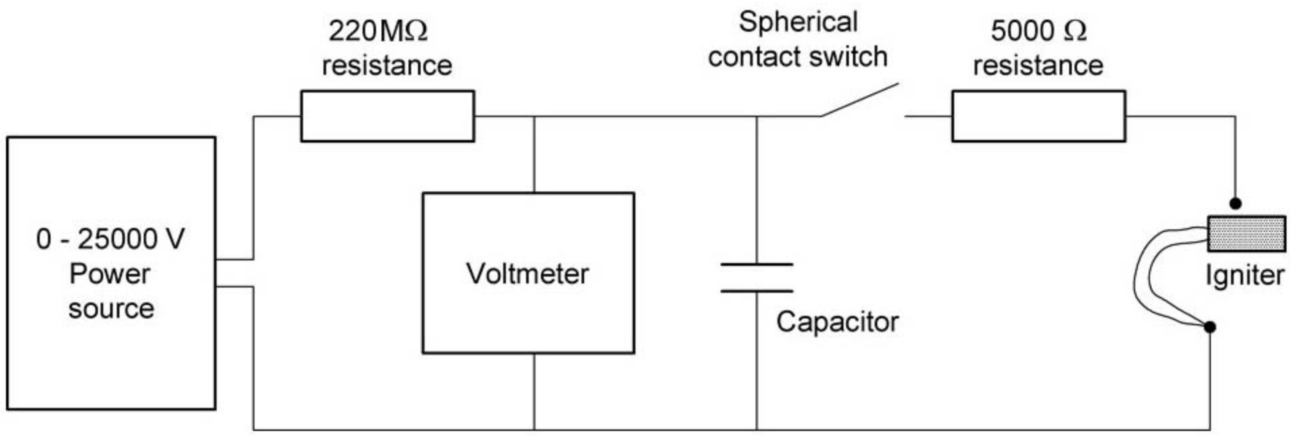


Figure 16 — ESD test circuit

6.3.20.2.2 Procedure

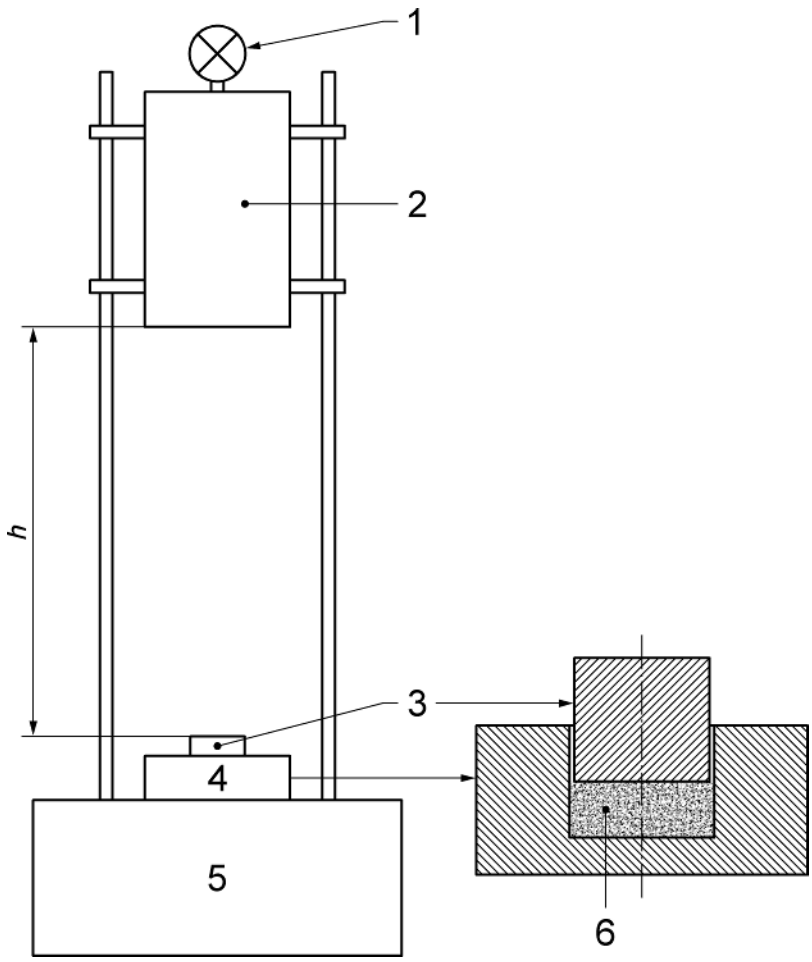
The mass of pyrotechnic composition as in Table 1 is required.

Perform the test at (20 ± 5) °C, discharge 25 000 V from a 330 pF capacitor or 20 000 V from a 500 pF capacitor or 15 000 V from a 889 pF capacitor through a 5 000 *Ω* resistance.

6.3.20.3 Impact

6.3.20.3.1 Apparatus

The general design of the impact test machine is described in Figure 17.



Key

1 release device

2 weight M to be dropped

3 piston

4 anvil

5 massive base

6 pyrotechnic composition

Figure 17 — Impact test machine

6.3.20.3.2 Procedure

Select the mass of pyrotechnic composition as in Table 1.

Up to 30 samples of pyrotechnic composition (volume close to 10 mm^3) are required.

Initiation of the composition is considered a positive result.

Perform the test at (20 ± 5) °C and:

— place the first sample of composition on the anvil of the test machine, then place the weight M at a distance h above the upper surface of the sample of composition, so that the product $M * g * h$ (with g = 9,81 $m.s^{-2}$) is equal to 8 J;

— release the weight and record the result;

— if it is positive, the test is stopped;

— if it is negative, place the second sample of composition on the anvil, then place the weight M at a distance h above the upper surface of the sample of composition, so that the product $M * g * h$ is equal to 15 J;

— release the weight and record the result;

— if it is positive, a sequence of tests using a similar procedure to the Bruceton method (see Annex A) with a pitch of 1 J is applied to 25 of the remaining samples of composition. The test is stopped as soon as there is a positive result at 8J;

— if it is negative, tests are made at 15 J, until there is a positive result, with a maximum of four more samples of composition and then, if no positive result is observed, the test is stopped;

— if a positive result is observed, a sequence of tests using a similar procedure to the Bruceton method (see Annex A) with a pitch of 1 J is applied to 25 of the remaining samples of composition. The test is stopped as soon as there is a positive result at 8 J.

NOTE More detailed information can be found in EN 13631–4:2002

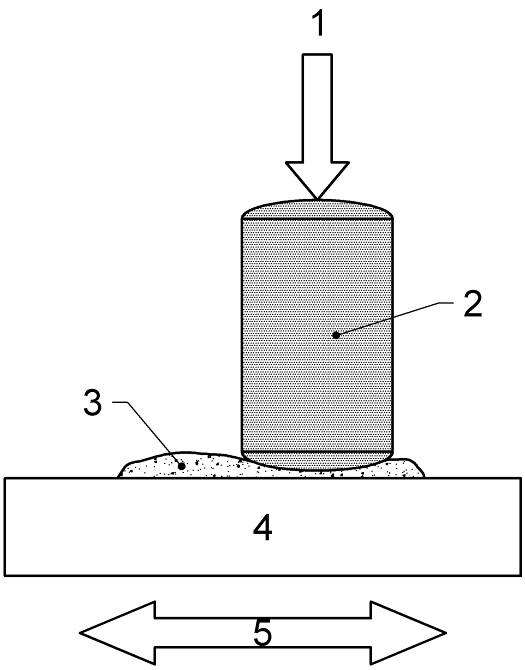
6.3.20.4 Friction

6.3.20.4.1 Apparatus

The application of the friction force is described in Figure 18.

A sample of pyrotechnic composition is placed on a porcelain plate (25 mm (length) × 25 mm (width) × 5 mm (height), roughness 9 μm – 32 μm) which can be given a linear to-and-fro motion.

A porcelain pin (15 mm (length) × 10 mm (diameter), roughness 9 μm – 32 μm) exerts a force F on the sample of pyrotechnic composition.



Key

1 applied force F

2 porcelain pin

3 pyrotechnic composition

4 porcelain plate

5 motion of the plate

Figure 18 — Friction test machine

6.3.20.4.2 Procedure

Up to 30 samples of pyrotechnic composition (volume close to 10 mm^3) are required. Each sample will be spread on the porcelain plate in the shape of a thin strip 15 mm long and 3 mm wide (leading to a thickness of (0,40 ± 0,05) mm)

Initiation of the sample of composition is considered a positive result.

Perform the test at (20 ± 5) °C and:

— place the first sample on the porcelain plate, and then apply the porcelain pin on it with an applied force of 80 N (or the closest value which can be delivered by the test machine). Start the motion of the plate and record the result;

— if it is negative, carry out the same test on a second sample with an applied force of 160 N (or the closest value which can be delivered by the test machine);

— start the motion of the plate and record the result;

— if it is positive, a sequence of tests using a similar procedure to the Bruceton method (see Annex A) with a pitch of 16 N (or the closest pitch which can be delivered by the test machine) is applied to 25 of the remaining samples. The test is stopped as soon as there is a positive result at 80 N;

— if it is negative, tests are made at 160 N (or the closest value which can be delivered by the test machine), until there is a positive result, with a maximum of four more samples and then, if no positive result is observed, the test is stopped;

— if a positive result is observed, a sequence of tests using a similar procedure to the Bruceton method (see Annex A) with a pitch of 16 N (or the closest value which can be delivered by the test machine) is applied to 25 of the remaining samples. The test is stopped as soon as there is a positive result at 80 N.

NOTE More detailed information can be found in EN 13631–3:2004.

6.3.21 Water immersion test

The samples shall be visually inspected and any anomaly noted before subjecting them to the test.

The samples shall be immersed horizontally for at least 48 h under 0,5 m of water. Subject the samples to the functioning test in accordance with 6.3.4 within 2 h of being removed from the water.

6.3.22 Determination of the detonative / non- detonative characteristics

6.3.22.1 General

The purpose of the test is to check that the tested igniter cannot detonate the charge as defined in 6.3.22.2. If this charge is initiated and detonates, the igniter has detonative characteristics and then shall be considered a detonator which falls outside the scope of this standard.

The test is carried out on three igniters at (20 ± 5) °C.

6.3.22.2 Apparatus

The equipment and material needed for the test is composed of:

— Pentaerythritoltetranitrate (PETN) of density (1,00 ± 0,04) g/cm^3, placed under natural settling in cylindrical cartridges in a soft case (e.g. kraft paper or a film made of thin plastic) with a diameter of 30 mm and of a mass of at least 50 g. The ends of the cartridges shall exhibit a flat surface;

— 10 cm × 10 cm steel plates of 1 mm thickness serving to determine whether detonation occurs; the steel plate shall be supported at 5 cm above the floor of the test area so that there is a clear gap beneath the steel plate.

6.3.22.3 Test method

The following test method applies to the determination of the detonative / non- detonative characteristics of the igniter:

— one igniter is placed at one end of the PETN cartridge in such a way that it touches the flat surface. As a rule the known or anticipated effect is orientated towards the centre of the cartridge. If these conditions cannot be kept (due to the shape of the article), the igniter shall be placed in the best possible way as if it was intended to initiate the PETN cartridge;

— then place the cartridge on the steel plate in the anticipated direction of the detonation;

— fire the igniter;

— a detonation is considered to have occurred when a clean hole has been punched through the steel plate;

— repeat the test with the other two igniters;

— the test result is recorded in the following way:

  — if at least one detonation of PETN cartridges occurred during the test, the article has "detonative characteristics";

  — if not, the article has "non-detonative" characteristics.

6.3.23 Visual examination

The visual examination shall be done either by the naked eye or using magnifying equipment (see 6.2.17). Record any anomalies.

For delay fuses, record any evidence of lateral emission of gases, flames or hot particles.

7 Minimum labelling requirements and instructions for use

7.1 General

Ignition devices shall be marked with the information specified in 7.2 and 7.3.

