BS EN 16701:2014

BSI Standards Publication

Energetic materials for defence — Safety, vulnerability — Friability

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 16701:2014.

The UK participation in its preparation was entrusted to Technical Committee DEF/1, Defence standardization.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 85192 6

ICS 71.100.30

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2014.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 16701

May 2014

ICS 71.100.30

English Version

Energetic materials for defence - Safety, vulnerability - Friability

Matériaux énergétiques de défense - Sécurité, vulnérabilité - Friabilité

Energetische Wehrmaterialien - Sicherheit, Verwundbarkeit - Sprödigkeit

This European Standard was approved by CEN on 10 April 2014.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of 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 United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 16701:2014 E

Contents

Page

Foreword

This document (EN 16701:2014) has been prepared by Technical Committee CEN/TC SS C20 “Explosives and firework”, the secretariat of which is held by CCMC.

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 November 2014 and conflicting national standards shall be withdrawn at the latest by November 2014.

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.

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.

Introduction

This document is derived from procedure SEN-216-01, promulgated by the Groupe d'Études des Modes Opératoires (French Test Procedures Study Group) in February 2003.

Annexes known as “informative” are given for information purposes. Annexes A to E are informative.

The term friability covers the notions of fragmentation following mechanical stress and burning vivacity of the fragments.

1 Scope

This European Standard describes a method for assessing the deflagration to detonation transition (DDT) risk of an explosive material subjected to a mechanical threat.

Testing applies to any compact solid explosive material.

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.

NF T 70-714, *Energetic materials for defence — Performance — Closed Vessel firing*

3 Test method principle

A cylinder of bare explosive material is projected against a flat steel plate, under normal incidence and according to its axis of revolution.

The friability of the explosive material is characterised as a function of the impact velocity (IV), by the maximum value taken by the dP/dt function derived from the P(t) signal measured by burning the fragments collected following impact at a constant volume in a closed vessel.

All of these operations are generally carried out at ambient temperature, unless otherwise specified.

4 Apparatus

4.1 Launching device

The launching device shall be able to transmit to the sample, without damaging it, a velocity between 70 m/s and at least 200 m/s.

For example, the following pneumatic launch device may be used, which includes (see general diagram in Annex A):

— an air tank with a volume of 3,3 L, consisting of a tube with an inside diameter of 50 mm and outside diameter of 60 mm, equipped with a pneumatic control valve at each end. This tank is connected to a compressed air bottle used for establishing a pressure of 1,2 MPa;

— a launcher tube with an inside diameter between 18,2 mm and 18,6 mm and a length of 1,50 m connected to the pneumatic valve by means of a connection ring.

A gun propellant launch device may also be used; it consists of the following elements:

— a test tube with a calibre 12 cylindrical core (inside diameter between 18,2 mm and 18,6 mm) and 70 mm counter boring, with an effective length of 700 mm;

— a gun propellant cartridge whose description is given in Annex B.

4.2 Fragment collection and impact device

This device includes (see Figure A.1):

— a flat steel plate with a diameter of 630 mm and 20 mm thick. The front face is machined with a roughness Ra 3,2 (see EN ISO 12085:1997, EN ISO 4287:1998, and EN ISO 1302:2002). This disk is fixed to a concrete wall;

— a fragment collecting box consisting of a tube (for example made of PMMA.) with an inside diameter of 630 mm and a length of 1,50 m. The PMMA tube slots on to the impact disk.

The other end of the tube is sealed using a PMMA disk in which a 100 mm square central hole has been made on the side in the cylinder's axis.

NOTE An impact disk and a fragment collecting box with a diameter of 200 mm can be used for the characterisation of highly friable explosive materials, in order to limit the dispersion of fine dust.

4.3 Closed vessel

It consists of a combustion chamber sealed by one or two plugs supporting the ignition electrodes, a pressure sensor and a blow down. The unit shall withstand a minimum static pressure of 300 MPa. Its volume should be around 130 cm^3 (see Figure C.1).

