INTERNATIONAL STANDARD

ISO 8486-2

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Bonded abrasives — Determination and designation of grain size distribution —

Part 2:
Microgrits F230 to F1200

Abrasifs agglomérés — Détermination et désignation de la distribution granulométrique —
Partie 2: Micrograins F230 à F1200

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Contents

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Annexes

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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.

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

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 F1200*

Annexes A, B and C of this part of ISO 8486 are for information only.

Bonded abrasives — Determination and designation of grain size distribution —

Part 2:
Microgrits F230 to F1200

1 Scope

This part of ISO 8486 sets forth a method for determining or checking the size distribution of microgrits from F230 to F1200 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 reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 8486. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8486 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 8486-1:1996, *Bonded abrasives — Determination and designation of grain size distribution — Part 1: Macrogrits F4 to F220.*

3 Definitions

For the purposes of this part of ISO 8486 the definitions given in ISO 8486-1 as well as the following apply.

3.1 microgrits: Grits with grain size distributions which are determined by sedimentation.

4 Method of checking grain size distribution

4.1 Grain size distribution

The grain size distribution of microgrits F230 to F1200 is determined according to the following criteria:

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

b) the median grain size (theoretical grain diameter) must 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) must attain at least the $d_{s94/95}$ value at the 94/95 % point of the grain size distribution curve.

These three criteria must be met. The values are specified in table 1 for the photosedimentometer (94 %) and in table 2 for the US sedimentometer (95 %).

Testing of microgrits F230 to F1200 is carried out by sedimentation according to clause 5 of this standard.

4.2 Grading

The "F" microgrit-series is a graduated series of eleven microgrits starting at a median particle size of 53 µm and ending at 3 µm determined by 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 and where the following equation applies to the factor "f"

$$53 = 3\left(\sqrt[4]{2}\right)^{10} \cdot f^{(0+1+2+3+\ldots\ldots+9)}$$

$$f = \sqrt[45]{\frac{53}{3\left(\sqrt[4]{2}\right)^{10}}} = 1{,}025\,7$$

This produces a series of ratios starting at 1,189 and ending at 1,495.

Table 1 — Grain size distribution of microgrits F230 to F1200 (photosedimentometer)

Grit designation	d_{s3} value max. µm	Median grain size d_{s50} value 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 (at 80 %)

Table 2 — Grain size distribution of microgrits F230 to F1200 (US sedimentometer)

Grit designation	d_{s3} value max. µm	Median grain size d_{s50} value 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 (at 80 %)

NOTE — These values were calculated by the following algorithms, based on ISO round-robin tests. Factors for conversion from Eppendorf photosedimentometer (x) to US sedimentometer (y) are:

d_{s3} value	$y = 0{,}760x + 15{,}1$	$k^{1)} = 0{,}999\,7$
d_{s50} value	$y = 0{,}961x + 4{,}8$	$k = 0{,}999\,2$
$d_{s94/95}$ value	$y = 1{,}090x + 1{,}3$	$k = 0{,}999\,7$

1) k is the correlation factor via which the confidence interval limits for linear relationships were verified.

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

Grit designation	Median grain size µm	Formula
F230	53	Starting point
F240	45	$f^0 = 1 = \frac{53}{44,5} \cdot \frac{1}{\sqrt[4]{2}}$
F280	37	$f^1 = \frac{44,5}{36,5} \cdot \frac{1}{\sqrt[4]{2}}$
F320	29	$f^2 = \frac{36,5}{29,2} \cdot \frac{1}{\sqrt[4]{2}}$
F360	23	$f^3 = \frac{29,2}{22,8} \cdot \frac{1}{\sqrt[4]{2}}$
F400	17	$f^4 = \frac{22,8}{17,3} \cdot \frac{1}{\sqrt[4]{2}}$
F500	13	$f^5 = \frac{17,3}{12,8} \cdot \frac{1}{\sqrt[4]{2}}$
F600	9	$f^6 = \frac{12,8}{9,3} \cdot \frac{1}{\sqrt[4]{2}}$
F800	7	$f^7 = \frac{9,3}{6,5} \cdot \frac{1}{\sqrt[4]{2}}$
F1000	5	$f^8 = \frac{6,5}{4,5} \cdot \frac{1}{\sqrt[4]{2}}$
F1200	3	$f^9 = \frac{4,5}{3} \cdot \frac{1}{\sqrt[4]{2}}$

Table 4 — Permissible deviations resulting from the variations due to the measuring technique (photosedimentometer)

Grit designation	Permissible deviations for the values		
	d_{s3} µm	d_{s50} µm	d_{s94} µm
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			

Table 5 — Permissible deviations resulting from the variations due to the measuring technique (US sedimentometer)

Grit designation	Permissible deviations for the values		
	d_{s3} µm	d_{s50} µm	d_{s95} µm
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			

5 Testing of microgrits F230 to F1200

5.1 General

The testing of microgrits F230 to F1200 is carried out by sedimentation.