The specified information for labelling shall be visible, legible and indelible in the language(s) of the country in which the ignition devices are offered for sale. For each language, it shall be presented as a whole and shall not be interrupted by other text. Additional text given in another language shall not conflict with the specified information.

Pyrotechnic cords and fuses do not present an external surface which is adapted to any labelling. In those cases, the label shall be placed on the smallest piece of packaging.

7.2 Labelling requirements

7.2.1 Name and type

Labels to be provided directly on the ignition device or on the smallest piece of packaging if it does not provide sufficient space for the labelling requirements shall include either the "generic type" or "subtype" to which the article belongs (see 4.1 and 4.2).

If a trade name is used in addition, it shall be clearly identified with the words "trade name" to distinguish it from the technical name.

7.2.2 CE marking and identification number

CE marking shall be displayed on the label.

CE-marking shall be followed by the identification number of the Notified Body responsible for:

— monitoring the existing quality system (in case of Modules D and E according to Directive 2007/23/EC);

— and/or checking conformity to type according to Module C according to Directive 2007/23/EC.

7.2.3 Category and registration number

The registration number for tracing products shall be marked in accordance with the example below:

XXXX – YY – ZZZZ...

where XXXX refers to the registration number of the Notified Body issuing the EC type examination certificate, YY refers to the category of article in abbreviated format (P1 or P2), and where ZZZZ... is a processing chronologic number given by the Notified Body issuing the EC-type examination certificate.

When the ignition device belongs to a family of individual items which has been submitted together to type examination, this number is the one which has been attributed to the whole family.

7.2.4 Age limit and specialist knowledge labelling

Category P1: The minimum age limit applicable in the country in which the article is offered for retail sale shall be clearly stated on the label. The minimum age limit of 18 years applies, if the individual Member State has not raised or lowered these age limits according to Directive 2007/23/EC Art. Seven (2).

Category P2: "For use only by persons with specialist knowledge" shall be stated on the label.

7.2.5 Net Explosive Content

The labelling shall include the Net Explosive Content (NEC) of the ignition device expressed in the appropriate units.

The abbreviation for the net explosive content (NEC) may be used for the labelling.

7.2.6 Details on manufacturer or importer

The labelling of ignition devices shall include as a minimum the name and address of the manufacturer or, where the manufacturer is not established in the European Community, the name of the manufacturer and the name and address of the importer. The address shall comprise at least the town and the country.

7.2.7 "Use by" date

Where the manufacturer provides a "use by" date, it shall be printed on the label in accordance with the example below:

Use by MM/YYYY or MM/YY

Where MM is the month (2 digits, e.g. 07) and YYYY or YY is the year (4 or 2 digits, e.g. 2015 or 15).

The ignition device shall function correctly until this "use by" date in accordance with the manufacturer's specifications. When this "use by" date is later than 18 months after the manufacturing date of the article, this shall be verified during the type test from information supplied by the manufacturer on the basis of functioning tests according to 5.3:

— either at the 'use by' date or at a later date;

— or after accelerated ageing according to 6.3.9.2.3 by thermally conditioning samples of the article at a temperature T and during a time period t determined by the Notified Body according to the 'use by' date specified by the manufacturer.

Such test shall be performed on four specimens of the ignition device or of an article that shares common design features with the ignition device and pyrotechnic compositions based on the same chemical substances as in the ignition device.

7.2.8 Printing

Labelling shall be clearly visible, easily legible, indelible and on a contrasting background colour. When measured in accordance with 6.2.1, the font sizes shall be such that the height of the character "X" (in upper case) is at least 2,8 mm for the information on generic type or subtype, name and registration number (including category), and at least 2,1 mm for the other information.

The minimum height of the CE marking shall be 5 mm.

Nonconformities of labelling are classed according to Table 3 for batch testing.

In type testing, no such nonconformities as described in Table 3 are acceptable.

7.2.9 Marking of very small items

If the ignition device does not provide enough space for the information as required by 7.2.1 until 7.2.7, at least the CE marking followed by the identification number of the notified body (see 7.2.2) and, where possible, the registration number shall be marked on the article.

However all information required by this European Standard shall be provided on the smallest piece of packaging. The manufacturer will ensure that the pack design prevents loss of information if the label is broken.

In this case, the pack shall be marked with the statement: "be sold as packaged". This statement shall appear adjacent to the type name or category. Printing shall be made in accordance with 7.2.8.

7.2.10 Ignition input

Where appropriate (e.g. non reversible delay fuses), the ignition input of the ignition device shall be indicated by the labelling or the instructions for use. Conformity to this requirement shall be verified by visual examination.

7.3 Instructions for use

Instructions for use shall be delivered with the ignition device and shall provide – in full text, sketches, images and/or graphical symbols – clear and complete information on:

— the method of ignition which shall be explained in detail;

— the safe test current;

— connections and firing equipment if required to be used, e.g. precise reference or specifications of firing device to be used;

— performances of the article, including description of main effects: nature (heat, pressure, projections...), origin, direction and amplitude and related markings on the article (where appropriate), ignition capability, parameters for the burning times of main charge, delay times (if any), as well as linear burning rate of pyrotechnic cords and fuses;

— likely hazards, including projected fragments, burning material or hot slag;

— if any, protections, shunts, safety pins, etc. to be removed or safe/arm switch or lock to be actuated before use, and corresponding identification (marking, label, etc.);

— description of normal use of the article and related operating instructions;

— safety instructions to prevent from untimely or inadvertent initiation or ignition in normal handling and normal use;

— electrical characteristics (e.g. all-fire current, no-fire current, resistance, etc.) for electric igniters and electrically triggered fuzes;

— optical characteristics (e.g. all-fire power, no-fire power, optical wavelength, etc.) for optical igniters and optically triggered fuzes;

— serial use of igniters: maximum number of items which can be connected at the same time;

— precautions to be taken at the opening of the package (if any);

— safety instructions for storage, transport and safety features;

— for articles that were not functioned at their ‘use by’ date: method of disposal, either operating and safety instructions to dispose of the articles or access to a professional disposal network;

— for articles that were functioned before their ‘use by’ date, method of disposal of the remnants (if any).

NOTE Instructions for use may include such sentences as the following: “A proper firing system with key lock outs may be used to initiate these devices” (or equivalent) and “Use 3 to 5 A DC or AC current” or “Use 9 to 12 V DC voltage”, plus “Check connections before firing” or “Test current < XX A DC”, or “Use only firing equipment ref. XXXX” or another sentences if more appropriate.

Annex A
(informative)

Bruceton method

A.1 General

The Bruceton method is used to determine the level of stimulus at which there is a 50 % probability of obtaining a positive result.

A.2 Procedure

The method involves the application of different levels of stimulus and determining whether or not a positive reaction occurs. The performance of the trials is concentrated around the critical region. It takes place by decreasing the stimulus in one level at the next trial if a positive (= fire) result is obtained and by increasing the stimulus in one level if a negative (= no-fire) result is obtained. Usually about five preliminary trials are performed to find a starting level in approximately the right region and then at least 25 trials are performed to provide the data for the calculations.

S_0 and S_{100} being respectively the all-fire and the no-fire levels claimed by the manufacturer, the first preliminary test is performed by application of the stimulus:

$$S = \frac{S_0 + S_{100}}{2}$$

and the pitch of the sequence of tests is determined by the following formula:

$$\Delta S = \frac{S_{100} - S_0}{6}$$

The preliminary phase of the test ends as soon as there is a first change “positive → negative” or “negative → positive”.

A.3 Calculation of results

In determining the level at which the probability of obtaining a positive result is 50 % (S_{50}), only the positive results (+) or only the negative results (−) are used, depending on which has the smaller amount. If the numbers are equal, either may be used. The data are recorded in a Table (e.g. as in Table 1) and summarized as shown in Table A.2. Column 1 of Table 2 contains the stimuli, in ascending order, starting with the lowest level for which a test result is recorded. In column 2, “I” is the number corresponding to the number of equal increments above the base or zero line. Column 3 contains the number of negative results $n_i = n(-)$ for each value of the stimulus, because $n(-) < n(+)$. The fourth column tabulates the result of multiplying ‘i’ times “n_i” and the fifth column tabulates the results of multiplying the square of “I” times “n_i”.

A mean is calculated from the following Formula (A.1):

$$S_{50} = S_{\min} + \Delta S \cdot \left(\frac{A}{N_S} \pm 0,5 \right) \tag{A.1}$$

where:

$N_S = \sum n_i$;

$A = \sum (i \cdot n_i)$;

S_{min} is the lowest value of the stimulus;

ΔS is the pitch.

If negative results are used, the sign inside the brackets is positive; it is negative if positive results are used. The standard deviation σ may be estimated using Formula (A.2):

$$\sigma = 1{,}620 \cdot \Delta S \cdot \left(\frac{N_S \cdot B - A^2}{N_S^2} + 0{,}029 \right) \quad \text{(A.2)}$$

where

$B = \sum (i^2 \cdot n_i)$

Formula (A.2) gives a quite accurate estimate of σ as long as $\frac{N_S \cdot B - A^2}{N_S^2} > 0{,}3$

(see reference [1] in the case this ratio is less than 0,3).

A.4 Values at 95 % confidence level

For an optimal application of the Bruceton test, *i* is between 3 and 6. When *i* is equal to 1 or 2, the value of S_{50} is still correct, but σ is not. When *i* is higher than 6, it is necessary to increase the number of tests. For a sequence of 25 tests, calculated results are acceptable if:

$$0{,}5 \le \frac{\Delta S}{\sigma} \le 2$$

and the values of the 'no-fire' stimulus S_{NF} and the 'all-fire' stimulus S_F such as the probability *P* of having respectively no-fires or fires at γ confidence level can be calculated from Formulae (A.3) and (A.4):

$$S_{NF} = S_{50} - k \cdot \sigma - t \cdot \sqrt{s_\mu^2 + k^2 \cdot s_\sigma^2} \quad \text{(A.3)}$$

$$S_F = S_{50} + k \cdot \sigma + t \cdot \sqrt{s_\mu^2 + k^2 \cdot s_\sigma^2} \quad \text{(A.4)}$$

where

k is given by table of inverses of the law of normal distribution such as $\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{k} e^{\frac{-t^2}{2}} \cdot \mathrm{dt} = P$;

t is given by table of Student-t distribution *t(ν,γ)* with *ν* degrees of freedom for two-sided critical regions (see A.7 hereafter), with *ν* is equal to N_S–1;

$s_\mu = \frac{1}{\sqrt{n}} \frac{6\sigma + \Delta S}{7}$ is the standard error of the mean;

$s_\sigma = \frac{1}{\sqrt{n}} \frac{\sigma}{\Delta S} (1{,}1\Delta S + 0{,}3\sigma)$ is the standard error of the standard deviation where

n total number of fires or no-fires (depending on the outcome of the analysis). It is not the total number of device fired;

σ standard deviation;

ΔS step increment (pitch).

