INTERNATIONAL STANDARD

ISO 8486-2

Second edition
2007-08-01

Bonded abrasives — Determination and designation of grain size distribution —

Part 2: Microgrits F230 to F2000

Abrasifs agglomérés — Détermination et désignation de la distribution granulométrique —

Partie 2: Micrograins F230 à F2000

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8486-2 was prepared by Technical Committee ISO/TC 29, *Small tools*, Subcommittee SC 5, *Grinding wheels and abrasives*.

This second edition cancels and replaces the first edition (ISO 8486-2:1996), which has been technically revised.

ISO 8486 consists of the following parts, under the general title *Bonded abrasives — Determination and designation of grain size distribution*:

— *Part 1: Macrogrits F4 to F220*

— *Part 2: Microgrits F230 to F2000*

Bonded abrasives — Determination and designation of grain size distribution —

Part 2:
Microgrits F230 to F2000

1 Scope

This part of ISO 8486 sets forth a method for determining or checking the size distribution of microgrits F230 to F2000 in fused aluminium oxide and silicon carbide.

It specifies the grit designation for the testing of those grits used in the manufacture of bonded abrasive products and general industrial applications and those removed from bonded products, as well as loose grits used in polishing.

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.

ISO 8486-1, *Bonded abrasives — Determination and designation of grain size distribution — Part 1: Macrogrits F4 to F220*

3 Terms and definitions

For the purposes of this document, terms and definitions given in ISO 8486-1 and the following apply.

3.1
microgrits
grits with grain size distributions that are determined by sedimentation and mean grain sizes (d_{s50}) of 60 µm or less

4 Method of checking grain size distribution

4.1 Grain size distribution

The grain size distribution of microgrits F230 to F2000 is determined according to the following criteria:

a) the grain size (theoretical grain diameter) shall not exceed the maximum permissible d_{s3} value at the 3 % point of the grain size distribution curve;

b) the median size (theoretical grain diameter) shall be within the specified tolerances of the d_{s50} value at the 50 % point of the grain size distribution curve;

c) the grain size (theoretical grain diameter) shall attain at least the d_{s80}, $d_{s94/95}$ values at the 80 % and 94/95 % points of the grain size distribution curve.

The three criteria shall be met simultaneously. The values are specified in Table 1 for a photosedimentometer (94 %) and in Table 2 for a US sedimentation tube (95 %).

The testing of microgrits F230 to F2000 is to be carried out by sedimentation according to Clause 5.

Table 1 — Grain size distribution of microgrits F230 to F2000 based on photosedimentometer and mastergrits (see 6.1)

Grit designation	d_{s3} **value** max. µm	**Median grain size** d_{s50} **value** µm	d_{s80} **value** min. µm	d_{s94} **value** min. µm
F230	82	53 ± 3	—	34
F240	70	44,5 ± 2	—	28
F280	59	36,5 ± 1,5	—	22
F320	49	29,2 ± 1,5	—	16,5
F360	40	22,8 ± 1,5	—	12
F400	32	17,3 ± 1	—	8
F500	25	12,8 ± 1	—	5
F600	19	9,3 ± 1	—	3
F800	14	6,5 ± 1	—	2
F1000	10	4,5 ± 0,8	—	1
F1200	7	3 ± 0,5	1	—
F1500	5	2 ± 0,4	0,8	—
F2000	3,5	1,2 ± 0,3	0,5	—

Table 2 — Grain size distribution of microgrits F230 to F1200 based on US sedimentation tube and checking minerals

Grit designation	d_{s3} value max. µm	Median grain size d_{s50} value µm	d_{s80} value min. µm	d_{s95} value min. µm
F230	77	55,7 ± 3	—	38
F240	68	47,5 ± 2	—	32
F280	60	39,9 ± 1,5	—	25
F320	52	32,8 ± 1,5	—	19
F360	46	26,7 ± 1,5	—	14
F400	39	21,4 ± 1	—	10
F500	34	17,1 ± 1	—	7
F600	30	13,7 ± 1	—	4,6
F800	26	11 ± 1	—	3,5
F1000	23	9,1 ± 0,8	—	2,4
F1200	20	7,6 ± 0,5	2,4	—
NOTE These values were calculated based on ISO round-robin tests.				

4.2 Grading

The F series is a graduated series of thirteen microgrits, starting at a median particle size of 53 µm and ending at 1,2 µm, as determined by a photosedimentometer. This series follows on from the finest grain in the F series macrogrits F220 (63 µm) and uses the same ratio as that series, i.e. $\sqrt[4]{2}$.

The calculation of the individual grain size values (see Table 3) has been made as follows:

a) the ratio of the median grain sizes F230 and F240 is $\sqrt[4]{2} \cdot f^0$, i.e. it corresponds approximately to the progressive ratio of the test sieves for macrogrits;

b) the ratio of the median grain sizes of the following grits F240 and F280 is $\sqrt[4]{2} \cdot f^1$;

c) the ratio of the succeeding grain sizes is $\sqrt[4]{2} \cdot f^n$

where n = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and where the following equation applies to the factor f:

$$53 = 1{,}2\left(\sqrt[4]{2}\right)^{12} \cdot f^{(0+1+2+3+.....+11)}$$

$$f = \sqrt[66]{\frac{53}{1{,}2\left(\sqrt[4]{2}\right)^{12}}} = 1{,}026$$

This produces a series of ratios starting at 1,189 and ending at 1,581.

Table 3 — Calculation of the f^n factors (photosedimentation)

Grit designation	Median grain size µm	Formula
F230	53	Starting point
F240	44,5	$f^0 = 1 = \frac{53}{44,5} \cdot \frac{1}{\sqrt[4]{2}}$
F280	36,5	$f^1 = \frac{44,5}{36,5} \cdot \frac{1}{\sqrt[4]{2}}$
F320	29,5	$f^2 = \frac{36,5}{29,5} \cdot \frac{1}{\sqrt[4]{2}}$
F360	22,8	$f^3 = \frac{29,2}{22,8} \cdot \frac{1}{\sqrt[4]{2}}$
F400	17,3	$f^4 = \frac{22,8}{17,3} \cdot \frac{1}{\sqrt[4]{2}}$
F500	12,8	$f^5 = \frac{17,3}{12,8} \cdot \frac{1}{\sqrt[4]{2}}$
F600	9,3	$f^6 = \frac{12,8}{9,3} \cdot \frac{1}{\sqrt[4]{2}}$
F800	6,5	$f^7 = \frac{9,3}{6,5} \cdot \frac{1}{\sqrt[4]{2}}$
F1000	4,5	$f^8 = \frac{6,5}{4,5} \cdot \frac{1}{\sqrt[4]{2}}$
F1200	3	$f^9 = \frac{4,5}{3} \cdot \frac{1}{\sqrt[4]{2}}$
F1500	2	$f^{10} = \frac{3}{2} \cdot \frac{1}{\sqrt[4]{2}}$
F2000	1,2	$f^{11} = \frac{2}{1,2} \cdot \frac{1}{\sqrt[4]{2}}$

5 Testing microgrits F230 to F2000

5.1 General

Microgrits F230 to F2000 are tested by means of sedimentation.

The criteria for determining the grain size distribution are

a) the theoretical grain size at the 3 % point of the grain size distribution curve (d_{s3} value),

b) the theoretical grain size at the 50 % point of the grain size distribution curve (d_{s50} value), and

c) the theoretical grain size at the 80 %, 94/95 % point of the grain size distribution curve (d_{s80}, $d_{s94/95}$ values).

5.2 Permissible deviations

When retesting the measured results, allowance shall be made for the variations due to the measuring technique (sampling, sample preparation, different operators and instruments). These permissible deviations, given in Tables 4 and 5, have been determined on the basis of the standard deviation resulting from a cooperative test carried out by the members of ISO TC 29/SC 5. The tolerances given in Tables 1 or 2 are to be increased by these values.

