BRITISH STANDARD

BS EN
15188:2007

Determination of the spontaneous ignition behaviour of dust accumulations

ICS 13.230

British Standards

National foreword

This British Standard is the UK implementation of EN 15188:2007. It is identical with EN 15188.

The UK participation in its preparation was entrusted to Technical Committee FSH/23, Fire precautions in industrial and chemical plant.

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

EN 15188:2007 is concerned with the determination of the spontaneous ignition behaviour of dust accumulations. It prescribes test apparatus, the preparation of samples, an experimental procedure and discusses the analysis of results.

The characterization of the self-ignition behaviour of dust deposits of different scale and of different bulk geometric shapes from tests on a number of differently sized samples can be obtained by plotting the logarithms of the volume/surface ratios versus the reciprocal of the self ignition temperature. EN 15188:2007 recognizes that the spread of the slope of the straight lines from this plot determined by different laboratories using differently constructed ovens is fairly large. Scale up of these results to industrial scale may lead to non-negligible differences in the values of ignition temperature.

This should be taken into account when using this standard.

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EUROPEAN STANDARD

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EN 15188

August 2007

ICS 13.230

English Version

Determination of the spontaneous ignition behaviour of dust accumulations

Détermination de l'aptitude à l'auto-inflammation des accumulations de poussières

Bestimmung des Selbstentzündungsverhaltens von Staubschüttungen

This European Standard was approved by CEN on 13 July 2007.

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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 Management Centre has the same status as the official versions.

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Foreword

This document (EN 15188:2007) has been prepared by Technical Committee CEN/TC 305 “Potentially explosive atmospheres - Explosion prevention and protection”, the secretariat of which is held by DIN.

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 2008, and conflicting national standards shall be withdrawn at the latest by February 2008.

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 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 94/9/EC.

For relationship with EU Directive 94/9/EC, see informative Annex ZA, which is 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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The self-ignition behaviour of combustible dusts depends on their chemical composition as well as on related substance properties. It also depends on the size and geometry of the body of material, and, last but not least on the ambient temperature.

The reason behind self-heating (or possibly self-ignition) is that the surface molecules of combustible dust particles undergo exothermic reactions with the oxygen in air transported into the void volume between the particles even at normal temperatures. Any heat then released will cause the temperature of the reactive dust-air system to rise, thus accelerating the reaction of additional dust molecules with oxygen, etc. A heat balance involving the heat produced inside the bulk (quantity and surface of reactive surface molecules, specific heat producing rate) and the heat loss to the surroundings (heat conductivity and dimension of the bulk, heat transfer coefficient on the outside surface of the bulk and the size of the latter) is decisive as to whether a steady state temperature is reached at a slightly higher temperature level (the heat loss terms are larger than the heat production term), or whether temperatures in the bulk will continue to rise up to self-ignition of the dust, if heat transport away from the system is insufficient (in this case the heat production term is larger than all heat losses).

The experimental basis for describing the self-ignition behaviour of a given dust is the determination of the self-ignition temperatures (T_{SI}) of differently-sized bulk volumes of the dust by isoperibol hot storage experiments (storage at constant oven temperatures) in commercially available ovens. The results thus measured reflect the dependence of self-ignition temperatures upon dust volume.

Plotting the logarithms of the volume/surface ratios [$\lg (V/A)$] of differently sized dust deposits versus the reciprocal values of the respective self-ignition temperatures [$1/T_{\mathrm{SI}}$ in K^{-1}] or following other evaluation procedures – described in Annex A – one produces straight lines, allowing interpolation, to characterise the self-ignition behaviour of dust deposits of a different scale and of a different bulk geometric shapes (see 5.1). Experience has shown that the spread of slopes of such straight lines determined by different laboratories using differently constructed ovens is fairly large. This is the reason why scale up of those results to industrial scale will lead to non-negligible errors in T_{SI}.

Experience has shown, that it seems necessary to prescribe the installation of a unique inner chamber into the oven, surrounding the dust samples and the thermocouples, with an also prescribed air flow through this chamber. In this way the spread of results should be minimised. Decisions on the design of this inner chamber and on the amount of air flow respectively other test setups leading to comparable results have to be carried out later on.

If it is possible based on suitable thermo analytic test procedures (adiabatic, isothermal or dynamic tests) to derive a reliable formal kinetic model, which describes the heat production of the substance as a function of temperature, then the volume dependency of the self-ignition temperature may be calculated according to the methods described in Annex A.

1 Scope

This European Standard specifies analysis and evaluation procedures for determining self-ignition temperatures (T_{SI}) of combustible dusts or granular materials as a function of volume by hot storage experiments in ovens of constant temperature. The specified test method is applicable to any solid material for which the linear correlation of lg (V/A) versus the reciprocal self-ignition temperature $1/T_{SI}$ (with T_{SI} in K) holds (i.e. not limited to only oxidatively unstable materials).

This European Standard is not applicable to the ignition of dust layers or bulk solids under aerated conditions (e.g. as in fluid bed dryer).

This European Standard should not be applied to dusts like recognised explosives that do not require atmospheric oxygen for combustion, nor to pyrophoric materials.

NOTE Because of regulatory and safety reasons “recognised explosives” are not in the scope of this European Standard. In spite of that, substances which undergo thermal decomposition reactions and which are not “recognised explosives” but behave very similarly to self-ignition processes when they decompose are in the scope. If there are any doubts as to whether the dust is an explosive or not, experts should be consulted.

