Explosives for civil uses — Detonators and relays —

Part 15: Determination of equivalent initiating capability

The European Standard EN 13763-15:2004 has the status of a British Standard

ICS 71.100.30

British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee CII/61, Explosives for civil uses, which has the responsibility to:

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 19 and a back cover.

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Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 44602 6

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13763-15

October 2004

ICS 71.100.30

English version

Explosives for civil uses - Detonators and relays - Part 15: Determination of equivalent initiating capability

Explosifs à usage civil - Détonateurs et relais - Partie 15: Détermination de la capacité d'amorçage équivalente

Explosivstoffe für zivile Zwecke - Zünder und Verzögerungselemente - Teil 15: Bestimmung der Zündstärke

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Ref. No. EN 13763-15:2004: E

Contents

Foreword

This document (EN 13763:2004) has been prepared by Technical Committee CEN /TC 321, "Explosives for civil uses", the secretariat of which is held by AENOR.

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of an identical text or by endorsement, at the latest by April 2005, and conflicting national standards shall be withdrawn at the latest by April 2005.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 93/15.

For relationship with EU Directives, see informative Annex ZA, which is an integral part of this standard.

This document is one of a series of standards on *Explosives for civil uses – Detonators and relays*. Other parts of this series are:

EN 13763-1	Part 1: Requirements
EN 13763-2	Part 2: Determination of thermal stability
EN 13763-3	Part 3: Determination of sensitiveness to impact
EN 13763-4	Part 4: Determination of resistance to abrasion of leading wires and shock tubes
EN 13763-5	Part 5: Determination of resistance to cutting damage of leading wires and shock tubes
EN 13763-6	Part 6: Determination of resistance to cracking in low temperatures of leading wires
EN 13763-7	Part 7: Determination of the mechanical strength of leading wires, shock tubes, connections, crimps and closures
EN 13763-8	Part 8: Determination of resistance to vibration of plain detonators
EN 13763-9	Part 9: Determination of resistance to bending of detonators
EN 13763-11	Part 11: Determination of resistance to damage by dropping of detonators and relays
EN 13763-12	Part 12: Determination of resistance to hydrostatic pressure
EN 13763-13	Part 13: Determination of resistance of electric detonator to electrostatic discharge
EN 13763-16	Part 16: Determination of delay accuracy
EN 13763-17	Part 17: Determination of no-fire current of electric detonators
EN 13763-18	Part 18: Determination of series firing current of electric detonators
EN 13763-19	Part 19: Determination of firing impulse of electric detonators
EN 13763-20	Part 20: Determination of total electrical resistance of electric detonators
EN 13763-21	Part 21: Determination of flash-over voltage of electric detonators
EN 13763-22	Part 22: Determination of capacitance, insulation resistance and insulation breakdown of leading wires

EN 13763-23	Part 23: Determination of the shock-wave velocity of shock tubes
EN 13763-24	Part 24: Determination of the electrical non-conductivity of shock tubes
EN 13763-25	Part 25: Determination of transfer capability of surface connectors, relays and coupling accessories
EN 13763-26	Part 26: Definitions, methods and requirements for devices and accessories for reliable and safe function of detonators and relays
CEN/TS 13763-27	Part 27: Definitions, methods and requirements for electronic initiation system

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Introduction

General

When fired, the explosive charge of detonators must provide a pulse of sufficient energy to initiate the explosive or a detonating cord/shock tube, with which they are intended to be used.

In the test procedure described in this document, the output performance of a test piece is compared with a reference having known characteristics and mass of charge. This document describes two tests: an underwater initiating capability test and a functioning test at low and high temperatures.

Underwater initiating capability

This test is based on the principle that the detonation of an explosive charge under water generates a spherical shock-wave and a volume of gas, which expands and then collapses as the bubble rises through the water. The shock-wave and the volume of gas bear a finite relationship to the energy released. Thus, by measuring:

- the shock-wave pressure; and
- the time interval between the shock-wave pressure peak and the first collapse of the gas bubble,

and calculating the parameters proportional to:

- equivalent shock energy; and
- equivalent bubble energy,

the energy output of the test detonators can be compared with the energy output of the reference detonator to which the manufacturer claims equivalence.