Table 4 — Permissible deviations resulting from variations due to measuring technique — Method based on mastergrits

(Determination, for example, by sedimentation or electrical resistance method)

Dimensions in micrometres

Grit designation	Permissible deviations for values			
	d_{s3}	d_{s50}	d_{s80}	d_{s94}
F230	+ 3,5	± 2,5	—	− 1,5
F240				
F280	+ 2,5	± 1,5	—	− 0,8
F320				
F360				
F400				
F500	+ 2	± 1	—	− 0,5
F600				
F800				
F1000	+ 1,5	± 0,5	—	− 0,4
F1200			− 0,4	—
F1500	+ 1,0	± 0,4	− 0,3	—
F2000	+ 1,0	± 0,3	− 0,2	—

Table 5 — Permissible deviations resulting from the variations due to the measuring technique — US sedimentation tube method

Dimensions in micrometres

Grit designation	Permissible deviations for the values			
	d_{s3}	d_{s50}	d_{s80}	d_{s95}
F230	+ 1,5	± 1,5	—	− 1,5
F240				
F280	+ 1,5	± 1	—	− 1,5
F320				
F360				
F400				
F500	+ 1,5	± 0,8	—	− 1,5
F600				
F800				
F1000	+ 1,5	± 0,5	—	− 1,5
F1200			− 1,5	—

5.3 Designation of test method

The designation of the method for testing microgrits F230 to F2000 shall include an indication of the measuring instrument used:

— test-MICRO F — Sedigraph series[1)];

— test-MICRO F — US sedimentation tube[1)];

— test-MICRO F — Coulter counter[1)].

1) Sedigraph, US sedimentation tube and Coulter counter are examples of suitable products available commercially. This information is given for the convenience of users of this part of ISO 8486 and does not constitute an endorsement by ISO of these products.

6 Test methods

6.1 Test method based on Micro-F-Mastergrits

Each of the *Micro-F-Mastergrits* [2] (hereafter referred to as "mastergrit") used in testing is accompanied by a certificate of the *Staatliche Materialprüfungsanstalt Darmstadt* (MPA) stating the value at the 50 % point determined by means of a cooperative test carried out by the members of ISO TC 29/SC 5. The values measured shall be corrected on the basis of the mastergrit values.

The determination of grain sizes by use with other principles of measurement than sedimentation may give deviating results.

6.1.1 Preparation of the sample

It is recommended that the sample be dispersed by means of ultrasonics.

6.1.2 Test procedure

The test shall be carried out in accordance with the instructions for the measuring instrument used.

6.1.3 Evaluation

6.1.3.1 Determination of grain size distribution

The principle upon which this part of ISO 8486 is based is the comparison of the median d_{s50} (50 % by volume weight) point given by the mastergrit with that determined by the testing laboratory on its own instruments.

The difference between these two values is also to be added algebraically to the 3 %, 50 %, 80 % or 94/95 % values of the sample.

The following procedure applies:

a) determine the d_{s50} value of the mastergrit, and calculate the difference between this value and the corresponding value shown on the MPA Darmstadt certificate;

b) measure the d_{s3}, d_{s50}, d_{s80} or $d_{s94/95}$ values of the sample and add, algebraically, the mastergrit difference as determined above;

c) compare the corrected measured results with the values in Table 1.

EXAMPLE SiC F240, for the d_{s50} value:

— Mastergrit (MG):

MG - d_{s50} value according to MPA certificate	44,9 µm
MG - d_{s50} value measure	42,3 µm
Difference	+ 2,6 µm

— Sample:

Value measured	42,8 µm
To be added	+ 2,6 µm
Corrected value of the sample	45,4 µm

From Table 1, this value is within the tolerances of the d_{s50} value for grit F240.

2) *Micro-F-Mastergrits*, of fused aluminium oxide and silicon carbide, can be obtained from the *Staatliche Materialprüfungsanstalt Darmstadt*, Grafenstraße 2, 64283 Darmstadt, Germany. This information is given for the convenience of users of this part of ISO 8486 and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

6.1.3.2 Evaluation of corrected test results

A sample complies with this part of ISO 8486 if the corrected values for d_{s3}, d_{s50}, d_{s80} or $d_{s94/95}$ are within the permissible limits given in Table 1 or 2.

When retesting a material, allowance shall be made for the variation due to the measuring techniques.

The limit deviations given in Tables 1 or 2 are to be amended by the values given in Tables 4 or 5.

6.1.4 Measuring apparatus

6.1.4.1 X-ray gravitational technique

6.1.4.1.1 General

The X-ray gravitational technique is a method for the determination of the particle size distribution of a powder dispersed in a liquid using gravity sedimentation. The measurement of the concentration of solids setting in a liquid suspension is achieved by monitoring the incremental signal absorption from a beam of X-rays. The method of determining the particle size distribution is applicable to powders which can be dispersed in liquids or powders which are present in slurry form. The typical particle size range for analysis is from about 0,1 µm to about 300 µm. The method is typically used for materials containing particles of approximately the same chemical composition which produce adequate X-ray opacity.

6.1.4.1.2 Underlying theory

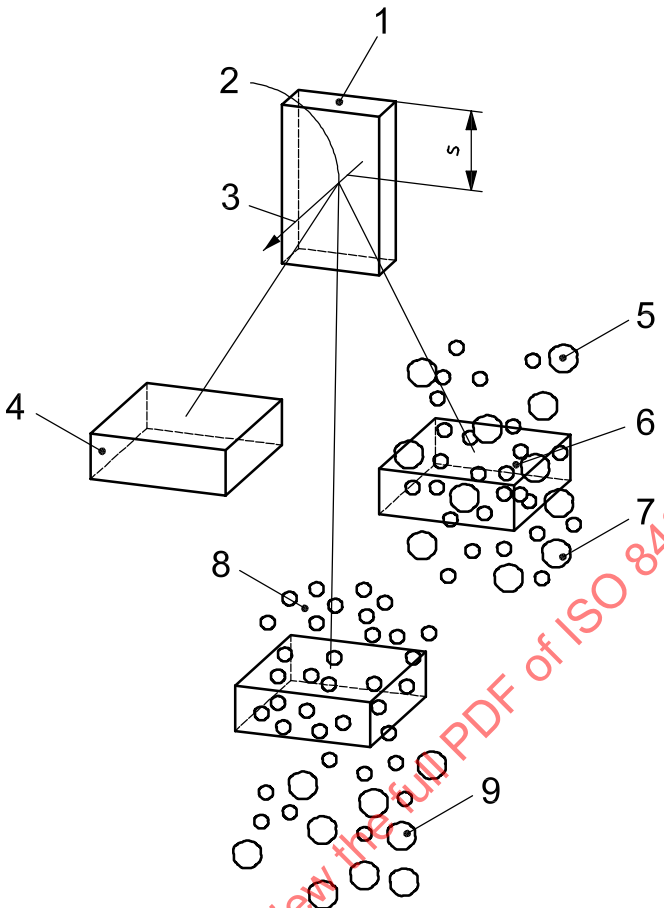
The method is based on two physical phenomena: low energy X-ray absorption and gravitational sedimentation, where Stokes' law describes the gravitational sedimentation of a particle as a function of particle diameter. These two phenomena allow both the particle diameter and the corresponding mass of all particles of that size to be determined.

a) Particle diameter determination

Particle size is determined from velocity measurements by applying Stokes' law under the known conditions of liquid density and viscosity, and particle density. Settling velocity is determined at each relative mass measurement from knowledge of the distance the X-ray beam from the top of the sample cell and the time at which the mass measurement was taken. From the velocity equals distance divided by time relationship, it can be determined the maximum velocity of all particles remaining above the measurement zone, these velocities being associated with the finer particles, see Figure 1.

b) Mass determination

A narrow, horizontally collimated beam of X-rays is used to measure directly the relative mass concentration of particles in the liquid medium. This is done by first measuring the intensity of a reference X-ray beam that is projected through the clear liquid medium prior to the introduction of the sample. A homogeneously dispersed mixture of solid sample and liquid is next circulated through the cell. The solid particles absorb some of the X-ray energy, which again is measured, this time to establish a value for full scale attenuation. Agitation of the mixture is ceased and the dispersion is allowed to settle while X-ray intensity is monitored.



