

PHILIPPINE NATIONAL STANDARD

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**Agricultural machinery – Dehusked Corn Dryer –
Methods of Test**



BUREAU OF PRODUCT STANDARDS

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National Foreword

This Philippine Agricultural Engineering Standards PAES 247:2010, Agricultural machinery – Dehusked Corn Dryer – Methods of Test was approved for adoption as Philippine National Standard by the Bureau of Product Standards upon the recommendation of the Agricultural Machinery Testing and Evaluation Center (AMTEC) and the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development of the Department of Science and Technology (PCARRD-DOST).

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PHILIPPINE AGRICULTURAL ENGINEERING STANDARD PAES 247: 2010
Agricultural Machinery – Dehusked Corn Dryer – Methods of Test

1 Scope

This standard specifies the methods of test and inspection for dehusked corn dryer. Specifically, it shall be used to:

- 1.1** verify the mechanism, dimensions, materials and accessories of the dehusked corn dryer 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 – Method of Sampling |
| PAES 203:2000 | Moisture Content Determination for Rice and Corn |
| PAES 246:2010 | Agricultural Machinery – Dehusked Corn Dryer – Specifications |

3 Definitions

For the purpose of this standard, the definitions given in PAES 246 and the following shall apply:

3.1

airflow rate

volume of air in cubic meters delivered to the mass of dehusked corn per minute

3.2

damaged kernels

corn kernels which are heat damaged, weather damaged, sprouted or distinctly damaged by insects, water, fungi and/or any other means

3.3

drying air temperature

mean temperature of the air to be used for drying the dehusked corn, measured at a number of points practicably as close to its entry to the drying bed

3.4

drying capacity

maximum capacity that the dehusked corn dryer can dry to meet the desired moisture content

3.5

fuel consumption

total amount of fuel consumed divided by the total drying time, expressed in kg/h

3.6

heating system efficiency

product of combustion efficiency and burner/furnace efficiency; the ratio of heat supplied to the dryer and the heat available from the fuel used, expressed in percent

3.7

holding capacity

load capacity

weight of dehusked corn required to fill the dryer at the input moisture content

3.8

moisture reduction rate

ratio of the average percent moisture content removed from the dehusked corn to drying time, expressed in percent per hour

3.9

static pressure

pressure build-up in the plenum chamber to maintain uniform distribution of air flow through the dehusked corn mass, expressed in mmH₂O

4 General Conditions for Test and Inspection

4.1 Machine on test

The machine on test shall be commercially produced or prototype unit or slightly used machine depending upon the test objective. Sampling and type of test shall be in accordance with PAES 103.

4.2 Role of manufacturer/distributor

The manufacturer/distributor shall submit specifications and other relevant information about the dehusked corn dryer and shall abide with the terms and conditions set forth by an official testing agency.

4.3 Role of the operator

An operator designated by the manufacturer shall be skilled and shall demonstrate, operate, adjust, and repair as the case maybe, related to the operation of the dryer.

4.4 Test site conditions

The site should have ample provisions for material handling and workspace and shall be suitable for normal working condition.

4.5 Test instruments

The instrument to be used shall have been calibrated and checked by the testing agency prior to the test proper. The suggested list of test instruments and materials needed to carry out the dehusked corn dryer test is shown in Annex A.

4.6 Termination of Test

If during testing, the dryer has a major component breakdown or malfunctions, the test engineer from the official testing agency shall terminate the test.

5 Test Preparation

5.1 Materials and equipment

5.1.1 Fuel

The fuel to be used shall conform to the specification supplied by the manufacturer.

5.1.2 Material to be dried

The dehusked corn to be used shall be single variety and the moisture content shall be the highest available moisture content to be used in the test.

5.1.3 Measuring instruments

The measuring instruments for performance testing, especially moisture testers shall be calibrated by the testing station prior to the tests.

5.2 Preparation of the dryer for testing

To ensure that the dryer has been assembled and installed in accordance with the instruction of the manufacturer based on installation manual, verification shall be made by the manufacturer and testing authority.

5.3 Test set-up

Thermometer shall be mounted on or inside the dryer for temperature sensing. These shall be mounted at the following locations: (1) near the dryer to sense ambient temperature; (2) at the plenum interface; (3) after the plenum; and (4) immediately outside the dryer to sense exhaust air temperature. Temperature sensors shall be partially shielded to minimize errors from heat radiation effects.

For the measurement of airflow and static pressure, pitot tube and manometer or any other suitable apparatus shall be installed.

The control of drying air condition shall be made by adjustment of the setting of automatic control forming part of the dryer, or by manual adjustment of the furnace by the representative of the manufacturer if automatic temperature control mechanism is not fitted. Adjustments for the purpose of maintaining a steady temperature of the drying air may be made in any time but any adjustment of automatic control shall have been sanctioned by the testing center.

6 Test and Inspection

6.1 Verification of the technical data and information of the manufacturer

6.1.1 This inspection is carried out to verify the mechanism, main dimensions, materials and accessories of the dryer in comparison with the list of technical data and information of manufacturer.

