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Agricultural Machinery- Coffee grinder- Methods of test

BUREAU OF PHILIPPINE STANDARDS (BPS)

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Foreword

The implementation of Republic Act 10601 also known as the Agricultural and Fisheries Mechanization (AFMech) Law of 2013 mandated the Bureau of Agriculture and Fisheries Standards (BAFS) to develop standard specifications and test procedures for agricultural and fisheries machinery and equipment.

The Bureau, in collaboration with concerned Department of Agriculture (DA) Bureaus and attached agencies, Philippine Regulatory Board of Agricultural and Biosystems Engineering (PRB-ABE) and University of the Philippines Los Baños – Agricultural Machinery Testing and Evaluation Center (UPLB-AMTEC), embarked on a project entitled "Development of Philippine National Standard/ Philippine Agricultural Engineering Standard for Coffee Grinder".

Coffee is one of the high value crops in the country. In 2013, Philippines has an existing coffee production area of 116, 459 hectares that produces 78, 634 metric tons (Philippine Statistics Authority).

Aside from roasting, another critical operation in coffee processing is grinding as it can reduce the quality and aroma in coffee. The development of standard specifications and test procedures for coffee grinders is therefore essential to preserve the overall quality of coffee and meet the varying requirements of the local and international market thereby safeguarding the country's coffee industry.

This standard will serve as reference for Agricultural and Biosystems Engineers (ABEs) in the preparation and evaluation of specifications and test reports for coffee grinders pursuant to Republic Act No. 10915 otherwise known as the Philippine Agricultural and Biosystems Engineering Act of 2016.

This standard has been technically prepared in accordance with Bureau of Philippine Standards (BPS) Directives Part 3:2003 – Rules for the Structure and Drafting of International Standards.

The word "shall" is used to indicate mandatory requirements to conform to the standard.

The word "should" is used to indicate that among several possibilities, one is recommended as particularly suitable without mentioning or excluding others.

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Agricultural machinery - Coffee grinder - Methods of test

1 Scope

This standard specifies the methods of test for coffee grinders. Specifically, it shall be used to:

1.1 verify the mechanisms, dimensions, materials and accessories of the coffee grinder and the list of specifications submitted by the manufacturer;

1.2 determine the performance of the machine;

1.3 evaluate the ease of handling and safety features; and

1.4 report the results of the tests.

2 References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this National Standard

PAES 103:2000 Agricultural Machinery – Methods of Sampling

3 Definitions

For the purpose of this standard, the following definitions apply.

3.1
fineness modulus
classification system that indicates the uniformity of grind in the resultant product and is defined as the sum of the weight retained above each sieve divided by 100

3.2
foreign matter
impurity
all matters other than RCB

3.3
laboratory sieve shaker
equipment with definite shaking motion used to sort size of the ground materials using standard screen sieves

3.4
overall height
distance between the horizontal supporting plane surface and the horizontal plane touching the uppermost part of the grinder machine

NOTE All parts of the coffee grinder projecting upwards are contained between these two planes.

3.5
overall length
distance between the vertical planes at the right angles to the median plane of the grinder and touching its front and rear extremities

3.6
overall width
distance between the vertical planes parallel to the median plane of the machine, each plane touching the outermost point of the grinder on its respective side

3.7
prime mover
used to run the coffee grinder

3.8
reduction ratio
ratio of the average size of input to the average size of the end-product

3.9
running-in period
preliminary operation of the machine to make various adjustments prior to the conduct of the test until the operation is stable

4 General Conditions for Test

4.1 Selection of coffee grinder to be tested

Coffee grinder submitted for testing shall be sampled in accordance to PAES 103.

4.2 Role of the test applicant

The test applicant shall submit specifications and other relevant information about the coffee grinder. They shall abide with the terms and conditions set forth by the official testing agency, provide testing materials and shoulder other variable cost.

4.3 Role of the representative of the test applicant

An officially designated representative of the test applicant shall operate, demonstrate, adjust, repair as the case maybe and decide on matters related to the operation of the machine.