Key

1 sample cell
2 measurement zone
3 transmitted X-ray beam
4 clear liquid
5 homogeneously distributed particles
6 particles in measurement zone
7 particles below the measurement zone (all particles larger than D_1 have fallen below measurement zone)
8 particles above measurement zone
9 collection of particles partially separated by size

Figure 1 — Measurement zone shown at three stages of an analysis

For the analysis, the liquid medium — which must not react with the sample — shall be selected according to the particle size range and density of the sample to be analyzed. It shall be ensured that Stokes' law is able to be applied due to the laminar flow around the particle. This condition is satisfied for spherical particles as long as the Reynolds' number is

$$Re = \frac{D^3 \rho_0 g \left(\rho - \rho_0\right)}{18\eta^2} < 0{,}3 \tag{1}$$

where

Re is the Reynolds' number;

D is the diameter of the spherical particle;

ρ_0 is the density of the fluid medium;

g is the acceleration of gravity;

η is the viscosity of the fluid medium.

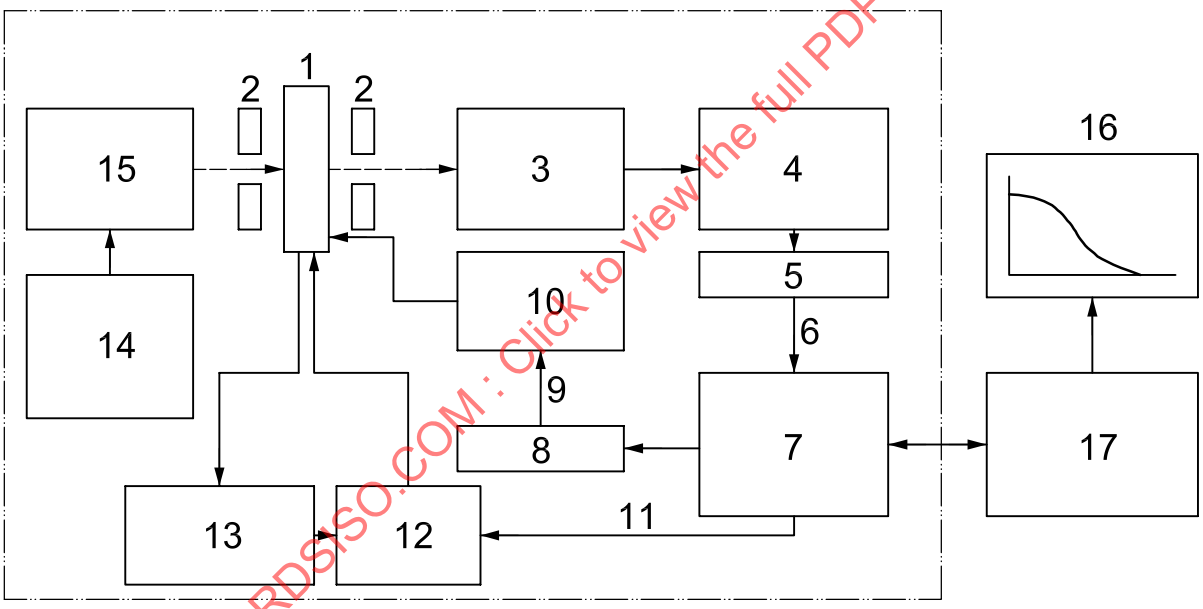
For given liquid properties, the maximum diameter of a spherical particle is

$$D_{\max} = \sqrt[3]{\frac{18\eta^2\, Re}{\rho_0 g\ (\rho - \rho_0)}} \tag{2}$$

$Re = 0{,}3$, to comply with Stokes' law.

6.1.4.1.3 Test apparatus

The test apparatus consists of a sample pump, sample cell, positioning and moving system for the sample cell, an X-ray source, which transmits X-rays through the sample cell into the detector, a converter of X-ray intensity into concentration, a recorder X-Y and the corresponding power supplies. (See also the block diagram shown in Figure 2.)



Key

1 sample cell
2 slit
3 X-ray detector
4 intensity-concentration converter
5 ADC (analog-to-digital converter)
6 concentration signal (Y)
7 microcontroller and interface controller
8 DAC (analog-to-analog converter)
9 position signal (X)
10 digital to position translator
11 pump speed
12 sample pump
13 dispersed sample, mixing chamber
14 high voltage power supply and filament transformer
15 X-ray tube
16 particle size (X) vs. percent finer (Y) graph
17 personal computer, measurement and evaluation software

Figure 2 — Block diagram, sedimentation particle size analyzer

6.1.4.1.4 Sedimentation medium

Use deionized water or water ethylene glycol mixtures according to Table 6 as the sedimentation medium.

6.1.4.1.5 Dispersant

Use $Na_4P_2O_7$ as the dispersing agent, in accordance with Table 6.

6.1.4.1.6 Viscosity

The viscosity is adapted by changing the water content in the medium.

The measurement of viscosity may be made by using an Ubbelohde viscosimeter. The maximum permitted deviation from the values given in Table 6 is $\pm$ 0,1 MPa · s.

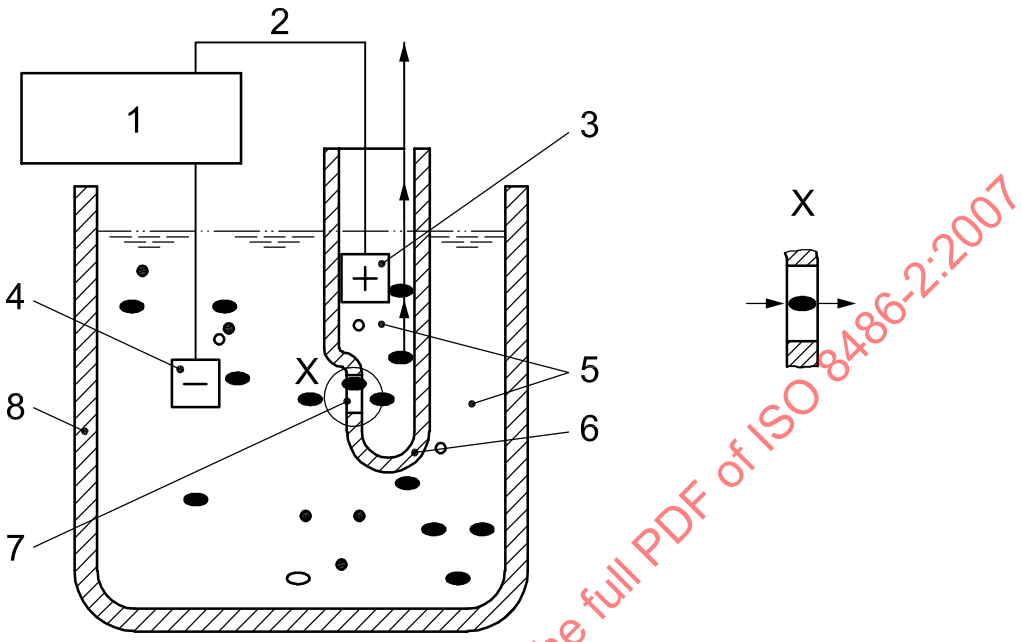
Table 6 — Sedimentation medium and dispersing agent for testing grains of aluminium oxide and silicon carbide

Grit designation	**Sedimentation medium at 20 °C**	**Dispersing agent Tetrasodium diphosphate** ($Na_4 P_2 O_7$) g/l	
		Aluminium oxide	Silicon carbide
F230	1,2 Ethandiol 95 %, viscosity 15,2 MPa · s, Density 1,107 g/cm^3	0,2	0,2
F240			
F280	1,2 Ethandiol 74 %, viscosity 7,7 MPa · s, Density 1,091 g/cm^3	0,2	0,2
F320			
F360			
F400			
F500	Deionized water conductivity $\leqslant$ 5 µS	0,45	0,2
F600			0,1
F800			
F1000	Deionized water conductivity $\leqslant$ 5 µS	0,45	No additive
F1200			
F1500			
F2000			

6.1.4.2 Electrical resistance test method

6.1.4.2.1 Apparatus, apertures and verified samples

The apparatus shall be constructed as shown in Figure 3. See also Annex A.



Key

1 aperture current
2 vacuum
3 internal electrode
4 external electrode
5 particle electrolyte solution
6 aperture tube
7 aperture
8 sample beaker

Figure 3 — Example of apparatus for electric resistance test method

6.1.4.2.1.1 **Aperture tube**, having an aperture diameter in accordance with Table 7.

