Foreword

The pursuance of this national standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) with funding from the Department of Agriculture.

This standard has been technically prepared in accordance with 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.

In the preparation of this standard, the following documents/publications were considered:

Henderson, S.M. and R. L. Perry. Agricultural Process Engineering. 3rd Ed. Westport, Connecticut, 1976.

Procedures of Inspection and Test for Grinding Mills, AMTEC, UPLB.

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ANNEXES

Agricultural Machinery – Hammer Mill – Methods of Test

1 Scope

This standard specifies the methods of test and inspection for hammer mill used for milling grains and other agricultural products. Specifically, it shall be used to:

1.1 verify the mechanism, dimensions, materials, accessories of the hammer mill 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;

1.4 analyze the products of milling through laboratory analysis; and

1.5 report the results of the tests.

2 References

The following normative documents contain provisions which through reference in this text constitute provisions of these standards:

PAES 103:2000 **Agricultural Machinery** – Method of Sampling

PAES 216:2004 **Agricultural Machinery** – Hammer Mill - Specifications

3 Definitions

For the purpose of this standard, the definitions given in PAES 216:2004 and the following shall 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 fractions retained above each sieve divided by 100

3.2
foreign matter
impurity
all matters other than input materials such as sand, gravel, dirt, pebbles, stones, metal fillings, lumps of earth, clay, mud, chaff, straw, weed seeds and other crop seeds

3.3
hammer mill
device used for milling which consists of rotating hammer(s) and a heavy perforated screen at the bottom

3.4
input capacity
weight of input materials per unit loading time into the hopper/intake pit, expressed in kilogram per hour

3.5
laboratory sieve shaker
equipment with definite shaking motion used to sort size of the milled materials using standard screen sieves

3.6
milling capacity
quantity of input materials that the hammer mill can process to produce milled materials per unit of time, expressed in kilogram per hour

3.7
output capacity
weight of the milled materials collected, expressed in kilogram per hour

3.8
overall height
distance between the horizontal supporting surface and the horizontal plane touching the uppermost part of the hammer mill

NOTE All parts of the hammer mill projecting upwards are contained between these two planes.

3.9
overall length
distance between the vertical planes at the right angles to the median plane of the hammer mill and touching its front and rear extremities

NOTE All parts of the hammer mill, in particular, components projecting at the front and at the rear are contained between these two planes. Where an adjustment of components is possible, it shall be set at minimum length.

3.10
overall width
distance between the vertical planes parallel to the median plane of the hammer mill, each plane touching the outermost point of the hammer mill on its respective side

NOTE All parts of the hammer mill projecting laterally are contained between these two planes.

3.11
primemover
electric motor, or internal combustion engine used to run the hammer mill

3.12
purity
amount of input materials free of foreign matter expressed as percentage of the total weight of the sample

3.13
running-in period
preliminary operation of the machine to make various adjustments prior to the conduct of test until the operation is stable

4 General Conditions for Test and Inspection

4.1 Selection of hammer mill to be tested

Hammer mill submitted for test shall be sampled in accordance with PAES 103.

4.2 Role of manufacturer/dealer

The manufacturer shall submit specifications and other relevant information about the hammer mill and shall abide with the terms and conditions set forth by an official testing agency.

4.3 Role of the representative of the manufacturer/dealer

An officially designated representative of the manufacturer shall operate, adjust, repair, and shall decide on matters related to the operation of the machine.

4.4 Test site conditions

The hammer mill shall be tested as installed for normal operation. The site should have ample provisions for material handling, temporary storage and workspace.

4.5 Test instruments

The instruments to be used shall have been calibrated and checked by the testing agency prior to the measurements. The suggested list of minimum field and laboratory test equipment and materials needed to carry out the hammer mill test is shown in Annex A.

4.6 Test material

Test materials to be used shall be corn with the following characteristics:

4.6.1 Test material characteristics

4.6.1.1 Variety : locally grown (as much as possible single variety)

4.6.1.2 Moisture Content : maximum moisture content of 14 %

4.6.1.3 Purity : 98 %, minimum

4.6.2 Quantity to be supplied

The amount of test material to be supplied shall be at least 75 % of input capacity of the hammer mill.

5 Test and Inspection

5.1 Verification of the manufacturer's technical data and information

5.1.1 This inspection is carried out to verify the mechanism, dimensions, materials and accessories of the hammer mill in comparison with the list of manufacturer's technical data and information.

5.1.2 A plain and level surface shall be used as reference plane for verification of dimensional hammer mill specifications.