NOTE A more complete description is given in French Standard NF T 70–714.

It is possible to check the suitability of the combustion chamber using (9 ± 0,1)g of double - base propellant with the following characteristics: 5,225 kJ/g formed as square pellets: 8 mm × 8 mm x 0,8 mm.

With this sample it is necessary to obtain:

— P_{max} = (80 ± 5) MPa;

— $(dP/dt)_{max}$ = (14,5 ± 1,0) MPa/ms;

in compliance with the specifications regarding:

— the geometry of the combustion chamber;

— the acquisition and processing of the signal;

— the definition of the ignition mechanism.

These specifications are stated in French Standard NF T 70–714.

These results are obtained with a closed vessel whose combustion chamber has a constant volume of approximately 130 cm^3 (see Figure C.1).

4.4 Measurement apparatus

4.4.1 Measurement of the impact velocity

The impact velocity is measured 1,55 m from the impact disk using, for example, two optical barriers that are 10 cm away and connected to a chronometer (see layout in Annex A).

This velocity shall be measured at ± 1 m/s.

4.4.2 Recording of the pressure when burning inside the closed vessel

In general, reference should be made to French Standard NF T 70–714 for the choice of elements for the measurement chain (pressure sensor, charge amplifier, numbering and memory storage apparatus).

For example, a KISTLER 6203 piezoelectric sensor can be used combined with a KISTLER 5001 charge amplifier.

5 Test specimen

The test specimen is cylindrical, with a diameter of (18,0 ± 0,1) mm. Its length is adjusted to obtain a mass of (9,0 ± 0,1) g.

It is obtained either directly by casting, or by punching, or by machining a block, or by compression.

6 Procedure

6.1 Performing a trial

6.1.1 Impact of the test specimen

Several methods could be used to attain the desired impact velocity. The chosen launching method should not damage the sample.

The sequence of operations is as follows, according to the launch procedure used:

— with a pneumatic launch device, the plastic tamping plug is inserted into the tube muzzle then pushed in using a variable depth index rod according to the expected velocity. The sample is then inserted through the tube muzzle and pushed in until it stops against the tamping plug;

The pressure is established in the air tank by opening valve 1. Firing is triggered by opening valve 2 (see Annex A);

— with a gun device, are successively inserted through the muzzle a plastic tamping plug using an indexed rod, then the sample to test on contact with the tamping plug.

The propellant cartridge is inserted into the chamber and the moving head is locked using the breech.

Then, firing is triggered.

The impact velocity (IV) of the test specimen is recorded and all of the fragments are carefully collected then weighed.

The mass loss for each sample shall be lower than or equal to 0,3 g, before burning it in the closed vessel.

In case of an explosive event at the impact, the highest velocity for which there is no reaction is noted in the test report.

6.1.2 Firing in the closed vessel

6.1.2.1 Verification of the apparatus

Before each test series in the manometric vessel, test firing can be performed with the Double – Based Propellant (defined in 4.3).

The maximum pressure derivative obtained is noted and a variation of ± 1,0 MPa/ms of this derivative is permitted in relation to the reference value:

$$\left(\frac{dP}{dt}\right)_{\max} = 14{,}5 \text{ MPa/ms}$$

In the event where the maximum pressure derivative would have varied by more than 1,0 MPa/ms, the corrective actions should be carried out in accordance with the French standard NF T 70-714 (for example, change of the seals, checking of the pressure sensor calibration and the condition of the vessel body).

6.1.2.2 Burning the impacted sample

Burning in the closed vessel is performed as follows:

— weigh approximately 0,5 g of black powder with the characteristics (grain size: 0,75 mm; Potassium Nitrate 74 %, Sulphur 10,5 %, Carbon 15,5 %, moisture < 1 %), which is inserted into a capsule that has a resistance wire running through it; a capsule loaded with 1 g of black powder could be used in case of ignition difficulties;

— assemble the ignition capsule on its plug and connect the wire to the ignition electrodes;

— insert the fragments collected after impact into the vessel, then close the closed vessel with the plug equipped with ignition system;

— start burning.

