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Fertilizers — Determination of dust content

National foreword

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Fertilizers - Determination of dust content

Engrais - Détermination de la teneur en poussière

Düngemittel - Bestimmung des Staubgehaltes

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Contents

European foreword

This document (CEN/TR 14061:2021) has been prepared by Technical Committee CEN/TC 260 “Fertilizers and liming materials”, the secretariat of which is held by DIN.

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This document supersedes CR 14061:2000.

Significant changes between this document and CR 14061:2000 are as follows:

a) modification of the figures to contain neutral language;

b) adaption to current principles and rules for structure and drafting.

This document is published by the European Committee for Standardization. It is published for information only and does not have the status of a European Standard.

The Annexes A and B are informative.

Introduction

0.1 General

In production and handling of fertilizers dust generation is of great concern by both producers and users of the fertilizer products. For health and environmental reasons, it is of great interest to control and reduce the amount of dust generation. In the fertilizer industries there are a wide variety of apparatus for dust determination, most being used as “in-house” methods in plants and laboratories.

The content of this document was developed by CEN/TC 260/WG 2 between 1991 and 2000 in order to develop a standard dust test. A spouting bed apparatus was designed for gravimetric determination of dust, and after two preliminary ringtests a conclusive ringtest involving six laboratories was carried out. Not being able to develop a statistical significant method for the determination of dust, TC 260 decided by resolution 105/1997 to change the deliverable of this work item into a CEN Technical Report. The change of deliverable has been approved by CEN/BT with its resolution BT C172/1999.

0.2 General background

When handling fertilizer grains, dust is at every moment generated on the surface. The fertilizer thus contains more or less free dust, and has a potential for generating more dust (abrasion dust) when subject to subsequent handling.

In all existing gravitational test methods dust will be generated during the testing time, and the two types of dust will be measured simultaneously. The scope of the method is expressed in Annex A and the aim is to:

“...specify a method for the determination of the ***dust potential*** *of solid fertilizers and is applicable to granular and prilled fertilizers.*

Dust particles, which cause reduced visibility in air are too small to be determined by this method.”

0.3 Background for choice of method

Fluidized particle powders are generally divided into four characterizing groups (A, B, C, D) [1]. Group C particles are small, cohesive and are difficult to fluidize. Aeratable powders belong to group A, and many fluidized bed catalysts characterize this group. Sand typifies group B, in which inter-particle forces are negligible, in contrast with group A powders. Large and/or dense particles in general belong to group D, and fertilizer particles (2 mm to 4 mm) in air are in this group. A flow diagram can be used to broadly identify flow regimes appropriate to combinations of gas velocity and particle properties. It can be shown that the fertilizer system is in the lower part of the spouted bed regime.

A criterion that can be used to distinguish between group B and D is the numerical inequality that classifies a powder as spoutable if:

$$(\rho_p - \rho_f) \cdot d_p^{1,24} > 0,23$$

For a typical fertilizer this value will be about 1,4 and about 0,5 for an urea prill.

From previous experiments with other methods based on a fluidized bed and the above calculations, it was decided to base the method upon the spouted bed principle.

1 Scope

This document is applicable to the determination of dust potential of solid fertilizer, obtained in prilling or granulation process. Compacted or crystalline materials were not considered.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Symbols and abbreviated terms

4.1 Technical Symbols

C_D	drag coefficient
d_p	particle diameter, expressed in metres (m)
d_s	average spout diameter, expressed in metres (m)
D_p	average particle diameter, expressed in metres (m)
D	diameter of spouting section, expressed in metres (m)
D_i	inner orifice diameter, expressed in metres (m)
g	gravity, expressed in kilograms per metres per square seconds (kg/m s^2)
H	bed height, expressed in metres (m)
Re	Reynolds number
v_t	terminal velocity, expressed in metres per seconds (m/s)
v_{ms}	minimum spouting height
ρ_p	particle density, expressed in kilograms per metres to the third power (kg/m^3)
ρ_f	fluid density, expressed in kilograms per metres to the third power (kg/m^3)
μ	viscosity, expressed in Newton seconds per square metres (Ns/m^2)

4.2 Statistical symbols and abbreviations

df	degrees of freedom
F	mean square between groups/mean square within groups
F_{crit}	tabulated value form the F-distribution for a significance level of 0,05 confidence interval
MS	mean square
P-value	significance level corresponding to a given F (should be less than 0,05 to reject the null-hypothesis)
SS	sum of squares

5 Calculation of the spouting bed apparatus

5.1 Particle terminal velocity

A particle falling freely in a fluid will finally reach its terminal velocity. The forces acting on it are gravitational, accelerating, buoyancy force and drag (friction) force. The drag force can be expressed by a drag coefficient C_D, which is expressed by Formula (1):

$$C_D = \frac{4}{3}\frac{\left(\rho_p - \rho_f\right) d_p g}{\rho_f v_t^2} \tag{1}$$

By calculation and plotting log C_D against log Re (Reynolds number) the so-called “standard drag-curve” can be obtained which has three broad regions:

— Laminar region, $Re < 0{,}2$;

— Transitional region (tr), $0{,}2 < Re_{tr} < 1000$;

— Turbulent region, $Re > 1000$.