2 Terms and definitions

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

2.1
self-ignition temperature
T_{SI}
highest temperature at which a given volume of dust just does not ignite

NOTE Self-ignition temperature is expressed in °C.

2.2
oven temperature
arithmetic mean of the measured values of two thermocouples, both freely installed in an oven at half the distance between the wall and the surface of the dust sample

NOTE Oven temperature is expressed in °C.

2.3
sample temperature
temperature measured at the centre of the dust sample using a thermocouple

NOTE Sample temperature is expressed in °C.

2.4
induction time
interval of time between reaching the storage temperature and an ignition

NOTE Induction time is expressed in h.

2.5
ignition
initiation of combustion

[EN 13478:2001, 3.20]

3 Test apparatus

3.1 Sample baskets

The samples have to be loosely filled into mesh wire baskets of different volumes. The baskets have to be open at the top and closed at the bottom. They consist of a narrow-meshed wire net, made of e.g. stainless steel. The width of the mesh has to be chosen in such a way that the dust cannot fall through the mesh, but the diffusion of oxygen from the oven air into the dust sample is not hindered. Recommended shapes of the mesh wire baskets are that of a cylinder with a height to diameter ratio of 1 or that of a cube.

To allow an assessment of the self-ignition behaviour of dust accumulations of larger sizes than the laboratory-scale at least three mesh wire baskets of different volumes have to be used for the tests.

NOTE 1 A higher level of certainty is achieved with four different sample volumes.

The smallest volume should normally be in the order of 10 cm^3 and the largest should normally not be smaller than approximately 1 l.

If only a limited amount of sample material is available, even smaller baskets may be used. However it has to be assured that the volume of the basket following in a series exceeds that of the previous one by a factor of 2 at a minimum.

NOTE 2 For the sake of comparing products with respect to their self-ignition behaviour in devices or apparatus, where the sizes of the dust accumulations are limited for the reason of a specific design, often the determination of the self-ignition temperature for a basket of 400 cm^3 or 1 000 cm^3 is sufficient.

3.2 Oven

Commercially available ovens can be used. They shall have an air inlet opening in the lower section and an air outlet opening in the upper section (see schematic drawing in Figure 1). They should have a useful volume of about 120 l (enabling the installation of an inner chamber into the oven, surrounding the dust samples and the thermocouples, being equipped with an upstream heat exchanger consisting of copper tube coils) and be controllable in a temperature range from 35 °C to 300 °C. This construction enables a prescribed air flow through this chamber. The oven temperature shall be stable within a range of ± 1 % of the respective oven temperature.

Alternative test arrangements can be used to provide the specified test conditions. For example, the test basket can be shielded by placing it inside an additional mesh wire basket. Mechanically ventilated ovens can also be used provided the test basket is shielded (e.g. by using an inner chamber or an additional mesh wire basket).

3.3 Thermocouples

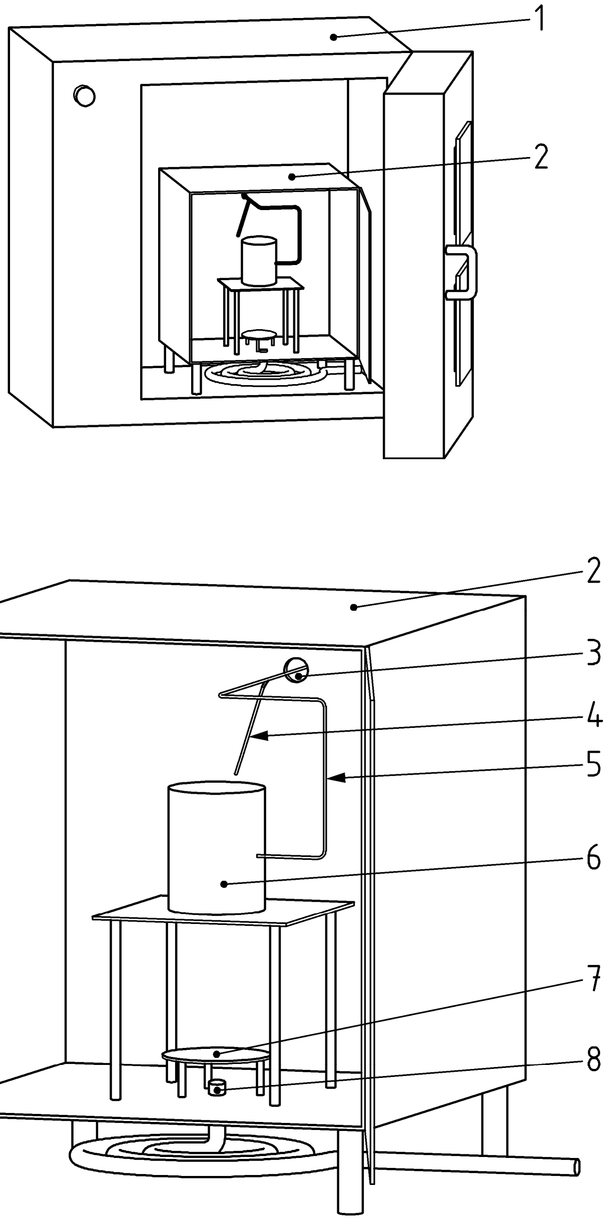
Both for measuring the sample temperature as well as for measuring the oven temperature, sheathed thermocouples with an external diameter of e.g. 1 mm are recommended.