For P = 99,9 % and γ = 95 %, k and t have the following values:

k = 3,090

N_S–1	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
t	2,228	2,201	2,179	2,160	2,145	2,131	2,120	2,110	2,101	2,093	2,086

A.5 Example

Using the following data from Tables A.1 and A.2:

— lowest current S_{min} = 2,10 A;

— pitch ΔS = 0,1 A;

— sum of $n_i(-)$ = 12;

— sum of $i \cdot n_i$ (–) = 16;

— sum of $i^2 \cdot n_i$ (–) = 30;

the mean current is given by Formula (A.1) as:

$$S_{50} = 2,10 + 0,10 \times [(16/12) + 0,5] = 2,28 \text{ A}$$

and the standard deviation by Formula (A.2) as:

$$\sigma = 1,62 \times 0,10 \times [((12 \times 30 - 16^2)/12^2) + 0,029] = 0,12 \text{ A}$$

and, at 95 % confidence level:

$$\frac{\Delta S}{\sigma} = 0,833$$

$$s_\mu = \frac{0,12}{\sqrt{12}} \cdot 0,97 = 0,034$$

$$s_\sigma = \frac{0,12}{\sqrt{12}} \cdot 1,45 = 0,050$$

$$S_{NF} = 2,28 - 3,090 \cdot 0,12 - 2,201 \cdot \sqrt{0,034^2 + 3,090^2 \cdot 0,050^2} = 1,56\text{A}$$

$$S_F = 2,28 + 3,090 \cdot 0,12 + 2,201 \cdot \sqrt{0,034^2 + 3,090^2 \cdot 0,050^2} = 3,00\text{A}$$

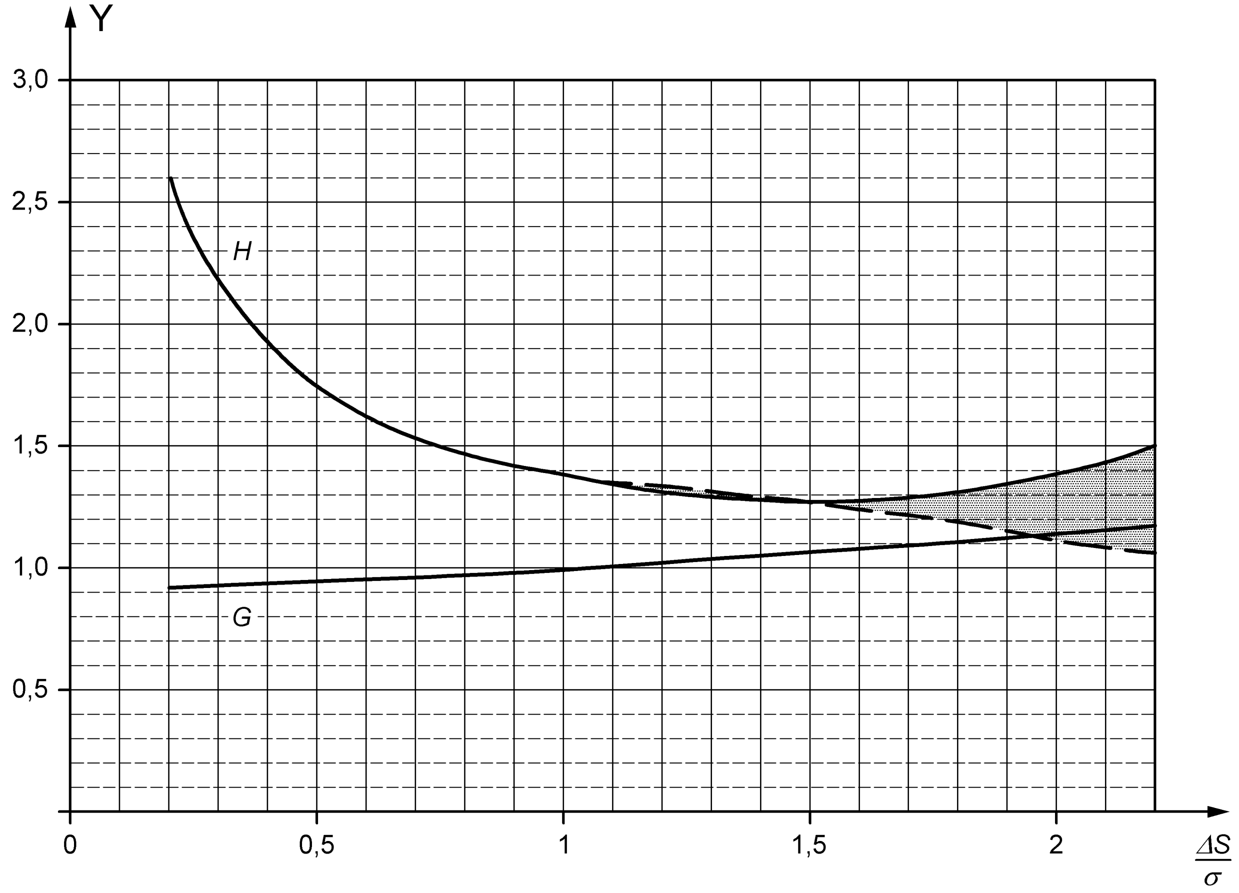
Table A.1 — Recording data

Current (A)																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	+	-
2,50								+																		1	
2,40							-		+				+				+		+							4	1
2,30				+		-				+		-		+		-		-		+		+				5	4
2,20	+		-		-						-				-						-		+		+	3	5
2,10		-																						-			2
																										13	12

Table A.2 — Summarizing data

Current (A)		**Calculation using negatives**		
	$i(-)$	$n_i(-)$	$i(-) \times n_i(-)$	$i(-)^2 \times n_i(-)$
2,40	3	1	3	9
2,30	2	4	8	16
2,20	1	5	5	5
2,10	0	2	0	0
Totals		$N_S = 12$	$A = 16$	$B = 30$

A.6 Curves of *G* and *H* functions



Key

Y coefficients *G* and *H*

NOTE Relative to *H* curve: For values of $\Delta S/\sigma$ higher than 1,1, the solid branch corresponds to values of *H* when the mean falls on a test level; the dashed branch gives the values of *H* when the mean is midway between two levels. Linear interpolation between these two cases can be made for other positions of the mean.

Figure A.1 — Curves of *G* and *H* functions

A.7 Table of Student-t distribution

Table A.3 — Table of Student-t distribution

Two Sided	50 %	60 %	70 %	80 %	90 %	95 %	98 %	99 %	99,5 %	99,8 %	99,9 %
1	1,000	1,376	1,963	3,078	6,314	12,71	31,82	63,66	127,3	318,3	636,6
2	0,816	1,061	1,386	1,886	2,920	4,303	6,965	9,925	14,09	22,33	31,60
3	0,765	0,978	1,250	1,638	2,353	3,182	4,541	5,841	7,453	10,21	12,92
4	0,741	0,941	1,190	1,533	2,132	2,776	3,747	4,604	5,598	7,173	8,610
5	0,727	0,920	1,156	1,476	2,015	2,571	3,365	4,032	4,773	5,893	6,869
6	0,718	0,906	1,134	1,440	1,943	2,447	3,143	3,707	4,317	5,208	5,959
7	0,711	0,896	1,119	1,415	1,895	2,365	2,998	3,499	4,029	4,785	5,408

8	0,706	0,889	1,108	1,397	1,860	2,306	2,896	3,355	3,833	4,501	5,041
9	0,703	0,883	1,100	1,383	1,833	2,262	2,821	3,250	3,690	4,297	4,781
10	0,700	0,879	1,093	1,372	1,812	2,228	2,764	3,169	3,581	4,144	4,587
11	0,697	0,876	1,088	1,363	1,796	2,201	2,718	3,106	3,497	4,025	4,437
12	0,695	0,873	1,083	1,356	1,782	2,179	2,681	3,055	3,428	3,930	4,318
13	0,694	0,870	1,079	1,350	1,771	2,160	2,650	3,012	3,372	3,852	4,221
14	0,692	0,868	1,076	1,345	1,761	2,145	2,624	2,977	3,326	3,787	4,140
15	0,691	0,866	1,074	1,341	1,753	2,131	2,602	2,947	3,286	3,733	4,073
16	0,690	0,865	1,071	1,337	1,746	2,120	2,583	2,921	3,252	3,686	4,015
17	0,689	0,863	1,069	1,333	1,740	2,110	2,567	2,898	3,222	3,646	3,965
18	0,688	0,862	1,067	1,330	1,734	2,101	2,552	2,878	3,197	3,610	3,922
19	0,688	0,861	1,066	1,328	1,729	2,093	2,539	2,861	3,174	3,579	3,883
20	0,687	0,860	1,064	1,325	1,725	2,086	2,528	2,845	3,153	3,552	3,850
21	0,686	0,859	1,063	1,323	1,721	2,080	2,518	2,831	3,135	3,527	3,819
22	0,686	0,858	1,061	1,321	1,717	2,074	2,508	2,819	3,119	3,505	3,792
23	0,685	0,858	1,060	1,319	1,714	2,069	2,500	2,807	3,104	3,485	3,767
24	0,685	0,857	1,059	1,318	1,711	2,064	2,492	2,797	3,091	3,467	3,745
25	0,684	0,856	1,058	1,316	1,708	2,060	2,485	2,787	3,078	3,450	3,725
26	0,684	0,856	1,058	1,315	1,706	2,056	2,479	2,779	3,067	3,435	3,707
27	0,684	0,855	1,057	1,314	1,703	2,052	2,473	2,771	3,057	3,421	3,690
28	0,683	0,855	1,056	1,313	1,701	2,048	2,467	2,763	3,047	3,408	3,674
29	0,683	0,854	1,055	1,311	1,699	2,045	2,462	2,756	3,038	3,396	3,659
30	0,683	0,854	1,055	1,310	1,697	2,042	2,457	2,750	3,030	3,385	3,646
40	0,681	0,851	1,050	1,303	1,684	2,021	2,423	2,704	2,971	3,307	3,551
50	0,679	0,849	1,047	1,299	1,676	2,009	2,403	2,678	2,937	3,261	3,496
60	0,679	0,848	1,045	1,296	1,671	2,000	2,390	2,660	2,915	3,232	3,460
80	0,678	0,846	1,043	1,292	1,664	1,990	2,374	2,639	2,887	3,195	3,416
100	0,677	0,845	1,042	1,290	1,660	1,984	2,364	2,626	2,871	3,174	3,390
120	0,677	0,845	1,041	1,289	1,658	1,980	2,358	2,617	2,860	3,160	3,373

Annex B
(informative)

Dichotomic (or Langlie) method

B.1 General

The dichotomic (or Langlie) method is used to determine the level of stimulus at which there is a 50 % probability of obtaining a positive result. It converges quicker than Bruceton method towards the mean of the statistical distribution of the fire levels of the igniters and can be used as an alternative of Bruceton method peculiarly when the no-fire and all-fire levels are not well-known.

B.2 Procedure

The method involves the application of a variable stimulus to a set of igniters which are sampled in a random way from a batch and determining whether or not a positive reaction occurs. The stimulus is a continuous variable which can take all the possible values within a given test interval.

The performance of the trials is not necessarily concentrated around the critical region at the beginning of the test sequence. The stimulus to be applied to each igniter in the sequence is determined according to the results of the previous tests by application of the following flowchart.

Let S_{100} and S_0 be values of the stimulus which are likely to initiate the igniters in 100 % and 0 % of cases respectively ($S_{100} > S_0$), and N the number of igniters in the test sample.