Criteria for the determination of 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 94/95 % point of the grain size distribution curve ($d_{s94/95}$ value).

The permissible values are given in tables 4 and 5.

5.2 Designation of the test method

The designation of the test method for microgrits F230 to F1200 shall include an indication of the measuring instrument used thus:

— test-MICRO F – Eppendorf photosedimentometer;
— test-MICRO F – Sedigraph series;
— test-MICRO F – US sedimentometer;
— test-MICRO F – "Others".

5.3 Test method

The test method is based on Micro-F-mastergrits[2].

2) Micro-F-mastergrits of fused aluminium oxide and silicon carbide can be obtained from Staatliche Materialprüfungsanstalt Darmstadt, Grafenstraße 2, D-64283 Darmstadt.
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.

Each Micro-F-mastergrit is accompanied by a certificate of the Staatliche Materialprüfungsanstalt Darmstadt (MPA) stating the value at the 50 % point determined by means of their Eppendorf photosedimentometer. The values measured shall be corrected on the basis of the mastergrit values.

The determination of grain sizes by use of different measuring instruments, e.g. with the Eppendorf photosedimentometer, with the different types of sedigraphs or with instruments using other principles of measurement may give deviating results.

5.4 Preparation of the sample

Prior to the test the sample shall be heated at a temperature of 600 °C ± 20 °C for at least 10 min. It is recommended that the sample be dispersed by means of ultrasonics for example.

5.5 Test procedure

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

5.6 Evaluation

5.6.1 Determination of grain size distribution

The principle upon which this method is based is the comparison of the median (50 %) size determined in a cooperative test on the Micro-F-mastergrits of MPA Darmstadt with that determined by the testing laboratory on its own instruments.

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

The following method applies:

a) determine the d_{s50} value of the Micro-F-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} and $d_{s94/95}$ 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 measured	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.

5.6.2 Evaluation of the corrected test results

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

When checking the measured results allowance must be made for the variations due to the measuring technique. These permissible deviations, given in tables 4 or 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 tables 1 and 2, are to be increased by these values.

6 Measuring instruments: Technical description and measuring methods

6.1 General

This clause describes the application of the Eppendorf photosedimentometer and the US sedimentometer for testing microgrits F230 to F1200 of fused aluminium oxide and silicon carbide to be used for bonded abrasive products and for polishing in the form of loose abrasive grains.

6.2 Eppendorf photosedimentometer

The Eppendorf photometer 1101 M is used, in combination with the sedimentation accessory equipment 1551, for testing microgrits[3].

3) Obtainable from Eppendorf Gerätebau Netheler & Hinz GmbH, Barkhausenweg 1, D-22339 Hamburg 63.

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.

The Eppendorf photosedimentometer consists mainly of:

a) a sedimentation tube of high light-transmitting capacity (cylindrical measuring cell) with a water jacket, the temperature of which is maintained constant at 20 °C ± 0,5 °C by means of a thermostat;

