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APPENDICES

Appendix A

The mesh size of standard screen compares with the actual size of the openings

ASTM Standard Screen Sizes

"Mesh" sieve designation	Sieve opening	
	mm	in.
4	4.76	0.187
6	3.36	0.132
10	2.00	0.0787
12	1.68	0.0661
16	1.19	0.0469
20	0.84	0.0331
40	0.42	0.0165
80	0.177	0.0070
120	0.125	0.0049
170	0.088	0.0035
200	0.074	0.0029
230	0.063	0.0025
270	0.053	0.0021
325	0.044	0.0017
400	0.037	0.0015

Source: ASTM E11, Annual Book of ASTM Standards, American Society for Testing and Materials, Philadelphia, 1970.

Appendix B

Standard Test Method for Flow Rate of Metal Powders[1]

This standard is issued under the fixed designation B 213; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval. B 213

1. Scope

1.1 This test method covers the determination of the flow rate of metal powders and is suitable only for those powders which will flow unaided through the specified apparatus.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Significance and Use

2.1 The flow rate of a metal powder determines the rate of filling of a die cavity in the pressing of sintered metal parts or bearings. High flow rates (low flow times) are usually desired for high productivity. The test method may be part of the purchase agreement between powder manufacturer and P/M parts producers, or it may be an internal quality control test for powder blended by a parts producer. It is commonly applied to ferrous powders and copper base alloys, but may be used on other powders as well. The test is not applicable to wet or pasty mixtures of metal powders, since they will not flow through the funnel and are not commonly used in P/M processing.

3. Apparatus

3.1 *Powder Flowmeter Funnel*—A standard flowmeter funnel[2] (Fig. 1) having a calibrated orifice of 0.10 in. (2.54 mm) in diameter.

3.2 *Stand*[2]—A stand (Fig. 1) to support the powder flowmeter funnel.

3.3 *Base*—A level, vibration-free base to support the powder flowmeter.

3.4 *Stop Watch.*

3.5 *Balance*—A balance suitable for weighing accurately to 0.01 g.

4. Test Specimen

4.1 The test specimen shall be 50 g, weighed to the nearest 0.1 g.

5. Procedure

5.1 The test specimen shall be tested as sampled. It should be noted, however, that moisture, oils, stearic acid, stearates, waxes, etc., may alter the characteristics of the powder.

5.2 Carefully load the test specimen into the flowmeter funnel while keeping closed the discharge orifice at the bottom of the funnel by placing a dry finger under it. Take care that the short stem of the funnel is filled.

5.3 Start the stop watch simultaneously with removal of the finger from the discharge orifice and stop it at the instant the last of the powder leaves the funnel. Record the elapsed time in seconds.

6. Report

6.1 The elapsed time shall be multiplied by the correction factor (see Note) and the result reported in seconds to the nearest second.

NOTE —The manufacturer supplies the funnel calibrated as follows: Using the procedure described in Section 5, the flow rate of standard 150-mesh Turkish emery is determined. The average of five determinations (the extremes of which shall not differ by more than 0.4 s) is stamped on the bottom of the funnel. The correction factor of the unused funnel is 40.0 divided by this number. It is recommended that the factor be periodically verified by the user by determining, by the above method, the flow rate of the standard 150-mesh Turkish emery.[3] If the flow rate has changed from that stamped on the instrument, the new correction factor will be 40.0 divided by this new flow rate. Before adopting the new correction factor, however, it is recommended that the cause of the change be investigated. If the flow rate has increased, it is probable that repeated use has burnished the orifice and the new correction factor may be used. A decrease in flow rate may indicate a plating of soft powder upon the orifice. This should be carefully removed with the aid of a pipe cleaner and the calibration test rerun, the new correction factor being calculated if required. It is recommended that the use of a funnel be discontinued after the flow rate of the standard sample has increased such that the time of flow is less than 37 s. The manufacturer's experience indicates that, under conditions of almost continuous daily use, a decrease in time of flow of 3 s should be expected after 5 years of service.

7. Precision and Bias

7.1 The precision of this test method is presently being determined by Subcommittee B09.02.

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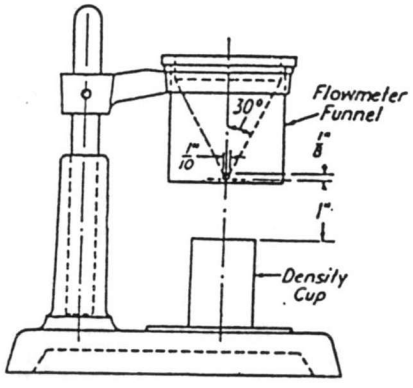
[1] This test method is under the jurisdiction of ASTM Committee B-9 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.02 on Base Metal Powders.

Current edition approved Feb. 23, 1990. Published April 1990. Originally published as B 213 – 46 T. Last previous edition B 213 – 83.

[2] The powder flowmeter funnel, density cup, and stand are available from Alcan Powders and Pigments, 901 Lehigh Ave., Union, NJ 07083-7632.

[3] Standardized No. 150 emery grit is no longer being sold. In those instances where the user desires to verify the correction factor and does not possess the No. 150 emery grit, the funnel may be returned to Alcan Powders and Pigments, 901 Lehigh Ave., Union, NJ 07083-7632, for re-calibration and re-certification. It is recommended that verification be done at least annually depending on frequency of use.



Metric Equivalents

in.	mm
1/10	2.54
1/8	3
1	25

FIG. 1 Flowmeter Apparatus

Appendix C

Standard Test Method for Tap Density of Powders of Refractory Metals and Compounds by Tap-Pak Volumeter[1]

This standard is issued under the fixed designation B 527; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers determination of the tap density (packed density) of refractory metal powders and compounds by means of the Tap-Pak Volumeter.[2]

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Apparatus

2.1 *Graduated Cylinder*,[3] calibrated to contain 25 mL at 20°C, internal diameter 15 mm, height 180 mm and weight approximately 60 g.

2.2 *Holder*—A cylinder holder weighing 1 lb (454 g).

2.3 *Tapping Device*, consisting of a baseplate with single-phase a-c condenser motor, with worm drive, reduction ratio 15 to 1, cam shaft speed 250 rpm, tapping stroke travel 3.2 mm.

2.4 *Counter*—A four-digit adjustable counter, which can be preset to deliver numbers of taps between 1 and 9999.

2.5 *Balance*, having a capacity of at least 100 g and a sensitivity of 0.1 g.

3. Significance and Use

3.1 This test method covers the evaluation of the tapped density physical characteristic of powders. The degree of correlation between the results of this test and the quality of powders in use will vary with each particular application and has not been fully determined.

4. Test Specimen

4.1 The test specimen shall be 50 g except as noted in 4.2.

4.2 For refractory metal and compound powders too voluminous to fit into the 25-mL graduated cylinder, reduce sample size to 20 g or 10 g, as necessary, and follow the standard procedure.

5. Procedure

5.1 Weigh 50 g of the test specimen to an accuracy of ±0.1 g.

5.2 Pour the test specimen carefully into the graduated cylinder, using a funnel. To ensure proper level, rotate the funnel while pouring the test specimen.

5.3 Preset the counter for 3000 taps.

5.4 Start tapping device.

5.5 Read the tapped volume, V, in millilitres, by calculating the mean value between the highest and the lowest point at the tapped volume.

6. Calculation and Report

6.1 Calculate tap density in grams per cubic centimetre to the nearest tenth by dividing 50 g (10 or 20 g for samples as noted in 4.2) by the tapped volume, V, read in millilitres as follows:

$$\text{Tap density, g/cm}^3 = 50\ \text{g}/V$$

where:

V = tapped volume, mL.

7. Precision and Bias

7.1 Precision has been determined from round-robin testing performed prior to the approval of this test method. Those results which have been re-verified show a precision of from ± 1 to 2 % of the value determined as the 2 σ limits. The variation depends upon the tap density of the powder being determined which can vary between 2.0 and 8.0 g/cm^3.

7.2 Bias cannot be stated since there is no universally accepted standard instrument, nor are instruments sold as certified standards.

[1] This test method is under the jurisdiction of ASTM Committee B-9 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.03 on Refractory Metal Powders.

Current edition approved Aug. 30, 1985. Published December 1985. Originally published as B 527 – 70. Last previous edition B 527 – 81.

[2] Tap-Pak Volumeter Model No. JEL ST2 manufactured by J. Engelsmann A.G. of Ludwigshafen a. Rh. West Germany. Available through Shandon Southern Instruments Inc., 171 Industry Drive, Pittsburgh, PA 15275.

[3] Example: Corning, No. 3046, Pyrex Brand.

Appendix D

Standard Test Method for WATER ABSORPTION, BULK DENSITY, APPARENT POROSITY, AND APPARENT SPECIFIC GRAVITY OF FIRED WHITEWARE PRODUCTS[1]

This standard is issued under the fixed designation C 373; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method covers procedures for determining water absorption, bulk density, apparent porosity, and apparent specific gravity of fired unglazed whiteware products.

2. Apparatus and Materials

2.1 *Balance*, of adequate capacity, suitable to weigh accurately to 0.01 g.

2.2 *Oven*, capable of maintaining a temperature of 150 ± 5 C (302 ± 9 F).

2.3 *Wire Loop, Halter, or Basket*, capable of supporting specimens under water for making suspended mass measurements.

2.4 *Container*—A glass beaker or similar container of such size and shape that the sample, when suspended from the balance by the wire loop, specified in 2.3, is completely immersed in water with the sample and the wire loop being completely free of contact with any part of the container.

2.5 *Pan*, in which the specimens may be boiled.

2.6 *Distilled Water.*

3. Test Specimens

3.1 At least 5 representative test specimens shall be selected. The specimens shall be unglazed and shall have as much of the surface freshly fractured as is practical. Sharp edges or corners shall be removed. The specimens shall contain no cracks. The individual test specimens shall weigh at least 50 g.

4. Procedure

4.1 Dry the test specimens to constant mass (Note) by heating in an oven at 150 C (302 F), followed by cooling in a desiccator. Determine the dry mass, *D*, to the nearest 0.01 g.

NOTE—The drying of the specimens to constant mass and the determination of their masses may be done either before or after the specimens have been impregnated with water. Usually the dry mass is determined before impregnation. However, if the specimens are friable or evidence indicates that particles have broken loose during the impregnation, the specimens shall be dried and weighed after the suspended mass and the saturated mass have been determined, in accordance with 4.3 and 4.4. In this case, the second dry mass shall be used in all appropriate calculations.

4.2 Place the specimens in a pan of distilled water and boil for 5 h, taking care that the specimens are covered with water at all times. Use setter pins or some similar device to separate the specimens from the bottom and sides of the pan and from each other. After the 5-h boil, allow the specimens to soak for an additional 24 h.

4.3 After impregnation of the test specimens, determine to the nearest 0.01 g the mass, *S*, of each specimen while suspended in water. Perform the weighing by placing the specimen in a wire loop, halter, or basket that is suspended from one arm of the balance. Before actually weighing, counterbalance the scale with the loop, halter, or basket in place and immerse in water to the same depth as is used when the specimens are in place. If it is

[1] This method is under the jurisdiction of ASTM Committee C-21 on Ceramic Whitewares and Related Products.

Current edition approved Aug. 29, 1972. Published October 1972. Originally published as C 373 – 55 T. Last previous edition C 373 – 56 (1970).

desired to determine only the percentage of water absorption, omit the suspended mass operation.

4.4 After the determination of the suspended mass or after impregnation, if the suspended mass is not determined, blot each specimen lightly with a moistened, lint-free linen or cotton cloth to remove all excess water from the surface, and determine the saturated mass, M, to the nearest 0.01 g. Perform the blotting operation by rolling the specimen lightly on the wet cloth, which shall previously have been saturated with water and then pressed only enough to remove such water as will drip from the cloth. Excessive blotting will introduce error by withdrawing water from the pores of the specimen. Make the weighing immediately after blotting, the whole operation being completed as quickly as possible to minimize errors due to evaporation of water from the specimen.

5. Calculations

5.1. In the following calculations, the assumption is made that 1 cm³ of water weighs 1 g. This is true within about 3 parts in 1000 for water at room temperature.

5.1.1 Calculate the exterior volume, V, in cubic centimetres, as follows:

$$V = M - S$$

5.1.2 Calculate the volumes of open pores and impervious portions in cubic centimetres as follows:

Volume of open pores, cm³ $= M - D$

Volume of impervious portions, cm³ $= D - S$

5.1.3 The apparent porosity, P, expresses, as a percentage, the relationship of the volume of the open pores of the specimen to its exterior volume. Calculate the apparent porosity as follows:

$$P = [(M - D)/V] \times 100$$

5.1.4 The water absorption, A, expresses as a percentage, the relationship of the mass of water absorbed to the mass of the dry specimen. Calculate the water absorption as follows:

$$A = [(M - D)/D] \times 100$$

5.1.5 Calculate the apparent specific gravity, T, of that portion of the test specimen that is impervious to water, as follows:

$$T = D/(D - S)$$

5.1.6 The bulk density, B, in grams per cubic centimetre, of a specimen is the quotient of its dry mass divided by the exterior volume, including pores. Calculate the bulk density as follows:

$$B = D/V$$

6. Report

6.1 For each property, report the average of the values obtained with at least 5 specimens, and also the individual values. Where there are pronounced differences among the individual values, another lot of 5 specimens shall be tested and in addition to individual values the average of all 10 determinations shall be reported.

7. Precision and Accuracy

7.1 This method is accurate to ±0.2 percent water absorption in interlaboratory testing when the average value recorded by all laboratories is assumed to be the true water absorption. The precision is approximately ±0.1 percent water absorption on measurements made by a single experienced operator.

Appendix E

X-ray Diffraction Card

of

Hydroxyapatite

($Ca_5(PO_4)_3OH$)

9-432 MAJOR CORRECTION

d	2.81	2.78	2.72	8.17
I/I$_1$	100	60	60	11

$Ca_5(PO_4)_3(OH)$ $1/2[Ca(OH)_2 \cdot 3Ca_3(PO_4)_2]$ ★

CALCIUM HYDROXIDE ORTHOPHOSPHATE (HYDROXYAPATITE)

Rad. CuKα$_1$ λ 1.5405 Filter Dia. 114.6mm
Cut off 50 I/I$_1$ PHOTOMETER* (GUINIER CAMERA)
Ref. DEWOLFF, TECHN. PHYS. DIENST, DELFT, HOLLAND

Sys. HEXAGONAL S.G. $P6_3/M$ (176)
a_o 9.418 b_o c_o 6.884 A C 0.7309
α β γ Z 2 D_x 3.16
Ref. IBID.

ε n_ω n_ε
2V D 3.08 mp Color Sign
Ref.

* I/I$_1$ ARE PEAK VALUES FROM A PATTERN WHICH SHOWS SLIGHT BROADENING OF PRISM REFLECTIONS.
SAMPLE OBTAINED FOLLOWING THE PROCEDURE INDICATED BY HODGE C.S., IND. ENG. CHEM. ANAL. ED. 10 156 (1938).

d Å	I/I$_1$	hkl	d Å	I/I$_1$	hkl
8.17	12	100	2.040	2	400
5.26	6	101	2.000	6	203
4.72	4	110	1.943	30	222
4.07	10	200	1.890	16	312
3.88	10	111	1.871	6	320
3.51	2	201	1.841	40	213
3.44	40	002	1.806	20	321
3.17	12	102	1.780	12	410
3.08	18	210	1.754	16	402,303
2.814	100	211	1.722	20	004,411
2.778	60	112	1.684	4	104
2.720	60	300	1.644	10	322,223
2.631	25	202	1.611	8	313
2.528	6	301	1.587	4	501,204
2.296	8	212	1.542	6	420
2.262	20	310	1.530	6	331
2.228	2	221	1.503	10	214,421
2.148	10	311	1.474	12	502
2.134	4	302	1.465	4	510
2.065	8	113	PLUS ADDITIONAL LINES		

Appendix F

X-ray Diffraction Card

of

Beta Tricalcium Phosphate

(β - $Ca_3(PO_4)_2$)

9-169 MAJOR CORRECTION

d	2.88	2.61	3.21	4.15	β-$Ca_3(PO_4)_2$ ★
I/I$_1$	100	65	55	12	BETA CALCIUM ORTHOPHOSPHATE (WHITLOCKITE)

Rad. $CuK\alpha_1$ λ 1.5405 Filter Dia. 114.6mm
Cut off 50 I/I$_1$ PHOTOMETER
Ref. DEWOLFF, TECH.. PHYS. DIENST, DELFT, HOLLAND

Sys. HEXAGONAL S.G. $R\bar{3}c$ (167)
a_o 10.429 b_o c_o 37.38 A C 3.583
α β γ Z 21 D_x 3.07
Ref. IBID. SPACE GROUP AND Z FROM ISOMORPHOUS WHITLOCKITE

$\varepsilon\alpha$ $n\omega\beta$ $\varepsilon\gamma$ Sign
2V D mp Color
Ref.

SAMPLE OBTAINED BY HEATING A COMMERCIAL SAMPLE

d Å	I/I$_1$	hkl	d Å	I/I$_1$	hkl
8.15	12	012	2.607	65	220
6.49	16	104	2.562	6	0.1.14
6.22	6	006	2.553	8	223
5.21	20	110	2.520	12	2.1.10
4.80	2	113	2.439	6	131
4.39	d	202	2.407	10	1.2.11,226
4.15	4	018	2.375	6	315
4.06	16	024	2.263	10	1.0.16
4.00	4	116	2.249	4	1.1.15
3.45	25	1.0.10	2.241	2	042
3.40	4	211	2.195	14	404
3.36	10	122	2.165	12	3.0.12
3.25	d	119,208	2.103	4	1.2.14
3.21	55	214	2.076	d	0.2.16
3.11	2	0.0.12,125	2.063	4	321
3.01	16	300	2.061	6	232
2.880	100	0.2.10,217	2.033	10	048
2.757	20	128	2.023	6	324
2.710	10	306	2.017	4	3.1.11
2.674	8	1.1.12	SEE FOLLOWING CARD		

Vita

Miss wanna Kositamongkol recieved her Bachelor Degree of Science in Material Science(Ceramics) from Faculty of Science, Chulalongkorn University in 1981 and started to work at the Department of Science Service in 1983.

She began her master study in November 1992 and complete the programme in April 1995.