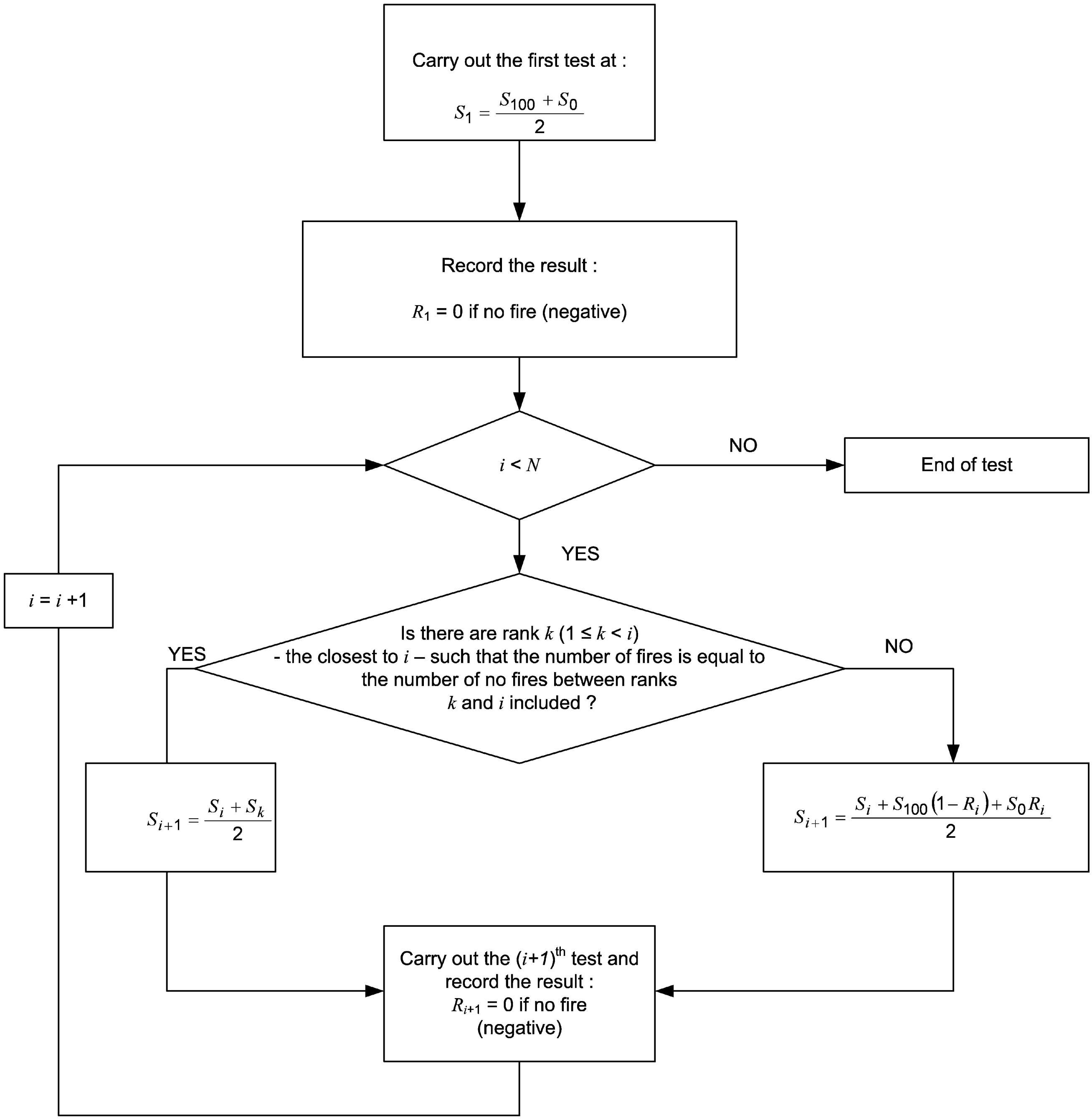


Figure B.1 — Flowchart of Dichotomic method

B.3 Calculation of results

Among the test results, select:

— the highest level S_M of the stimulus which has led to “no-fire” of the igniter ($R_M = 0$);

— the lowest level S_m of the stimulus which has led to “fire” of the igniter ($R_m = 1$).

and then, calculate the number n of distinct test values of the stimulus which are comprised between S_m *and* S_M, these two values excluded.

A first estimate of the mean μ_0 is calculated from the following formula:

$$\mu_0 = \frac{S_m + S_M}{2} \tag{B.1}$$

and the corresponding standard deviation σ_0 may be estimated using:

$$\sigma_0 = \frac{N(S_M - S_m)}{8 \cdot (n+2)} \tag{B.2}$$

NOTE In the case $S_M \le S_m$, it is necessary to make supplementary tests until $S_M > S_m$ or to apply the Bruceton Method within the interval] S_m, S_M [

Then better estimates of the mean μ_e and standard deviation σ_e can be calculated by means of an iterative algorithm based on the maximization of the likelihood function which gives the probability of obtaining the given test results with given values of μ and σ, as illustrated by the following flowchart (see Figure B.2) where:

$$t_i = \frac{S_i - \mu}{\sigma}$$

$$p_i = \frac{1}{\sqrt{2\pi}} e^{-\frac{t_i^2}{2}}$$

$$P_i = \int_{-\infty}^{t_i} p_i . dt$$

$$h_i = -\frac{1}{P_i} \quad \text{if } R_i = 1 \qquad \text{or} \qquad \frac{1}{1-P_i} \quad \text{if } R_i = 0$$

and

$$A = \sum_{i=1}^{N} p_i \cdot h_i$$

$$B = \sum_{i=1}^{N} t_i \cdot p_i \cdot h_i$$

$$C = \sum_{i=1}^{N} p_i \cdot h_i (1 - p_i \cdot h_i)$$

$$D = \sum_{i=1}^{N} t_i \cdot p_i \cdot h_i . (t_i - p_i \cdot h_i)$$

$$E = D - A$$

$$F = \left[\sum_{i=1}^{N} t_i^2 \cdot p_i \cdot h_i \cdot (t_i - p_i \cdot h_i) \right] - B$$

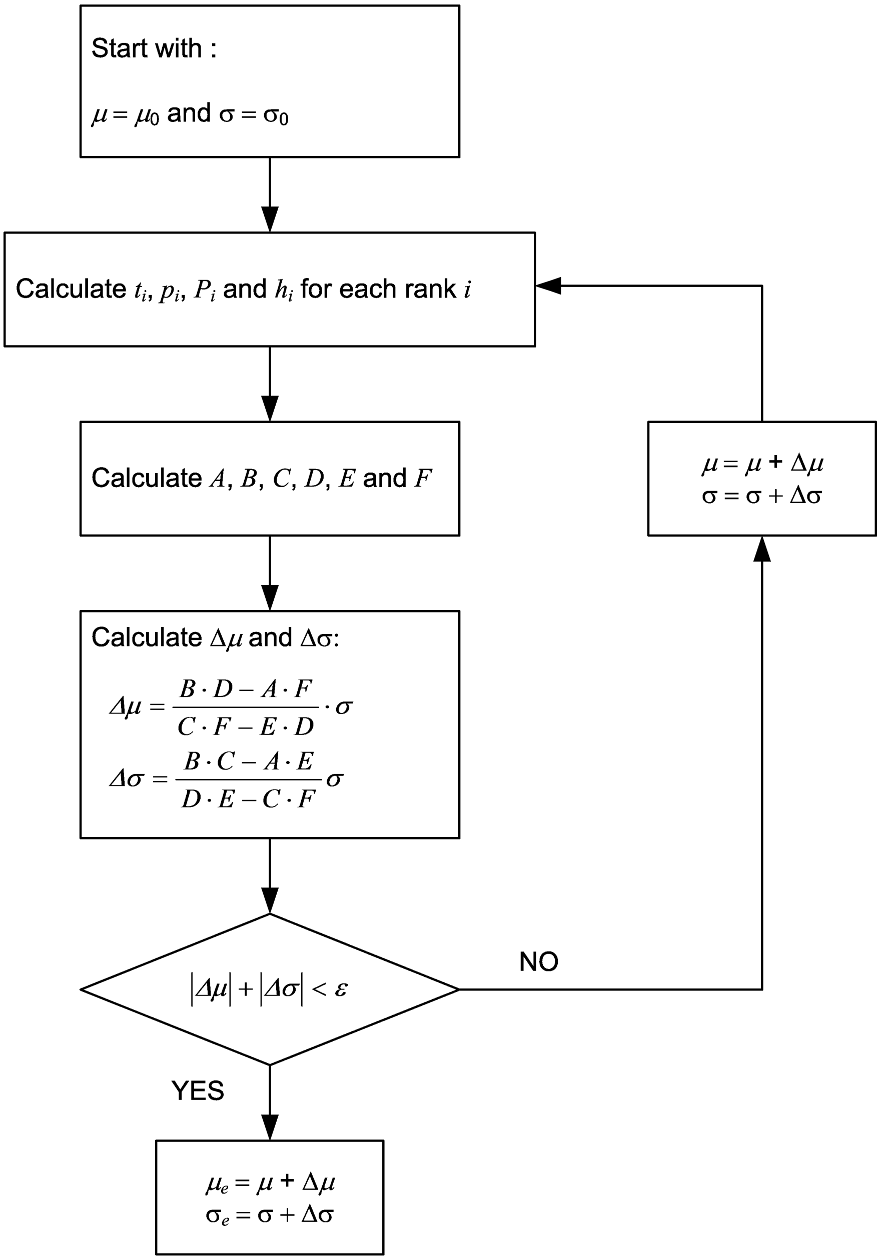


Figure B.2 — Iterative algorithm for better estimates of μ and σ

ε being a very small number, which is preferably chosen to obtain estimates of μ and σ with three decimals, e.g. = 5.10^{-4}.

Such an iterative algorithm can easily be solved by means of a spreadsheet (MS Excel or other similar application).

After carrying out this iterative procedure, a correction of standard deviation needs to be done. Computer simulations show that σ_e is always underestimated and a correction is applied according to Formula (B.3):

$$\sigma_{ec} = \frac{\sigma_e}{\beta} \quad \text{(B.3)}$$

where β depends on the tested sample size N and is given by the following Figure B.3.

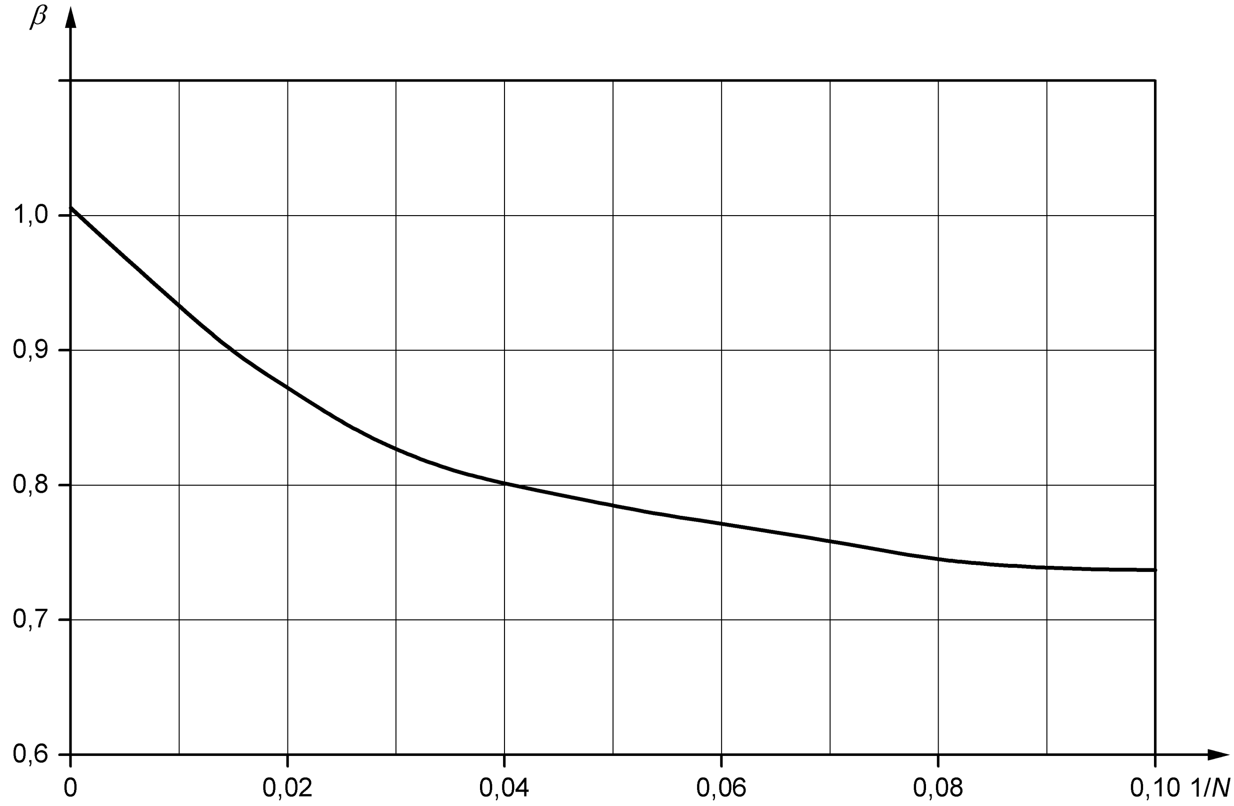


Figure B.3 — Correction of the estimated standard deviation

B.4 Values at 95 % confidence level

From these estimates μ_e and σ_e, the values of the "no-fire" stimulus S_{NF} and the 'all-fire' stimulus S_F such as the probability P of having respectively no-fires or fires at (1-α) confidence level can be calculated from Formulae (B.4) and (B.5):

$$S_{\mathrm{NF}} = \mu_e - k \cdot \sigma_{ec} - K \cdot \sqrt{Var(\mu_e) + k^2 \cdot Var(\sigma_e)} \tag{B.4}$$

$$S_{\mathrm{F}} = \mu_e + k \cdot \sigma_{ec} + K \cdot \sqrt{Var(\mu_e) + k^2 \cdot Var(\sigma_e)} \tag{B.5}$$

where

k is given by table of inverses of the law of normal distribution such as $\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{k} e^{\frac{-t^2}{2}} \cdot dt = P$;