3.4 Temperature recording equipment

Appropriate data acquisition may be used for measuring and recording signals of the thermocouples.

4 Preparation of dust samples

To investigate situations occurring in practice a representative sample should be used (produced by the operating conditions of the process). The sample characteristics shall be recorded in the test report. The bulk density of the dust for each experiment is determined by weighing the baskets as well as the moisture content of the dust before and after filling.



Key

1	heating oven
2	inner chamber (volume ≈ 50 l)
3	air outlet, diameter ≈ 10 mm
4	thermocouple for measuring oven temperature
5	thermocouple for measuring sample temperature
6	wire gauze cylinder with dust sample
7	deflector
8	air inlet (preheated air, adjustable flow rate), diameter ≈ 8 mm

Figure 1 — Suggested experimental setup for hot storage tests

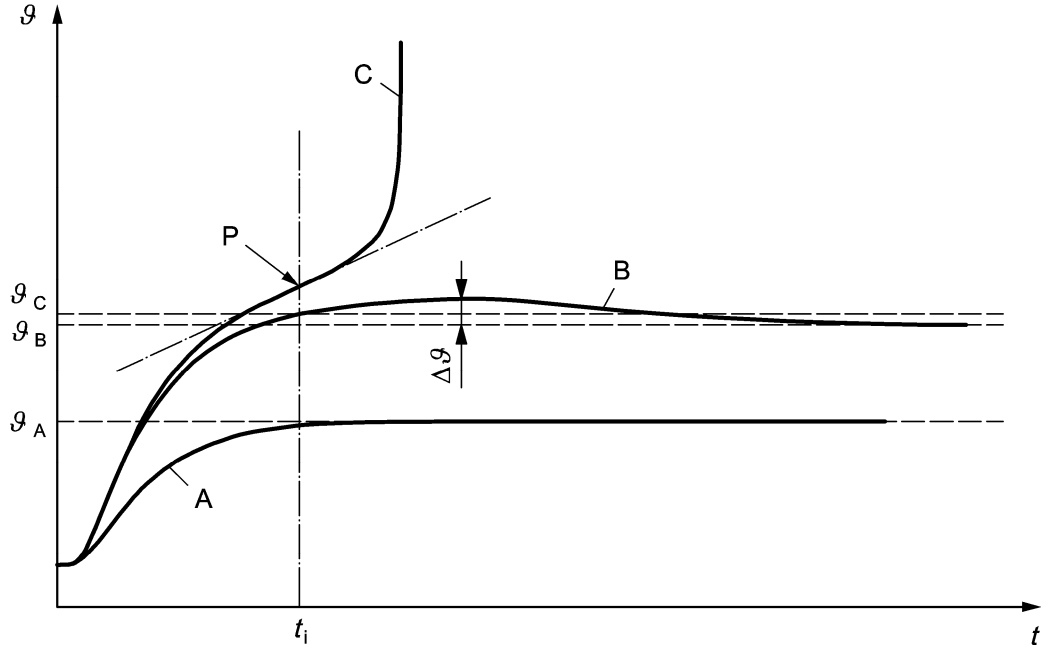
If the results are required to compare different dusts with each other (for the purpose of tabular data compilations), tests shall to be carried out with the dust having passed through a sieve of 250 μm mesh aperture and dried to constant weight at 50° C in a vacuum drying chamber. If necessary, the substance may be ground and/or sieved. All preparation procedures shall be recorded and included in the report, especially when altering the grain size, quoting the grain size distribution of the sample tested.

5 Procedure

5.1 Experimental Procedure

The test basket shall be filled with the dust sample by tapping it several times. Then remove any surplus dust from the upper margin and position the basket at the centre of the oven that has been preheated to the test temperature. The thermocouple for measuring the sample temperature is to be positioned with its hot junction directly at the centre of the sample. The hot junctions of two additional thermocouples on opposite sides will be freely installed in the air space, each at half the distance between the sample surface and the inner wall of the oven. These two thermocouples are used to measure the oven temperature, corresponding to, in critical cases, the T_{SI}. The air inlet and air outlet openings of the oven shall be left open during the test to enable fresh air to enter and combustion gases to leave the oven. The temperatures of these three thermocouples shall be recorded continuously over time. A sufficient number of hot storage tests – with a fresh dust sample for each test – shall be carried out to determine the highest oven temperature at which no ignition occurs, as well as the lowest oven temperature at which the dust sample showed an ignition for each sample volume chosen. Normally the test can be stopped if the temperature in the sample falls (see case B in Figure 2) or if a situation like case C in Figure 2 occurs. Striking features during testing (e.g. production of gases, physical changes to the sample) and mass lost of samples have to be written down.

NOTE Figure 2 is an idealised one. In some cases the type B curve is followed by a steep increase of sample temperature after the temperature drop has occurred. Attention should be paid to the fact that this may happen after significantly long periods of time. In such cases such modified type B curves have to be evaluated as type C ones. This situation may also occur with type A curves.



Key

ϑ temperature
t duration of the test
P inflection point

Figure 2 — Idealised temperature courses over time in dust samples of the same volume at hot storage temperatures ϑ_A to ϑ_C

When carrying out the tests using the procedure described in this European Standard, precautions to safeguard the health and safety of personnel and other persons shall be taken. Apart from the obvious hazards associated with the handling of the test dust and using equipment at high temperatures, there are two aspects that need special attention:

a) Many dusts will generate hazardous vapours (toxic, corrosive etc.) during decomposition. Adequate extraction should be provided to the area around the oven to capture any vapours emanating from the oven.

b) Some dusts can generate flammable gases or vapours during decomposition in sufficient quantity to create an explosive atmosphere inside the oven. Personnel shall be protected against the effects of such an explosion if this is a potential scenario, by appropriate measures.