NOTE The detailed burning procedure is described in the French standard NF T 70–714.

6.1.3 Using the burning results

NOTE The burning results are used to calculate the maximum pressure derivative $(dP/dt)_{max}$, according to the methods described in the French standard NF T 70–714 (signal levelling and processing).

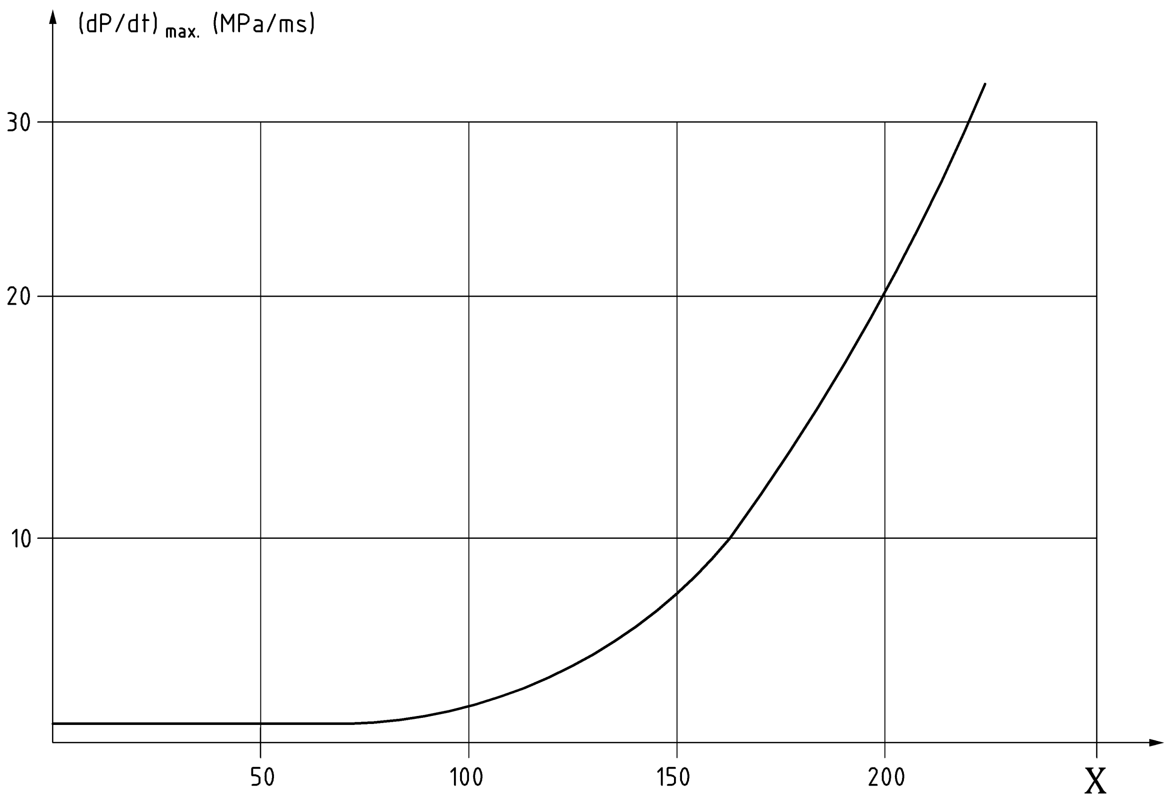
The pressure signal is measured by adapting the acquisition frequency according to the fragmentation condition of the sample. It varies, for example, from 10 kHz for a sample that is not very fragmented to 100 kHz for a significantly fragmented sample.

6.2 Performing a test

The trials start at low velocities, below 80 m/s, then continue up to velocities of 200 m/s to 250 m/s, or at least up to a velocity designated IV_{max}, over which the French standard NF T 70-714 is no more applicable for example due to the combustion of the sample at the impact.

The number of trials shall be sufficient to obtain at least eight values of the $(dP/dt)_{max}$ function using the closed vessel. Five values shall be in the speed range [120 m/s – 150 m/s] if IV_{max} is below 150 m/s.