K is given by table of inverses of the law of normal distribution such as $\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{K} e^{\frac{-t^2}{2}} \cdot dt = 1 - \frac{\alpha}{2}$;

$$Var(\mu_e) = 2{,}5 \cdot \frac{\sigma_{ec}^2}{N}$$

$$Var(\sigma_{ec}) = \frac{Var(\sigma_e)}{\beta^2}$$ with: $$Var(\sigma_e) = 3{,}2 \cdot \frac{\sigma_{ec}^2}{N}$$

For P = 99,9 % and $(1\text{-}\alpha)$ = 95 %, k and K have the following values:

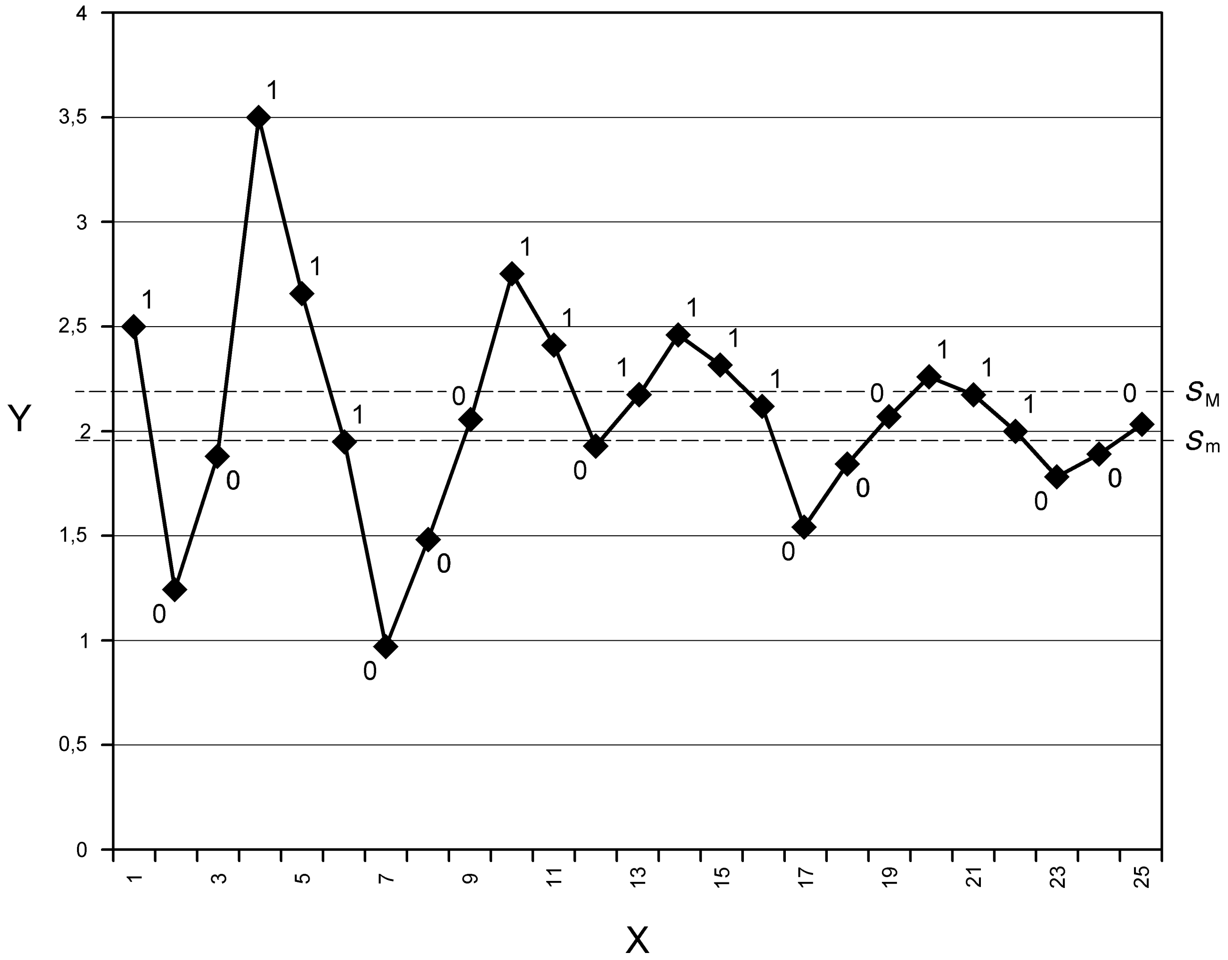
$k = 3{,}090$ and $K = 1{,}960$

B.5 Example

Figure B.4 hereafter gives a graphic plot of a sequence of 25 tests of electric igniters according to the dichotomic method. Table B.1 shows the corresponding results of this sequence of tests.

In the present example, S_{100} and S_0 had been given the respective values 5 A and 0 A.

Then S_1 = 2,5 A



Key

Y direct current (A)

X test number

Figure B.4 — Graphic plot

Table B.1 — Test results

i	S_i	R_i	S_k
1	2,500	1	
2	1,250	0	S_1 = 2,500
3	1,875	0	
4	3,438	1	S_3 = 1,875
5	2,657	1	S_2 = 1,250
6	1,954	1	
7	0,977	0	S_6 = 1,954
8	1,466	0	S_5 = 2,657
9	2,062	0	S_4 = 3,438
10	2,750	1	S_9 = 2,062
11	2,406	1	S_8 = 1,466
12	1,936	0	S_{11} = 2,406
13	2,171	0	S_{10} = 2,750
14	2,461	1	S_{13} = 2,171
15	2,316	1	S_{12} = 1,936
16	2,126	1	S_7 = 0,977
17	1,552	0	S_{16} = 2,126
18	1,839	0	S_{15} = 2,316
19	2,078	0	S_{14} = 2,461
20	2,270	1	S_{19} = 2,078
21	2,174	1	S_{18} = 1,839
22	2,007	1	S_{17} = 1,552
23	1,780	0	S_{22} = 2,007
24	1,894	0	S_{21} = 2,174
25	2,034	0	

From the above table, the following values can be extracted:

S_M = 2,171 A and S_m = 1,954 A

and n is equal to 5 (which means five test values of current between 2,171 A and 1,954 A).

First estimates of the mean μ_0 and standard deviation σ_0 can then be calculated:

μ_0 = (2,171 + 1,954)/2 = 2,063 A

σ_0 = 25.(2,171–1,954)/(8.(5+2)) = 0,097 A

and the iterative calculations illustrated by the second above flowchart gives after four iterations (see Table B.2) the final estimates of the mean μ_e and standard deviation σ_e:

μ_e = 2,085 A

$\sigma_e = 0{,}152$ A

For a sequence of 25 tests, the correction factor β of the standard deviation is equal to 0,80. Then the final estimate of the standard deviation is equal to:

$$\sigma_{ec} = \frac{0{,}152}{0{,}80} = 0{,}190 \text{ A}$$

and, at 95 % confidence level:

$$Var(\mu_e) = 2{,}5 \cdot \frac{0{,}190^2}{25} = 0{,}00361$$

$$Var(\sigma_e) = 3{,}2 \cdot \frac{0{,}190^2}{25} = 0{,}00462$$ and $$Var(\sigma_{ec}) = \frac{0{,}00462}{0{,}8^2} = 0{,}00722$$

$$S_{NF} = 2{,}085 - 3{,}090 \cdot 0{,}190 - 1{,}960 \cdot \sqrt{0{,}00361 + 3{,}090^2 \cdot 0{,}00722} = 0{,}97 \text{ A}$$

$$S_F = 2{,}085 + 3{,}090 \cdot 0{,}190 + 1{,}960 \cdot \sqrt{0{,}00361 + 3{,}090^2 \cdot 0{,}00722} = 3{,}20 \text{ A}$$

Table B.2 — Iterative calculation of μ_e and σ_e

Test results		
i	S_i	R_i
1	2,500	1
2	1,250	0
3	1,875	0
4	3,488	1
5	2,657	1
6	1,954	1
7	0,977	0
8	1,486	0
9	2,062	0
10	2,750	1
11	2,406	1
12	1,936	0
13	2,171	0
14	2,461	1
15	2,316	1
16	2,126	1
17	1,552	0
18	1,839	0
19	2,078	0
20	2,270	1
21	2,174	1
22	2,007	1
23	1,780	0
24	1,894	0
25	2,034	0

N = 25
S_M = 2,171
S_m = 1,954
n = 5
Mu$_0$ = 2,063
Sigma$_0$ = 0,097

First iteration			
t_i	p_i	P_i	h_i
4,516	0,00001	1,00000	-1,00000
-8,387	0,00000	0,00000	1,00000
-1,935	0,06130	0,02647	1,02718
14,715	0,00000	1,00000	-1,00000
6,137	0,00000	1,00000	-1,00000
-1,120	0,21307	0,13136	-7,61285
-11,205	0,00000	0,00000	1,00000
-5,951	0,00000	0,00000	1,00000
-0,005	0,39894	0,49794	1,99180
7,097	0,00000	1,00000	-1,00000
3,546	0,00074	0,99980	-1,00020
-1,306	0,17008	0,09581	1,10596
1,120	0,21307	0,86864	7,61285
4,114	0,00008	0,99998	-1,00002
2,617	0,01300	0,99556	-1,00446
0,655	0,32182	0,74392	-1,34423
-5,270	0,00000	0,00000	1,00000
-2,307	0,02787	0,01052	1,01064
0,160	0,39387	0,56356	2,29126
2,142	0,04024	0,98390	-1,01636
1,151	0,20571	0,87513	-1,14269
-0,573	0,33856	0,28336	-3,52914
-2,916	0,00568	0,00177	1,00178
-1,739	0,08789	0,04099	1,04274
-0,294	0,38205	0,38431	1,62418

A = 0,77685
B = 2,98828
C = -8,03662
D = 0,61569
E = -0,16116
F = -8,61028

Mu$_1$ = 2,074
Sigma$_1$ = 0,130

Delta Mu = 0,01192
Delta Sigma = 0,03340
Delta Mu + Delta Sigma = 0,04532

Second iteration			
t_i	p_i	P_i	h_i
3,267	0,00192	0,99946	-1,00054
-6,328	0,00000	0,00000	1,00000
-1,531	0,12361	0,06291	1,06713
10,851	0,00000	1,00000	-1,00000
4,472	0,00002	1,00000	-1,00000
-0,924	0,26023	0,17764	-5,62929
-8,424	0,00000	0,00000	1,00000
-4,517	0,00001	0,00000	1,00000
-0,095	0,39713	0,46201	1,85878
5,186	0,00000	1,00000	-1,00000
2,545	0,01564	0,99454	-1,00549
-1,063	0,22685	0,14399	1,16821
0,741	0,30309	0,77076	4,36218
2,967	0,00488	0,99850	-1,00150
1,854	0,07148	0,96816	-1,03289
0,396	0,36887	0,65392	-1,52925
-4,010	0,00013	0,00003	1,00003
-1,807	0,07794	0,03537	1,03667
0,027	0,39879	0,51095	2,04479
1,501	0,12927	0,93336	-1,07140
0,764	0,29788	0,77768	-1,28588
-0,518	0,34894	0,30239	-3,30703
-2,260	0,03103	0,01191	1,01205
-1,385	0,15290	0,08303	1,09055
-0,310	0,38019	0,37817	1,60815