6.1.4.2.1.2 **Electrolyte**, to be used as the dispersing agent of a sample. The electrolyte shall be a sodium chloride solution of 1 % to 4 % in concentration, or a sodium pyrophosphate solution of 4 % in concentration and filtered. In selecting a filter: where an aperture tube having a minimum diameter of 50 µm is used, the electrolyte shall be filtered twice through a 0,8 µm filter; where a tube having a maximum diameter of 50 µm is used, it shall be filtered twice through a 0,2 µm filter.

For the coarse grain with a great sedimentation speed, in order to raise its viscosity, an electrolyte and glycerol mixed in the ratio of 7:3 may be used.

6.1.4.2.1.3 **Sample for calibration**, with the latex grains as recommended in the instrument manual used for the calibration of each apparatus type.

The calibration shall be carried out in accordance with the instructions for the measurement instrument used.

6.1.4.2.2 Applicable section of aperture tube

The aperture tube to be used for the measurement shall be chosen in accordance with Table 7.

Table 7 — Aperture tubes

Dimensions in micrometres

Grain size		F230	F240	F280	F320	F360	F400	F500	F600	F800	F1000	F1200	F1500	F2000
Aperture diameter	from	560		400		200		140	100	70	50	30	20	
	to	200		200		140	100	70	50		30	20	15	

The measurement parameters used shall be in accordance with Tables 8 and 9.

Table 8 — Upper limit of measuring speed to ensure single particle measurement

Dimensions in micrometres

Aperture diameter	560	400	280	200	140	100	70	50	30	20	15
Particles per second	230	400	600	800	1 200	1 500	2 500	3 500	4 500	6 000	

Table 9 — Minimum number of particles to be counted

Dimensions in micrometres

Grain size	F230 to F320	F360 to F500	F600 to F2 000
Number of particles	20 000	50 000	100 000

6.2 US sedimentation tube

6.2.1 Testing by sedimentation

The testing of microgrits F230 to F2000 by sedimentation shall be carried out using the US sedimentation tube, whereby the grain size distribution is determined.

The principle of measurement is to determine the volumes of a suspension of the grit sample settled in the collecting tube per unit of time and to calculate the equivalent grain diameter by Stokes' law.

The criteria for the determination of the grain size distribution are

a) the grain size at the time when 3 % of the volume of the sample has settled (d_{s3} value),

b) the median grain size at the time when 50 % of the volume of the sample has settled (d_{s50} value), and

c) the grain size at the time when 80 %, 94/95 % of the volume of the sample has settled (d_{s80}, d_{s94} and d_{s95} values).

The permissible values are given in Table 2.

6.2.2 Test apparatus

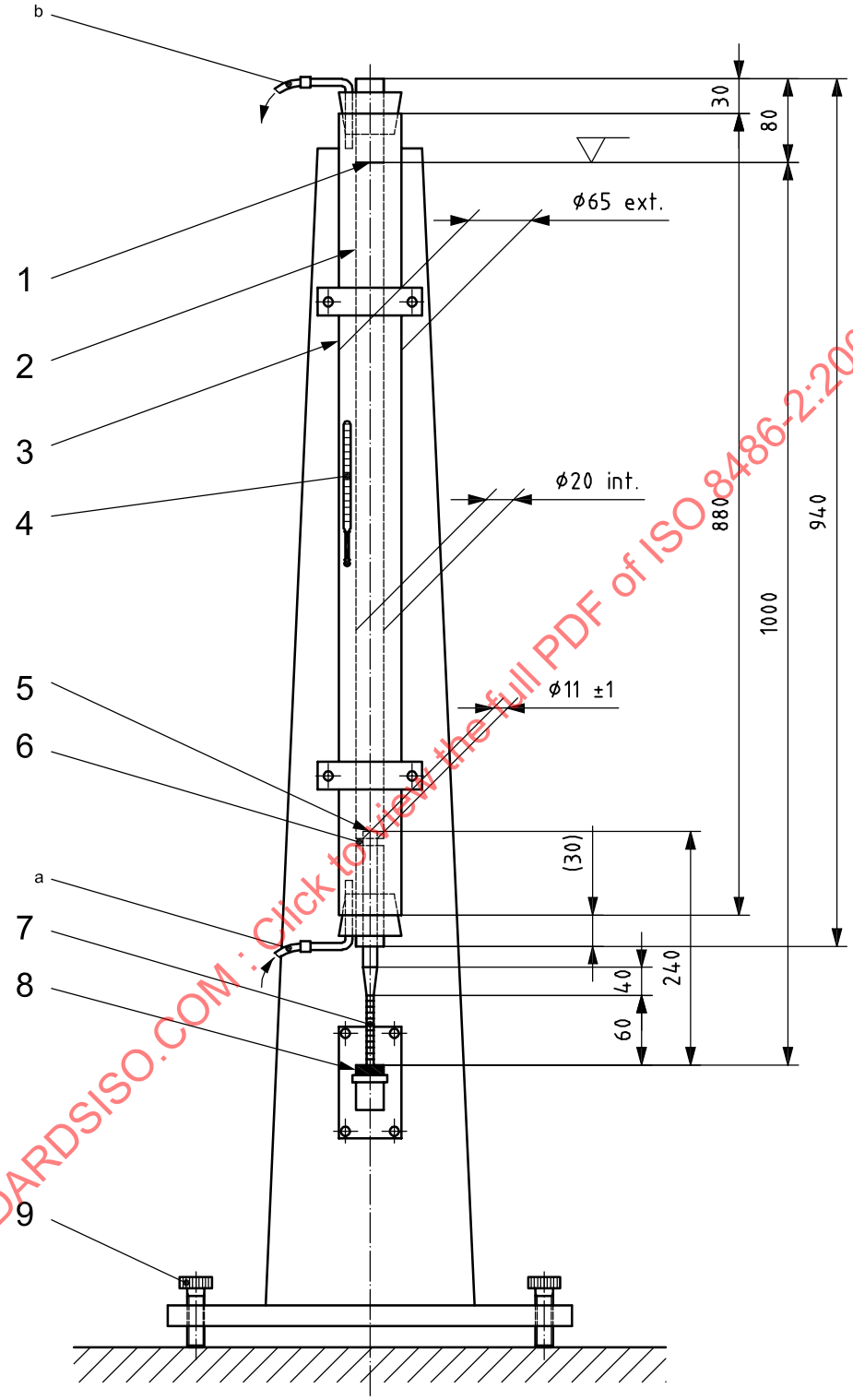
The US sedimentation tube consists of a vertical sedimentation tube of 940 mm length and 20 mm inside diameter. It is surrounded by a water jacket in which the water temperature is maintained at a constant level.

A graduated collecting tube is fixed at the bottom of the sedimentation tube. The entire assembly is mounted on a frame whose base plate is fitted with level adjusting screws for keeping the tube vertical (see Figure 4).

For the design and dimensions of the collecting tube, see Figure 5.

To improve the accuracy of sedimentation volume readings, it is recommended that a horizontal beam light source and a magnifying glass be used. The recording of the sedimentation times will be rendered easier by the use of a time printer.