Functioning test at high and low temperatures

This test checks that the energy output of the detonators does not vary when they are fired at high and low temperatures, by firing detonators in contact with aluminium witness plates at ambient, high and low temperatures and comparing the depths of indentations made in the plates.

1 Scope

This document specifies a method of determining the equivalent initiating capability of detonators.

This document also specifies a functioning test (after storage) at high and low temperatures.

This document is not applicable to surface connectors or detonating cord relays.

2 Normative references

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

EN 573-3, *Aluminium and aluminium alloys – Chemical composition and form of wrought products - Part 3: Chemical composition*

EN 13857-1:2003, *Explosives for civil uses – Part 1: Terminology.*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:1999).*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13857-1:2003 apply.

4 Test pieces

4.1 Underwater initiating capability test

Select 20 detonators of each specific type, having the same construction and shell material and having the same design, quantity and type of primary and secondary charge.

4.2 Functioning test at high and low temperatures

Select 50 detonators from each specific type, having the same construction and shell material and having the same design, quantity and type of primary and secondary charge.

5 Apparatus

5.1 Underwater initiating capability test

5.1.1 Blasting tank (Water tank or outdoor facility), with a volume of at least 500 l, and constructed in such a way that shock-wave reflections from the walls are avoided, for example, in the case of a small tank (as shown in Figure 1), by lining the walls with plastics foam.

5.1.2 Positioning system, for the pressure sensor and detonator. The distance between the centre of the sensor and the detonator shall be (400 ± 5) mm. The bottom of the detonator and sensor shall be placed (400 ± 5) mm below the water surface. The distance between any wall and the detonator shall be at least 200 mm.

5.1.3 Pressure sensor, with a rise time < 2 µs.

5.1.4 Amplifier, with suitable gain and facility to connect the sensors and the oscilloscope.

5.1.5 **Storage oscilloscope**, with minimum 10 MHz sampling frequency.

5.1.6 **Computer**, with software for calculation of results.

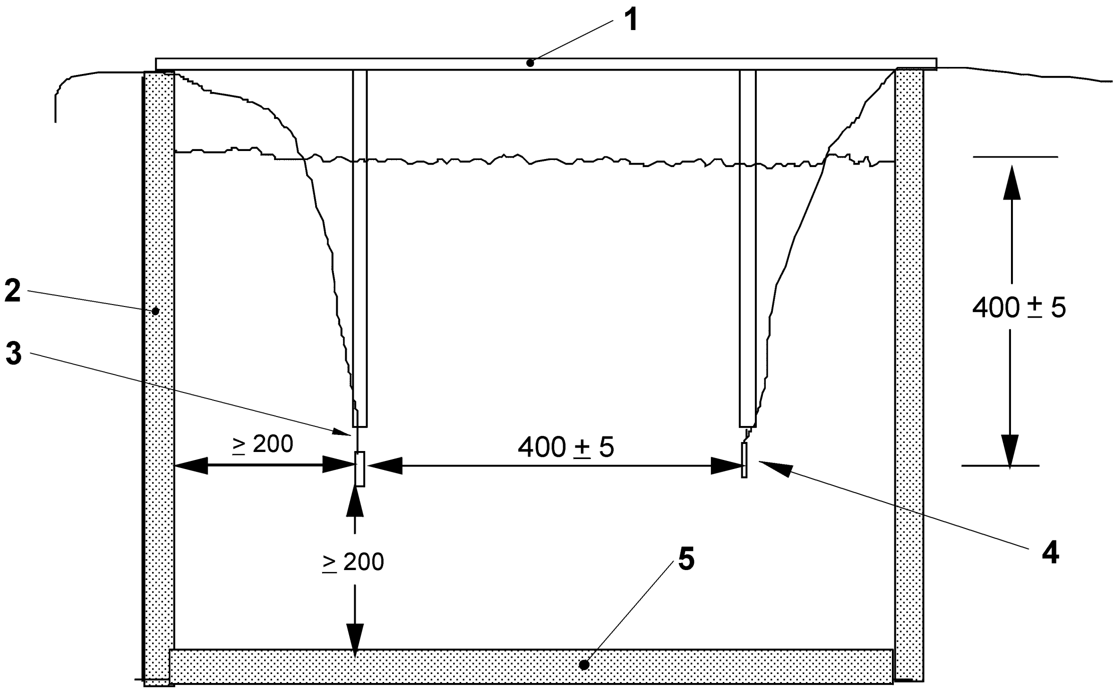
5.1.7 **Firing device**, for initiating the submerged detonators.