The drag coefficient equation can be multiplied with $\rho_f^2 v_t^2 d_p^2/\mu^2$ and rearranged as:

$$C_D Re_t^2 = \frac{4}{3}\frac{\left(\rho_p - \rho_f\right) d_p^3 g}{\mu^2} \tag{2}$$

The group $C_D Re_{tr}^2$ is dimensionless containing only the physical properties of the particle/fluid system including the particle diameter d_p. The Re-number and the terminal velocity (v_t) can be estimated by graphical methods.

Calculations prove that transitional flow describes the system of fertilizer dust in air, thus giving Table 1.

Table 1 — System of fertilizer dust in air

Particle size d_p **µm**	**$C_D Re_{tr}^2$**	**Re_{tr}**	**v_t** **m/s**
100	88	3,0	0,5
150	300	7,7	0,8
200	704	15,0	1,3

The air velocity was chosen to be 0,75 m/s in the classification section (110 mm ⌀) of the apparatus, and irregular particles less than 150 µm will then be carried over, according to calculations.

5.2 Spouting section

The spouting section is characterized by the "minimum spouting height", v_{ms}, that depends on the particle (fertilizer) properties, spouting column geometry and the inlet orifice diameter:

$$v_{ms} = \left(\frac{d_p}{D}\right)\left(\frac{D_i}{D}\right)^{1/3}\left(\frac{2gH\left(\rho_p - \rho_f\right)}{\rho_f}\right)^{1/2} \quad (3)$$

Based on 500 g fertilizer, v_{ms} = 1,0 m/s and diameter D = 85 mm of spouting section, the theoretical expression of v_{ms} [1] was rearranged. Inner orifice diameter D_i:

$D_i^{1/3}$= 5,645 10^{-4} d_p

thus giving the figures:

d_p	2,0 mm	3,0 mm	4,0 mm
D_i	22,5 mm	6,6 mm	2,8 mm

Depending on the average particle diameter (d_p) the inner orifice diameter (D_i) should thus be varied, according to the theory.

5.3 Maximum spoutable bed height

The maximum spoutable bed height (H_s) can be estimated from the correlation:

$$H_s = 0{,}345\ (D^2 - d_s^2) \cdot D^{0{,}384} \cdot d_s^{-1{,}384} \quad (4)$$

where d_s is the average spout diameter. D = 85 mm and estimated d_s = 15 mm gives $H_s \sim$ 38 mm, which is higher than the chosen bed height. However, the calculation assumes spherical particles, and practical maximum spoutable depth will therefore be lower than the theoretical value.

Based on the calculations above the spouting bed apparatus was designed and tested.

5.4 Design of apparatus

The column was designed with the dimensions according to Table 2.

Table 2 — Design of apparatus

Classification section		Spouting section	
Column diameter	110 mm	Column diameter	85 mm
Column height	400 mm	Column height	120 mm
Outlet diameter	40 mm	Cone height	85 mm
Air velocity	1 m/s	Total height (incl. bottom inlet)	220 mm
Fertilizer mass	400 g	Cone inlet diameter	23 mm[b]
Air rate	25 m³/h[a]	Air velocity (overall)	1,2 m/s

[a] The air velocity in the classification section was chosen to be 0,75 m/s in order to carry 150 m particles over (see 5.1).

[b] Adapters with diameters 7, 8, ...,18 mm were made to include most fertilizers. A 440 m grid was fitted into the adapter inlet.

5.5 Flowmeter

A calibrated flowmeter is connected to the column. The flowmeter should have a capacity of approximate 40 m^3/h.

6 Initial testing

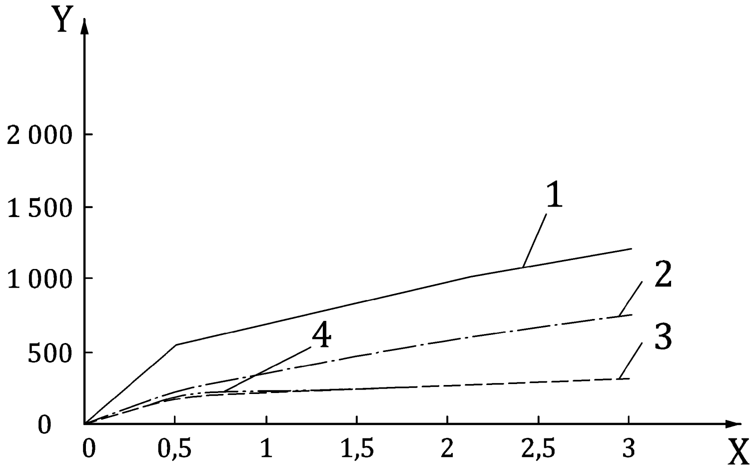
6.1 Determination of dust weight

Initially the dust was collected by a filter at the outlet of the apparatus. However, because of safety (pressurized air in the glass apparatus) and inaccuracy in measurements due to accumulation of dust on column walls, it was decided to record the difference in weight of the fertilizer sample during the test.