Dimensions in millimetres

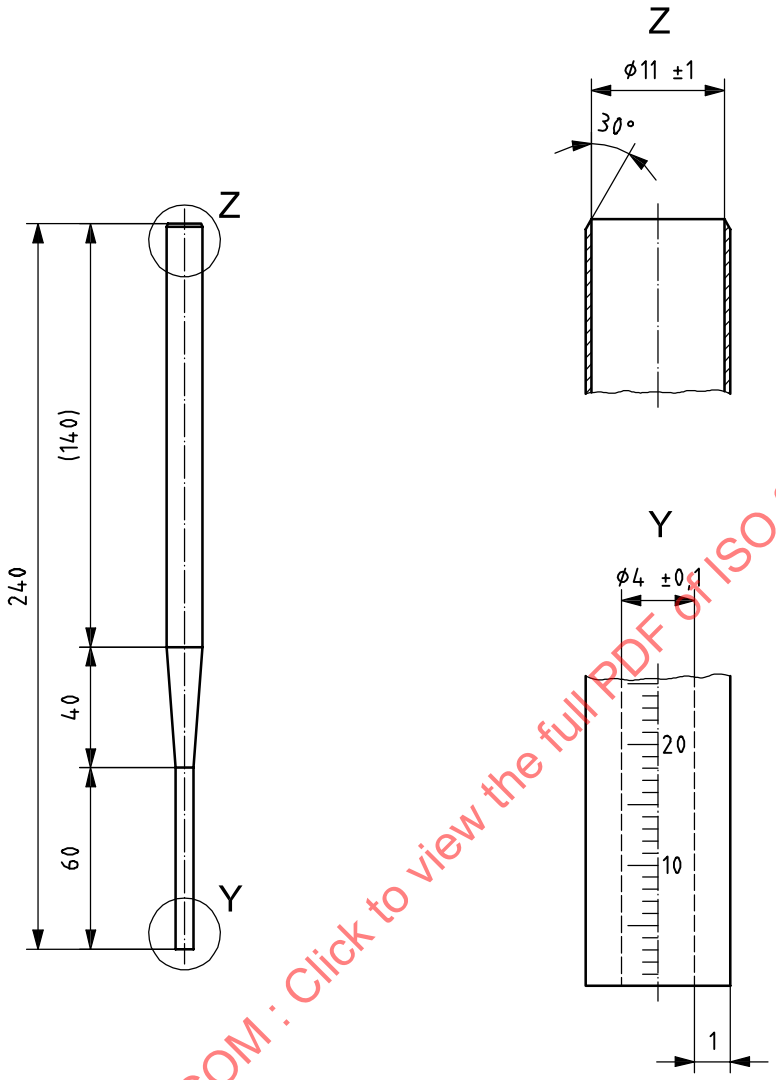


Key

1 methyl alcohol level (initial)
2 sedimentation tube
3 water jacket
4 thermometer
5 collecting tube (see Figure 5)
6 rubber centring spacer
7 scale for height of sedimentation
8 rubber gasket
9 vertical adjusting screws
a water inlet
b water outlet

Figure 4 — US sedimentation tube

Dimensions in millimetres



Dial graduation and figures to be in white.

50 division marks at equal intervals (graduation about 1 mm).

Length of division mark: 3 mm.

Every fifth division mark: 4 mm.

Thickness of division mark: 0,25 mm.

Figure 5 — Collecting tube

6.2.3 Test equipment

6.2.3.1 Sedimentation medium

Use methyl alcohol of 95 % up to 99 % as the sedimentation medium.

Adjust the sedimentation medium using the checking minerals specified in 6.2.4.1.3.

6.2.3.2 Dispersing agent

In order to avoid grain agglomeration, a dispersing agent such as EDTA (tetrasodium salt of ethylendiamine tetra-acetic acid) shall be added to the methyl alcohol, i.e. 4 ml of a 1 % aqueous EDTA-solution per litre of methyl alcohol.

6.2.3.3 Checking minerals

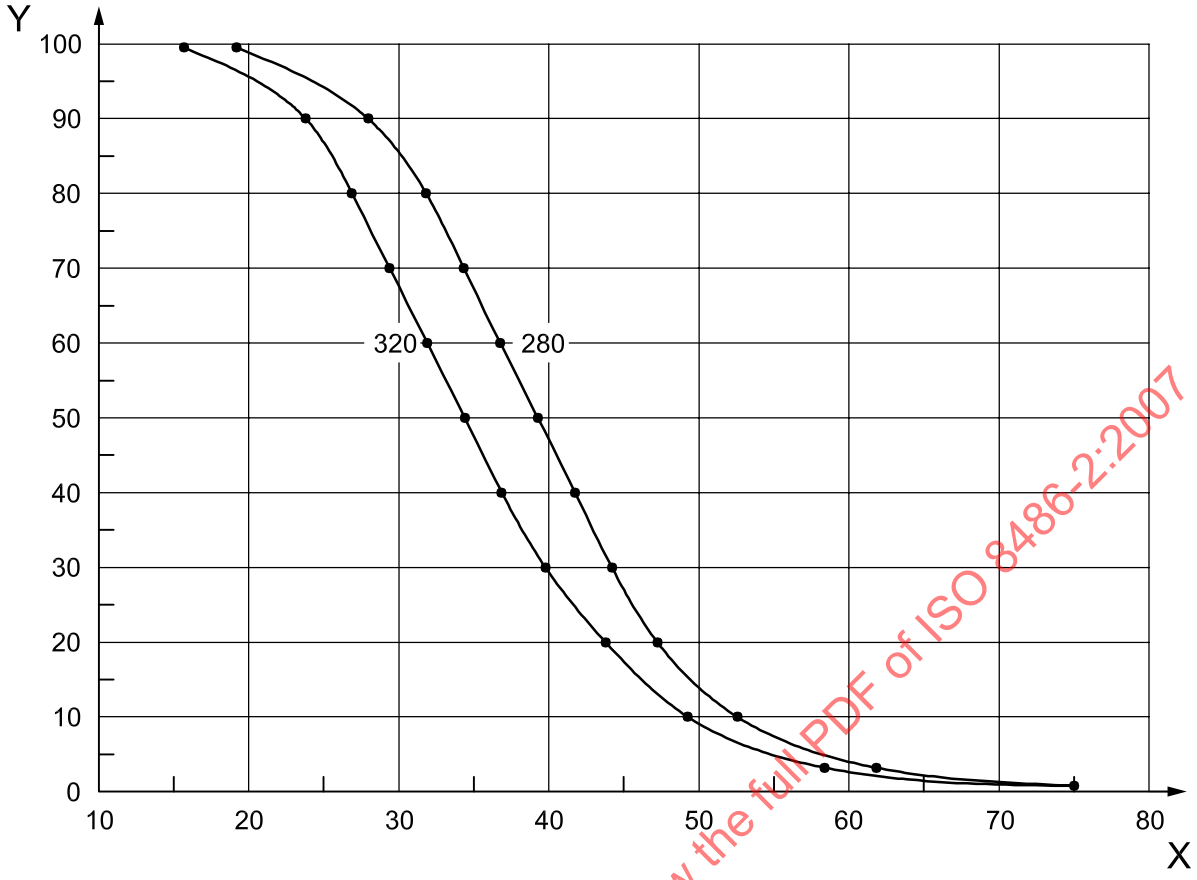
The adjustment of the whole measuring procedure is controlled by means of checking minerals 280 and 320[3)]. Each supply of checking minerals is accompanied by a cumulative volume grain size distribution curve (see Figure 6). The 10 %, 20 %, 30 %, 40 % and 50 % points shall not deviate by more than ± 2 % from the sizes indicated in Table 10.

NOTE The grain size distributions of the checking minerals do not correspond to identical grain sizes of this part of ISO 8486.

Table 10 — Grain size of checking minerals

Volume percentage of settled checking minerals	Grain size d µm	
	Checking mineral	
	280	320
0	74,7	75,1
3	62,1	58,7
10	52,9 ± 1,06	49,8 ± 1
20	47,9 ± 0,96	44,2 ± 0,88
30	44,7 ± 0,89	40,5 ± 0,81
40	42 ± 0,84	37,5 ± 0,75
50	39,7 ± 0,79	34,9 ± 0,7
60	37,4	32,5
70	35	30,1
80	32,3	27,5
90	28,8	24,4
100	20	16,5

3) Checking minerals can be obtained from the *Staatliche Materialprüfungsanstalt Darmstadt*, Grafenstraße 2, 64283 Darmstadt, Germany. This information is given for the convenience of users of this part of ISO 8486 and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.



Key

X grain size, d, µm

Y volume percentage

Figure 6 — Cumulative volume grain size distribution curve of checking minerals 280 and 320

6.2.4 Testing

6.2.4.1 Preparation for testing

6.2.4.1.1 Setting up test device

When setting up the US sedimentometer for use as the test device, check that the collecting tube is positioned centrally in the sedimentation tube. It is held in the vertical position by a rubber spacer located about 30 mm from the top of the collecting tube. Check this using a plumb line suspended from the top of the sedimentation tube and the collecting tube. The plumb line shall pass centrally through both the sedimentation tube and the collecting tube. The device is adjusted by means of the adjusting screws on the base plate.

After adjustment, fill the water jacket and connect it to a thermostat.