4.4 Test site conditions

The coffee grinder shall be tested as installed for normal operation. The site should have ample provisions for material handling, temporary storage, workspace and suitable for normal working condition. Adequate ventilation and lighting shall be provided in the area.

4.5 Suspension/Termination of test

If during the test run, the machine stops due to breakdown or malfunction so as to affect the machine's performance, the test may be suspended. If the machine will not be able to continue operation, the test shall be terminated.

5 Test Preparation

5.1 Preparation of the coffee grinder for testing

The manufacturer/distributor/dealer and testing authority shall check the coffee grinder so as to ensure that the grinder has been assembled and installed in accordance with the instruction of the manufacturer. The official testing agency will test the coffee grinder according to the desired output of the manufacturer.

In case of testing commercially manufactured coffee grinder, the machine sampled for acceptance, lot, routine, and type tests in accordance with PAES 103:2000 – Agricultural Machinery – Method of Sampling shall be submitted for test.

5.2 Test instruments and other materials

The suggested list of minimum field and laboratory test equipment and materials needed to carry out the coffee grinder test is shown on Annex A. These instruments should be calibrated regularly. It shall be physically checked and cleaned for operation before and after each test. A checklist of instruments and materials shall be prepared to be used before departure to and from the testing area.

5.3 Test materials

RCB to be used shall be from commonly or locally grown coffee with 5 – 7% wet-based moisture content and 99% purity. The amount of test material to be supplied shall be sufficient for one hour of continuous run. At least three (3) trials shall be conducted with minimum duration of fifteen (15) minutes per trial. The excess amount shall be used for running-in prior to the actual conduct of test trials. However, if the test materials are beyond the recommended characteristics, the manufacturer has the option not to pursue the test.

5.4 Running-in and preliminary adjustments

The coffee grinder shall have undergone a running-in period before starting the test. It shall be operated for sufficient duration with or without load at the test site by the official representative of the manufacturer. During the running-in period, the various

adjustments of the machine shall be made according to the recommendation of the manufacturer.

NOTE No other adjustments shall be permitted during the test.

6 Pre-test Observation

6.1 Verification of specifications

The specifications claimed by the manufacturer and the physical details given in Annex B shall be verified by the testing agency. A stable and level surface shall be used as reference plane for verification of dimensional machine specifications.

6.2 Test samples

Random representative test samples shall be collected from the test material for determination of moisture content and fineness modulus. Samples shall be prepared in such a way that test sample to be used for the running-in and in each test trial have identical characteristics in terms of moisture content and variety. Care should be taken so as to prevent alterations of the conditions of the test samples. Sampling procedure is shown in Annex C.

7 Performance Test

7.1 Operation of the coffee grinder

The coffee grinder shall be operated at the manufacturer's recommended setting of its components. The same speed and feeding rate recommended by the manufacturer shall be maintained during the test run. The testing authority shall make all measurements, which form part of the test and take the prescribed samples. After the test run, the area shall be cleaned and then prepared for the next test trial. This procedure shall be repeated for the succeeding test trials.

7.2 Test trials

A minimum of three (3) test trials, with duration of at least fifteen (15) minutes per trial, shall be adopted.

7.3 Sampling

Samples shall be collected at different outlets using each test trial. Sampling procedure is shown in Annex C.

7.4 Data collection

7.4.1 Duration of test

The duration of each test trial shall start from the feeding of the test materials into the grinding mechanism (first drop) and ends at the last drop of the test materials. However, all discharge from the different outlets shall be included after the cut-off time.

7.4.2 Noise level

The noise emitted by the machine, with or without load, shall be measured using a noise level meter both at the location of the operators. The noise, expressed in decibel [dB (A)], shall be measured approximately 50 mm away from the ear level of the operators.

7.4.3 Power requirement

In each trial, a power meter/watt-hour meter shall be used to measure power requirement.

7.4.4 Speed of components

The speed of the rotating shafts of the major components of the coffee grinder shall be taken using a tachometer.