5.1.3 The items to be inspected and verified shall be recorded in Annex B.

5.2 Field performance test

5.2.1 This is carried out to obtain actual data on overall machine performance.

5.2.2 Initial data of the crop conditions such as moisture content and purity shall be recorded.

5.2.3 Test materials to be used

Test materials prepared to be used for the running-in and for each test trial shall be the same.

5.2.4 Running-in and preliminary adjustment

Before the start of the test, the hammer mill should have undergone running-in period wherein various adjustments of the hammer mill shall be made according to the recommendation of the manufacturer. (No other adjustments shall be permitted while the test is on-going).

5.2.5 Termination of test

If during the test run, the machine stops due to major component breakdown or malfunctions, the test shall be terminated by the test engineer.

5.2.6 Operation of the hammer mill

The hammer mill shall be operated at the recommended settings of the manufacturer and the setting shall be maintained during the test trial. After the test run, the milling area shall be cleaned and then prepared for the next test trial. This procedure shall be repeated for the succeeding test trials.

5.2.7 Test trial

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

5.2.8 Data collection

5.2.8.1 Duration of test

The duration of each test trial shall start with the feeding of all test materials into the intake hopper and ends after the last discharge from the output chute and shall be recorded as operating time.

5.2.8.2 Noise level

The noise emitted by the machine shall be measured using a noise level meter at the location of the operators and baggers. The noise level shall be measured approximately 50 mm away from the ear level of the operators and baggers.

5.2.8.3 Speed of components

The speed of the rotating shafts of the major components of the hammer mill shall be taken using a tachometer.

NOTE Measurements shall be taken with and without load for sub-clauses 5.2.8.2 and 5.2.8.3 as specified in Annex C.

5.2.8.4 Fuel/Power consumption

Before the start of each test trial, the fuel tank shall be filled to its capacity. After each test trial the tank shall be refilled using graduated cylinder. The amount of refueling is the fuel consumption for the test. When filling up the tank, keep the tank horizontal so as not to leave empty space in the tank. In case an electric motor is used as the primemover, a power meter shall be used to measure electric energy consumption.

5.2.9 Sampling and sample handling

5.2.9.1 Sampling for test materials

The conditions of the test materials such as moisture content and purity shall be taken using three “representative samples” each weighing 1 kg which represent the different conditions of test materials in the bulk. This is done by randomly taking samples from the bulk. Half (500g) of the 1 kg sample shall be used for laboratory analysis and the other half (500 g) shall be used for reference purposes or for an eventual second check in case of review.

5.2.9.2 Sampling from output chute

During each test trial, three samples each weighing 200 g shall be randomly collected from the output of the hammer mill to be analyzed in the laboratory for the determination of fineness modulus. Half (100 g) of the 200 g sample shall be used for laboratory analysis and

the other half (100 g) shall be used for reference purposes or for an eventual second check in case of review.

5.2.9.3 Handling of Samples

All samples to be taken to the laboratory shall be placed in appropriate containers and properly labeled. If the sample is to be used for determining moisture content, it must be kept in dry and airtight containers.

5.2.9.4 Data recording and observations

Record sheet for all data and information during the test is given in Annex C.

6 Laboratory Analysis

Laboratory analysis shall be made to determine the purity, moisture content and fineness modulus. The laboratory test data sheet to be used is given in Annex D.

6.1 Purity determination

Take three 500 g samples from the "representative samples" of the input. Clean the samples to remove the impurities, the clean samples shall be weighed and recorded.

6.2 Moisture content

This shall be taken using a calibrated moisture meter or by oven method.

6.2.1 If a calibrated moisture meter is applicable, five samples shall be taken for moisture content determination.

6.2.2 If oven method is used, the following procedure shall be used:

6.2.2.1 For each test trial, select three representative sample weighing at least 100 g of milled materials and place in the moisture can. The moisture can shall be sealed to ensure that no moisture is lost or gained by the sample between the time it was collected and when it is weighed. Record the initial weight.

6.2.2.2 Dry the sample in the oven with temperature of 103 ^{o}C $\pm$ 1 ^{o}C for 72 h.

6.2.2.3 After removing the samples from the oven, the moisture can with the sample should be placed in a desiccator and allowed to cool to the ambient temperature.

6.2.2.4 Weigh the moisture can plus the dried sample. Record the final weight. Calculate the moisture content using Equation E.1 in Annex E.

6.3 Determination of fineness modulus

Three 100 g milled samples from the output chute shall be shaken using a laboratory sieve shaker with standard screen sieves for a period of 10 min. After shaking, the stack of sieves

shall be dismounted and the weight of the material in each sieve shall be taken. Calculation of fineness modulus is outlined in Annex D.