6.1.2 The following observations shall also be made:

6.1.2.1 Quality of manufacture

6.1.2.2 Adequacy of protection of components (e.g. bearings, shaftings, belts, etc.)

6.1.2.3 Presence of safety devices

6.1.2.4 Operation and maintenance manual, spare parts catalogue, special tools required for adjustments and repair kit shall be made available to the end-users.

6.1.3 The items to be measured, inspected and observed shall be recorded in Annex B.

6.2 Performance test

6.2.1 This is carried out to obtain and validate data on the overall dehusked corn dryer performance.

6.2.2 Data on dehusked corn to be dried shall be recorded in Annex C.

6.2.3 Operation of the dehusked corn dryer

The dryer shall be operated at the drying air temperature of dehusked corn as specified by the manufacturer.

6.2.3.1 The following shall be measured at two-hour intervals or as necessary.

6.2.3.1.1 Air velocity

Measurement of air velocity shall be made at the air duct.

6.2.3.1.2 Temperature

Dehusked corn temperature, drying air temperature, ambient and exhaust air temperature (wet bulb and dry bulb) shall be recorded.

6.2.3.1.3 Static pressure

This shall be taken at the plenum/transition duct (between blower and the dryer).

6.2.3.1.4 Sound level

This shall be measured with the dryer full of dehusked corn, operating at recommended settings of different components, with burner on. (The station of the operator will be considered to be within one meter of the controls).

6.2.3.1.5 Moisture content

Samples for moisture determination shall be taken at the bottom, middle and top layer of the dehusked corn being dried. (Refer also to PAES 203)

6.2.3.1.6 Power, fuel and speed

Measurement of the power and fuel consumption shall be taken during each test run. Speed of the prime mover and fan shall be obtained and recorded.

6.2.3.2 Sampling for determination of dehusked corn quality

This shall be done to inspect the physical quality of the dehusked corn after drying operation. Samples from the input and final output shall be taken during each test run. All samples to be taken to the laboratory shall be placed in appropriate containers and properly labeled.

6.2.4 Data collection**6.2.4.1** Duration of test

The duration for each drying cycle shall be such that one full capacity of dehusked corn has been dried from the initial to the final moisture content.

6.2.4.2 Data recording and observations

6.2.4.2.1 All the data obtained and any observations of breakdown and failure on the dryer shall be recorded in Annex C.

6.2.4.2.2 Visual inspection test shall be made on welded parts of the dehusked corn dryer and shall be recorded in Annex C.4.

7 Laboratory Analysis

This is carried out to have physical analysis on the samples before and after drying operation. The following shall be determined:

- 7.1** Variety of the corn
- 7.2** Moisture content
- 7.3** Kernel-Dehusked corn ratio
- 7.4** Bulk density, kg/m³
- 7.5** Cracked/broken/split corn kernels
- 7.6** Damage kernels
- 7.7** Discoloration (for dehusked corn dryer using a direct-fired heating system)
- 7.8** Data collected and obtained shall be recorded in Annex D.

8 Formula

The formula to be used during calculation and testing are given in Annex E.

9 Test Report

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

- 9.1** Title
- 9.2** Summary
- 9.3** Purpose and Scope of Test
- 9.4** Methods of Test
- 9.5** Condition of Machine
- 9.6** Description of the Machine
Table 1 – Machine Specifications
- 9.7** Results and Discussions
- 9.8** Observations (include pictures)
Table 2 – Performance test data
- 9.9** Names, signatures and designation of test engineers

Annex A

Suggested List of Test Instruments and Materials

A.1	Instruments	Quantity
A.1.1	Field	
A.1.1	Thermometer (range: 0°C to 100°C)	4
A.1.2	Digital timers (range: 24 hours) Accuracy: 0.1 sec	
A.1.3	Tape measure (with maximum length of 5m)	1
A.1.4	Weighing scale (capacity: 1000 kg) 0.1 kg accuracy	
A.1.5	Vernier Caliper Accuracy: 0.1 mm	1
A.1.6	Moisture meter	1
A.1.7	Scientific Calculator	1
A.1.8	Pitot tube	1
A.1.9	Manometer	1
A.1.10	Tachometer (contact type or photo electric type) Range: 0 rpm to 5,000 rpm	1
A.1.11	Air velocity meter	1
A.1.12	Power meter (60 Hz, 220V)	1
A.1.13	Marking pen and pencil	1
A.1.14	Digital Camera	1
A.1.2	Laboratory	
A.1.2.1	Weighing scale (capacity: 5 kg) 0.01 g accuracy	1
A.1.2.2	Desiccators	1
A.1.2.3	Magnifying glass	1
A.2	Materials	
A.2.1	Sample bags	
A.2.2	Labeling tags which include	
A.2.2.1	Date of test	
A.2.2.2	Trial number	