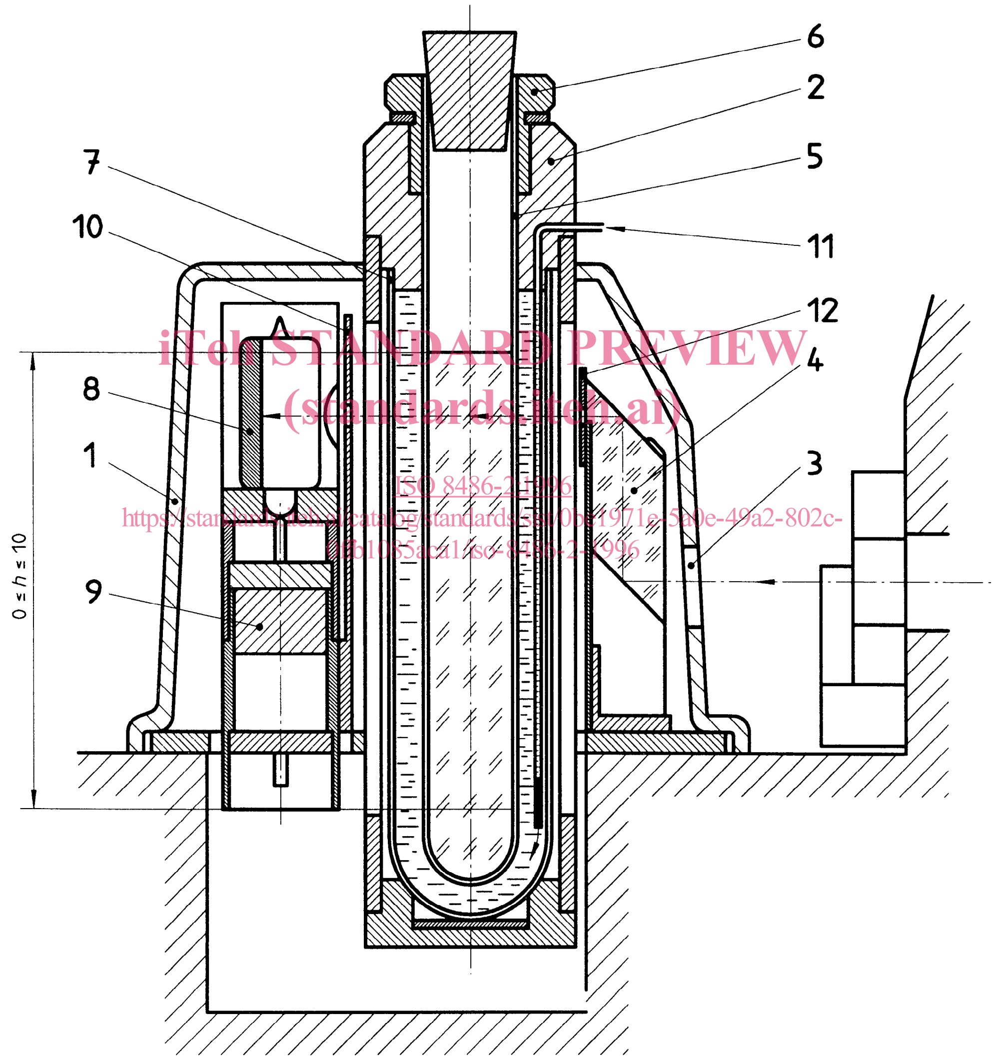
b) a light source from which a light beam falls onto a photoelectric cell passing through the sedimentation tube;

c) a galvanometer recording, at any given moment of the measurement procedure, the intensity of the light falling onto the photocell and consequently the light absorption in the sedimentation tube;

d) a device for the height adjustment of the sedimentation tube as against the light beam providing a maximum height of sedimentation, h, of 10 cm.

The fundamental assembly of the sedimentation equipment 1551 to be used in combination with the Eppendorf photometer is shown in figure 1.

Dimensions in centimetres



Key

1 Case (light-proof)
2 Heating jacket
3 Opening for light beam
4 Deviating prism
5 Sedimentation tube (cylindrical measuring cell)
6 Cell adjusting screw
7 Glass inset for heating jacket
8 Photoelectric cell
9 Photocell adapter
10 Screen
11 Inlet for heating jacket
12 Screen with slit

Figure 1 — Sedimentometer accessory equipment 1551 to be used in combination with the Eppendorf photometer

6.2.1 Test equipment

6.2.1.1 Sedimentation medium

Distilled water with a conductivity ≤ 5 µS or mixtures of distilled water and 1,2-ethandiol (ethylene glycol) shall be used as sedimentation media. These liquids may contain in some cases, an addition of tetra sodium diphosphate ($Na_4P_2O_7$) as dispersing agent.

The sedimentation medium and the concentration of the dispersing agent to be used for the different grain sizes of fused aluminium oxide and silicon carbide are given in table 6.

It is essential that the mixtures have the viscosities specified in table 6, in order to achieve required standards of measurement.

6.2.1.2 Adjustment of the sedimentation medium

The viscosity of the water-1,2-ethandiol sedimentation medium must be exactly adjusted by means of a viscosimeter. It is recommended to use the Ubbelohde viscosimeter (KPG design with suspended level, capillary No. 1, constant $k = 0{,}01$)[4].

The permissible deviation of the viscosity values according to table 6 shall not exceed ± 0,1 mPa·s.

6.2.2 Preparation of the sample

Prior to the test the sample shall be heated at a temperature of 600 °C ± 20 °C for at least 10 min. To remove agglomerates it is recommended that the dispersed sample be treated by means of ultrasonics for example.

6.2.3 Test procedure

6.2.3.1 Adjustment of the zero point

First, the light beam switch is set to the locked position. Then the light spot shall undergo fine adjustment by means of the knurled screw "light value correction" so that it is exactly on the zero point at the left end of the scale.

6.2.3.2 Adjustment and correction of the blank value

The measuring bulb shall be filled to at least half way with the pure sedimentation liquid and placed in the holding device in such a way that the upper metal edge is at 10 cm of the height scale on the bulb side. After this, the lever designated as "light beam switch" shall be set to open.

The light beam must now pass through the clear sedimentation medium and not be impeded by the surface of the liquid.

Table 6 — Sedimentation media and dispersing agent for the testing of grains of fused aluminium oxide and silicon carbide

Grit designation	Sedimentation medium at 20 °C	Dispersing agent tetrasodium diphosphate g/l	
		fused aluminium oxide	silicon carbide
F230	1,2-ethandiol 95 % Viscosity 15,2 mPa·s Density 1,107 g/cm³	0,2	0,2
F240			
F280	1,2-ethandiol 74 % Viscosity 7,7 mPa·s Density 1,091 g/cm³	0,2	0,2
F320			
F360			
F400			
F500	Distilled water Conductivity ≤ 5 µS	0,45	0,2
F600			0,1
F800			
F1000	Distilled water Conductivity ≤ 5 µS	0,45	no additive
F1200			

4) Manufacturer: Schott-Geräte GmbH, Im Langgewann 5, D-65719 Hofheim am Taunus.

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.

With the optical light path in the open position, the median line of the light spot indicator shall be set to 0 (top) or 100 (bottom) by means of the knob "alignment right scale end".

On the left scale end the adjustment is made analogously. Here the adjustment to ∞ (top) or 0 (bottom) is made by means of the knob "alignment left scale end", with the optical light path being closed. It is necessary to re-adjust the values on the right and left scale ends. The position of the step switch of the light spot correction shall be recorded as the "clear value".

The measuring bulb shall be filled up to the top mark with the sedimentation liquid. The clear value shall be checked.

6.2.3.3 Measurement

The amount of grit to be tested (dispersed sample) which is loaded into the measuring bulb shall be such that, after it has been carefully shaken, there shall be an initial extinction of 1,3 to 1,7. Bubbles should be avoided.

The measuring bulb is closed with a rubber stopper and then heated to 20 °C ± 0,5 °C for a period of at least 10 min in a water circuit controlled by a thermostat.

Before starting the measurement, the contents of the measuring bulb shall be homogenized by turning the bulb through 180° to the left and to the right for a period of 2 min (10 times per minute – do not shake). Bubbles should be avoided in this case also.

After this, the measuring bulb shall be placed in the test apparatus. Measuring can be started.

The extinction values shall be read and recorded at the intervals given in the first column of table 7.

Table 7 — Grain sizes as a function of the sedimentation time and height

1		2	3	4	5	6	7	8
Time of sedimentation		**Height of sedimentation**	**Grain size** (theoretical grain diameter *d*)					
			Fused aluminium oxide			Silicon carbide		
			Water[1)]	1,2-ethandiol at 74 %[1)]	1,2-ethandiol at 95 %[1)]	Water[1)]	1,2-ethandiol at 74 %[1)]	1,2-ethandiol at 95 %[1)]
min	s	cm	µm	µm	µm	µm	µm	µm
0	21	10	54,5			63,2		
0	30	10	45,6	128,6		52,8		
0	42	10	38,5	108,7		44,7	126,8	
1	00	10	32,2	90,9	127,5	37,4	106,1	
1	25	10	27,1	76,4	107,5	31,4	89,1	125
2	00	10	22,8	64,3	90,1	26,4	75	105,3
2	50	10	19,1	54	75,7	22,2	63	88,4
4	00	10	16,1	45,5	63,7	18,7	53	74,4
5	40	10	13,5	38,2	53,6	15,7	44,6	62,5
8	00	10	11,4	32,1	45,1	13,2	37,5	52,6
11	20	10	9,6	27	37,9	11,1	31,5	44,2
16	00	10	8,1	22,7	31,9	9,3	26,5	37,2
18	00	7,95	6,8	19,1	26,8	7,9	22,3	31,3
20	00	6,25	5,7	16,1	22,5	6,6	18,8	26,3
22	00	4,85	4,8	13,5	18,9	5,6	15,8	22,1
24	00	3,75	4	11,4	15,9	4,7	13,3	18,6
26	00	2,9	3,4	9,6	13,5	4	11,2	15,7
28	00	2,2	2,9	8,1	11,3	3,3	9,4	13,2
30	00	1,65	2,4	6,7	9,5	2,8	7,9	11
38	20	1,5	2	5,7	8	2,3	6,6	9,3
54	20	1,5		4,8	6,7	2	5,6	7,8

1) See table 6.

Depending on the grain size distribution of the sample, extinction will remain nearly constant for a certain period of time. Negligible variations in the order of 0,01 extinction units from measuring point to measuring point may be ignored. The actual commencement of sedimentation of abrasive grits is indicated by increasing light intensity.

6.2.4 Evaluation

The following method of calculation, derived from Stokes' Law and Lambert-Beer's Law gives satisfactory results in the case of well-graded grain sizes.

It follows that the mass of a grain fraction is proportional to the product of the extinction difference between two successive measurements and the diameter of the grains.

Table 7 gives, in column 1, the reading times and in column 2 the appropriate heights of sedimentation.

Columns 3 to 8 contain the grain sizes calculated according to Stokes' Law which correspond to those times and sedimentation heights in grains of fused aluminium oxide and silicon carbide for each of the three sedimentation media.

6.2.4.1 Determination of the grain size distribution

The following factors shall be listed for the evaluation in a model form corresponding to annex A:

a) time of reading;

b) height of sedimentation;

c) position of the step switch of the light spot correction;

d) extinction as read;

e) grain size.

An example for the evaluation of grain size testing on silicon carbide having approximately 13 µm is shown in table 8. In this example distilled water with a conductivity ≤ 5 µS mixed with 0,2 g tetra sodium diphosphate per litre of water is used as sedimentation medium (see table 6, silicon carbide grain size F500).

The values for the grain size in table 8, column 7, have therefore been deduced from table 7, column 6. Thereafter

— the values read off shall be entered in columns 3 and 4 of table 8; column 5 shall contain the figures giving the extinction value with allowance being made for the clear value;

— column 6 shall contain the difference between two successive figures of column 5;

— the product of the values from columns 6 and 7 shall be calculated and shown in column 8; the results shall be added together;

— column 9 shall contain the figures of column 8 as mass percentages of their sum;

— column 10 shall contain the cumulative sums of the figures of column 9.

The grain size distribution follows from table 8, columns 7 and 10. The measuring values can be plotted on a graph.

If, on measuring microgrit fines using the Eppendorf photosedimentometer (in which the sedimentation time is that corresponding to a theoretical grain size of 2 µm), a residual extinction is found, due to the fact that certain mass percentages have not completely deposited, the evaluation must be carried out as follows:

The rectified residual extinction present (column 5) is carried over to the following line of column 6 and multiplied by half the theoretical grain size (2 µm) belonging to the residual extinction from the last lines of table 7 (38 min 20 s or 54 min 20 s).

The values in columns 9 and 10 are calculated as described before.

In the graph the cumulating sum is limited to 2 µm. If the 94 % value of a grit is less than 2 µm, the % value corresponding to a grain size of 2 µm is indicated, rather than the 94 % value.

Hence, in the present example the silicon carbide microgrit contains

a) 10,2 % mass percentage exceeding 18,7 µm,

b) 29,9 % mass percentage exceeding 15,7 µm and so on up to

c) 100 % mass percentages exceeding 4 µm.

The grain size distribution curve can be plotted with the values of columns 7 and 10 of table 8.

To determine the d_{s3} value the first measured value (in the example 10,2 % mass with 18,7 µm) shall be connected by a straight line to the next higher value of the grain diameter given in table 8, column 7. The point of intersection with the 3 % line is the required d_{s3} value.

NOTE 1 The step switch of the light spot correction makes it possible to read high extinction values off the lower and more precise part of the scale.

Each step corresponds to an extinction value of 0,25. An extinction of, for example, 1,37 can be read with a higher degree of accuracy than 0,12 by turning the switch for 5 steps ($5 \times 0,25 = 1,25$ and $1,37 - 1,25 = 0,12$).

Position 3 of the step switch (table 8, column 3, last line) indicates the clear value of the measuring cell