5.1.8 **Thermometer**, to measure the water temperature.

5.1.9 **Barometer**, to measure the atmospheric pressure.

5.1.10 **Reference detonators**; ten reference detonators of strength equivalent to that claimed by the manufacturer for the detonators to be tested (see 6.1.2.).

Dimensions in millimetres



Key

1 Positioning arrangement

2 Water tank

3 Detonator

4 Pressure sensor

5 Non-reflecting, energy-absorbing material

Figure 1 - Example of water tank with positioning system for sensor and detonator

5.2. Functioning test at high and low temperatures

5.2.1 Arrangement for firing detonators against witness plates, see examples in Figure 2 and Figure 3.

5.2.2 Heating cabinet, capable of maintaining a temperature 10 ºC higher than the highest safe operating temperature claimed by the manufacturer.

5.2.3 Freezing chamber, capable of maintaining a temperature at least 10 ºC lower than the lowest safe operating temperature claimed by the manufacturer.

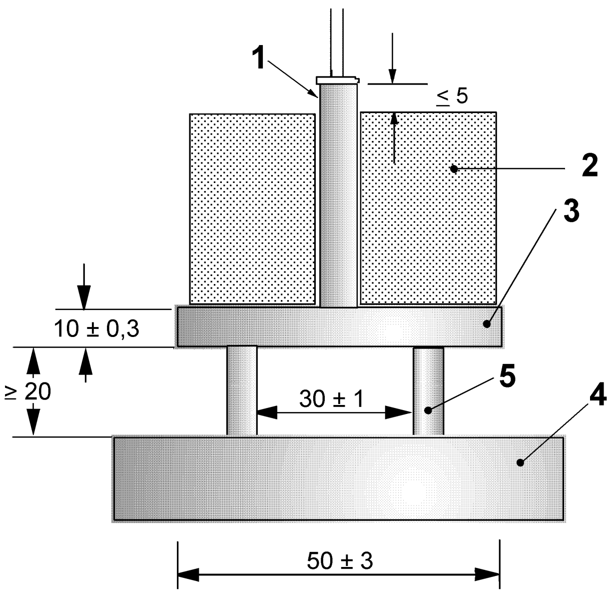
5.2.4 Witness plates, size (50 ± 3) mm x (50 ± 3) mm with a thickness of (10 ± 0,3) mm, made from aluminium designated EN AW-6082 in accordance with EN 573-3.

NOTE If a hole is obtained in the witness plate, the thickness of the plate may be increased.

5.2.5 Depth indicator gauge, with a pin point diameter of 0,60 mm and measuring accuracy ± 0,01 mm.

5.2.6 Insulating foam, of expanded polystyrene foam or similar material, with an outside diameter of at least 50 mm and a hole through the centre with a diameter not more than 1 mm greater than that of the detonator. The height of the foam shall be such that, when the detonator is inserted, not more than 5 mm of detonator shell (at the closure end) remains exposed.

