BRITISH STANDARD

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13938-5:2004

Explosives for civil uses — Propellants and rocket propellants —

Part 5: Determination of voids and fissures

The European Standard EN 13938-5:2004 has the status of a British Standard

ICS 71.100.30

National foreword

This British Standard is the official English language version of EN 13938-5:2004.

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

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

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Explosives for civil uses - Propellants and rocket propellants - Part 5: Determination of voids and fissures

Explosifs à usage civil - Cordeaux détonants et mèches lentes - Partie 5: Propergols solides pour autopropulsion - Guide pour la détermination des vides et des fissures

Explosivstoffe für zivile Zwecke - Treibladungspulver und Raketentreibstoffe - Teil 5: Bestimmung von Lunkern und Rissen

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Foreword

This document (EN 13938-5:2004) 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of an identical text or by endorsement, at the latest by February 2005, and conflicting national standards shall be withdrawn at the latest by February 2005.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(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

This document is one of a series of standards with the generic title *Explosives for civil uses – Propellants and rocket propellants.* The other parts of this series are listed below:

prEN 13938-1 Part 1: Requirements

prEN 13938-2 Part 2: Determination of resistance to electrostatic energy

EN 13938-3 Part 3: Determination of deflagration to detonation transition

EN 13938-4 Part 4: Determination of burning rate under ambient conditions

EN 13938-6 Part 6: Guide for the determination of integrity of inhibitor coatings

EN 13938-7 Part 7: Determination of properties of black powder

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

Introduction

The presence of excessively large or numerous voids or fissures in solid rocket propellant can result in dangerously high pressures due to increased propellant burning surfaces. The maximum size and number of voids and fissures permitted in a solid rocket propellant to ensure safe functioning are therefore an essential part of the acceptance criteria for the product. For small rocket motors this can be achieved by burning them in the way they are designed for and measuring the thrust continually. Significant voids and fissures can be recognized by a sudden increase of thrust.

1 Scope

This document specifies a method for checking small rocket motors for voids and fissures and provides a guide to non-destructive testing (NDT) methods for detecting voids and fissures in other solid rocket propellants.

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 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 and the following apply.

3.1
small rocket motor
rocket motor which does contain not more than 100 g of solid rocket propellant(s)

3.2
NDT method
discipline applying a physical principle in non-destructive testing

NOTE An example of an NDT method is ultrasonic testing.

3.3
NDT technique
specific way of utilising an NDT method

NOTE An example of an NDT technique is immersion ultrasonic testing.

3.4
NDT procedure
orderly sequence of rules, which describes step by step how and in which sequence a NDT technique should be applied to a specific field

3.5
void
unintended inclusion of a gas bubble

3.6
fissure
unintended longitudinal discontinuity in the propellant material

3.7
solid rocket propellant
propellant consisting of one or more blocks, usually with a central hole, designed to burn in a controlled manner

4 NDT methods

Voids and fissures in solid rocket propellant grains can be detected by various NDT methods normally used for the testing of metals and welds. The NDT method and technique selected will depend on many factors. Among them it may be useful to distinguish:

- a) minimum size of voids and fissures to be detected;
- b) type of propellant to be inspected;
- c) type of inspection (continuous production line inspection or the individual inspection of samples);
- d) number of units to be inspected.

The main types of NDT methods used in the detection of voids and fissures are shown in Table 1.

Table 1 – NDT methods

NDT method	Comments
Film radiography (X-ray or isotopes)	– suitable for all types of propellant units – involves a lot of pictures to cover all appropriate angles of incidence – personnel protection required
X- ray radioscopy	– suitable for all types of propellant units – no films involved – personnel protection required
X-ray tomography	– suitable for all types of propellant units – more expansive than X-ray radioscopy – personnel protection required
Ultrasonic	– a liquid or gel is required for sound transmission – may be well adapted for in-line inspection – no personnel protection required

5 Destructive testing of small rocket motors

5.1 Test pieces

For this test, 20 rocket motors of the same design shall be selected, i.e. the same dimensions, chemical composition, assembly, nozzle, and finish.

5.2 Apparatus

The apparatus consists of the following parts (see Figure 1):