5.2 Evaluation of tests

Figure 2 shows idealised temperature curves over time in samples from three hot storage tests of the same volume and the same dust, but at different oven temperatures. The dashed horizontal lines show the oven temperatures (ϑ_A to ϑ_C) of the respective hot storage tests (A, B and C).

If one works at temperatures significantly lower than the T_{SI} the sample temperature will approach asymptotically the oven temperature (curve A).

Higher oven temperatures show noticeable reactions with oxygen in the body of dust. Then sample temperatures temporarily will be higher than oven temperatures. This indicates the beginning of the self-heating processes, without self-ignition of the sample (curve B).

There are two methods to decide whether ignition takes place or not:

a) when the temperature at the centre of the sample rises at least 60 K above its oven temperature;

b) when the temperature at the centre of the sample shows an inflection point, with respect of time, if it occurs above the oven temperature.

Curve B relates to an oven temperature ϑ_B, slightly below the T_{SI}. At its maximum, the sample temperature surpasses the oven temperature by an amount $\Delta\vartheta$ (to be less than 60 K). Thereafter the sample temperature decreases to oven temperature.

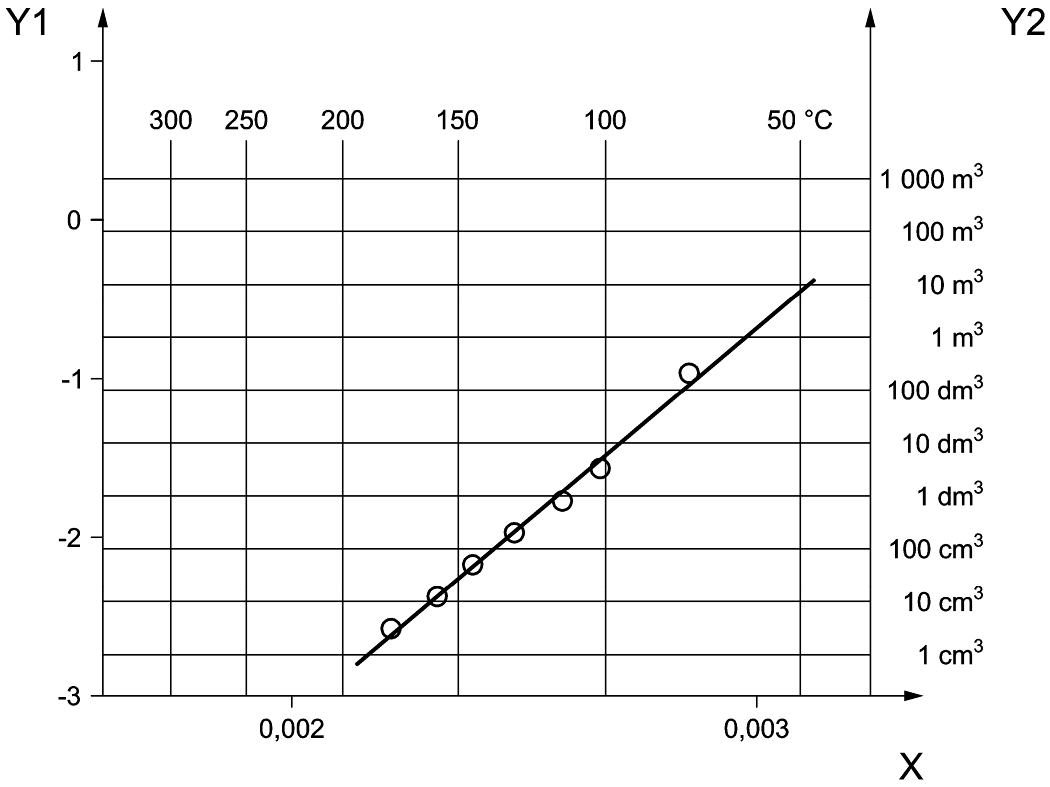
Curve C relates to the oven temperature ϑ_C , a value just above the T_{SI}. Heat production in the sample has now reached a point at which it continuously surpasses the heat loss (by heat conduction, convection and radiation). No stationary condition can now occur. After an induction time the temperature of the sample raises rapidly, until self-ignition occurs.

The self-ignition temperature lies between the oven temperatures of curves B and C.

The selection of the hot storage temperatures for the decisive final two tests shall be made in such a way that the oven temperatures of the test just producing ignition (curve C) and that of the test not producing an ignition (curve B) differ by not more than 5 K. When extrapolating the results to larger storage volumes the margin between the final tests shall be smaller or equal to 2 K. The result of T_{SI} measurements is rounded down to the nearest degree.

Figure 3 plots the T_{SI} of many different volumes of a dust as a diagram ($\lg(V/A)$ versus $1/T$). The line passing through the T_{SI}-values separates the regions of steady state and unsteady behaviour of the dust volumes. Self-ignition occurs in the region above the curve.

Besides the temperature recordings, the time interval between the positioning of a sample in the oven and the achieving of the storage temperature as well as the complete storage period, should be recorded for every test. Additionally, the time interval between the achieving of the storage temperature and the ignition (induction time, case C), i.e. the achieving of the maximum temperature (case B) should be recorded.