Dimensions in millimetres



Key

1 Detonator

2 Expanded PS foam glued or taped to the witness plate

3 Witness plate

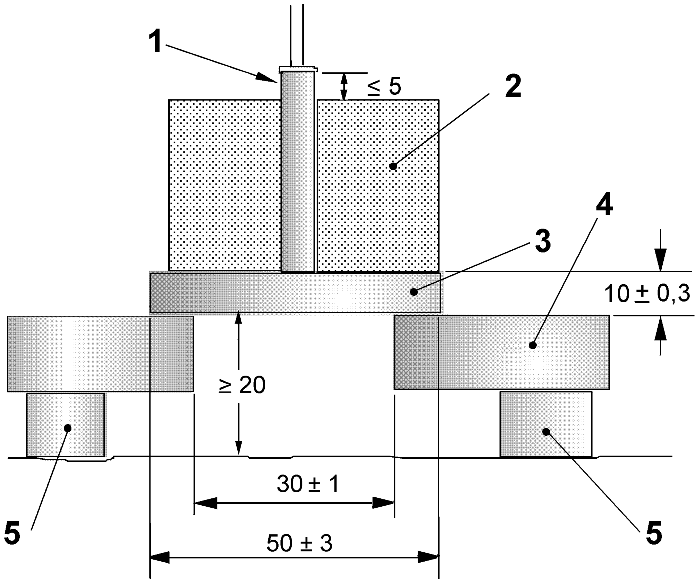
4 Steel plate

5 Section of steel tube

NOTE The witness plate is supported by a piece of steel tube, again supported by a thick steel plate.

Figure 2 - Example of arrangement for firing detonators against witness plates.

Dimensions in millimetres



Key

1 Detonator

2 Expanded PS foam glued or taped to the witness plate

3 Witness plate

4 Steel plate

5 Supports for the steel plate

NOTE The aluminium plate is placed directly on a thick steel plate with a hole in the centre so that there is free space underneath the area where an indentation from the detonation is expected.

Figure 3 - Example of an alternative arrangement for firing detonators against witness plates.

6 Procedure

6.1 Underwater initiating capability test

6.1.1 General

The water temperature shall not vary by more than ± 2 ºC, and the atmospheric pressure shall not vary by more than ± 5 kPa during the test. The amount of water in the tank and the type of sensor shall not vary during the test.

6.1.2 Firing of reference detonators

Fire 10 reference detonators (see 5.1.10), which the manufacturer claims to correspond to the strength of the detonators under testing. Fire five reference detonators before the test series and five after the completion of the test series.

Fix each detonator vertically at (400 ± 5) mm from the pressure sensor and at least 200 mm from any wall of the tank. Fire the detonators with the manufacturer's specified series firing current (for electric detonators) or with a suitable initiator (for shock tubes). Record the shock-wave pressure and the time interval between the shock-wave pressure peak and the first collapse of the gas bubble.

6.1.3 Firing of test detonators

Fire 20 detonators. Fix each detonator vertically at (400 ± 5) mm from the pressure sensor and at least 200 mm from the wall of the tank. Fire the detonators with the series firing current recommended by the manufacturer (for electric detonators) or with a suitable initiator (for shock tubes). Record the shock-wave pressure and the time interval between the shock-wave pressure peak and the first collapse of the gas bubble.

6.1.4 Calculation of results

6.1.4.1 Equivalent shock energy

By exploiting the output voltage from the pressure sensor, the computer and software calculates the integral under the squared pressure/time curve, from which the equivalent shock energy E_s in Pa^{2}s can be derived, using the general equation:

$$E_s = \int_{t=0}^{t=\theta} (P^2)\, dt \qquad (1)$$

where

P is the measured pressure, in pascals

θ is the time, in seconds, at which the sensor output has decreased to Pmax/e, where Pmax is the maximum measured pressure and e is the base of natural logarithms.

Calculate the individual values, mean value and the standard deviation for test detonators and reference detonators.

6.1.4.2 Equivalent bubble energy

The bubble energy in s^3 can be calculated using the equation given below, based on the time interval between the shock-wave pressure peak and the first collapse of the gas bubble created from the detonation gases:

$$\boldsymbol{E_b = (t_b)^3} \qquad \textbf{(2)}$$

where

t_b is the bubble period, in seconds, between the shock-wave pressure peak and the first collapse of the gas bubble produced by the detonation gases.

Calculate the individual values, mean value and the standard deviation for test detonators and reference detonators.

6.2 Functioning test at high and low temperatures

6.2.1 General

Attach a piece of adhesive tape onto the face of the witness plate at the position at which the detonator is to be placed.

NOTE Protecting the witness plate in this way prevents the detonator shell material from adhering to the plate leading to false readings when determining the depth of the indentations.

Assemble the detonator, insulation and witness plate as shown in Figure 2 or Figure 3, with the detonator perpendicular to the witness plate.

Place the assembly on a support so that there is a free space, at least 20 mm high, underneath the witness plate (as shown in Figure 2 or Figure 3, for example.). Fire the detonator in accordance with the manufacturer´s firing instructions.

Determine the depth of the indentation in the witness plate using the indicator gauge (see 5.2.5).

Remove all burrs from the plate before performing the measurement and place the indicator pin into the indentation. Move the plate around until the lowest point of the indentation is found. Then lift the pin and move the plate to a position so that the pin is 3 mm from the edge of the plate and measure the plate thickness. Repeat the procedure by turning the plate through 90° from the first reading and again measure the thickness. Calculate the mean value of the two readings. Calculate the indentation depth as the difference between the mean value of the original plate thickness and the determined thickness in the deepest point of the indentation. Repeat this procedure for each tested detonator assembly and record the values.

6.2.2 Test at ambient temperature

Store ten detonators at ambient temperature for four hours. Assemble the detonators, insulation and witness plates as described in 6.2.1**.** Fire each detonator and determine the depth of indentation produced in the witness plate as described in 6.2.1. Calculate the mean value d.

6.2.3 High temperature test

Select 20 detonators. Assemble the detonators, insulation and witness plates as described in 6.2.1**.** Store the detonators in the heating cabinet for at least 4 h at a temperature (10 ± 2) °C higher than the highest safe operating temperature claimed by the manufacturer. Remove the detonators one by one from the heating cabinet and support them as described in 6.2.1. Fire each detonator within a time period of 45 s to 60 s after removal from the heating cabinet.

Determine the depth of the indentation produced in each witness plate, as described in 6.2.1, and record the lowest individual value as d_{h}.

Calculate the ratio d_h /d.

6.2.4 Low temperature test

Select 20 detonators. Assemble the detonators, insulation and witness plates as described in 6.2.1. Store the detonators in the freezing chamber for at least 4 h at a temperature (10 ± 2)°C lower than the lowest safe operating temperature claimed by the manufacturer. Remove the detonators one by one from the freezing chamber and support them as described in 6.2.1. Fire each detonator within a time period of 45 s to 60 s after removal from the freezing chamber. Determine the depth of the indentation produced in each witness plate, as described in 6.2.1, and record the lowest individual value as d_l.

Calculate the ratio d_l /d.

7 Test report

The test report shall conform to EN ISO/IEC 17025. In addition, the following information shall be given:

a) equivalent shock energy and the equivalent bubble energy for each reference detonator and for each test detonator;

b) mean value of the equivalent shock energy and the mean value of the equivalent bubble energy for the reference detonators and the test detonators;

c) depth of indentation in each of the witness plates;

d) ratios d_h/d and d_l/d.

Annex A
(normative)

Specifications for reference detonators

The series of reference detonators shall be as listed in Table A.1 and as illustrated in Figures A.1 to Figure A.4. The priming charge shall be 0,30 g ± 0,01 g of high explosive in each detonator and the base charge shall be within + 3 % of the values given in Table A.1.

The dimensions shall be as shown in Figures A.1 to Figure A.4, with the values of A to F given in Table A.1.

Table A.1 - Base charge and dimensions of reference detonators

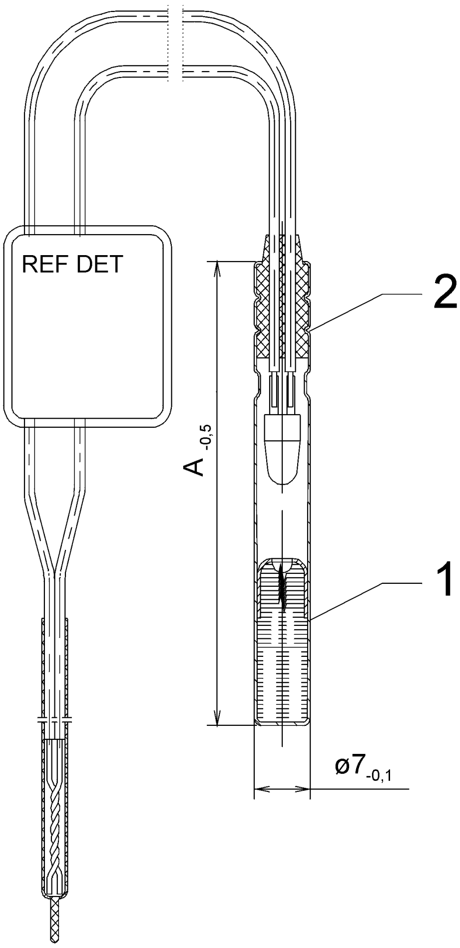
Detonator	Base charge (g)	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)
REF.DET 1	0,25	53	41,6	53,6	50	35	29
REF.DET 2	0,4	53	38,8	53,6	50	35	29
REF.DET 3	0,6	53	34,8	53,6	50	35	29
REF.DET 4	0,8	65,5	43	66,1	62,5	47,5	29
REF.DET 5	1,0	65,5	39	66,1	62,5	47,5	29
REF.DET 6	1,2	65,5	35	66,1	62,5	47,5	29

Table A.2 - Specification for PETN for base charge

Melting point	≥ 140 °C
Acidity (as HNO_3)	≤ 0,005 % by mass
Alkalinity (as $NaNO_3$)	≤ 0,005 % by mass
Gas liberation (Bergmann-Junk test)	≤ 2,5 ml/g
Grit (sandy parts)	None
Dipentaerythritol tetranitrate	≤ 2 % by mass
Deflagration point	≥ 210 °C
Bulk density	≥ 0,70 g/ml
Graphite	> 0,5 % by mass and ≤ 1,0 % by mass

Reference detonators drawings (Figures A.1 to A.4)

Dimensions in millimetres

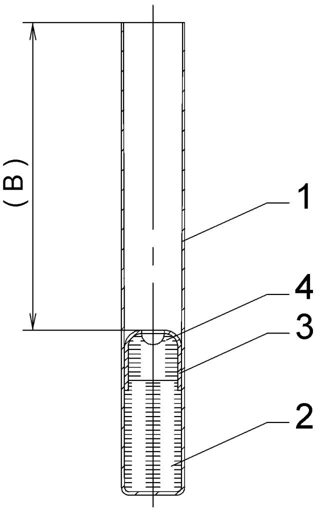


Key

1 Detonator shell with explosives and inner cup

2 Electric fusehead with sealing plug and leading wires

Figure A.1 - Complete detonator



Key

1 Copper shell

2 PETN base charge

3 Inner cup

4 Priming charge

Figure A.2 - Loaded detonator with inner cup.

Dimensions in millimetres

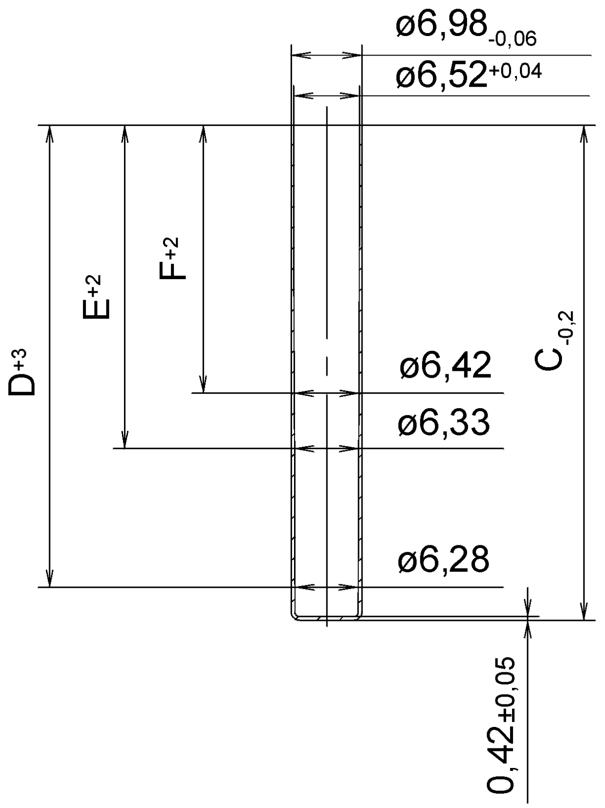


Figure A.3 - Detonator shell

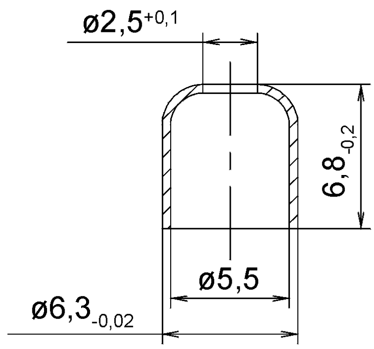


Figure A.4 - Inner cup

Table A.3 - Product specifications and descriptions for reference detonators

Figure Nº	Item	Part	Description	Remarks
A.1	Complete detonator	1	Detonator shell with explosives and inner cup	See also Figure A.2. The shell lengths A in millimetres for different charges are shown in Table A.1. Use of an inner cup, see under A.4 below.
		2	Electrical fusehead with sealing plug and leading wires.	The initiating energy for the detonator can be provided non electrically, i.e. by a shock tube.
A.2	Loaded detonator shell with Explosives and inner cup	1	Copper shell	See Figure A.3. The distance B in millimetres from the top of the inner cup or the top of the priming charge for the different type of reference detonators, see Table A.1
		2	2/3 of the total PETN base charge pressed at 440 bars ± 10 %	The PETN must meet the specifications given in Table A.2, and may contain up to 0,5% of carbonaceous matter to prevent electrostatic charges during handling and to improve the flow properties.
			1/3 of the total PETN base charge	Not more than 400 mg of PETN shall be compressed at any one loading operation.
		3	Inner cup	If used, inserted at a pressure of 440 bars ± 10 %
		4	Priming charge (initiation charge) compressed at 440 bars ± 10 %	Free choice of the substance Pressing the priming charge onto a highly compressed part of the base charge is not permitted.
A.3	Detonator shell		Hollow-drawn shell of pure copper, or copper-zinc alloy with a maximum zinc mass fraction of 5 %.	If required, the shells for making standard detonators should be selected by checking the exact dimensions of each shell to be used. The distances marked C, D, E and F for the different types of reference detonators are specified in millimetres in Table A.1.
A.4	Inner cup (pierced)		Made from CuZn 95/5 alloy.	It is not required to use a pierced inner cup.

Annex B
(informative)

Range of applicability of the test method

B.1 Underwater initiating capability test

The range is mainly limited by the medium in which the detonators are tested. Thus, the practical range is considered to be between 0 ºC and +80 ºC.