NOTE: Measurements shall be taken with and without load.

7.5 Data recording and observations

Record sheet for all data and information during the test is given in Annex D. Observations to be taken during the performance test shall be recorded in this sheet.

8 Laboratory Analysis

Laboratory analysis shall be made to determine the moisture content and fineness modulus. The laboratory procedure to be followed in the analysis is given in Annex E while the data sheet is given in Annex F.

9 Presentation of results

Machine specifications and the results of the test shall be presented in tabular form in which data shall be taken from Annexes B and D. A schematic diagram of the power transmission system and arrangement of the sieve shall also be included. Observations made on the machine while in operation shall be supported with photographs.

10 Formula

The formulas to be used during calculations and testing are given in Annex G.

11 Test Report

The test report shall include the following information in the order given:

11.1 Title

11.2 Summary of Results (including the performance compared with the criteria)

11.3 Purpose and Scope of Test

11.4 Methods of Test

11.5 Conditions of the Machine

11.6 Description of the Machine

11.7 Results and Discussions

11.8 Observations (include pictures)

11.9 Names and Signatures of Test Engineers

Annex A
(normative)

Minimum List of Field and Laboratory Test Equipment and Materials

A.1 Field Test Equipment and Materials

EQUIPMENT/MATERIAL	QUANTITY
A.1.1 Hand-held Tachometer	1
A.1.2 Stop Watch Resolution: 0.1 second	2
A.1.3 Measuring Tape	1
A.1.4 Noise Level Meter Range: 30 – 130 dB (A)	1
A.1.5 Weighing Scale Capacity: 100 kg Resolution: 0.1 kg	1
A.1.6 Clamp-on AC/DC Power Meter 1000 V	1
A.1.7 Camera	1

A.2 Laboratory Test Equipment and Materials

EQUIPMENT/MATERIAL	QUANTITY
A.2.1 Digital Weighing Scale Resolution: 0.01 g Capacity: 2500 g	1
A.2.2 Set of Standard Screen Sieves	1
A.2.3 Laboratory Sieve Shaker	1
A.2.4 Air oven	1
A.2.5 Desiccators	1
A.2.6 Aluminum Moisture Cans	9
A.2.7 Sample Bags	20
A.2.8 Labeling Tags which include: Date of Test Coffee Grinder on Test Sample Source Variety Trial Number	20

Annex B
(informative)

Specifications of Coffee Grinder

Name of Applicant (Distributor) :
_____
Address :
_____
Tel. No. :
_____

Name of Manufacturer :
_____
Address :
_____
Tel. No. :
_____

General Information:
Serial No.: _____ Brand/Model : _____
Classification: _____ Make : _____
Production date of the machine to be tested: _____

Item*	Manufacturer's Specification	Verification by the Testing Agency
B.1 Main structure		
B.1.1 Overall dimensions (mm)		
B.1.1.1 Length		
B.1.1.2 Width		
B.1.1.3 Height		
B.1.2 Weight (kg), if applicable without the prime mover		
B.2Rated output capacity (kg/h)		
B.3Prime mover		
B.3.1 Electric motor		
B.3.1.1 Brand		
B.3.1.2 Model		
B.3.1.3 Serial Number		
B.3.1.4 Make		
B.3.1.5 Rated power (kW)		
B.3.1.6 Rated speed (rpm)		
B.3.1.7 Phase		
B.3.1.8 Voltage (V)		
B.3.1.9 Current (A)		
B.3.1.10 Frequency (Hz)		
B.4 Hopper		
B.4.1 Overall dimensions (mm)		

B.4.1.1 Length		
B.4.1.2 Width		
B.4.1.3 Height		
B.4.2 Height from the ground (mm)		
B.4.3 Material		
B.4.4 Location		
B.4.5 Means of attachment		
B.5 Output Chute		
B.5.1 Overall dimensions (mm)		
B.5.1.1 Length		
B.5.1.2 Width		
B.5.1.3 Height		
B.5.2 Height from the ground (mm)		
B.5.3 Material		
B.5.4 Location		
B.5.5 Means of attachment		
B.6 Grinding Mechanism		
B.6.1 Type		
B.6.2 Dimension, L x W x T (mm)		
B.6.3 Means of attachment		
B.6.4 Material		
B.7 Safety devices		
B.8 Special features		

*The parameter will be checked upon availability.