A = 0,36229
B = 0,83994
C = -7,05974
D = 0,94541
E = 0,58312
F = -6,27915

Mu$_2$ = 2,084
Sigma$_2$ = 0,149

Delta Mu = 0,00913
Delta Sigma = 0,01827
Delta Mu + Delta Sigma = 0,02741

Third iteration			
t_i	p_i	P_i	h_i
2,803	0,00784	0,99747	-1,00253
-5,611	0,00000	0,00000	1,00000
-1,404	0,14890	0,08016	1,08715
9,455	0,00000	1,00000	-1,00000
3,860	0,00023	0,99994	-1,00006
-0,872	0,27273	0,19156	-5,22020
-7,449	0,00000	0,00000	1,00000
-4,023	0,00012	0,00003	1,00003
-0,145	0,39476	0,44231	1,79312
4,486	0,00002	1,00000	-1,00000
2,171	0,03782	0,98502	-1,01521
-0,993	0,24359	0,16028	1,19087
0,589	0,33548	0,72196	3,59656
2,541	0,01581	0,99447	-1,00556
1,565	0,11728	0,94118	-1,06249
0,286	0,38299	0,61246	-1,63277
-3,578	0,00066	0,00017	1,00017
-1,646	0,10289	0,04985	1,05247
-0,037	0,39866	0,48508	1,94206
1,255	0,18148	0,89528	-1,11697
0,609	0,33145	0,72869	-1,37232
-0,515	0,34933	0,30315	-3,29869
-2,043	0,04945	0,02050	1,02093
-1,276	0,17674	0,10097	1,11231
-0,334	0,37735	0,36934	1,58564

A = 0,04913
B = 0,11222
C = -7,03963
D = 1,04494
E = 0,99582
F = -5,62899

Mu$_3$ = 2,085
Sigma$_3$ = 0,152

Delta Mu = 0,00152
Delta Sigma = 0,00323
Delta Mu + Delta Sigma = 0,00475

Fourth iteration			
t_i	p_i	P_i	h_i
2,734	0,00951	0,99687	-1,00314
-5,502	0,00000	0,00000	1,00000
-1,384	0,15308	0,08317	1,09071
9,243	0,00000	1,00000	-1,00000
3,768	0,00033	0,99992	-1,00008
-0,864	0,27477	0,19391	-5,15704
-7,301	0,00000	0,00000	1,00000
-3,947	0,00017	0,00004	1,00004
-0,152	0,39436	0,43959	1,78441
4,381	0,00003	0,99999	-1,00001
2,114	0,04266	0,98276	-1,01754
-0,982	0,24628	0,16301	1,19475
0,566	0,33987	0,71435	3,50083
2,477	0,01857	0,99337	-1,00667
1,521	0,12538	0,93593	-1,06845
0,270	0,38470	0,60629	-1,64938
-3,512	0,00084	0,00022	1,00022
-1,621	0,10719	0,05248	1,05539
-0,047	0,39851	0,48142	1,92834
1,218	0,18991	0,88847	-1,12553
0,586	0,33602	0,72103	-1,38690
-0,514	0,34951	0,30349	-3,29498
-2,010	0,05292	0,02222	1,02272
-1,259	0,18062	0,10403	1,11611
-0,336	0,37698	0,36825	1,58291

A = 0,00091
B = 0,00251
C = -7,04724
D = 1,05353
E = 1,05262
F = -5,53445

Mu$_4$ = 2,085
Sigma$_4$ = 0,152

Delta Mu = 0,00003
Delta Sigma = 0,00007
Delta Mu + Delta Sigma = 0,00011

Annex C
(informative)

Mechanical Conditioning (Shock Apparatus)

Illustrated in the following Figures C.1, C.2 and C.3 comprising the following components:

— **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;

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

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

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

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

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

— **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 elastomer spring;

— **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;

— **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;

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

— **a steel base plate**, thickness 12 mm;

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

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

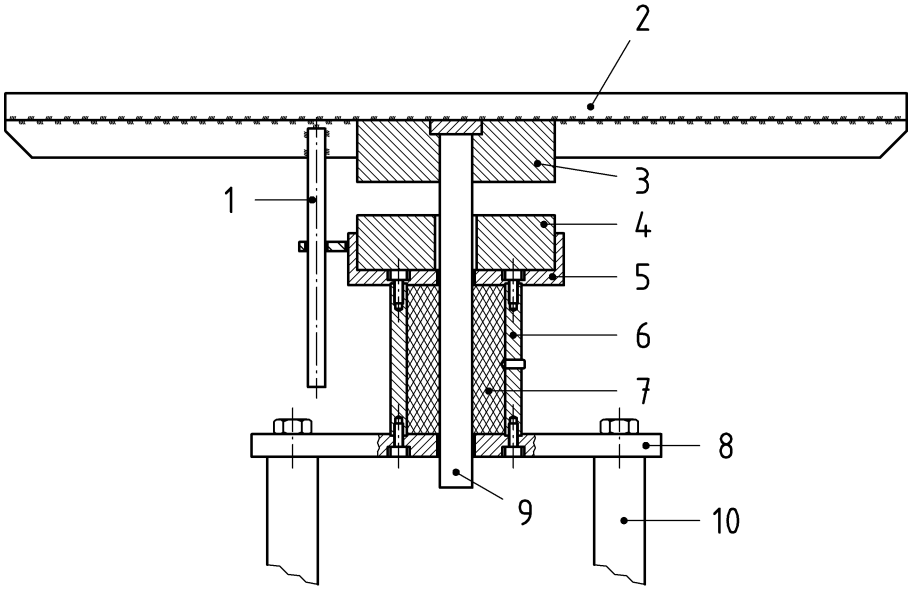
— **an attachment to the shaft**, allowing adjustment to the overall length, fitted with a cam wheel, outside diameter 30,0 mm, with a contact surface 8,0 mm wide;

— **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 (see Figure C.1); alternatively differently shaped cams with the same drop height may be used (see Figure C.2);

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

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

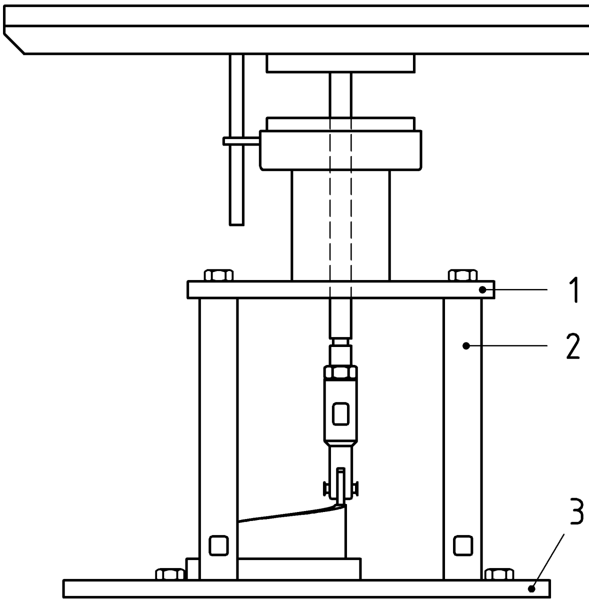
— **cellular rubber sheet**, 100 mm thick. The material used should have an apparent density when determined in accordance with ISO 845, of 35 kg/m³ and an indention hardness check, when determined in accordance with EN ISO 2439 of 215 N.



Key

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

Figure C.1 — Detail of top section of mechanical shock apparatus



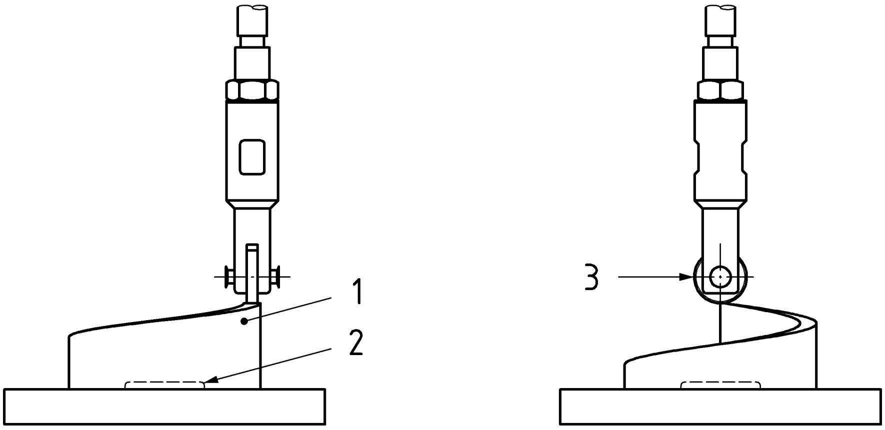
Key

1 mounting plate

2 supporting pillar

3 base plate

Figure C.2 — General assembly of mechanical shock apparatus



Key

1 cam

2 collar

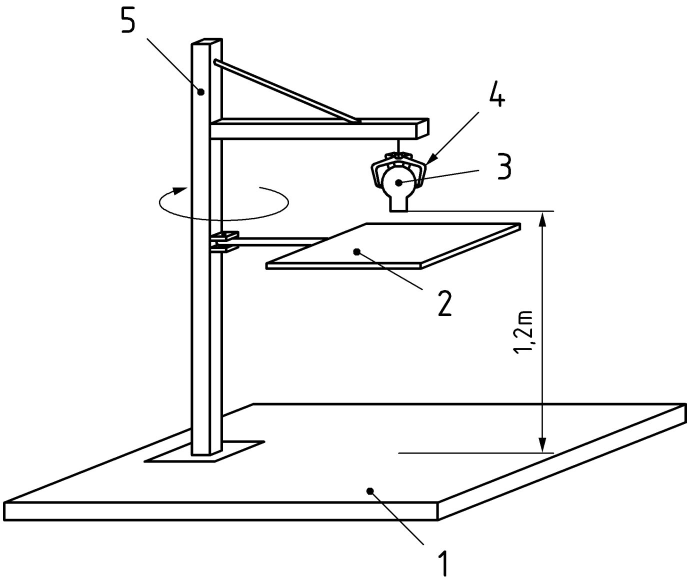
3 cam wheel

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

Annex D
(informative)

Mechanical Impact Test (Drop Test)

An example of typical equipment which may be used is illustrated by the following picture (other equivalent designs may be used) in Figure D.1.



Key

1 metal plate

2 movable safety plate

3 article to be tested

4 release device

5 metallic frame

Figure D.1 — Overview of impact test apparatus

The metal plate should be placed on a hard soil, e.g. a concrete slab, and its thickness should be higher than 10 mm of steel.

The release device should neither deliver an initial linear and/or rotation velocity to the article nor modify its fall from the vertical.

A video recording is usefully to check whether the fall of the article is correct and in order to get full knowledge of the behaviour of the article during and after its contact with the metal plate.

Annex E
(informative)

Adjustment of the ESD generator

E.1 Apparatus

The apparatus is shown schematically in Figure E.1 and comprises the following:

— ESD generator (see 6.2.16);

— cables if required, to connect the ESD generator and the leading wires or connector of the igniters to be tested;

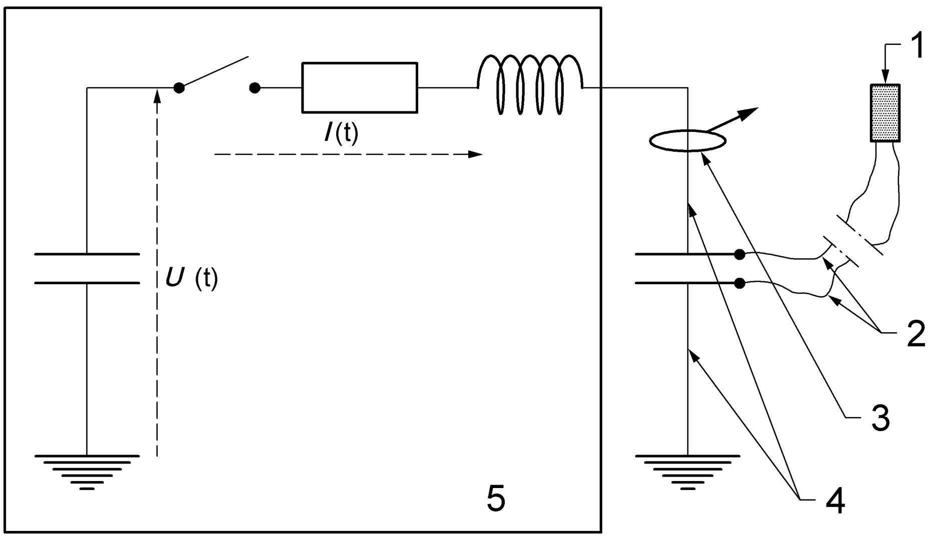
— where appropriate, pair of leading wires, cut from one igniter;

— a resistor with a DC resistance equivalent to that of the bridgewire of the igniter;

— inductively-coupled current probe, with a bandwidth of at least 10 MHz;

— oscilloscope, capable of integrating and of calculating square functions, with a bandwidth of at least 20 MHz.

The ESD generator, leading wires and cables, resistor and all measuring equipment should be placed in the same positions as those used for the testing of the igniters under test.



Key

1 DC equivalent resistance

2 leading wires

3 current probe to oscilloscope

4 cable to igniter

5 ESD generator

Figure E.1 — Apparatus for adjusting the ESD generator

E.2 Procedure

- Assemble the ESD generator and the apparatus as shown in Figure E.1. Ensure that the leading wires (if any), cables (if any) and resistor are kept at a distance of at least 100 mm from the ground and from any conductive objects that might cause leakage paths to earth;
- the current probe should be placed on one of the leading wires or on a connecting cable;
- select an initial applied voltage of twice the mean flash-over voltage of the igniter to be tested;
- apply the discharge and record the current versus time;
- calculate the ESD impulse – W_{ESD} – from the formula:

$$W_{ESD} = \int_{t_1}^{t_2} i^2 \cdot dt$$

where

i is the current in amperes (A);

t_1 is the time at which the current begins to flow in seconds (s);

t_2 is the time in seconds (s) at which the current has decayed to the extent that the oscillations no longer exceed the no-fire current of the igniter determined according to 5.9.

Adjust the voltage to repeat the procedure described above until the calculated impulse is equal to the required value. If the voltage necessary to achieve the required impulse is less than the flash-over voltage of the igniter, change the capacitance to the nearest available lower value.

Annex F
(informative)

Specification of grinding steel for wire abrasion test

F.1 Type

Grinding steel manufactured by using a chemical etching process.

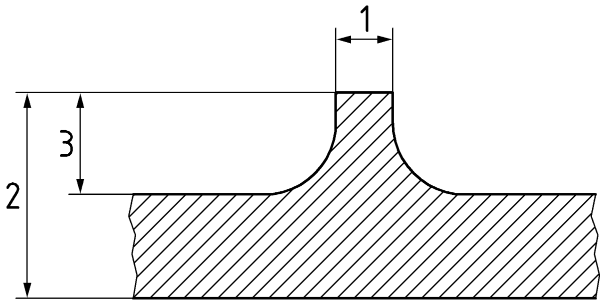
F.2 Material

Martensitic stainless steel

F.3 Dimensions

The cross section dimensions of the grinding steel should comply with Figure F.1. The values indicated refer to the mean values for the set of abrasive strips required for testing i.e. the mean value for three strips, each with a size of 10 mm × 145 mm.

NOTE The conformity of the strips against the specified tolerances can be verified by selecting an appropriate number of measurement points on a representative area of the grinding steel.



Key

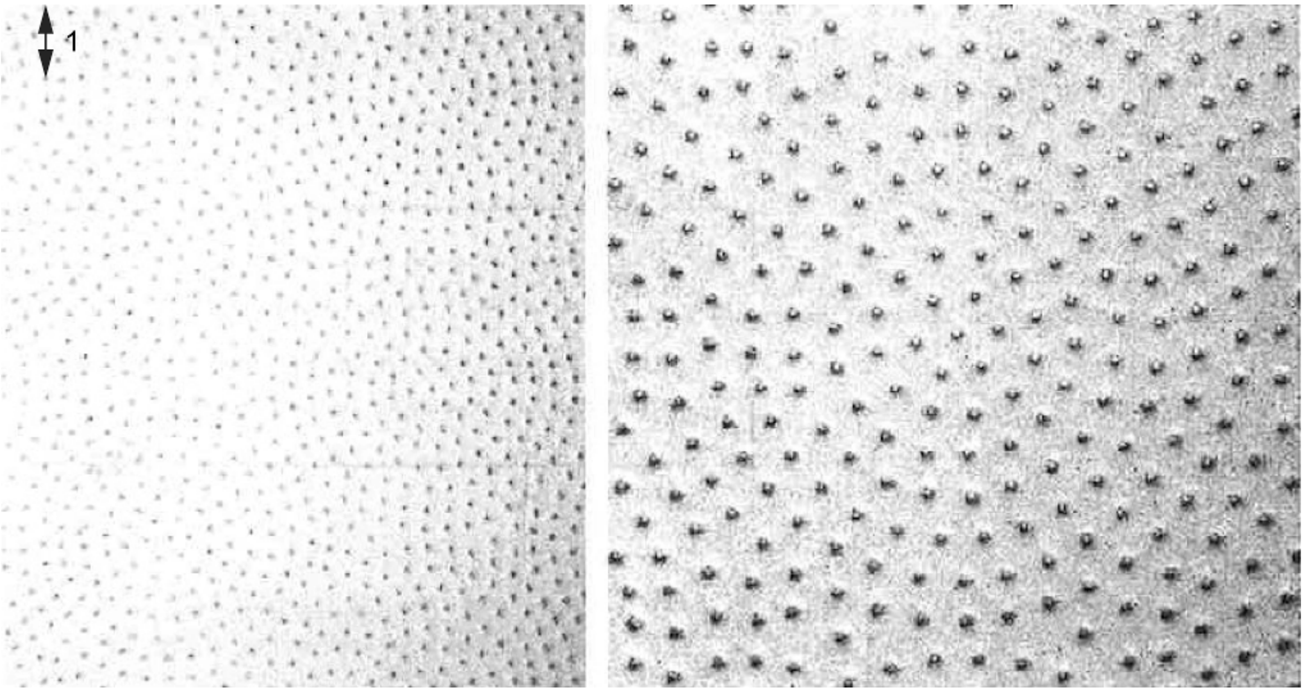
1 Mean value, diameter 0,06 mm to 0,13 mm

2 Mean value, thickness 0,27 mm to 0,35 mm

3 Mean value, depth 0,14 mm to 0,20 mm

Figure F.1 — Cross-section of grinding steel

The cutting point pattern of the grinding steel should comply with Figure F.2 a) or Figure F.2 b). The cutting points of the grinding steel are distributed in circular sections orientated as in Figure F.2.a). Each section contains seven circular rows around a centre cutting point. The cutting points are placed on these circular rows. The circular diameters and number of cutting points are given in Table F.1.



Key

1 length direction of abrasive strip

a) Cutting point pattern for circles related to the length direction of strips **b) Cutting point pattern for one circle**

Figure F.2 — Cutting point pattern

Abrasive strips should be cut to size (see 6.3.12.2.1) from the grinding steel. The strips should be cut in the direction indicated in Figure F.2 a) related to the cutting point pattern. The centres of the circles should coincide with the centre of the strip indicated in Figure F.2 b).

Table F.1 — Circular diameters and number of cutting points

Row number	Diameter (±5 %) (mm)	Number of cutting points
1	1,6	6
2	3,1	12
3	4,7	18
4	6,2	24
5	7,8	30
6	9,3	35
7	10,9	41

F.4Availability of abrasive strips (informative)

Though the commercial availability of the grinding steel required for the abrasive strips, specified in this Annex F, has been checked, it has been considered convenient to provide a contact point for obtaining such material:

SP – Swedish NationalTesting and Research lnstitute

Department of Electronics

Box 857

5-501 15 Borås

Sweden

Tel.: +46 33 16 50 00

Fax: +46 33 13 55 02

E-mail: info@sp.se

This information is given for the convenience of the user of this European Standard and does not constitute an endorsement by CEN of this provider.

Annex G
(normative)

Determination of the duration of accelerated ageing test to demonstrate the correct functioning at the “use by ” date

Where thermal conditioning according to 6.3.9.2.2 or 6.3.9.2.3 leads to successful functioning test, articles which are intended for use after prolonged storage at a specified temperature T_{LS} ± 5,0 °C or which are kept for more than two days at or above a maximum use temperature T_{UM} shall be subject to additional thermal conditioning as follows:

Store the articles for N days at a temperature of 75 °C ± 2,5 °C or 1,25 times the maximum use temperature ± 2,5°C in the climatic chamber and then for at least one day at 20 °C ± 5,0 °C before testing according to 5.10.

When a manufacturer has designed or described an article as being suitable for use in humid conditions, the climatic chamber is maintained at 95 % relative humidity (RH).

N (in days) is calculated by use of the following formula:

$$N = 365{,}25 \cdot H_{LS} \cdot K_1(T_{LS}, T_{UM}) + 30 \cdot H_{LU} \cdot K_2(T_{UM})$$

where:

H_{LS} = specified life span in storage (in years)

H_{LU} = specified life span at the maximum use temperature (in months)

T_{LS} = long storage temperature (in °C)

T_{UM} = maximum use temperature (in °C)

and $K_1(T_{LS}, T_{UM})$, $K_2(T_{UM})$ are coefficients that can be calculated from the following Figures G1 and G2.

NOTE In the case where the above formula gives values greater than 90 days, the temperature of the ageing test would better be increased as much as it is affordable by the design and pyrotechnic compositions of the article.

EXAMPLE 1:

For T_{LS} = 20°C and T_{UM} = 50°C, the thermal conditioning test is performed à 75°C and Figures G1 and G2 give:

K_1 = 0,007 and K_2 = 0,083.

Then, to demonstrate a life span in storage of 9 years and a life span at the maximum use temperature of 12 months, the thermal conditioning test shall be performed during:

N = 9 × 365,25 × 0,007 + 12 × 30 × 0,083 = 23,01 + 29,88 = 53 days

EXAMPLE 2:

For T_{LS} = 20°C and T_{UM} = 90°C, the thermal conditioning test is performed à 112,5°C and Figures G1 and G2 give:

K_1 = 0,00017 and K_2 = 0,107.