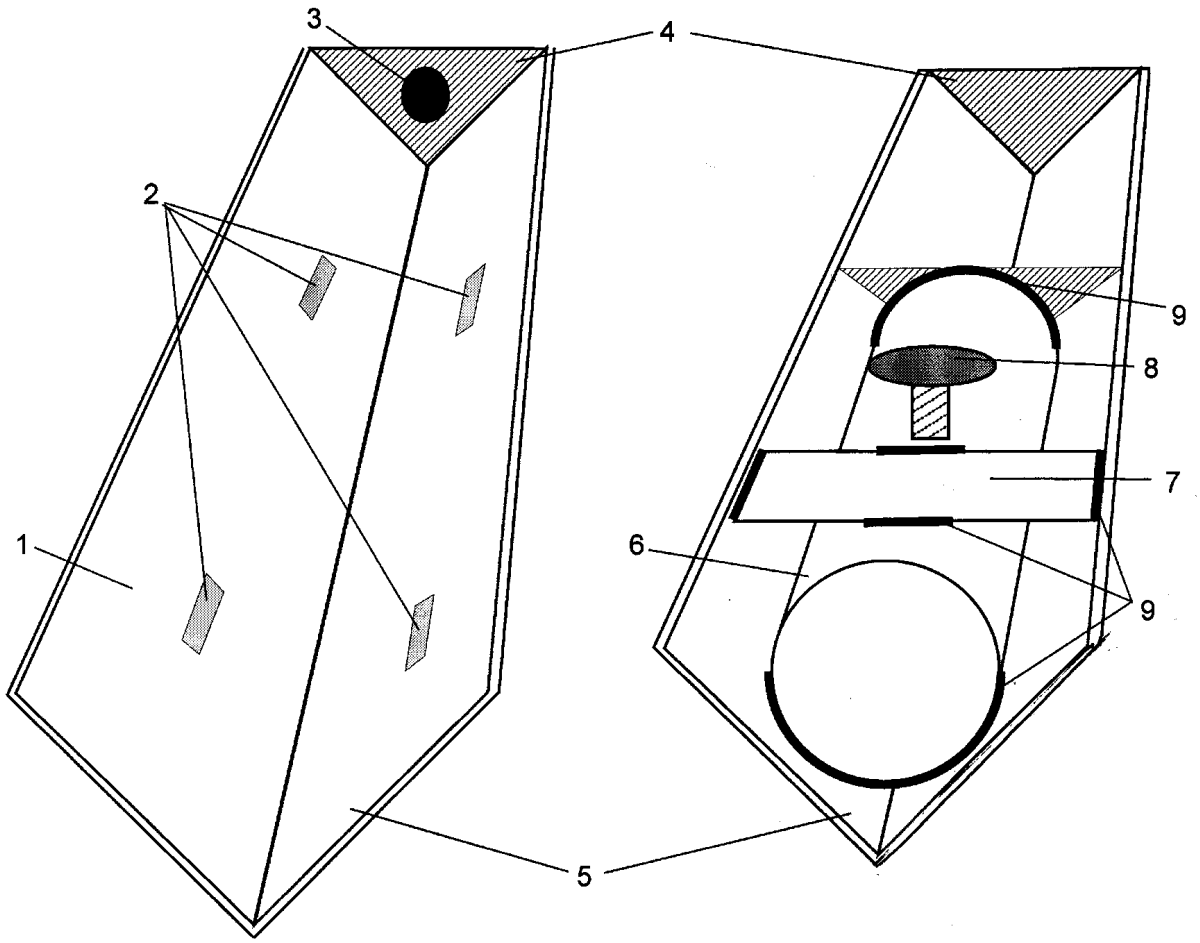
— **5.2.1** a V-shaped carrier made of steel onto which a steel tube is welded providing a mounting for the test piece. Additionally a steel plate is welded onto the top of the tube and to the carrier. The test piece is fixed in the tube by a fastening screw at the top part of the steel tube. The rear end of the tube is closed by a steel plate which is also welded to the carrier. The tube shall be fixed in a way that the thrust of the test piece operates precisely along the length of the carrier. The rear end of the carrier is closed by a steel plate and can be additionally fitted with a steel bolt or similar to transfer the thrust force onto the force transducer;

— **5.2.2** a V-shaped steel trough equipped with a force transducer at the rear end and with ball bearers built into the sidewalls to provide a virtual frictionless movement of the carrier. The trough is firmly mounted on a base made of steel or concrete;

— **5.2.3** a transient recorder or a x-t-plotter to record the signal of the force transducer during the test with a resolution of at least 2 ms;

— **5.2.4** an igniter as stipulated by the manufacturer of the small rocket motors.

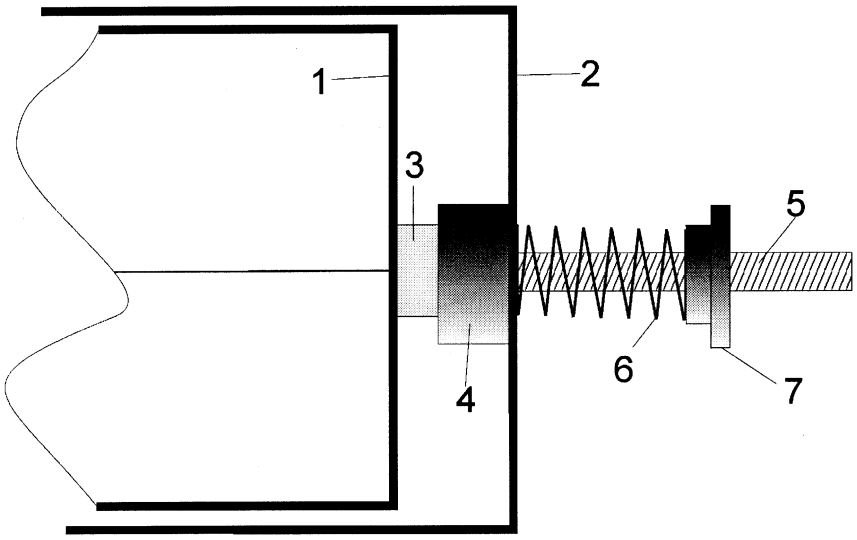
To avoid effects of inertia the force transducer is preloaded with a certain force, for example 10 N to 30 N. This can be accomplished in several ways, e.g. a spring, a weight, tilting the trough (see Figure 2 for an example).



Key

1 Trough
2 Ball bearers
3 Force transducer
4 Rear steel plates
5 Front end
6 Steel tube
7 Steel plate
8 Fastening screw
9 Weld seams

Figure 1 – Example of an apparatus for measuring the thrust of small rocket motors



Key

1 Carrier (rear end)
2 Trough (rear end)
3 Adapter to transfer the thrust to the transducer (attached to the carrier)
4 Force transducer (attached to the trough)
5 Threaded bolt
6 Spring
7 Thumb screw

Figure 2 – Example of preloading the force transducer

5.3 Procedure

Insert the test piece into the steel tube until the end opposite the nozzle comes in touch with the rear steel plate. If the test piece is too short, i.e. the nozzle does not stick out of the tube for about 10 mm, insert a piece of metal of suitable thickness before the test piece. Fix the test piece by means of the fastening screw. Mount the igniter as prescribed by the manufacturer to give a reliable ignition of the test piece. The recording of the force measurement is started and the igniter is triggered. The thrust (in N) is measured during the complete burning duration.

Repeat the procedure for each of the remaining 19 test pieces.

5.4 Evaluation of test results

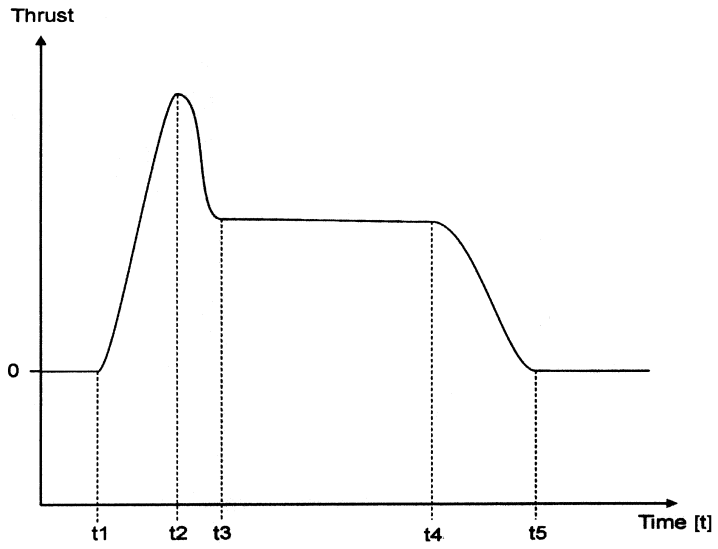
5.4.1

For each test piece determine from the recordings (see Figure 3 for an example) the maximum and the mean thrust (overall mean) between t_3 and t_4, the burning duration ($t_5 - t_1$) and the total impulse (in $N.s^{-1}$) by integrating the recorded thrust vs. time data from t_3 to t_5. Then calculate the mean impulse and the standard deviation from the 20 results.

5.4.2

To determine whether significant voids and fissures are present, examine the recordings as follows:

Divide the range from t_3 to t_4 into ten parts and calculate for each part the mean thrust (partial mean). Calculate the differences between the partial means and the overall mean determined in accordance with 5.4.1. If any of the differences is greater than 10 % of the overall mean record it.



Key

t_1 Start of burning
t_2 Maximum during ignition phase
t_3 Start of main thrust phase
t_4 End of main thrust phase
t_5 End of burning

Figure 3 – Example of a thrust vs. time diagram (idealized)

6 Test report

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

For non-destructive testing:

a) reference to this document, i.e. EN 13938-5;

b) reference to the acceptance criteria for the product tested;

c) reference to the NDT procedure used;

d) identification of the NDT record(s);

e) results of the tests;

For small rocket motors:

f) reference to this document, i.e. EN 13938-5;

g) number of test pieces that did not function as they were supposed to, if any;

h) mean impulse and the standard deviation;

i) maximum and mean thrust for each test piece;

j) number of test pieces with partial mean thrusts differing by more than 10% from the overall mean thrust, if any.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 93/15/EEC

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 New Approach Directive 93/15/EEC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative Clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity with I.1 and II.2.D(c) of that Directive and associated EFTA regulations.

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

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