The $(dP/dt)_{max}$ curve as a function of the impact velocity IV (see example in Figure 1) and IV as a function of $(dP/dt)_{max}$ are plotted by interpolation.



Key

X impact velocity (m/s)

Figure 1 — Example of (*dP/dt*)$_{max}$ curve as a function of the impact velocity

7 Expression of results

The behaviour of the explosive material is characterised by the $(dP/dt)_{max}$ = f(IV) (Impact velocity) curve.

Based on this curve, the $(dP/dt)_{max}$ value is determined at 150 m/s.

NOTE 1 As an example, the threshold of 15 MPa/ms is used by the UN to define Extremely Insensitive Detonating Substances (EIDS).

Based on the curve IV = $f((dP/dt)_{max})$, the value of the critical impact velocity (CIV) is determined for which the maximum pressure derivative reaches 18 MPa/ms.

NOTE 2 As an example, the CIV is used in the French regulations concerning the pyrotechnic safety.

NOTE 3 Examples of results for typical explosives materials are given in Annex E.

8 Test report

The test report shall include the following information at least:

a) the reference to this document;

b) the date of the test;

c) the complete identification of the explosive material;

d) the method of obtaining (sample preparation);

e) the density of the explosive material;

f) the conditioning method;

g) the climatic conditions of the test;

h) for each trial:

   1) the impact velocity;

   2) if applicable, the reaction to the impact;

   3) the maximum pressure obtained in the closed vessel;

   4) the maximum pressure derivative;

i) the $(dP/dt)_{max}$ for IV = 150 m/s;

j) the CIV;

k) if applicable the IV_{max}

l) any observations.

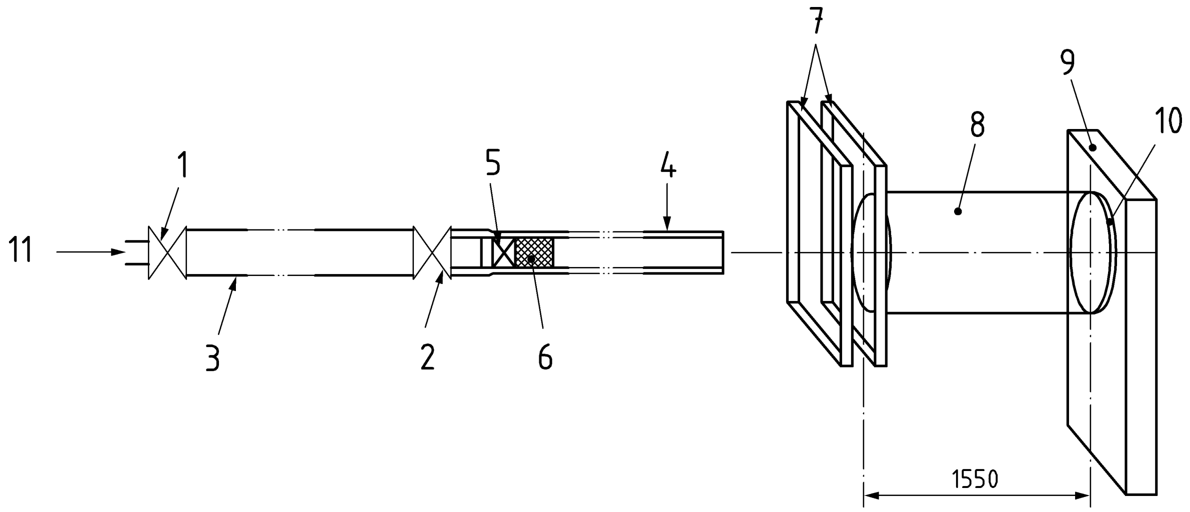
The $(dP/dt)_{max}$ curve as a function of the impact velocity and impact velocity as a function of $(dP/dt)_{max}$ are appended to the test report.

An example of a test report is given in Annex D.