Then, to demonstrate a life span in storage of 9 years and a life span at the maximum use temperature of 12 months, the thermal conditioning test shall be performed during:

N = 9 × 365,25 × 0,00017 + 12 × 30 × 0,107 = 0,55 + 38,52 = 39 days

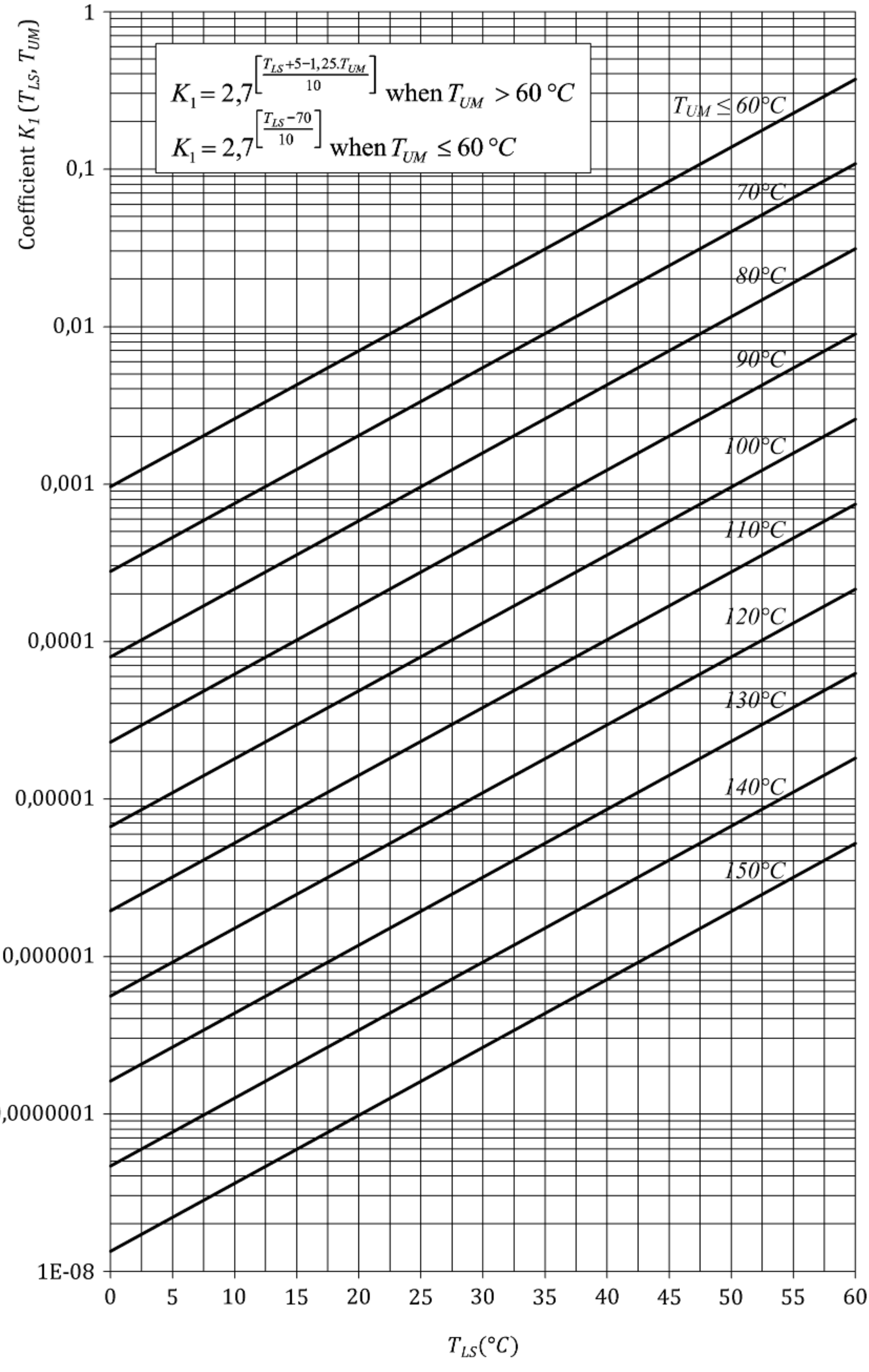


Figure G.1 — Coefficient K_1

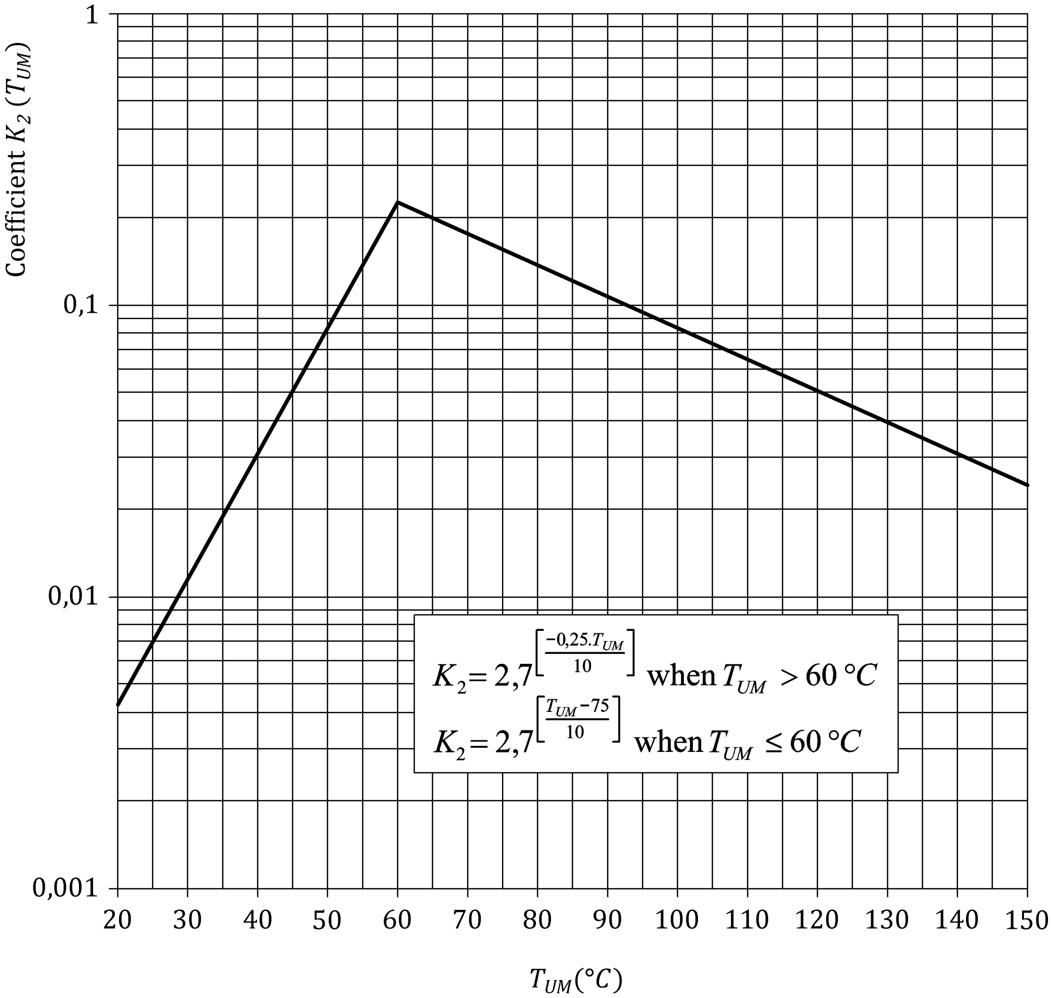


Figure G.2 — Coefficient K_2

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2007/23/EC on the placing on the market of pyrotechnic articles

This European Standard has been prepared under a mandate given to CEN by the European Union and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 2007/23/EC on the placing on the market of pyrotechnic articles.

Once this European Standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this European Standard as given in Table ZA.1 confers, within the limits of the scope of this European Standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and Directive 2007/23/EC

Essential Requirements (ESR) of Directive 2007/23/EC	Clause(s)/sub-clause(s) of this EN	Qualifying remarks/Notes
(1)	5.3, 5.9, 5.10, 6.3.4 to 6.3.8, 6.3.16	
(2)	5.1, 6.3.2, 7.3	
(3) first paragraph	5.3, 6.3.4 to 6.3.8	
(3) second paragraph	5.3, 5.4, 5.6, 5.7, 5.8, 5.10, 6.3.4 to 6.3.17, 6.3.21	
3 (a)	5.1, 6.3.1, 6.3.2	
3 (b)	5.4, 5.7, 5.8, 6.3.4, 6.3.9, 6.3.12 to 6.3.15, 6.3.21	
3 (c)	5.6, 6.3.10, 6.3.11	
3 (d)	5.1, 5.4, 6.3.2, 6.3.9	
3 (e)	5.7, 6.3.9, 6.3.21	
3 (f)	5.4, 6.3.4, 6.3.9	
3 (g)	5.5, 6.3.10, 6.3.11	
3 (h)	7	
3 (i)	5.4, 5.5, 5.6, 5.8, 6.3.9 to 6.3.15, 6.3.17, 6.3.21	
3 (j)	7.3	
3 last sentences	5.6, 6.3.10, 6.3.11	
4	See Annex ZB	
B1	5.1, 5.5, 5.6, 5.8, 6.3.2, 6.3.10 to 6.3.15, 6.3.17, 6.3.18, 6.3.19, 6.3.22	
B2	7.2.10	
B3	5.3, 6.3.4 to 6.3.8	
B4	5.4, 6.3.9, 7.2.7	

C1	5.3, 5.9, 5.10, 6.3.4 to 6.3.9, 6.3.16, 6.3.20.3	
C2	5.5, 5.12, 5.13, 6.3.19, 6.3.20	
C3	5.5	
C4	5.5, 5.6, 5.8, 6.3.10, 6.3.14, 6.3.15, 6.3.17	
C5	7.3	
C6	5.2, 5.9, 5.10, 5.11, 6.3.3, 6.3.4, 6.3.17, 6.3.18, 7.3	
C7	5.4, 5.8, 6.3.9, 6.3.12, 6.3.13	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this European Standard.

Annex ZB
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2013/29/EU on the placing on the market of pyrotechnic articles

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the Directive 2007/23/EC on the placing on the market of pyrotechnic articles, which is repealed by Directive 2013/29/EU.

Once EN 16265 is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of EN 16265 as given in Table ZB.1 confers, within the limits of the scope of EN 16265, a presumption of conformity with the requirements of that Directive and associated EFTA regulations.

Table ZB.1 — Correspondence between EN 16265 and Directive 2013/29/EU on the placing on the market of pyrotechnic articles

Essential Requirements (ESR) of Directive 2013/29/EU	Clause(s)/sub-clause(s) of this EN	Qualifying remarks/Notes
(4) (a)	1, 5.1.3, 6.3.22	
(4) (b)	1, 5.1.3, 6.3.22	
(4) (c)	1, 5.1.3, 6.3.22	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this European Standard, in particular Directive 2007/23/EC. See Annex ZA for details.

Bibliography

[1] *Directive 2007/23/EC of the European Parliament and of the Council of 23 May 2007 on the placing on the market of pyrotechnic articles*, OJ L 154, 14.6.2007, p 1-21, available from http://eur-lex.europa.eu/LexUriServ.do?uri=OJ:L:2007:154:0001:0021:en:PDF

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[7] EN 16263-1, *Pyrotechnic articles — Other pyrotechnic articles — Part 1: Terminology*

[8] EN 16263-2, *Pyrotechnic articles — Other pyrotechnic articles — Part 2: Requirements*

[9] EN 16263-3, *Pyrotechnic articles — Other pyrotechnic articles — Part 3: Categories and types*

[10] EN 16263-4, *Pyrotechnic articles — Other pyrotechnic articles — Part 4: Test methods*

[11] EN 16263-5, *Pyrotechnic articles — Other pyrotechnic articles — Part 5: Minimum labelling requirements and instructions for use*

[12] EN 13631-3:2004, *Explosives for civil uses — High explosives — Part 3: Determination of sensitiveness to friction of explosives*

[13] EN 13631-4:2002, *Explosives for civil uses — High explosives — Part 4: Determination of sensitiveness to impact of explosives*

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

[15] EN ISO 845, *Cellular plastics and rubbers — Determination of apparent density (ISO 845)*

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

[17] *Directive 2013/29/EU of the European Parliament and of the Council of 12 June 2013 on the harmonization of the laws of the Member States relating to the making available on the market of pyrotechnic articles (recast)*, OJL 178; 28.6.2013, available from http://eur-lex.europa.eu/LexUriServ.do?uri=OJ:L:2013:178:0027:0065:en:PDF

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