6.2 Setting the test time

Initial tests were carried out in order to set the test-time. Dust generation of selected NP/NPK-fertilizers were measured at increasing time intervals.

Figure 1 shows a decreasing slope at approximate 0,5 min test time which is due to a change from free dust to abrasion dust. In order to include approximately the same amount of free dust as abrasion dust, a 2 min test time was chosen.



Key

X time (min)
Y dust (mg/kg)
1 blended NPK
2 granulated NP
3 granulated NPK
4 prilled NPK

Figure 1 — Dust generation as function of time

6.3 Preliminary ringtests

Two preliminary ring tests were run in order to improve the method.

7 Conclusive ring test

7.1 General

A final and conclusive ring test was run with six participating laboratories involved. Ten replicates of five fertilizers were tested at each laboratory and statistical results calculated by ANOVA.

7.2 Apparatus

The apparatus is described in Annex A.

7.3 Sample preparation

The ring tests were conducted using the following five types of homogenous fertilizer products: granulated urea; granulated CAN; granulated PK; granulated NPK; prilled NPK. The relevant producer of each fertilizer sent 12 separate samples (10 as required for the tests plus 2 spares in case a test had to be aborted) to the participant laboratories.

7.4 Procedure, test plan

The drafted test procedure is enclosed in Annex A. Ten replicates were tested for all five fertilizers.

7.5 Statistical methods

7.5.1 Statistical model

Each test result, y, is the sum of four components: $y = m + \mathrm{A} + B + e$

where m is the general average, A is the adapter diameter used, B is the between-laboratory variation and e is the random error occurring in every test.

The model for sample j at laboratory i is: $y_{\mathrm{ij}} = m + b_0 A_i + b_i + e_{ij}$

where b_0 and b_i are regression coefficients and A_i is the adapter diameter used in laboratory i.

7.5.2 Outliers

Assuming that the statistical model is correct, the residuals, e are normal distributed. A normal-plot is used to check for normality.

7.5.3 Regression analysis

In the regression analysis the outliers are removed. The regression analysis gives one significant PLS component (one-component explains model).

7.5.4 Correction for adapter-effect

After regression analysis the effect of chosen adapter was removed, and variance within laboratory and between laboratories were analysed.

7.5.5 ANOVA-analysis

The ANOVA-analysis performs simple analysis of variance, which tests the hypothesis that means from several samples are equal. The confidence-level is set to 95 %. Generally, analysis of variance, or ANOVA, is a statistical procedure used to determine whether means from two or more samples are drawn from populations with the same mean. This technique expands on the tests for two means, such as the *t*-test.

7.6 Statistical analysis of test data

7.6.1 Deviation from test plan

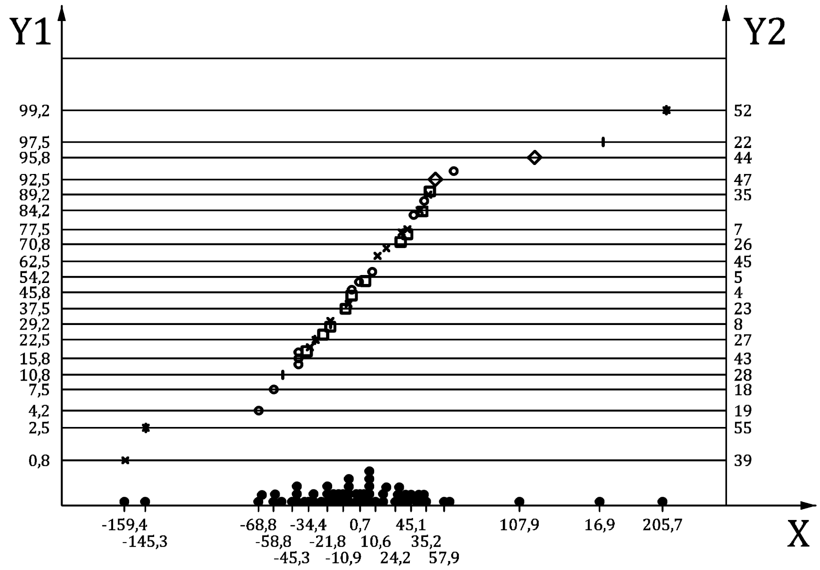
One laboratory (Lab-A) applied 25,2 m^3/h of air instead of 25,0 m^3/h as prescribed.

7.6.2 Example — granulated NPK

NOTE Five outliers were found.

7.6.2.1 Finding outliers

Assuming that the statistical model is correct, the residuals, e, are normal distributed. A normal-plot can be used to check for normality. In Figure 2 the residuals from PLS regression are plotted in a normal-plot. From the figure, five outliers are found. Outliers are samples not lying on the straight line defined by the majority of points. The outliers are laboratory Lab. C (22), Lab. D (39), Lab. E (44), Lab. F (52), Lab. F (55).