B.9 Illustration of transmission system

Annex C
(normative)

Sampling and Measurement for the Test Material

C.1 Sampling Procedures for RCB Input

The conditions of the RCB input such as moisture content and purity to be used in each test shall be taken using three (3) “representative samples”, which represent the different conditions of RCB input in the bulk. This is done by randomly taking samples at the top, middle and bottom portions of the bulk. Half of the sample shall be used for laboratory analysis and the other half shall be used for reference purposes or for an eventual second check in case of review. Samples representing the materials for each test trial shall be placed in appropriate containers for laboratory analysis.

C.2 Sampling from Output Chute

During each test trial, three (3) samples, each weighing 100 g shall be collected. The minimum amount of sample to be taken from the outlet of the coffee grinder to be analyzed in the laboratory for the determination of fineness modulus and moisture content shall be twice as much as what is needed for a particular analysis.

C.3 Handling of Samples

All samples to be used must be properly labeled and kept in airtight, dry and food grade containers.

C.4 Other Measurements Required During the Test Run

The speed of rotating components and noise level at operator’s or bagger’s location shall be taken. For each data, there shall be a minimum of five (5) observations. These shall be taken with and without load. Before taking the data, it should be ensured that the feed rate, speed and other functional characteristics have stabilized.

C.5 Measurement of Power Requirement

Use a power meter to measure the voltage, current, and the total electric power requirement of the coffee grinder. There shall be three (3) sets of data with a minimum of five (5) observations per set taken with and without load.

Data shall be taken simultaneous with the collection of samples for laboratory analysis.

Annex D
(informative)

Performance Test Data Sheet

Test Trial No.:_____ Date: _____
Test Engineers:_____ Location: _____
Assistants:_____ Machine: _____
Test Requested By: _____ Manufacturer: _____

Items	Trial 1	Trial 2	Trial 3	Average
D.1 Conditions of coffee bean				
D.1.1 Source				
D.1.2 Variety				
D.1.3 Moisture content (%)				
D.2 Weight of input (kg)				
D.3 Input capacity (kg/h)				
D.4 Operating time (h)	`			
D.5 Grinding capacity (kg/h)				
D.6 Specific energy consumption (kW-h/kg)				
D.7 Ground coffee bean (kg)				
D.8 Speed of components (rpm)				
D.8.1 Prime mover				
D.8.1.1 Without load				
D.8.1.2 With load				
D.8.2 Grinder shaft				
D.8.2.1 Without load				
D.8.2.2 With load				
D.9 Noise level [dB (A)]				
D.9.1 Feeder				
D.9.1.1 Without load				
D.9.1.2 With load				
D.9.2 Bagger				
D.9.2.1 Without load				
D.9.2.2 With load				
D.10 Power requirement				
D.10.1 Power (kW)				
D.10.1.1 Without load				
D.10.1.2 With load				
D.10.2 Current (A)				
D.10.2.1 Without load				
D.10.2.2 With load				
D.10.3 Voltage (V)				
D.10.3.1 Without load				
D.10.3.2 With load				

D.11 Other Observations

D.11.1 Ease of transporting the machine

_____
_____
_____
_____
_____
_____

D.11. Ease of cleaning the machine

_____
_____
_____
_____
_____
_____

D.11.3 Ease of adjusting and repairing of parts

_____
_____
_____
_____
_____
_____

D.11.4 Ease of loading input and collecting output

_____
_____
_____
_____
_____
_____

D.11.5 Safety

_____
_____
_____
_____
_____
_____

D.11.6 Labor Requirements

_____
_____
_____
_____
_____
_____

D.11.7 Failure or abnormalities that may be observed on the machine or its component parts during and after the cleaning operation.