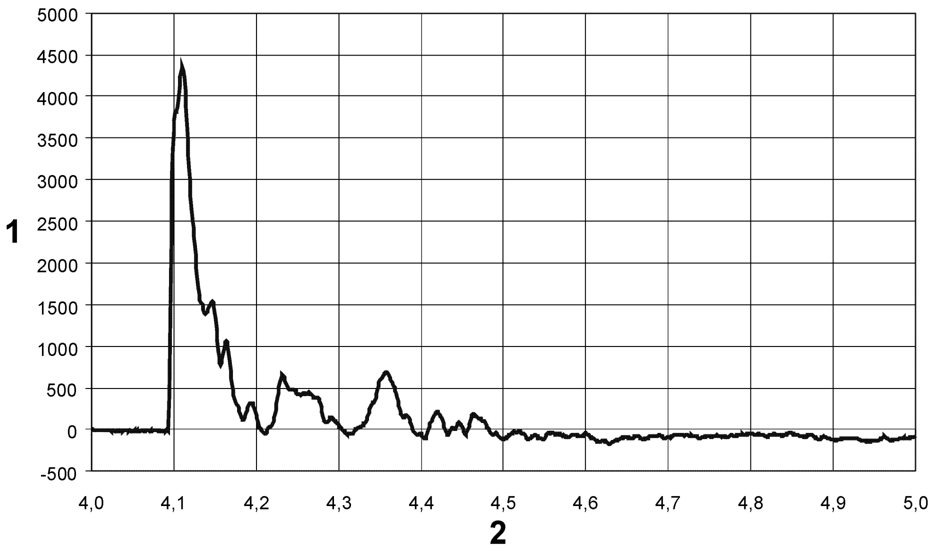
B.2 Function test at high and low temperatures

This range is assumed to be equal to the range of validity of the test results, and therefore considered to be from the lowest to the highest applied testing temperature, alternatively –40 ºC to + 90 ºC.

Annex C
(informative)

Examples of results from underwater testing

C.1 Typical curves for peak pressure and bubble period

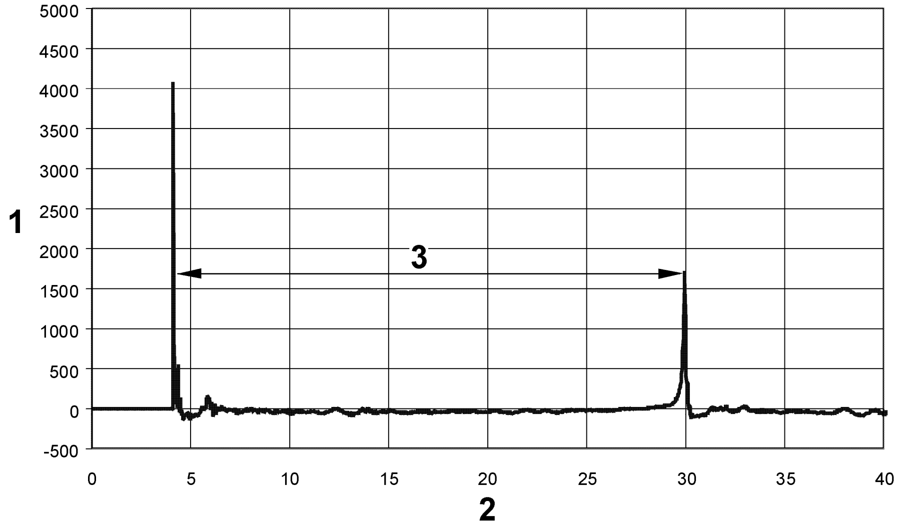


Key

1 Pressure (kPa)

2 Time (ms)

Figure C.1 - Example of an ideal pressure curve from a commercial detonator with 750 mg Tetryl base charge fired under water according to the method described in 6.1 of this document.



Key

1 Pressure (kPa)
2 Time (ms)
3 Bubble period

Figure C.2 - Typical readout of the bubble period with long time base (5 ms/div).

The first part of the curve (0 ms to 5 ms) is the compressed version of the readout shown in Figure C.1. The bubble period is the time from the peak of the detonation shock to the peak of the shock from the first collapse of the bubble.

Annex ZA
(informative)

Clauses of this European Standard addressing essential requirements or other provisions of EU Directives.

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 requirements of EU Directive 93/15/EEC.

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

The clauses of this standard are likely to support requirements I.1, I.2, II.1a, II.1g and II.2.C(a) of the Directive 93/15/EEC.

Compliance with this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

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