Key

Y1 $= \lg\left(\dfrac{V/1\,\mathrm{m}^3}{A/1\,\mathrm{m}^2}\right)$

Y2 V = volume (cylinder with $d = h$)

X reciprocal self-ignition temperature, $\dfrac{1}{T_{\mathrm{SI}}/1\,\mathrm{K}}$

Figure 3 — Pseudo-Arrhenius plot of self-ignition temperatures

In Figure 4 the necessary induction times t_i for producing critical ignition in cases of different test volumes have been plotted as lg t_i versus lg (V/A). From this figure it can be inferred, how much time is needed for samples to self-ignite when stored at temperatures slightly above T_{SI}.

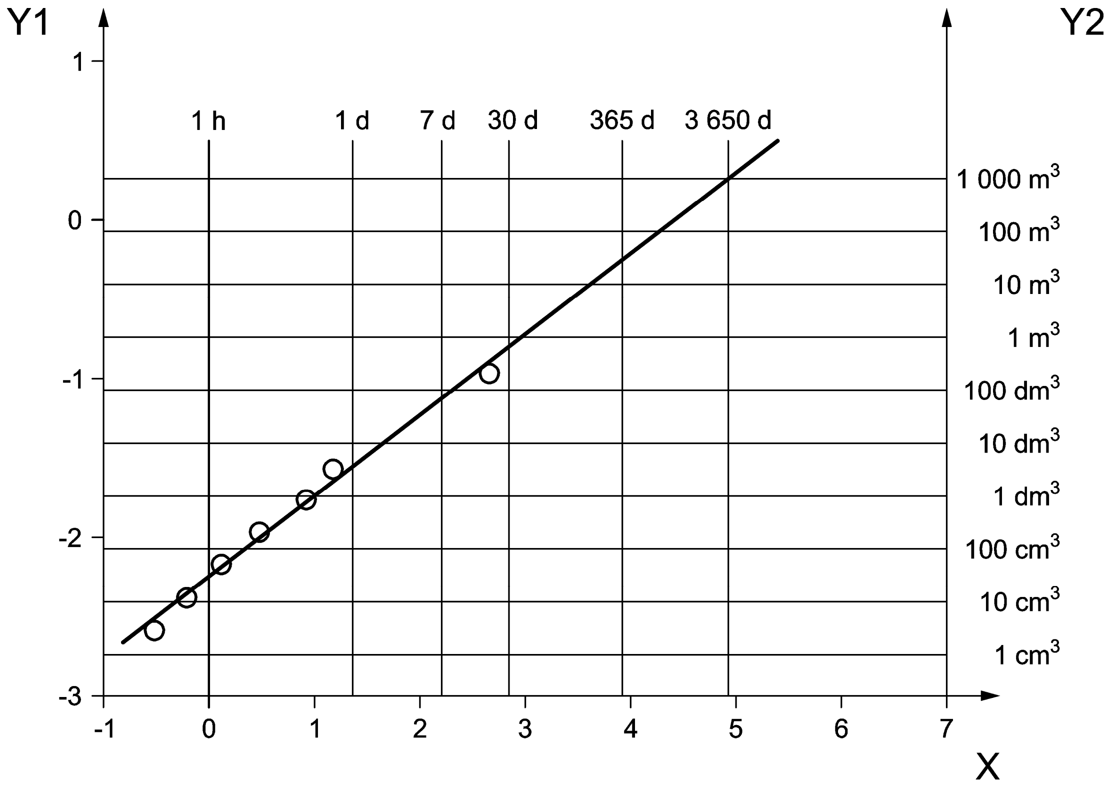
EXAMPLE A cylindrical volume ($d = h$) of 1 m^3 of the dust would self-ignite above 60 °C (see Figure 3). If that volume of the dust is stored at that constant temperature, a time of more than one month would pass until a fire could break out.

NOTE At temperatures higher than those equivalent to the respective T_{SI}, induction times will be reduced significantly.

The results of these tests are documented in a table, comparing sample volumes tested, the respective T_{SI} values, and induction times. Further, results are represented in graphs, such as Figure 3 and Figure 4.

5.3 Calibration of thermocouples

Thermocouple characteristics should be calibrated at annual intervals according to internal fixed rules.



Key

Y1 $= \lg\left(\dfrac{V/1\,\mathrm{m}^3}{A/1\,\mathrm{m}^2}\right)$

Y2 V = volume (cylinder with d = h)

X = lg (t_i / 1 h)

Figure 4 — Dependence of combustion induction times (t_i) on the volume/surface ratios of dust heaps

6 Test report

The test report shall include at least the following details:

a) reference to this European Standard (EN 15188:2007);

b) name and address of the test institute which carried out the tests;

c) number of the report, consecutive pagination of individual pages and information on the total number of pages in the report;

d) name and address of the client;

e) characterisation of the sample:

   1) sample description (including when known particle size distribution and moisture content);

   2) name or chemical composition of the sample;

   3) bulk density;

   4) sample preparation (if done e.g. for comparison of different dusts);

f) any changes to the test equipment or test procedures specified in this standard, the reasons for the changes and any other information relevant to specific tests;

g) date of receipt of the sample and testing dates;

h) striking features during testing (e.g. production of gases, physical changes to the sample);

i) test results (table of volumes tested together with respective T_{SI} values and induction times, diagrams of lg (V/A) versus $1/T$, and of lg (V/A) versus lg t_i;

j) signature and position of the person responsible for the technical operation of the test process and date of the test report;

k) statement that the results exclusively relate to the samples as received and tested.