6.2.4.1.2 Test temperature

The testing of the grain size shall be carried out under a constant temperature with a permissible deviation of ± 0,1 °C.

It is convenient to use a test temperature of 25 °C. The grain diameters indicated in Tables 11 and 12 for the respective times of sedimentation apply to this temperature only.

For the determination of the grain diameters for other test temperatures, see 6.2.5.1.

6.2.4.1.3 Adjustment of the sedimentation medium

The methyl alcohol used for the test shall be adjusted by means of one of the two checking minerals, 280 or 320.

The grain sizes corresponding to 10 %, 20 %, 30 %, 40 % and 50 % points shall not deviate by more than ± 0,5 µm from the values specified on the curves supplied with the checking minerals. The average of the algebraic sum of the deviations shall not exceed ± 0,3 µm.

If agreement with the accompanying curves is not reached within the permissible tolerances, then the density and viscosity of the sedimentation medium shall be changed such that agreement is obtained.

6.2.4.2 Test procedure

6.2.4.2.1 Filling of sedimentation tube

Fill the sedimentation tube with the previously adjusted sedimentation liquid to a height of 1 000 mm (measured from the bottom of the collecting tube). Then allow it to stand until equilibrium is reached between the water jacket connected to the thermostat and the sedimentation tube temperatures.

6.2.4.2.2 Preparation of the sample

Prior to the test, the sample shall be heated to a temperature of 600 °C ± 20 °C for at least 10 min.

6.2.4.2.3 Dispersion of the sample

Place a sufficient amount of the sample in a test-tube such that a height of 20 to 25 divisions in the collecting tube after sedimentation is obtained. For silicon carbide, this will be about 1,6 g; while for fused aluminium oxide it will be about 2,2 g.

It is recommended that the dispersed sample be submitted to ultrasonic treatment to remove agglomerates.

Transfer 15 ml of sedimentation medium containing the specified quantity of dispersing agent and the sample to be settled to a test-tube and shake the test-tube to achieve complete dispersion. Allow the grit to stand in the sedimentation medium for at least 30 min and then again shake the test-tube vigorously several times during this period. The temperature of the medium shall be the same as the temperature of the medium in the sedimentation tube.

6.2.4.2.4 Transfer to sedimentation tube

Place a suitable funnel in the sedimentation tube. Shake the test-tube containing the sample and the sedimentation liquid vigorously for at least 30 s. Then pour its contents onto the sedimentation liquid, down the slope of the funnel.

Subsequently, quickly remove the funnel from the sedimentation tube in order to prevent any residue from dropping into the tube as this would distort the results.

6.2.4.2.5 Start of measurement

Measurement shall begin at the time of transfer.

Table 11 — Theoretical grain diameter, d, for grits of fused aluminium oxide as function of time of sedimentation, t, when using methyl alcohol as sedimentation medium at test temperature 25 °C

t min	d µm	t min	d µm	t min	d µm	t min	d µm	t min	d µm
0,50	112,7	2,50	50,4	4,50	37,6	8,00	28,2	23,00	16,6
0,55	107,5	2,55	49,9	4,55	37,4	8,20	27,8	24,00	16,3
0,60	102,9	2,60	49,4	4,60	37,2	8,40	27,5	25,00	15,9
0,65	98,9	2,65	49	4,65	37	8,60	27,2	26,00	15,6
0,70	95,3	2,70	48,5	4,70	36,8	8,80	26,9	27,00	15,3
0,75	92	2,75	48,1	4,75	36,6	9,00	26,6	28,00	15,1
0,80	89,1	2,80	47,6	4,80	36,4	9,20	26,3	29,00	14,8
0,85	86,4	2,85	47,2	4,85	36,2	9,40	26	30,00	14,6
0,90	84	2,90	46,8	4,90	36	9,60	25,7	32,00	14,1
0,95	81,8	2,95	46,4	4,95	35,8	9,80	25,5	34,00	13,7
1,00	79,7	3,00	46	5,00	35,6	10,00	25,2	36,00	13,3
1,05	77,8	3,05	45,6	5,10	35,3	10,20	25	38,00	12,9
1,10	76	3,10	45,3	5,20	35	10,40	24,7	40,00	12,6
1,15	74,3	3,15	44,9	5,30	34,6	10,60	24,5	42,00	12,3
1,20	72,8	3,20	44,6	5,40	34,3	10,80	24,2	44,00	12
1,25	71,3	3,25	44,2	5,50	34	11,00	24	46,00	11,8
1,30	69,9	3,30	43,9	5,60	33,7	11,20	23,8	48,00	11,5
1,35	68,6	3,35	43,5	5,70	33,4	11,40	23,6	50,00	11,3
1,40	67,4	3,40	43,2	5,80	33,1	11,60	23,4	55,00	10,8
1,45	66,2	3,45	42,9	5,90	32,8	11,80	23,2	60,00	10,3
1,50	65,1	3,50	42,6	6,00	32,5	12,00	23	65,00	9,9
1,55	64	3,55	42,3	6,10	32,3	12,50	22,5	70,00	9,5
1,60	63	3,60	42	6,20	32	13,00	22,1	75,00	9,2
1,65	62,9	3,65	41,7	6,30	31,8	13,50	21,7	80,00	8,9
1,70	61,1	3,70	41,4	6,40	31,5	14,00	21,3	85,00	8,6
1,75	60,2	3,75	41,2	6,50	31,3	14,50	20,9	90,00	8,4
1,80	59,4	3,80	40,9	6,60	31	15,00	20,6	95,00	8,2
1,85	58,6	3,85	40,6	6,70	30,8	15,50	20,2	100,00	8
1,90	57,8	3,90	40,4	6,80	30,6	16,00	19,9	105,00	7,8
1,95	57,1	3,95	40,1	6,90	30,3	16,50	19,6	110,00	7,6
2,00	56,4	4,00	39,9	7,00	30,1	17,00	19,3	115,00	7,4
2,05	55,7	4,05	39,6	7,10	29,9	17,50	19,1	120,00	7,3
2,10	55	4,10	39,4	7,20	29,7	18,00	18,8	130,00	7
2,15	54,4	4,15	39,1	7,30	29,5	18,50	18,5	140,00	6,7
2,20	53,7	4,20	38,9	7,40	29,3	19,00	18,3	150,00	6,5
2,25	60,1	4,25	38,7	7,50	29,1	19,50	18	160,00	6,3
2,30	52,6	4,30	38,4	7,60	28,9	20,00	17,8	170,00	6,1
2,35	52	4,35	38,2	7,70	28,7	20,50	17,6	180,00	5,9
2,40	51,4	4,40	38	7,80	28,5	21,00	17,4	190,00	5,8
2,45	50,9	4,45	37,8	7,90	28,4	22,00	17	200,00	5,6

Table 12 — Theoretical grain diameter, d, for grits of silicon carbide as function of time of sedimentation, t, when using methyl alcohol as sedimentation medium at test temperature 25 °C