Key

X component 1, dust

Y1 percentiles (of normal distribution of residuals of PLS regression)

Y2 number of the measurement

□ Lab-A (measurement 1-10)

○ Lab-B (measurement 11-20)

\+ Lab-C (measurement 21-30)

x Lab-D (measurement 31-40)

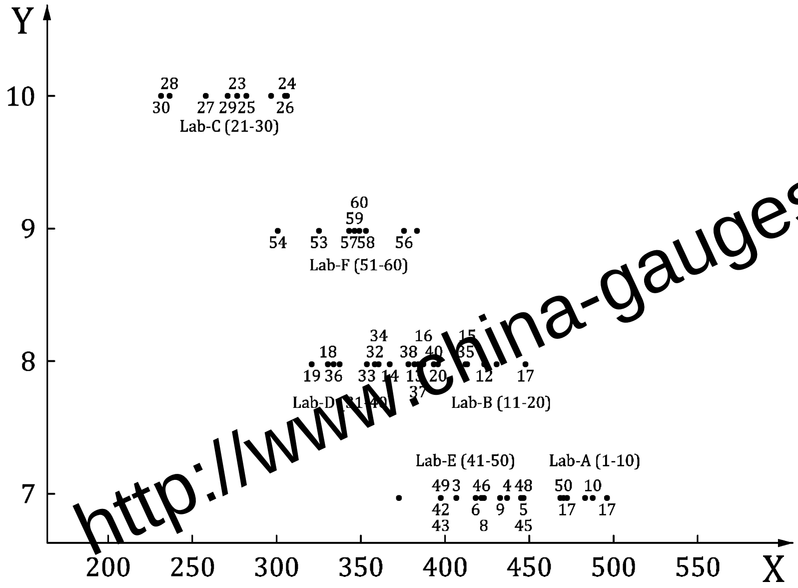
◇ Lab-E (measurement 41-50)

* Lab-F (measurement 51-60)

• residuals of the PLS regression

Figure 2 — Identification of outliers, granulated NPK

In Figure 3 measured dust is plotted against an adapter.



Key

X dust (mg/kg)

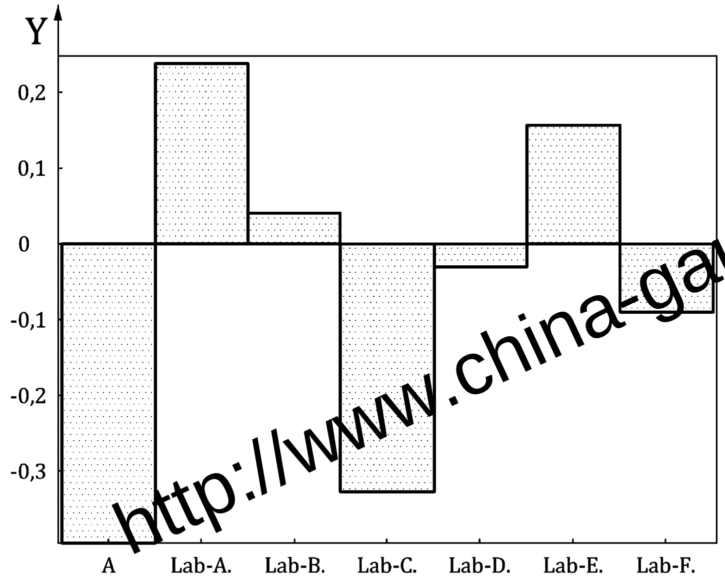
Y adapter

Figure 3 — Adapter versus dust, granulated NPK

For granulated NPK there is a relation between dust and the adapter used. The same relation is to some degree visible for granulated urea but not for the other fertilizers.

7.6.2.2 Interpretation of regression model

In the following analyses, the outliers are removed. Note that the variable "Air" is confounded with LAB-A. This means that the estimated effect of LAB-A is a sum of Air and LAB-A. Prior to regression analysis the variables are standardized. The regression analysis gives one significant PLS component. This one-component model explains 77 % of total variation in dust. The regression coefficients are given in Figure 4.