Annex A
(informative)

Evaluation of experimental results for self-ignition temperatures

A.1 Introduction

For the evaluation of the results of the experimental determination of self-ignition temperatures several methods are available, which may be distinguished by their mathematical background.

The simplest way to obtain a correlation between the relevant geometrical parameter *V*/*A* and the corresponding self-ignition temperature is the lg (*V*/*A*) versus $1/T_{\mathrm{SI}}$ plot as given in Figure 3.

A.2 Methods based on the thermal explosion theory

A more sophisticated method is based on the so-called thermal explosion theory as worked out by Frank-Kamenetzkii. According to this theory a correlation between a characteristic length of the dust sample r and its T_{SI} is given by the following equation:

$$\ln\left(\frac{\delta_{\mathrm{cr}}\, T_{\mathrm{SI}}^2}{r^2}\right) = \ln\left(\frac{\rho\, H_{\mathrm{o}}}{\lambda}\,\frac{E}{R}\,k_0\right) - \frac{E}{R\, T_{\mathrm{SI}}} \tag{A.1}$$

where

δ_{cr} is the critical Frank-Kamenetzkii parameter;

T_{SI} is the self-ignition temperature;

r is the radius or characteristic length of the dust sample;

ρ is the bulk density;

H_{o} is the gross calorific value;

λ is the heat conductivity;

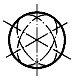
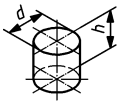
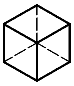
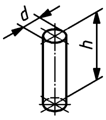
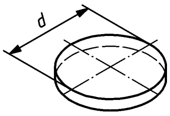
k_0 is the pre-exponential factor;

E is the apparent activation energy;

R is the universal gas constant.

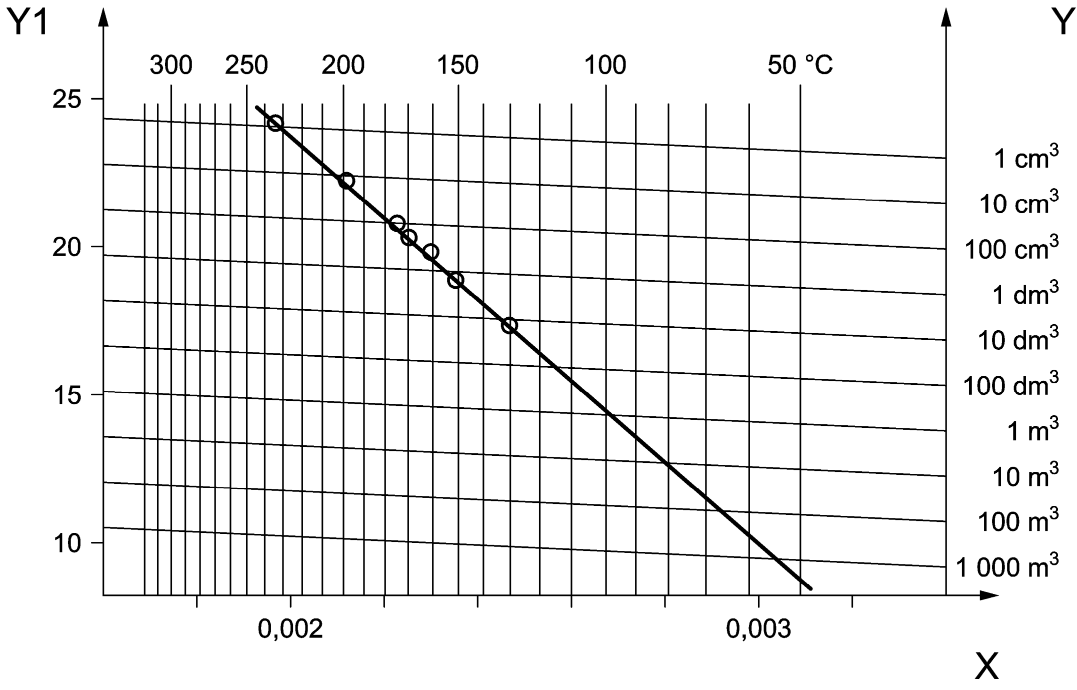
The critical Frank-Kamenetzkii parameter, δ_{cr}, depends on the geometry of the dust sample and has the values as displayed in Table A.1

Table A.1 — Critical Frank-Kamenetzkii parameter δ_{cr} of different simple geometries

Geometry of heap		Critical Frank-Kamenetzkii parameter δ_{cr} ($Bi = \infty$)[a]
	Sphere	3,32
	Cylinder ($d = h$)	2,76
	Cube	2,52
	Cylinder ($h \rightarrow \infty$)	2,00
	Plane slab ($d \rightarrow \infty$)	0,88

[a] *Bi* is the Biot number, see Equation (A.4).

Equation (A.1) gives a linear correlation between the term ln ($\delta_{cr} \cdot T_{SI}^2/r^2$) and the reciprocal T_{SI} with the term $\frac{E}{R}$ as the slope. Examples are given in the so-called Arrhenius plot shown in Figure A.1.



Key

Y1 $= \ln\left(\delta_{\text{cr}} \dfrac{T_{\text{SI}}^2 / 1\,\text{K}^2}{r^2 / 1\,\text{m}^2}\right)$

Y2 V = volume (cylinder with $d = h$)

X reciprocal self-ignition temperature, $\dfrac{1}{T_{\text{SI}} / 1\,\text{K}}$

Figure A.1 — Arrhenius plot of self-ignition temperatures – Frank-Kamenetzkii condition (*Bi* = ∞)

Provided the constants contained in Equation (A.1) are all known, this equation or the Arrhenius plot respectively, offers the possibility to predict iteratively the unknown T_{SI} value for any value of r or vice versa.

As pointed out in detail by Frank-Kamenetzkii [1], his approach is based on the assumption of an infinite heat transfer coefficient at the boundary surface between the dust sample and its environment. This is, however, valid only for large sample sizes. A more realistic approach was proposed by Thomas [2], introducing a correction of δ_{cr} values with respect to finite values of the heat transfer coefficient. The corrected values, δ_{cr} (Th), then become

— for cylinders ($d = h$):

$$\delta_{cr}(\text{Th})_{\text{cyl}} = \frac{0{,}8047}{0{,}2830 + \dfrac{0{,}7292}{Bi}} \qquad \text{(A.2)}$$

where

$\delta_{\text{cr}}(\text{Th})_{\text{cyl}}$ is the critical Frank-Kamenetzkii parameter, corrected according to Thomas, for cylinders;

Bi is the $_{\text{Biot}}$ number.

— and for cubes:

$$\delta_{cr}(\mathrm{Th})_{\mathrm{cube}} = \frac{0{,}7009}{0{,}2728 + \frac{0{,}6351}{Bi}} \tag{A.3}$$

δ_{cr} $(\mathrm{Th})_{\mathrm{cube}}$ is the critical Frank-Kamenetzkii parameter, corrected according to Thomas, for cubes;

Bi is the Biot number.

NOTE For details see Bowes [3] and Hensel & John [4].

The Biot number, *Bi*, may be calculated for compact shapes (like equidistant cylinders and cubes) as follows in Equation (A.4):

$$Bi = \frac{(H_{\mathrm{r}} + H_{\mathrm{c}})\,r}{\lambda} = \frac{\left[4\,\sigma\,T_{\mathrm{amb}}^{3} + \left(2 + 0{,}6 \times Ra^{1/4}\right)\frac{\lambda_{\mathrm{air}}}{d}\right] r}{\lambda} \tag{A.4}$$

where

Bi is the Biot number;

H_{r} is the radiative amount on heat transfer coefficient;

H_{c} is the convective amount on heat transfer coefficient;

r is the radius or characteristic length of compact shaped bodies;

σ is the Stefan-Boltzmann coefficient;

T_{amb} is the ambient temperature of the sample;

Ra is the Rayleigh number;

λ is the heat conductivity of dust sample;

λ_{air} is the heat conductivity of air;

d is the diameter of body.

This correction may considerably alter the solution of Equation (A.1). Despite the thermal explosion theory is more sophisticated and also more precise than the empirical lg (*V*/*A*)-versus-1/T_{SI} plot, there are some restrictions according to its applicability:

a) Only simple geometries like those as specified in Table A.1 can be treated;

b) some thermal boundary conditions cannot be treated, e.g. heat flux to be unequal to zero;

c) information about the temperature evolution with time cannot be obtained.

A.3 Numerical solution of Fourier's equation

All restrictions connected with the thermal explosion theory may be overcome by solving numerically the differential equation describing the evolution of the temperature field in the dust sample with time (Fourier's equation, Equation (A.5)),

$$\frac{\partial T}{\partial t} = a\nabla^2 T + \frac{1}{\rho\,c}\,\rho\,H_{\mathrm{o}}\,k_0\,\mathrm{e}^{-\frac{E}{R\,T}} \tag{A.5}$$

where

T is the temperature;

t is the time;

a is the thermal diffusivity $\left(a = \lambda / \rho \cdot c\right)$;

ρ is the bulk density;

H_o is the gross calorific value;

k_0 is the pre-exponential factor;

E is the apparent activation energy;

R is the universal gas constant.

The main advantages of applying Equation (A.5) compared to the above mentioned methods are:

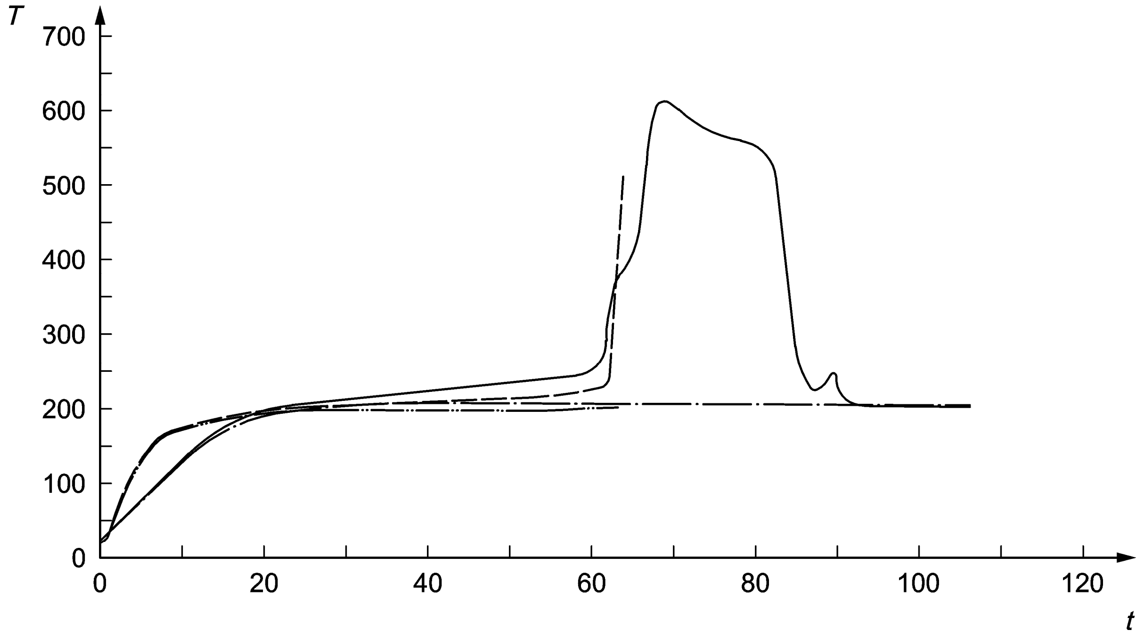
a) Any geometrical configuration may be considered;