t min	d µm	t min	d µm	t min	d µm	t min	d µm	t min	d µm
0,50	128,8	2,50	57,6	4,50	42,9	8,00	32,2	23,00	19
0,55	122,8	2,55	57	4,55	42,7	8,20	31,8	24,00	18,6
0,60	117,6	2,60	56,5	4,60	42,5	8,40	31,4	25,00	18,2
0,65	112,9	2,65	56	4,65	42,2	8,60	31,1	26,00	17,9
0,70	108,8	2,70	55,4	4,70	42	8,80	30,7	27,00	17,5
0,75	105,1	2,75	54,9	4,75	41,8	9,00	30,4	28,00	17,2
0,80	101,8	2,80	54,4	4,80	41,6	9,20	30	29,00	16,9
0,85	98,8	2,85	54	4,85	41,4	9,40	29,7	30,00	16,6
0,90	96	2,90	53,5	4,90	41,2	9,60	29,4	32,00	16,1
0,95	93,4	2,95	53	4,95	40,9	9,80	29,1	34,00	15,6
1,00	91,1	3,00	52,6	5,00	40,7	10,00	28,8	36,00	15,2
1,05	88,9	3,05	52,2	5,10	40,3	10,20	28,5	38,00	14,8
1,10	86,9	3,10	51,7	5,20	40	10,40	28,2	40,00	14,4
1,15	85	3,15	51,3	5,30	39,6	10,60	28	42,00	14
1,20	83,2	3,20	50,9	5,40	39,2	10,80	27,7	44,00	13,7
1,25	81,5	3,25	50,5	5,50	38,8	11,00	27,5	46,00	13,4
1,30	79,9	3,30	50,2	5,60	38,5	11,20	27,2	48,00	13,1
1,35	78,4	3,35	49,8	5,70	38,2	11,40	27	50,00	12,9
1,40	77	3,40	49,4	5,80	37,8	11,60	26,7	55,00	12,3
1,45	75,7	3,45	49	5,90	37,5	11,80	26,5	60,00	11,8
1,50	74,4	3,50	48,7	6,00	37,2	12,00	26,3	65,00	11,3
1,55	73,2	3,55	48,4	6,10	36,9	12,50	25,8	70,00	10,9
1,60	72	3,60	48	6,20	36,6	13,00	25,3	75,00	10,5
1,65	70,9	3,65	47,7	6,30	36,3	13,50	24,8	80,00	10,2
1,70	69,9	3,70	47,4	6,40	36	14,00	24,3	85,00	9,9
1,75	68,9	3,75	47	6,50	35,7	14,50	23,9	90,00	9,6
1,80	67,9	3,80	46,7	6,60	35,5	15,00	23,5	95,00	9,4
1,85	67	3,85	46,4	6,70	35,2	15,50	23,1	100,00	9,1
1,90	66,1	3,90	46,1	6,80	34,9	16,00	22,8	105,00	8,9
1,95	65,2	3,95	45,8	6,90	34,7	16,50	22,4	110,00	8,7
2,00	64,4	4,00	45,6	7,00	34,4	17,00	22,1	115,00	8,5
2,05	63,6	4,05	45,3	7,10	34,2	17,50	21,8	120,00	8,3
2,10	62,9	4,10	45	7,20	34	18,00	21,5	130,00	8
2,15	62,1	4,15	44,7	7,30	33,7	18,50	21,2	140,00	7,7
2,20	61,4	4,20	44,5	7,40	33,5	19,00	20,9	150,00	7,4
2,25	60,7	4,25	44,2	7,50	33,3	19,50	20,6	160,00	7,2
2,30	60,1	4,30	43,9	7,60	33	20,00	20,4	170,00	7
2,35	59,4	4,35	43,7	7,70	32,8	20,50	20,1	180,00	6,8
2,40	58,8	4,40	43,4	7,80	32,6	21,00	19,9	190,00	6,6
2,45	58,2	4,45	43,2	7,90	32,4	22,00	19,4	200,00	6,4

6.2.4.2.6 Recording measured values

The initial point of the grain size distribution curve is the time when the first continuous flow of particles reaches the bottom of the collecting tube. Check for agglomeration.

Observe the falling particles and record successively the times at which the surface of the settled grains reach a division line of the collecting tube (reading without parallax).

The end point of measurement is that time when all the particles have settled, i.e. when the height of sedimentation is no longer changing.

During sedimentation, the rubber gasket at the bottom of the collecting tube shall be tapped gently but continuously. This may be carried out by means of a tapper. It shall, however, not be tapped on the pressing lever supporting the tube or on the tube itself.

If agglomerations of abrasive grits can be observed during the sedimentation, this is a sign of insufficient pretreatment of the sample. In such cases the analysis shall be repeated.

6.2.5 Evaluation

6.2.5.1 Determination of grain diameter, d

The determination of the grain size distribution according to this test method is based on Stokes' law. Since all conditions, except the time of sedimentation and the grain size, are constant for a given microgrit, the Stokes' formula can be simplified as follows:

$$d = \frac{K}{\sqrt{t}} \tag{3}$$

where

d is the equivalent grain diameter, in micrometres;

K is the constant whose value is dependent upon temperature, material to be tested and sedimentation medium;

t is the time of sedimentation, in minutes.

When the test temperature is 25 °C, the K values for methyl alcohol are: 79,7 for fused aluminium oxide and 91,1 for silicon carbide.

These values represent a basis for the determination of the equivalent grain diameters given in Tables 11 and 12. For other test temperatures, the grain diameters are also to be calculated according to Stokes' law.

The K values for the temperatures between 18 °C and 30 °C are as given in Table 13.

Table 13 — K values

Test temperature θ °C	K values	
	Fused aluminium oxide	Silicon carbide
18	84,3	96,3
19	83,7	95,5
20	83,0	94,8
21	82,3	94,1
22	81,7	93,3
23	81,0	92,6
24	80,4	91,8
25	79,7	91,1
26	79,1	90,3
27	78,4	89,6
28	77,8	88,9
29	77,1	88,1
30	76,45	87,4

The formulae for the determination of the K values as follows:

— for fused aluminium oxide $K = 96{,}16 - 0{,}657\ \theta$

— for silicon carbide $K = 109{,}6 - 0{,}741\ \theta$

where θ is the temperature of medium in the sedimentation tube, in degrees Celsius.

NOTE Concerning the case of application described herein, Stokes' Law states that grit reaching the bottom of the collecting tube (or the surface of the grits already settled at the bottom of the collecting tube) after a time, t, in minutes, has an equivalent diameter, d, in micrometres.

6.2.5.2 Determination of the grain size

A form of the type given in Annex B can be used for the recording and interpretation of the data, showing:

— column 1: height of sedimentation, h, in division lines as marked on the collecting tube;

— column 2: time of sedimentation, t;

— column 3: volume percentage of the settled sample determined according to Table 14;

— column 4: grain size, d, for fused aluminium oxide determined according to Table 11 and for silicon carbide according to Table 12.

6.2.5.3 Plotting the grain size distribution curve

In the grain size distribution curve, the volume percentages of the sedimented sample are plotted on the ordinate against the grain equivalent sizes, d, on the abscissa, determined according to 6.2.5.2 (see Figures 7, 8 and 9).

Millimetre graph paper can be used for the grain size distribution curve (see Figure 7). However, it is more helpful to use logarithmic probability graph paper (see Figures 8 and 9). With this type of graph paper it is possible to interpret results from only a few measuring points (see Figure 9).

The volume percentages of the settled sample can be read off Table 14 for the respective heights of sedimentation, h. If the height of sedimentation of the total sample, h_{tot}, is, for example, 24 division marks, then Table 14 results in a volume percentage of the total sample of 45,8 % for a height of sedimentation of 11 division lines.

6.2.5.4 Evaluation of the grain distribution curve

In the grain size distribution curve, the d_s values for 3 %, 50 % and 95 % volume percentages of the sample are read and compared with the permissible values according to Table 2.

The sample is in accordance with this part of ISO 8486 when the values for d_{s3}, d_{s50} and d_{s95} are within the permissible limits.

When checking the measured results, allowance shall be made for variations due to the measuring technique. These permissible deviations, given in Table 5, have been determined on the basis of the standard deviations resulting from an ISO round-robin test. The tolerances for production microgrits given in Table 2 shall be increased by these values.

6.2.5.5 Example of testing a sample of fused aluminium oxide

A grit made of fused aluminium oxide is tested in the sedimentation medium at a temperature of 25 °C.

The time is measured and recorded when the first continuous flow of particles reaches the bottom of the collecting tube.

After this, the times are recorded when the sedimentation heights, h, have reached one division mark each. At the end of the measurement, the total sedimentation height, h_{tot}, reaches 24 division marks. The established times are entered in column 2 of the form shown in Annex B.

The volume percentages of the sample can only be determined after the termination of the measurement, when the total height of sedimentation, h_{tot}, is established. They are determined on the basis of Table 14 and entered in the form shown in Annex C.

For the times of sedimentation, t, given in column 2, the grain sizes, d, are determined from Table 11 and entered in column 4 of the form shown in Annex B.

For drawing up the grain size distribution curve, the volume percentages of the sample (column 3) are plotted against the corresponding grain size (column 4), see Figures 7, 8 and 9.

Figure 9 shows that when using the probability grid, a much lower number of points of measurement (6 points of measurement instead of 24 in Figure 7) can lead to a usable result. Only the points of measurement at the division lines 1, 2, 5, 10, 15 and 20 are entered. The established values are to be compared with the permissible values according to Table 4.

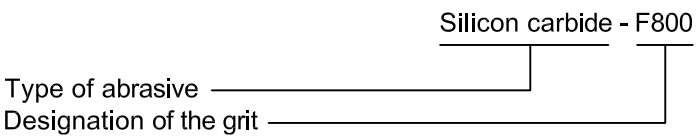
7 Designation

The designation of microgrits for fused aluminium oxide or silicon carbide complying with the requirements of this part of ISO 8486 shall comprise

a) the type of abrasive, and

b) the designation of the grit including the letter “F” for a bonded abrasive followed by a characteristic number representing the grit size.

EXAMPLE

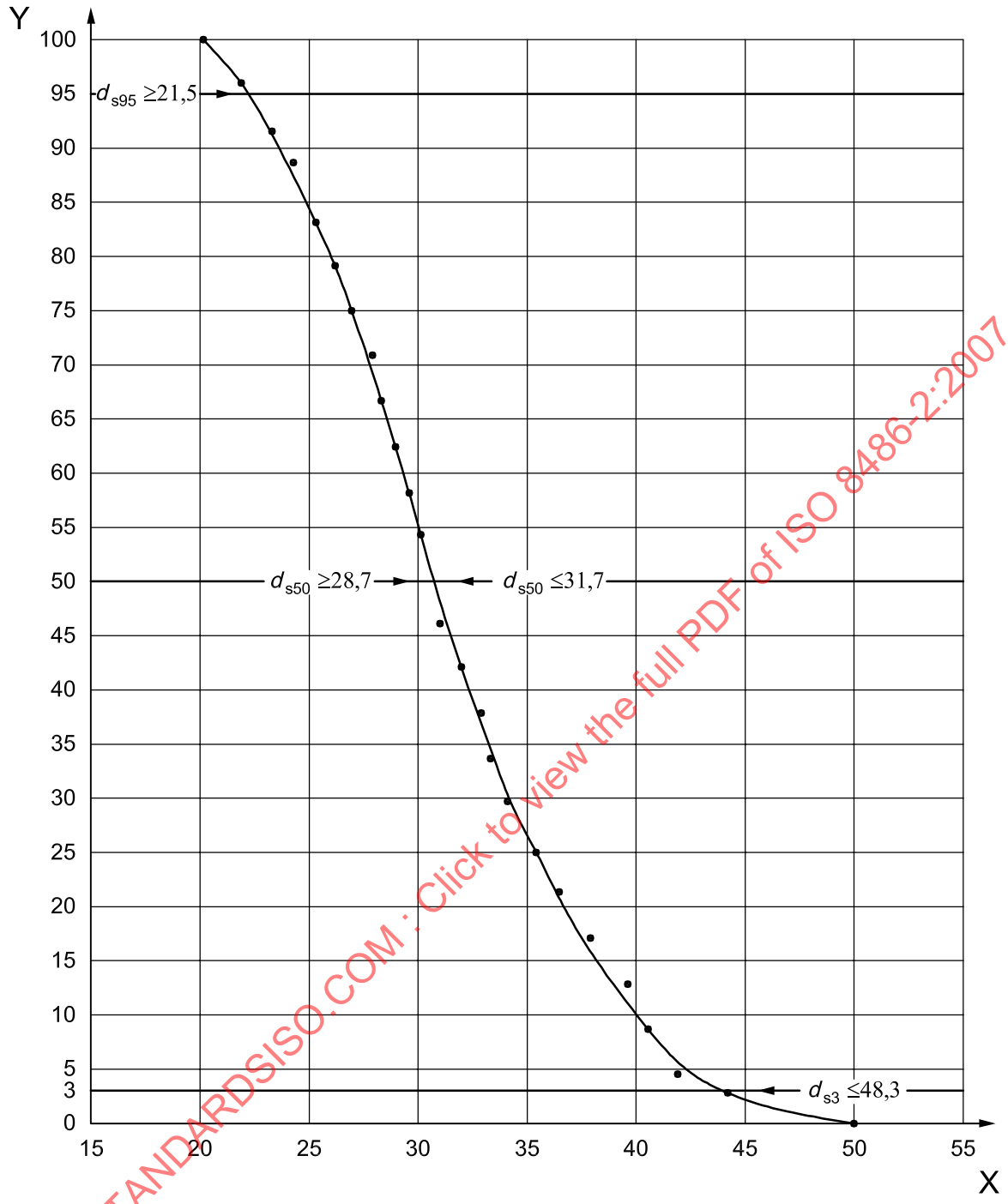


8 Marking

When packing grits of fused aluminium oxide and silicon carbide for bonded abrasive products and silicon carbide for bonded abrasive products and polishing with loose abrasive grains, the grit designation, e.g. “F240”, shall be marked on each of the smallest packing units.

Table 14 — Volume percentages of settled sample as function of height of sedimentation, h, related to total height of sedimentation, h_{tot}, of sample

Height of sedimentation	Total height of sedimentation, h_{tot}, of sample in division marks										
h	20,0	20,5	21,0	21,5	22,0	22,5	23,0	23,5	24,0	24,5	25,0
in division marks	Volume percentage of settled sample										
1	5,0	4,9	4,8	4,7	4,5	4,4	4,3	4,3	4,2	4,1	4,0
2	10,0	9,8	9,5	9,3	9,1	8,9	8,7	8,3	8,3	8,2	8,0
3	15,0	14,6	14,3	14,0	13,6	13,3	13,0	12,8	12,5	12,3	12,0
4	20,0	19,5	19,0	18,6	18,2	17,8	17,4	17,0	16,7	16,7	16,0
5	25,0	24,4	23,8	23,3	22,7	22,2	21,7	21,3	20,8	20,4	20,0
6	30,0	29,3	28,6	27,9	27,3	26,7	26,1	25,5	25,0	24,5	24,0
7	35,0	34,1	33,3	32,6	31,8	31,1	30,4	29,8	29,2	28,6	8,0
8	40,0	39,0	38,1	37,2	36,4	35,6	34,8	34,0	33,3	32,7	32,0
9	45,0	43,9	42,9	41,9	40,9	40,0	39,1	38,3	37,5	36,7	36,0
10	50,0	48,8	47,6	46,5	45,5	44,4	43,5	42,6	41,7	40,8	40,0
11	55,0	53,7	52,4	51,2	50,0	48,9	47,8	46,8	45,8	44,9	44,0
12	60,0	58,5	57,1	55,8	54,5	53,3	52,2	51,1	50,0	49,0	48,0
13	65,0	63,4	61,9	60,5	59,1	57,8	56,5	55,3	54,2	53,1	52,0
14	70,0	68,3	66,7	65,1	63,3	62,2	60,9	59,6	58,3	57,1	56,0
15	75,0	73,2	71,4	69,8	68,2	66,7	65,2	63,8	62,5	61,2	60,0
16	80,0	78,0	76,2	74,4	72,7	71,1	69,6	68,1	66,7	65,3	64,0
17	85,0	83,0	81,0	79,1	77,3	75,6	73,9	72,3	70,8	69,4	68,0
18	90,0	87,8	85,7	83,7	81,8	80,0	78,3	76,6	75,0	73,5	72,0
19	95,0	92,7	90,5	88,4	86,4	84,4	82,6	80,8	79,2	77,6	76,0
20	100,0	97,6	95,2	93,0	90,6	88,9	87,0	85,1	83,3	81,6	80,0
21	—	100,0	100,0	97,7	95,5	93,3	91,3	89,4	87,5	85,7	84,0
22	—	—	—	100,0	100,0	97,8	95,7	93,6	91,7	89,8	88,0
23	—	—	—	—	—	100,0	100,0	97,9	95,8	93,9	92,0
24	—	—	—	—	—	—	—	100,0	100,0	98,0	96,0
25	—	—	—	—	—	—	—	—	—	100,0	100,0



Key

X grain size, d, µm

Y settled volume percentage

NOTE Analysis values read off:

d_{s3} = 44 µm

d_{s50} = 30,8 µm

d_{s95} = 22 µm

Figure 7 — Grain size distribution curve, represented on linear graph paper — Measuring values and permissible limiting values