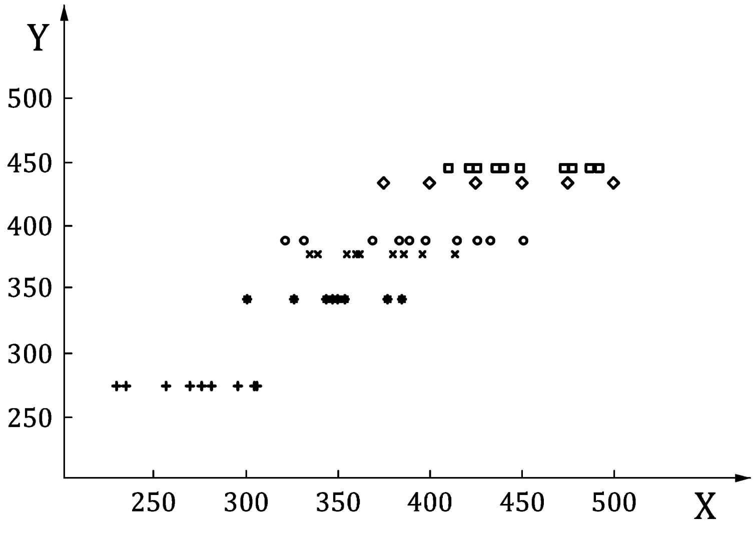
Key

A adapter

Y component 1, regression coefficient

Figure 4 — Regression coefficients, granulated NPK

Figure 4 shows the relative importance of each factor/laboratory. Obviously the **adapter** is the most important variable, followed by **LAB-A** (confounded with **Air)**, **LAB-C** and **LAB-E**. The regression coefficients given in Figure 4 are the same as given in the statistical model. The relation between modelled and measured **dust** is given in Figure 5.



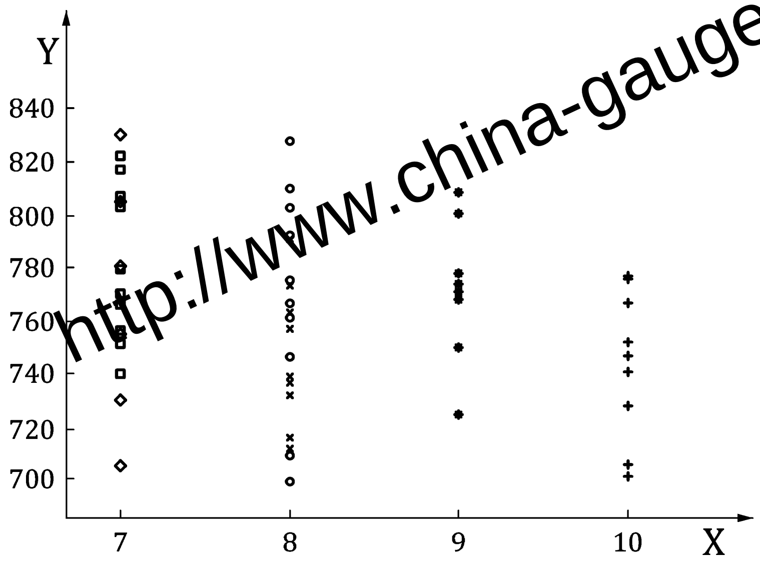
Key

X	measured dust (mg/kg)	+	Lab-C (measurement 21-30)
Y	modelled dust (mg/kg)	x	Lab-D (measurement 31-40)
□	Lab-A (measurement 1-10)	◇	Lab-E (measurement 41-50)
○	Lab-B (measurement 11-20)	*	Lab-F (measurement 51-60)

Figure 5 — Modelled versus measured dust, granulated NPK

7.6.2.3 Removing adapter effect

From Figure 4 it is clear that the most important factor is the adapter. This effect can be removed from the data by a simple subtraction. In Figure 6 the corrected dust values are plotted versus the adapter. After this subtraction there is no relation between dust and adapter.



Key

X adapter

Y corrected dust (mg/kg)

□ Lab-A (measurement 1-10)

○ Lab-B (measurement 11-20)

\+ Lab-C (measurement 21-30)

x Lab-D (measurement 31-40)

◇ Lab-E (measurement 41-50)

* Lab-F (measurement 51-60)

Figure 6 — Corrected dust values versus an adapter, granulated NPK

7.6.2.4 ANOVA analysis

The ANOVA analysis after subtraction of adapter effect for granulated NPK is given in Table 3, and summary of results in 7.6.3. $F < F_{crit}$ means that we cannot say that any mean value is different from the others.

Table 3 — ANOVA-analysis for granulated NPK after subtraction of adapter effect

ANOVA: Single factor

SUMMARY

Groups (LABORATORIES)	Count	Sum	Average	Variance
1	10	7 815	781,5	854,766 7
2	10	7 695	769,5	1 776,1
3	9	6 704	744,888 9	784,111 1
4	9	6 725,4	747,266 7	692,75
5	9	6 848,6	760,955 6	1 684,028
6	8	6 182,4	772,8	708,571 4

ANOVA

Source of variation	SS	df	MS	*F*	*P*-value	F_{crit}
Between Groups	9 830,359	5	1 966,072	1,7865 12	0,133 103	2,404 377
Within Groups	53 924,91	49	1 100,508			
Total	63 755,27	54				

The summary part in Table 3 shows the estimated mean and variance for each laboratory (group). It is checked if these mean values (representing a laboratory) are different from mean values representing the other laboratories.

The ANOVA-part of the table shows the test whether the variation between groups (laboratories) and variation within groups are equal or not.

The probability of obtaining a *F*-value of 1,865 12 if the two mean squares (MS), in fact, are equal is 0,133, i.e. 13,3 %. This probability is considered too high to reject the null-hypothesis (that the two MS are equal).

Accordingly, after subtraction of adapter effect for granulated NPK it cannot be rejected that data from different laboratories are from the same population.

7.6.3 Summary of ANOVA

ANOVA analysis is carried out on all five fertilizers, and results are presented in Table 4. Except granulated NPK, the result $F > F_{crit}$ is obtained for all fertilizers, and the *P*-value clearly shows that there are good reasons to reject the hypothesis that the data from different laboratories are from the same population.

Accordingly, the differences between test data from the various laboratories are too large and not statistically acceptable, even after subtraction of the adapter effect.

Table 4 — ANOVA analysis for five fertilizers after subtraction of adapter effect

Fertilizer	Number of outliers	df	MS	*F*	F_{crit}	*P*-value
		between laboratories				
		within laboratories				
Granulated NPK	5	5 49	1 966 1 100	1,786 512	2,404 377	0,133 103
Granulated PK	0	5 54	12 083 982 1 605 807	7,525 176	2,386 066	2,02E-05
Granulated CAN	1	5 53	5 117 631	8,106 502	2,389 442	9,77E-06
Granulated urea	5	5 49	912 732 7 362	123,976 2	2,404 377	1,36E-26
Prilled NPK	1	5 53	89 344 1 545	57,820 54	2,389 442	2,98E-20

8 Other methods

In house methods for visual dust determination are given in Annex B. None of the methods have been considered by CEN/TC 260/WG 2 as applicable for standardization, and no testing has been made in this field.

In an extensive research report [2] conclusions are drawn with respect to standardization if dustiness tests, and there are references to several studies. In the report it is concluded that:

"At the moment, only a qualitative comparison between different materials can be made. This means that standard materials with known properties and particle size distributions can the dustiness generating potential be determined."

Based on these conclusions and the evaluations made in the group, it was decided not to initiate any further standardization work in the field of dust.

9 Conclusion

A gravimetric test method for dust-potential based on the spouting-bed principle has been developed. A ringtest was arranged with six laboratories and five fertilizers involved. Statistical analysis (ANOVA) of the test results concluded that except for one fertilizer there are good reasons to reject that the data from different laboratories are from the same population. This means that the differences between test data from the various laboratories are too large and not statistically acceptable.

The gravimetric dust potential method developed can therefore not be used as a standard test method for the determination of dust.

Based on an external research study and evaluations in the Working Group, it was decided not to pursue any further standardization work in the field of dust measurement, and not to publish the final draft as a European standard.

Annex A
(informative)

Method for the determination of dust potential

A.1 Introduction

Dust particles generated during production and handling of solid fertilizers may reduce the quality of the material with respect to storage and spreading.

The amount of free dust in a fertilizer increases steadily during handling because of abrasion and breakdown. The dust formation may affect the caking tendency, and influence the flow characteristics of the fertilizer.

The dust potential as measured by the method described in this document, using a current of air, includes both the free dust and that generated by abrasion.

A.2 Scope

This Annex specifies a method for the determination of the dust potential of solid fertilizers and is applicable to granular and prilled fertilizers.

Dust particles which cause reduced visibility in air are too small to be determined by this method.

A.3 Terms and definitions

A.3.1

dust potential
sum of the free dust and the dust produced by abrasion, defined as the loss in mass of a fertilizer in a spouting bed under specified conditions of time and air flow

A.4 Principle

Weighing of the fertilizer before and after exposure to a flow of air in a spouting bed for a specific time.

A.5 Apparatus

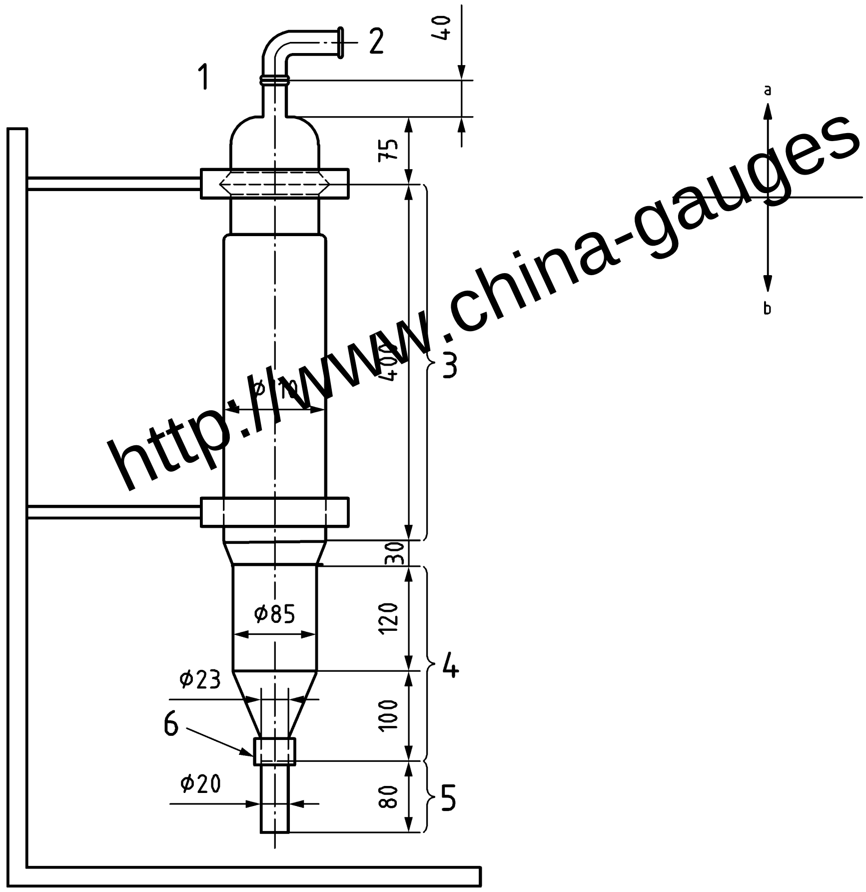
A.5.1 Dust potential apparatus (see Figure A.1), made up from following:

A.5.1.1 Column, made of glass.

The glass column has a lower spouting section (⌀ = 85 mm ± 0,2 mm) and an upper classification section (⌀ = 110 mm ± 0,2 mm).

A.5.1.2 Glass head, mounted on top of the column with a rubber o-ring and a steel-clip.

Linear dimensions in millimetres



Key

1	BCP	5	adapter
2	open outlet	6	screw cap (inner diameter 32 mm)
3	classification section	a	optional dimensions
4	spouting section	b	mandatory dimensions

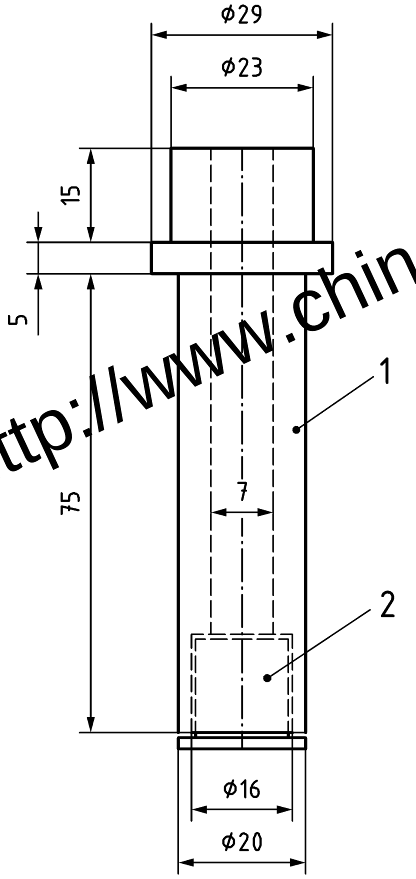
Figure A.1 — Apparatus for measuring dust potential

A.5.1.3 **Adapters**, made of PTFE with inner diameters in the range from 7 mm to 18 mm (see Figure A.2). A grid (0,5 mm) and a washer is fitted to the inlet of the adapter.

A.5.1.4 **Base**, made of steel with adjusting screws.

The dimensions of this apparatus given in the text and figures are mandatory.

Linear dimensions in millimetres



Key

1 adapter

2 grid

Figure A.2 — Adapter for dust potential apparatus

A.5.2 Flowmeter, of two-valve type calibrated in the flow range 15 Nm^3 air/h to 35 Nm^3 air/h at ambient temperature.

A.5.3 Balance, capable of weighing with an accuracy of ± 0,001 g.

A.5.4 Funnel, made of glass.

A.5.5 Spirit level.

A.6 Safety

Ensure that the glass-parts of the column and the flowmeter are in good shape, and that pressure cannot build up in the column. If a rotameter is used, ensure that the supply pressure is below the maximum allowed working pressure for the rotameter. It is recommended that a shield of Pyrex® [1] glass is mounted between the operator and the glass-tube in the rotameter.

[1] Pyrex® are an example of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by CEN of these products.

A.7 Test samples

Reduce and divide the test samples to give at least three test portions of 400 g each. Avoid excessive handling which may cause abrasion of the fertilizer.

A.8 Calibration of flowmeter

A.8.1 General

The calibration procedure depends on the type of flowmeter. The procedure recommended in the instrument manual should be used.

A.8.2 Calibration curves

Calibration curves shall be made in the flow range from 15 Nm^3 air/h to 35 Nm^3 air/h. Individual calibration curves shall be made with every adapter/grid/washer fitted into the column. During calibration the pressure shall be measured in the air-flow downstream to the outlet valve of the flowmeter, or as close to the flowmeter as possible.