_____
_____
_____
_____
_____
_____

D.11.8 Others

_____
_____
_____
_____
_____
_____

Annex E
(normative)

Laboratory Analysis

E.1 Purity Determination

Take three (3) 500 g samples of RCB. Clean the samples to remove the impurities and other foreign matters, the clean sample shall be weighed and recorded.

E.2 Moisture Content Determination

At least five (5) representative samples of 25 g each shall be taken randomly for moisture content determination, preferably using the Air-Oven Drying Method.

E.3 Determination of Fineness Modulus

Take three 100 g ground coffee samples from the output chute, and sift using a laboratory sieve shaker with standard screen sieves for a period of ten (10) minutes. After shaking, dismount the stack of sieves and the weight of the material in each sieve.

E.4 Total Grinding Loss

Compute for Total Grinding Loss as the amount of uncollected material or the difference in the amount of RCB input and the ground coffee output, expressed in percent.

Annex F
(informative)

Laboratory Analysis Data Sheet

Machine Tested:_____ Analyzed By: _____
Date of Test: _____ Date Analyzed: _____

F.1 Roasted Coffee Bean and Ground Coffee Conditions

F.1.1 Moisture Content (% wet basis)

Average					

F.1.2 Purity Determination

Initial Weight of Test Samples = 25 grams

ITEMS	**Trial 1**				**Trial 2**				**Trial 3**				**General Average**
	1	2	3	Ave	1	2	3	Ave	1	2	3	Ave	
Cleaned (g)													
Purity (%)													

F.2.2 Product Analysis (Fineness Modulus)

US Standard Sieve No.	**Percent of Materials Retained**			**Multiplier (depends on the Sieve No.**	**Weight Fractions Retained Above Each Sieve**			
	Trial 1	**Trial 2**	**Trial 3**	**(7 – 0)**	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**
12								
16								
20								
30								
40								
50								
100								
Pan								
SUM								
FM								
Average particle size diameter (mm)								
Classification								

F.2.3 Total Grinding Loss Determination

Trial No.		**Total Grinding Loss**	
		Duration	
		Sample Weight (g)	Total (kg)
1	**A**		
	B		
	C		
Average			
2	**A**		
	B		
	C		
Average			
3	**A**		
	B		
	C		
Average			
General Average			

Annex G
(normative)

Formula Used During Calculations and Testing

G.1 Moisture Content

$$MC_{wb} = \frac{W_i - W_f}{W_i} \; x \; 100$$

where:

MC_{wb} = Moisture content (%)
W_i = Initial mass of the sample (g)
W_f = Final mass of the sample (g)

G.2 Capacity

G.2.1 Grinding

$$G_c = \frac{W_i}{T}$$

where:

G_c = Grinding capacity (kg/h)
W_i = Weight of input RCB (kg)
T = Total operating time (h)

G.2.2 Input

$$C_i = \frac{W_{cb}}{T_i}$$

where:

C_i = Input capacity (kg/h)
W_{cb} = Total weight of input RCB (kg)
T_i = Input time (h)

G.2.3 Output

$$C_o = \frac{W_g}{T_o}$$

where:

C_o = Output capacity (kg/h)
W_g = Total weight of ground coffee (kg)
T_o = Output time (h)

G.3 Grinding Recovery

$$G_r = \frac{W_p}{W_i}\ x\ 100$$

where:

G_r = Grinding recovery (%)
W_p = Weight of ground coffee (kg)
W_i = Weight of input RCB (kg)

G.4 Purity

$$P = \frac{W_{cl}}{W_{uc}}\ x\ 100$$

where:

P = Purity (%)
W_{cl} = Weight of cleaned RCB (g)
W_{uc} = Weight of uncleaned RCB (g)

G.6 Total Grinding Loss

$$L_t = 100\% - G_r$$

where:

L_t = Total grinding loss (%)
G_r = Grinding Recovery (%)

G.7 Fineness Modulus

$$FM = \frac{\sum N}{100}$$

where:

FM = Fineness Modulus
N = Weight fractions retained above each sieve

N	=	Percent material Retained on each Sieve	x	Multiplier, 6-0 (depends on the mesh no.)