Annex A
(informative)

Example of an experimental device

Dimensions in millimetres



Key

1&2	pneumatic control valves
3	pressurized air tank
4	launcher tube
5	plastic tamping plug
6	sample of explosive material
7	optical barriers
8	PMMA fragment collecting box
9	concrete wall
10	flat steel plate
11	air supply

Figure A.1 — General diagram with pneumatic launcher

Annex B
(informative)

Description of the gun propellant device

B.1 General

The propellant cartridge consists of the following elements used for civilian purposes:

1) a calibre 12, primed cartridge case, reference 12/70/15;

2) a gun propellant (e.g. type D 20 sporting gun propellant) the mass of which depends on the required impact velocity;

3) a cardboard heat shield disk with a diameter equal to that of the cartridge case and a thickness of 1,2 mm, the role of which is to thermally isolate the plastic tamping plugs from the propellant;

4) plastic tamping plugs with the inside diameter of the cartridge case and with a thickness of 6,5 mm used for sealing and filling before crimping.

B.2 Cartridge preparation

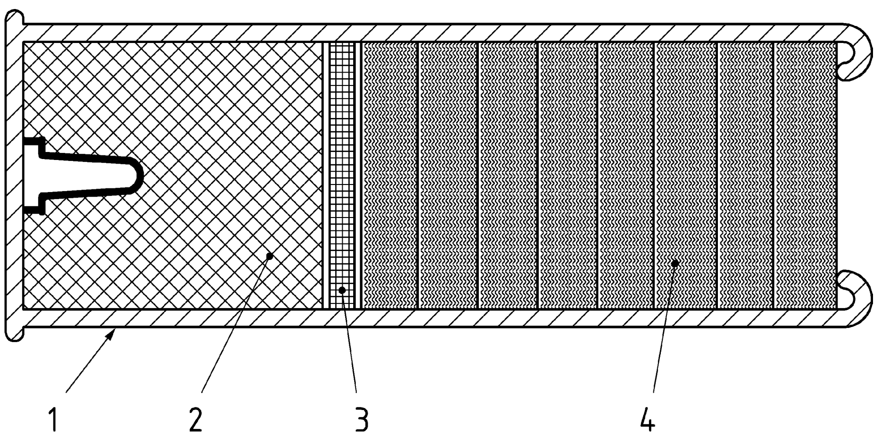
The following are successively inserted into the primed shell:

— the gun propellant;

— the cardboard heat shield disk;

— a minimum of eight plastic tamping plugs to complete filling of the cartridge and leave a length of approximately 5 mm reserved for crimping.

The cartridge is then crimped. Its final length shall be between 64 mm and 65 mm.