b) there are no restrictions according to the boundary conditions;

c) entire process from the beginning of the sample storage until the occurrence of the ignition may be calculated.

An appropriate method to solve Equation (A.5) numerically is provided by the Finite Element Method. Suitable software codes are available on the market.

As an example, Figure A.2 shows a comparison of measured and computed temperature-versus-time curves of hot storage experiments.



Key

T temperature, in °C

t time, in min

——·—— experimental, with oven temperature 195 °C

———— experimental, with oven temperature 199 °C

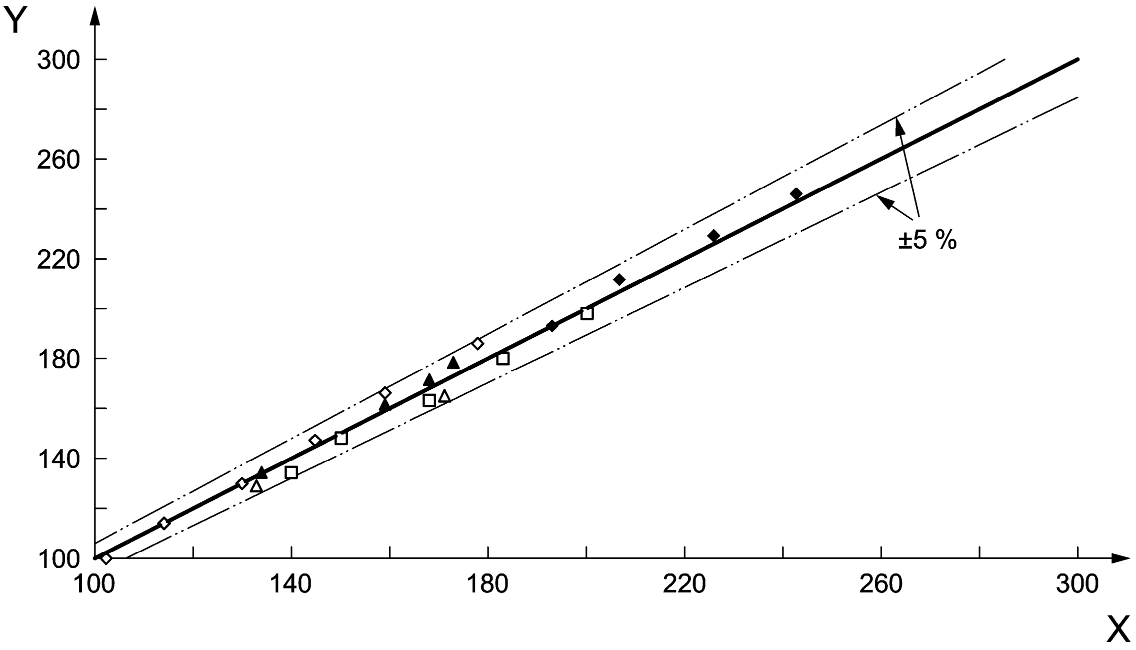
— — — computed, with oven temperature 184 °C

——··—— computed, with oven temperature 182 °C

Figure A.2 — Self-ignition behaviour of cork dust – Comparison of experimental and computed temperature-time curves for a volume of 100 cm³ (cylinder with *d* = *h*)

Figure A.3 gives a comparison of experimental and computed TSI for five different dusts as published by Krause and Schmidt [5] showing the capability of the numerical method applied to reproduce the experimental results satisfactorily.

It should, however, be mentioned that a limited number of experiments inevitably remain to generate the input data needed for the calculations.



Key

Y	$T_{\mathrm{SI,comp.}}$, in °C	▲	methionine
X	$T_{\mathrm{SI,exp.}}$, in °C	△	cocoa powder
◇	black coal (aged)	◆	cornstarch
□	cork dust		

Figure A.3 — Comparison of experimental and computed (Finite Element Method) self-ignition temperatures for five different dusts

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 94/9/EC

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 94/9/EC of 23 March 1994 concerning equipment and protective systems intended for use in potentially explosive atmospheres.

Once this standard is cited in the Official Journal of the European Union under that Directives 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 the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1— Correspondence between this European Standard and Directive 94/9/EC

Clauses of this EN	Essential Requirements (ERs) of EU Directive 94/9/EC	Qualifying remarks / Notes
6	Annex II, 1.2.4	

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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