7 Formula

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

8 Test Report

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

8.1 Name of testing agency

8.2 Test report number

8.3 Title

8.4 Summary

8.5 Purpose and scope of test

8.6 Methods of test

8.7 Table 1 – Hammer mill specifications

8.8 Results and discussion

8.9 Table 2 –Performance test data

8.10 Observations (include pictures)

8.11 Names, signatures and designation of test engineers

Annex A
(informative)

Minimum List of Field and Laboratory Test Equipment and Materials

A.1	**Equipment**	**Quantity**
A.1.1	**Field**	
A.1.1.1	Grain moisture meter (Capacitance or conductance type) Range: 6 % to 40 %	1
A.1.1.2	Tachometer (contact type or photo electric type) Range: 0 rpm to 5,000 rpm	1
A.1.1.3	Digital timers (range: 60 minutes) Accuracy: 0.1 sec	2
A.1.1.4	Tape measure (with maximum length of 5m)	1
A.1.1.5	Noise level meter Range: 30 dB(A) to 130 dB(A)	1
A.1.1.6	Weighing scale (capacity: 100 kg) Scale divisions: 500 g	1
A.1.1.7	Graduated cylinder (for engines) (500 mL capacity) or Watt-hour meter (for electric motors) 60 Hz, 220 V	1
A.1.1.8	Camera	1
A.1.2	**Laboratory**	
A.1.2.1	Weighing scale (Sensitivity: 0.1 g)	1
A.1.2.2	Grain sampler/divider	1
A.1.3	Laboratory sieve shaker	1
A.1.4	Set of standard screen sieves	1
A.1.4	Air oven	1
A.1.5	Desiccators	1
A.1.6	Aluminum moisture can	9
A.2	**Materials**	
A.2.1	Sample bags	100
A.2.2	Labeling tags which include	100
A.2.2.1	Date of test	
A.2.2.2	Hammer mill on test	
A.2.2.3	Sample source	
A.2.2.4	Variety	
A.2.2.5	Trial number	

Annex B
(informative)

Specifications of Hammer Mill

Name of Applicant/ Distributor: _____
Address: _____
Tel No: _____
Name of Manufacturer: _____
Address: _____
Tel No: _____

GENERAL INFORMATION

Make: _____ Type: _____
Serial No: _____ Brand/Model: _____
Production date of hammer mill to be tested: _____
Testing Agency: _____ Test Engineer: _____
Date of Test: _____ Location of Test: _____

Items to be inspected

ITEMS	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, without engine (kg), if Applicable		
B.2 Intake hopper/Loading pit		
B.2.1 Holding capacity, kg		
B.2.2 Materials of construction		
B.2.3 Features		
B.3 Milling assembly		
B.3.1 Type		
B.3.2 Dimension, W x D, mm		
B.3.3 Hammer		
B.3.3.1 Type		
B.3.3.2 Dimension, L x W x T, mm		
B.3.3.3 No. per anchor bar		
B.3.3.4 Means of attachment		
B.3.3.5 Material		
B.4 Screen		
B.4.1 Dimension, L x W, mm		
B.4.2 No. of screens		
B.4.3 Mesh Number		
B.4.4 Wire size, mm		
B.4.5 Materials of construction		
B.5 Clearance between the screen and		

ITEMS	Manufacturer's Specification	Verification by the Testing agency
the tip of the hammer , mm		
B.6 Aspirator		
B.6.1 Diameter, mm		
B.6.2 No. of vanes		
B.7 Primemover		
B.7.1 Electric motor		
B.7.1.1 Brand		
B.7.1.2 Type		
B.7.1.3 Make or manufacturer		
B.7.1.4 Serial number		
B.7.1.5 Rated power, kW		
B.7.1.6 Rated speed, rpm		
B.7.1.7 Phase		
B.7.1.8 Voltage, V		
B.7.1.9 Current, A		
B.7.1.10 Frequency, Hz		
B.7.2 Engine		
B.7.2.1 Brand		
B.7.2.2 Model		
B.7.2.3 Type		
B.7.2.4 Make or Manufacturer		
B.7.2.5 Serial number		
B.7.2.6 Rated power, kW		
B.7.2.7 Rated speed, rpm		
B.7.2.8 Displacement, cm^3		
B.7.2.9 Cooling system		
B.7.2.10 Starting system		
B.8 Safety devices		
B.9 Special features		