A.9 Procedure

A.9.1 Checking procedure

A.9.1.1 Assemble the glass column (A.5.1.1) in a vertical position with the aid of a spirit-level (A.5.5), and connect a medium adapter (A.5.1.3) with the washer and the grid. Connect the flowmeter (A.5.2) and hoses to the adapter and ensure that all connections are properly fastened.

A.9.1.2 Make sure that the flowmeter inlet valve is closed when pressurized air is supplied. The air must be dry (less than 500 mg water/Nm^3) and free from dust and hydrocarbons. Ensure that there can be no pressure build up in the apparatus.

A.9.2 Adjusting the spouting height

A.9.2.1 Pour one of the test portions through the opening of the column head by using the glass funnel (A.5.4).

A.9.2.2 Open the outlet valve of the flowmeter (A.5.2) to the maximum position. Open the inlet valve carefully until the flowmeter reads 25,0 Nm^3/h, taking care to avoid a sudden “blow up” of the fertilizer. The specified air flow should be established within 5 s.

A.9.2.3 Check that the top level of the spouting fertilizer is in the range from 4 cm to 6 cm above the top level of the fertilizer (preferably 5 cm) and if this is so, close the outlet valve and empty the apparatus by removing the adapter. Leave the inlet valve open at this set position. Replace the adapter.

A.9.2.4 Clean the column by opening the outlet valve fully, and increase the air stream to 40 Nm^3/h for 0,5 min by opening the inlet valve. Reduce the air stream to 25,0 Nm^3/h with the inlet valve and close the outlet valve.

A.9.2.5 If the spouting height is not within the specified range (A.9.2.3), choose a larger or smaller adapter as appropriate and repeat A.9.2.1 to A.9.2.4.

A.9.2.6 When material is poured into the column (see A.9.2.1), some fertilizer may enter the interior of the adapter and cause a sudden “blow-up” when the valve is opened. To avoid this, a minor air stream through the adapter may be supplied when the fertilizer is added to the column. Continue with A.9.2.2 as soon as possible.

A.9.3 Testing the material

A.9.3.1 Weigh the fertilizer sample in a container (beaker, bag etc.) to the nearest 1/1 000 g. Pour the sample into the column, open the flowmeter outlet valve to maximum opening within 5 s (see A.9.2.6), and blow 25,0 Nm^3/h of air through the column for 2 min. If necessary adjust the air stream with the inlet valve as soon as the spouting is established. Close the outlet valve.

A.9.3.2 Release the air hose, loosen and extract the screw cap from the adapter. Empty the fertilizer and the adapter into the container. Weigh the sample to the nearest 1/1 000 g and check that the accuracy of the balance is better than 10 % of the loss of weight of the sample.

It may be helpful to weigh the adapter with the fertilizer to avoid spillages. If this is done, the adapter shall be weighed separately and its mass allowed for in the final calculation.

A.9.3.3 Replace the adapter and clean the column as described in A.9.2.4.

A.9.3.4 Repeat A.9.3.1 to A.9.3.3 using another test portion.

A.9.3.5 Wash the apparatus after use with soap and water and a soft brush. Rinse thoroughly with distilled water and dry.

A.10 Expression of results

The dust potential of the fertilizer, w_d, expressed in mg/kg, is given by Formula (A.1):

$$w_d = [(m_s - m_a)/m_s] \cdot 10^6 \quad \text{(A.1)}$$

where

w_d is the dust potential, in milligrams per kilogram (mg/kg);

m_s is the mass of the test portion, in grams (g);

m_a is the mass of the test portion after testing, in grams (g).

Report the mean of the individual test results to the nearest mg.

A.11 Test report

The test report shall include the following information:

a) a reference to this method used;

b) all information necessary for complete identification of the sample;

c) the diameter of adapter;

d) the methods used for sampling and sample preparation;

e) the results and the method of expression used;

f) details of any unusual features noted during the determination;

g) details of any operations not specified in this document, or in any other standard to which the reference is made, or regarded as optional, as well as any factor which may have affected the results.

Annex B
(informative)

Optical methods for determination of fertilizer dust

See Table B.1

Table B.1 — Overview on optical methods for determination of fertilizer dust

	On-House-methods	**Productin**	**Principle**	**Registration**
1	Kemiral|Pernis	rotating drum	reflection	0/1'
2	Kemira|Danmark	falling stream of prod. test box with oblique plate	smoke detector SICK RM61	5'
3	Ke Nobel	test box with fan	smoke meter SICK RM61	0/5'
4	BASF	falling stream of prod. test box with oblique plate	smoke detector SICK RM41–03	I = f(t)
5	Casella	falling stream of prod test box with	transmission	I = f(t)
6	Casella	falling stream of prod test box with	light scattering	I = f(t)
	Commercial system			
7	Fa. Hund Umweltmesstechnik	air stream	IR scattering (calibration: ≥ 5 1 μg/m³)	I = f(t) M = f(t)
	Normative works			
8	**VDI 2066 (in VDI-Handbuch Reinhaltung der Luft, Bd4)**			
	Part 4 Part 6	gas - stream gas - stream	transmission light scattering	

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