Sieve Mesh Number	Percent of Material Retained	Multiplier (Depends on the Mesh Number)	Weight Fractions Detained Above Each Sieve
12	0.1	6	0.60
16	4.2	5	21.0
20	15.0	4	60.0
30	21.7	3	65.1
40	11.5	2	23.0
50	35.7	1	35.7
Pan	11.8	0	0
Total	100		205.4

G.8 Particle Size Diameter of Ground Product

$$d_i = (d_u \, x \, d_o)^{0.5}$$

where:

d_i = diameter of i^{th} sieve in the stack
d_u = diameter opening through which particles will pass (sieve proceeding i^{th})
d_o = diameter opening through which particles will not pass (i^{th} sieve)

$$d_{gw} = \; log^{-1} \left[\frac{\sum(W_i \log d_i)}{\sum W_i} \right]$$

For standard deviation:

$$S_{gw} = \; log^{-1} \left[\frac{\sum W_i \; (\log d_i - \log d_{gw})^2}{\sum W_i} \right]^{0.5}$$

where:

d_{gw} = average particle size (weight basis)
S_{gw} = standard deviation

Table G.1 - Comparison of Tyler and USA sieve numbers

Opening in microns	Tyler Number (meshes/inch)	USA Number
3360	6	6
2380	8	8
1680	10	12
1191	14	16
841	20	20
594	28	30
420	35	40
297	48	50

Table G.1 (continued)

Opening in microns	Tyler Number (meshes/inch)	USA Number
212	65	70
150	100	100
103	150	140
73	200	200
53	270	270

Sample:

Particle Size Analysis

US Sieve	Micron Size	Wt. grams	%	% less Than	log dia.	wt* log dia.	log dia – log d_{gw}	wt(log dia – log D_{gw})^2
6	3360	1.60	1.62	98.38	3.601	5.762	0.724	0.839
8	2380	3.20	3.24	95.15	3.451	11.045	0.574	1.055
12	1680	7.90	7.99	87.16	3.301	26.077	0.424	1.418
16	1191	19.40	19.62	67.54	3.151	61.122	0.273	1.450
20	841	18.00	18.20	49.34	3.000	54.006	0.123	0.273
30	594	15.00	15.17	34.18	2.849	42.739	-0.028	0.012
40	420	11.60	11.73	22.45	2.699	31.303	-0.179	0.370
50	297	8.00	8.09	14.36	2.548	20.384	-0.329	0.867
70	212	6.60	6.67	7.68	2.400	15.837	-0.478	1.506
100	150	3.40	3.44	4.25	2.251	7.654	-0.626	1.332
140	103	3.20	3.24	1.01	2.094	6.702	-0.783	1.961
200	73	0.90	0.91	0.10	1.938	1.744	-0.939	0.794
270	53	0.10	0.10	-0.00	1.794	0.179	-1.083	0.117
Pan	37	0.00	0.00	-0.00	1.646	0.000	-1.231	0.000
Summation 11.995		98.90	100.00				284.556	

Particle Size, d_{gw} 754 Surface Area (cm^2/gram) 83.2

Standard Dev., S_{gw} 2.23 Particles/gram 31953

Annex H
(informative)
Average Particle Size of Ground

Table H.1 - Average Particle Size of Ground

Average Particle Size	mm
Coarse Grind	1.25 – 1.50
Regular Grind	1.00 – 1.24
Drip Grind	0.75 – 0.99
Fine Grind	0.38 – 0.74
Espresso Grind	0.20 – 0.37

(1) Scott Baker and Tim Herrman (2002), “Evaluating Particle Size”, MF – 2051, Kansas State University Agricultural Experiment Station and Cooperative Extension Service Ted R. Lingle (1996), “Coffee Grading and Evaluation”, Specialty Coffee Association of America, The Coffee Brewing Handbook Series, Second Edition

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