Annex C
(informative)

Performance Test Data Sheet

Test Trial No. _____ Date: _____
Test Engineer: _____ Location: _____
Assistants: _____ Test Specimen: _____
Test Requested by: _____ Manufacturer: _____

ITEMS	Trial 1	Trial 2	Trial 3	AVE.
C.1 Conditions of Test Sample				
C.1.1 Variety				
C.1.2 Source				
C.1.3 Moisture content, %				
C.2 Weight of input, kg				
C.3 Input capacity, t/h				
C.4 Operating time, h				
C.5 Milling capacity, t/h				
C.6 Speed of components, rpm				
C.6.1 Primemover				
C.6.1.1 Without load				
C.6.1.2 With load				
C.6.2 Mill shaft				
C.6.2.1 Without load				
C.6.2.2 With load				
C.7 Noise level, db(A)				
C.7.1 Operator				
C.7.1.1 Without load				
C.7.1.2 With load				
C.8 Power consumption				
C.8.1 Power, kW				
C.8.1.1 Without load				
C.8.1.2 With load				
C.8.2 Current, A				
C.8.2.1 Without load				
C.8.2.2 With load				
C.8.3 Voltage, V				
C.8.3.1 Without load				
C.8.3.2 With load				
C.9 Fuel consumed, L				
C.10 Fuel consumption, L/h				
C.11 Minimum labor requirements				

C.12 Rate the following observations:

Items	Rating*				
	1	2	3	4	5
C.12.1 Ease of loading					
C.12.2 Ease of cleaning parts					
C.12.3 Ease of adjusting and repair of parts					
C.12.4 Ease of collecting output					
C.12.5 Ease of transporting the machine					
C.12.6 Safety					
C.12.7 Vibration					

* 1 – Very Good
  2 – Good
  3 – Satisfactory
  4 – Poor
  5 – Very Poor

C.13 Other Observations:

_____

_____

_____

Annex D
(informative)

Laboratory Test Data Sheet

Machine Tested: _____
Analyzed by: _____

D.1 Moisture Content Determination

Average			

D.2 Purity determination (500 g sample)

	Trial 1	**Trial 2**	**Trial 3**	**Average**
Final weight, g				
Purity, %				

D.3 Milled Product Analysis

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**	**Average**
12								
16								
20								
30								
40								
50								
100								
Pan								
SUM								
FM								
Average particle size diameter (mm)								
Classification								

D.4 Fineness Modulus for Classifying Ground Feeds

Material	Whole Grain	Grind			
		Coarse	Medium	Fine	Very Fine
Ear corn		4.80	3.60	2.40	1.80
Shelled corn	6.00	4.80	3.60	2.40	1.80
Barley	5.00	4.10	3.20	2.30	1.50
Oats	4.50	3.70	2.90	2.10	1.40
Soybeans	6.00	4.80	3.60	2.40	1.80
Wheat	5.00	4.10	3.20	2.30	1.50
Corn fodder	-	5.50	4.20	2.90	-
Hay	-	4.00	3.10	2.20	1.40

Source: Henderson, S.M. and R. L. Perry. Agricultural Process Engineering. 3rd Ed. Westport, Connecticut, 1976.

Annex E
(informative)

Formula Used During Calculations and Testing

E.1 Moisture content

$$MC_{wetbasis} = \frac{W_i - W_f}{W_i} \text{ x } 100$$

where:

MC = Moisture content, %
W_i = Initial mass of the sample, g
W_f = Final mass of the sample, g

E.2 Milling capacity

$$C_m = \frac{W_m}{T_o}$$

where:

C_m = Milling capacity, kg/h
W_m = Weight of milled product, kg
T_o = Total operating time, h

E.3 Product recovery, R_m (%)

$$R_m = \frac{W_p}{W_i}$$

where:

R_m = Product recovery, %
W_p = Weight of product, kg
W_i = Weight of input, kg

E.4 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, 7 - 0 (depends on the mesh No.)

E.5 Particle Size Diameter of ground product

$D = 0.0041(2^{F.M})$

where:

D = Particle size diameter
FM = Fineness Modulus

E.6 Fuel/Power consumption,

E.6.1 Power consumption, E_c (kW-h)

$E_c = P_c T_o$

where

E_c = Power consumption, kW-h
P_c = Power consumed, kW
T_o = Time of operation, h

E.6.2 Fuel consumption

$$F_c = \frac{F_1}{T_o}$$

where:

F_c = Fuel consumption, L/h
F_1 = Amount of fuel consumed, L
T_O = Time of operation, h