Key

1 cartridge case

2 gun propellant

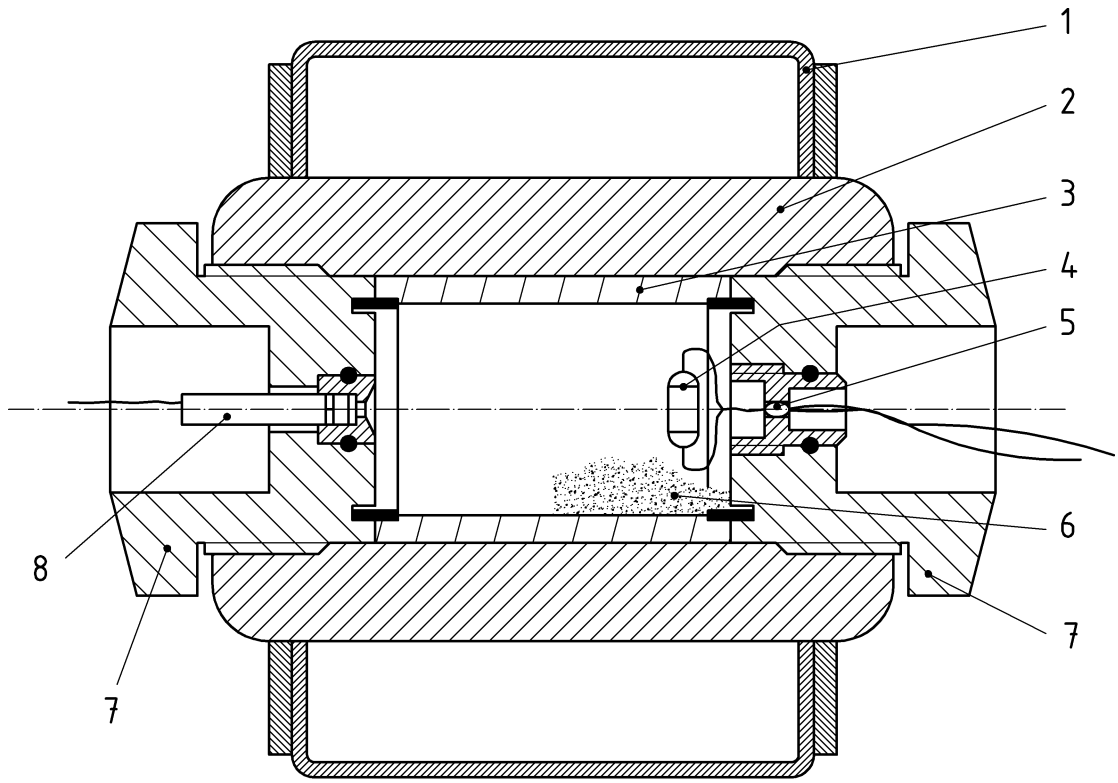
3 cardboard heat shield disk

4 plastic tamping plugs

Figure B.1

Annex C
(informative)

Example of a closed vessel



Key

1 support frame and heat regulation system

2 vessel body

3 combustion chamber case or sleeve

4 example of an igniting device (consists of a pharmaceutical capsule filled with black powder)

5 example of a combustion gas empting system

6 test sample

7 plugs

8 pressure sensor

Figure C.1

Annex D
(informative)

Example of a test report

Energetic materials for defence — Safety, vulnerability — Friability			EN 16701
Laboratory:	**Operator:**		**Date:**
Identification of the explosive material		Obtaining Method	
Name:		Density	
Reference:		Check	
Origin:		Conditioning, if applicable	
Characteristics:			
Testing conditions	Atmospheric pressure:		
	Relative humidity:		
	Ambient temperature:		

Trial no.	**Impact velocity** (m/s)	**Closed vessel burning reference**	P_{max} (MPa)	$(dP/dt)_{max}$ (MPa/ms)	**Reaction to impact**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

OBSERVATIONS	**RESULTS:**	
	$(dP/dt)_{max}$ for IV = 150 m/s	MPa/ms
	CIV for $(dP/dt)_{max}$ = 18 MPa/ms	m/s

Annex E
(informative)

Examples of results for typical Explosive Materials

Table E.1

Explosive Material	**(dP/dt)$_{max}$ for IV = 150 m/s (MPa/ms)**	**CIV for (dP/dt)$_{max}$ = 18 MPa/ms (m/s)**
TNT	8	/
Comp B	30	/
PBXN-109	11	173
PBXN-110	26	135
PBX HMX/PU 86/14	5	/
Double-Base Propellant NC/NGL 52/43	1	> 200
Composite Propellant AP/Al 82/4 (Butacene)	17	155
Composite Propellant AP/Al 68/20	9	189

Bibliography

[1] EN ISO 12085:1997, *Geometrical product specification (GPS) - Surface texture: Profile method - Motif parameters (ISO 12085:1996)*

[2] EN ISO 4287:1998, *Geometrical product specifications (GPS) - Surface texture: Profile method - Terms, definitions and surface texture parameters (ISO 4287:1997)*

[3] EN ISO 1302:2002, *Geometrical Product Specifications (GPS) - Indication of surface texture in technical product documentation (ISO 1302:2002)*

[4] Dictionnaire de pyrotechnie du GTPS — Publication de l'Association Française de Pyrotechnie (AFPyro)

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK