BS ISO 2926:2013

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Aluminium oxide used for the production of primary aluminium

Particle size analysis for the range 45 µm to 150 µm — Method using electro-formed sieves

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National foreword

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ISO 2926

Third edition
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Aluminium oxide used for the production of primary aluminium — Particle size analysis for the range 45 µm to 150 µm — Method using electroformed sieves

Oxyde d'aluminium utilisé pour la production d'aluminium primaire — Analyse granulométrique dans la gamme 45 µm à 150 µm — Méthode par emploi de tamis électroformés

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Foreword

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The committee responsible for this document is ISO/TC 226, *Materials for the production of primary aluminium*.

This third edition cancels and replaces the second edition (ISO 2926:2005), which has been technically revised to reflect modern industry practice. The major changes are:

— recommended effective aperture tolerance limits have been added;

— sieves are cleaned by brushing rather than using an ultrasonic bath;

— the mass of sample to be sieved is 50 g;

Introduction

This International Standard is based on AS 2879.6-1995 prepared by Standards Australia.

INTERNATIONAL STANDARD ISO 2926:2013(E)

Aluminium oxide used for the production of primary aluminium — Particle size analysis for the range 45 µm to 150 µm — Method using electroformed sieves

1 Scope

This International Standard specifies a dry sieve method using electroformed sieves for determining the mass distribution of the particle sizes in aluminium oxide used for the production of primary aluminium.

This method is applicable to calcined aluminium oxide containing a maximum of 20 % mass fraction of particles having a mean diameter exceeding 150 µm, and containing a maximum of 15 % mass fraction of particles having a mean diameter less than 45 µm.

This method is not applicable to the use of woven wire sieves.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3310-3, *Test sieves — Technical requirements and testing — Part 3: Test sieves of electroformed sheets*

3 Principle

A test portion of the crude sample is sieved mechanically through electroformed sieves.

Each of the separate fractions is weighed on the sieve, and a cumulative mass of material retained on each sieve aperture size is calculated.

4 Apparatus

4.1 Test sieves, each including a sieving medium (screen) and a frame.

The frames shall be cylindrical, having nominal diameters of 200 mm and heights between 50 mm and 75 mm. A lid and a bottom receiver shall be included. The sieves, lid and bottom receiver shall be capable of being fitted together tightly to form a series of test sieves[1)] .

The screens shall be constructed of smooth electroformed sheet having square openings. The aperture tolerances shall be in accordance with ISO 3310-3.

The sieve apertures shall have nominal sizes of 150 µm, 106 µm, 75 µm, 53 µm and 45 µm. Refer to Annex B for effective aperture determination and tolerance limits.

1) Certified electroformed sieves manufactured by Precision Eforming of Cortland, New York, USA, are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

4.2 Mechanical sieve shaker, capable of clamping the sieves mounted inside each other together with the top lid and bottom receiver to form a vertical assembly.

The apparatus[2)] shall impart to the sieve assembly a simultaneous horizontal rotary motion and a vertical tapping action resulting from the fall of a hammer. This combined action shall cause sufficient displacement of the aluminium oxide particles to prevent aggregation but not cause any deformation of the sieving screen or any size reduction of the aluminium oxide particles through shock or abrasion.

4.3 Laboratory top pan balance, capable of weighing the sieves to the nearest 0,01 g.

The balance may be fitted with a lightweight frame mounted on the weighing pan to enable direct weighing of test sieves and receiver.

4.4 Brush, fine bristled, soft, a few centimetres wide.

5 Procedure

5.1 Sample preparation

Split the sample into test portions by riffling or rotary sample division until the required mass is obtained.

Weigh the final split to the nearest 0,01 g. The mass (m_0) of the final split should fall in the range 45 to 55 g.

5.2 Preparation of test sieves

Prepare the test sieves as follows.

a) Clean each test sieve (4.1) in turn by inverting it over a suitable container, brushing the mesh to remove trapped particles and tapping the sieve frame lightly to remove any adhering particles.

b) Inspect each sieve to ensure that the mesh is not ruptured and there is not excessive aperture binding. Upon holding the sieve up to a light source, areas of blinding are visible as being darker in appearance. If more than 10 % of the sieve mesh is blinded the sieve is not sufficiently clean to use. Larger ruptures in the sieve may be seen by visual inspection. To see smaller ruptures magnification is required. Inspection using a stereo microscope is recommended; scan the entire mesh area and the edges to check for ruptures.

NOTE 1 Ruptures of the mesh can be successfully repaired using silver solder or hardening synthetic resin. When a repair is performed, check the repaired area under magnification to ensure the rupture is covered and that the solder is bonded to the mesh.

NOTE 2 Other options for cleaning sieves are given in Annex D.

5.3 Determination

Determine the size distribution as follows.

a) Weigh each sieve (masses m_1) on the top pan balance (4.3) to the nearest 0,01 g. Similarly, weigh the bottom receiver.

b) Assemble the test sieves (4.1) on the mechanical sieve shaker (4.2) in order of increasing aperture size from bottom to top, starting with the bottom receiver.

c) Spread the test portion (5.1) on the top-most sieve. Close with the tightly fitting lid and install the positioning cover. Lower the hammer onto the cover.

2) RO-TAP Testing sieve shakers, (W. S. Tyler Inc., Mentor, Ohio, U.S.A.), operated in accordance with the manufacturer's recommended settings, are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

d) Switch on the mechanical sieve shaker and allow it to operate for 30 min.

e) Remove the sieve stack, and weigh each sieve and its contents to the nearest 0,01 g (masses m_2).

f) Similarly weigh the bottom receiver and contents.

6 Calculation of results

Calculate the results as follows:

a) Calculate the masses of each retained sample from the following equation:

$$m_3 = m_2 - m_1 \quad (1)$$

where

m_3 is the mass of retained sample, in grams;

m_2 is the mass of test sieve plus retained sample, in grams;

m_1 is the mass of test sieve, in grams.

In the case of the sample collected in the bottom receiver, m_1 is the mass of the bottom receiver and m_2 is the mass of the bottom receiver plus contents.

b) Calculate the cumulative mass m_4 for each sieve size.

c) Calculate the mass recovered m_5, using the following equation:

$$m_5 = \sum m_3 \quad (2)$$

where m_3 is the mass of sieve contents for each sieve and the bottom receiver.

If the mass m_5 exceeds the mass of the original test portion (m_0) by more than 0,5 g, or if m_5 is less than m_0, then another test portion should be analysed. Due to absorption of moisture during the test, some increase in mass is normal. Any loss in mass is most likely caused by physical loss of sample.

d) Calculate, to two decimal places, the cumulative per cent final mass m_6 for each sieve aperture size, using the following equation:

$$m_6 = \frac{m_4}{m_5} \times 100$$

e) Prepare a table of values of m_6 corresponding to each successive nominal aperture size. Report each value of m_6 to one decimal place.

NOTE 1 It can be useful to plot a cumulative distribution curve of the mass passing through each sieve, expressed as a percentage, against the corresponding nominal aperture size, in order of decreasing aperture size.

NOTE 2 Annex A gives an example of a calculation (Table A.1) and reporting (Table A.2) of size analysis.

7 Test report

The test report shall include the following information:

a) the table of cumulative per cent mass retained for each nominal aperture size (m_6 values), expressed as per cent mass fraction of the original sample;

b) a reference to this International Standard, i.e. ISO 2926:2013;

c) any unusual features noted during the determination and any operation not included in this International Standard which may have affected the results.

8 Precision

The test program (see Annex C) was performed on four samples by seven laboratories using pre-mixing and splitting via rotary splitters. It showed that precision was partially sample dependant and thus an overall precision limit cannot be implied. The means, repeatability (*r*) and reproducibility (*R*) determined for each sample from the test program are given in Table 1.

The average precisions for the four samples are also given in Table 1. These averages are indicative of the precisions that can be expected from this method but users should also note the range of precisions possible for different samples as indicated by the results for the four individual test samples.

Table 1 — Precision for size analysis (at 95 % confidence level)

Means as percentage by mass (absolute)

		Sieve fraction				
Sample		**+150µm**	**+106µm**	**+75µm**	**+53µm**	**+45µm**
S128	**mean**	1,1	19,7	65,7	90,5	95,5
	r	0,4	1,5	2,2	1,1	0,7
	R	0,6	2,6	5,2	1,6	1,2
S129	**mean**	3,4	22,0	57,4	82,3	90,0
	r	0,3	0,9	1,1	0,8	0,7
	R	1,1	2,3	3,0	1,9	1,1
S130	**mean**	11,0	42,0	71,2	87,0	91,9
	r	0,8	1,6	1,9	1,5	1,1
	R	2,3	2,5	2,5	2,2	1,6
S131	**mean**	2,7	44,1	85,7	97,6	99,2
	r	0,4	0,7	0,8	0,6	0,4
	R	1,6	3,1	1,5	1,0	0,5
Average	**r**	0,5	1,2	1,5	1,0	0,7
	R	1,4	2,6	3,0	1,7	1,1
The results of the test programme from which these values were derived are presented in Annex C.						

Annex A
(informative)

Example of calculation of size analysis

Table A.1 — Example of calculation of size analysis

Sieve aperture or pan	Mass of sieve or pan	Sieve mass + mass retained	Mass retained	Cumulative mass	Retained cumulative
	m_1	m_2	m_3	m_4	m_6
µm	g	g	g	g	%
150	411,06	412,49	1,43	1,43	3,76
106	435,93	446,10	10,17	11,60	30,48
75	430,88	446,38	15,50	27,10	71,20
53	427,12	434,60	7,48	34,58	90,86
45	408,80	410,18	1,38	35,98	94,48
Pan	284,62	286,72	2,10		
Initial mass m_0 = 37,81 g.					
Total mass recovered m_5 = 38,06 g.					

Table A.2 — Example of reporting size analysis

Sieve fraction	Mass fraction retained (cumulative)
	%
+150 µm	3,8
+106 µm	30,5
+75 µm	71,2
+53 µm	90,9
+45 µm	94,5

Annex B
(informative)

Determination and use of effective aperture

The Effective Aperture (EA) is the size at which a sieve "cuts" a sample's particle size distribution. It is determined by sieving a suitable certified reference material (CRM), calculating a weight per cent passing the sieve and using the CRM's particle size distribution data to infer an EA. EA differences between sieves of the same nominal aperture size will explain biases between them. A sieve with a higher EA will give a lower retained mass per cent than one with a smaller EA. If EA's of sieves are to be compared, the same CRM must be used to determine their effective apertures because EA is dependent on the CRM used to determine it.

EA's were determined for all sieves used in this method's precision test program (see Annex C). Five laboratories reported their EA results and these are given in Table B.1.

It is recommended that the effective aperture for 45 µm sieves should be within ±2 µm of the nominal aperture and that the 150µm, 106 µm, 75 µm and 53 µm sieves be within ±5 µm.

Some recommended reference materials for effective aperture determination are NIST 1004a, BCR130, NIST 1004b and NIST 1017b. Refer to the manufacturer's specification for the sizing range.

Table B.1 — Results of effective aperture determinations

Percentage mass fraction

	Effective Apertures					NIST CRM
Nominal	**150 µm**	**106 µm**	**75 µm**	**53 µm**	**45 µm**	
Lab 1	153,8	108,5	71,6	53,0	45,6	1004b
Lab 2	153,3	107,9	74,5	51,9	44,2	1004c, 1017b
Lab 3	151,8	107,5	72,9	52,5	44,9	1004c, 1017b
Lab 4	148,5	107,0	74,8	55,8	44,6	1004b
Lab 5	153,5	108,5	80,0	56,6	44.6	1004a

Annex C
(informative)

Results of interlaboratory test programme

A test programme using this method was conducted according to AS 2850 on four different refinery aluminas by participants from seven Australian and Canadian alumina refinery laboratories. Samples were pre-mixed and split using rotary splitters. The between-laboratory means, repeatability (r) and reproducibility (R) at 95 % confidence levels are given in Table C.1.

All sieves in the test program complied with the recommended effective aperture limits given in Annex B.

Table C.1 — Results of test programme on four refinery aluminas by seven laboratories

Percentage mass fraction

Alumina sample	Laboratory	Per cent retained on each fraction				
		+150 µm	+106 µm	+75 µm	+53 µm	+45 µm
S-128	Lab 1	0,8	19,1	67,0	90,0	95,5
	Lab 2	1,0	20,4	64,6	90,6	95,7
	Lab 3	1,4	20,3	66,1	90,7	95,7
	Lab 4	1,0	19,4	63,4	89,9	96,0
	Lab 5	1,1	20,8	64,0	90,8	95,7
	Lab 6	1,2	19,8	67,1	90,8	94,8
	Lab 7	1,0	18,5	67,7	91,2	95,5
	Mean	1,1	19,7	65,7	90,5	95,5
	r	0,4	1,5	2,2	1,1	0,7
	R	0,6	2,6	5,2	1,6	1,2
S-129	Lab 1	3,2	21,7	58,1	81,8	89,9
	Lab 2	3,3	22,1	56,3	82,1	89,9
	Lab 3	4,1	23,0	58,6	82,7	90,1
	Lab 4	3,3	21,8	56,3	81,4	90,6
	Lab 5	3,8	23,0	56,5	82,4	89,9
	Lab 6	3,5	21,7	57,6	83,2	89,9
	Lab 7	2,9	20,9	58,2	82,7	89,5
	Mean	3,4	22,0	57,4	82,3	90,0
	r	0,3	0,9	1,1	0,8	0,7
	R	1,2	2,3	3,0	1,9	1,1
S-130	Lab 1	10,6	41,9	71,5	86,8	91,7
	Lab 2	10,4	41,2	70,0	86,7	91,5
	Lab 3	10,7	41,7	70,9	86,7	91,4
	Lab 4	11,4	42,3	70,9	86,4	92,1
	Lab 5	12,4	43,1	70,9	87,1	91,7
	Lab 6	11,0	42,7	72,1	88,2	92,8
	Lab 7	10,1	41,1	71,8	87,5	91,8
	Mean	11,0	42,0	71,2	87,0	91,9
	r	0,8	1,6	1,9	1,5	1,1
	R	2,3	2,5	2,6	2,2	1,6
S-131	Lab 1	2,1	42,6	85,5	97,6	99,3
	Lab 2	2,2	44,3	85,7	97,7	99,2
	Lab 3	2,9	44,5	85,4	97,5	99,1
	Lab 4	2,9	44,0	85,2	97,0	99,3
	Lab 5	3,6	45,1	85,6	97,9	99,1
	Lab 6	2,8	45,4	86,2	98,0	99,5
	Lab 7	2,1	42,8	86,5	97,8	99,1
	Mean	2,7	44,1	85,7	97,6	99,2
	r	0,4	0,7	0,8	0,6	0,4
	R	1,6	3,1	1,5	1,0	0,5

Annex D
(informative)

Ultrasonic cleaning of sieves

Where apartures are blinded with fine particles, brushing the sieve may not be effective in dislodging these particles. Ultrasonic cleaning is effective in removing these particles.

To ultrasonically clean sieves, submerge the sieve , in a vertical orientation in an ultrasonic bath containing either water dosed with a suitable surfactant or a 50 % aqueous solution of isopropanol. Activate sonification for periods of 10 to 15 s until apertures are cleared. High-powered ultrasonic power baths may damage sieve mesh, clean using a low power setting if available. It is recommended that ultrasonic cleaning should not be carried out regularly as damage to sieves has been reported under some ultrasonic cleaning conditions.

After sonification, rinse sieves in destilled or dionized water and dry in a warm oven (40 to 60°C).

Bibliography

[1] AS 2850, *Chemical analysis — Interlaboratory test programs — For determining precision of analytical method(s) — Guide to the planning and conduct*

[2] AS 2879.6-1995, *Alumina — Determination of the mass distribution of particle sizes using electroformed sieves*

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