Annex B

Specifications of Dehusked Corn Dryer

Name of Applicant/ Distributor: _____

Address: _____

Tel No: _____

Name of manufacturer: _____

Address: _____

Tel No: _____

GENERAL INFORMATION

Make: _____ Type: _____

Serial No: _____ Brand/Model: _____

Production date of Dehusked Corn Dryer: _____

Testing Agency: _____ Test Engineer: _____

Date of Test: _____ Location of Test: _____

Items to be inspected

ITEMS	Specification of Manufacturer	Verification by the Testing Agency
B.1 Machine Specifications		
B.1.1 Drying rate, kg/h		
B.1.2 Machine Structure		
B.1.2.1 Overall dimensions, mm		
B.1.2.1.1 length		
B.1.2.1.2 width		
B.1.2.1.3 height		
B.1.3 Drying bin		
B.1.3.1 Type		
B.1.3.2 Dimensions, mm		
B.1.3.2.1 length		
B.1.3.2.1 width/diameter		
B.1.3.2.1 height		
B.1.3.3 Holding capacity, kg		
B.1.3.4 Maximum dehusked corn depth, mm		
B.1.3.5 Material		
B.1.3.5.1 Frame		
B.1.3.5.2 Holding bin		
B.1.3.5.3 Wall		
B.1.4 Fan		
B.1.4.1 Type		
B.1.4.2 Brand/Model		
B.1.4.3 Airflow rate, m ³ /min		
B.1.4.4 Static pressure, Pa		
B.1.4.5 Material(s) of construction		

B.1.4.6 Prime mover		
B.1.4.7 Other (specify)		
B.1.5 Heater		
B.1.5.1 Type		
B.1.5.2 Brand/Model		
B.1.5.3 Fuel		
B.1.5.4 Heat output, kJ/h		
B.1.5.5 Fuel consumption, kg/h or L/h		
B.1.5.6 Capacity of fuel tank, L		
B.1.5.7 Method of temperature control		
B.1.5.8 Material(s) of construction		
B.1.5.9 Other (specify)		
B.1.6 Conveyor (for large dehusked corn dryer-mechanical loading)-if applicable		
B.1.6.1 Material		
B.1.6.2 Dimensions, mm		
B.1.6.2.1 length		
B.1.6.2.2 width		
B.1.6.1 Type		
B.1.6.2 Number		
B.1.6.3 Capacity, t/h		
B.1.7 Stairs (for manual loading)		
B.1.7.1 Materials		
B.1.7.2 Dimensions, mm		
B.1.7.2.1 length		
B.1.7.2.2 width		
B.1.7.2.3 height		
B.1.7.3 Railings		
B.1.7.3.1 Materials		
B.1.7.3.2 Dimensions, mm		
B.1.7.3.2.1 length		
B.1.7.3.2.2 diameter		
B.1.8 Outlet chute		
B.1.8.1 Materials		
B.1.8.2 Dimensions, mm		
B.1.8.2.1 length		
B.1.8.2.2 width		
B.1.8.2.3 height from ground		
B.1.9 Driving Mechanism for fan/blower and conveyors (for electric motor)		
B.1.9.1 Type		
B.1.9.2 Brand		
B.1.9.3 Make or manufacturer		
B.1.9.4 Serial number		
B.1.9.5 Rated power, kW		

B.1.9.6 Rated speed, rpm		
B.1.9.7 Frequency, Hz		
B.1.9.8 Voltage		
B.1.10 Driving Mechanism for fan/blower and conveyors (for engine)		
B.1.10.1 Type		
B.1.10.2 Brand		
B.1.10.3 Make or manufacturer		
B.1.10.4 Serial number		
B.1.10.5 Number of strokes to complete one cycle		
B.1.10.6 Number of cylinder		
B.1.10.7 cylinder arrangement		
B.1.10.8 Rated power, kW		
B.1.10.9 Rates speed, rpm		
B.1.11 Safety feature(s)		
B.1.11.1 Product safety		
B.1.11.2 Machine safety		
B.1.11.3 Safety of operator		

Annex C

Performance Test Data Sheet

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

	Trials			Ave
	1	2	3	
C.1 Crop Condition				
C.1.1 Kind/Variety				
C.1.2 Initial moisture content, %				
C.1.3 Total weight of corn, kg				
C.1.4 Cracked kernels, %				
C.1.5 Damaged kernels, %				
C.2 Holding capacity, kg				
C.3 Initial weight of test material, kg				
C.4 Initial moisture content, %				
C.5 Final moisture content, %				
C.6 Actual drying time, h				
C.7 Drying capacity, kg/h				
C.8 Moisture reduction rate, %/h				
C.9 Average drying air temperature, °C				
C.10 Ambient air temperature, °C				
C.10.1 Dry bulb				
C.10.2 Wet bulb				
C.11 Ambient air relative humidity, %				
C.12 Dryer exhaust air temperature, °C				
C.12.1 Dry bulb				
C.12.2 Wet bulb				
C.13 Exhaust air relative humidity, %				
C.14 Fan air velocity, m/s				
C.15 Air flow rate, m ³ /min				
C.16 Plenum static pressure, mmH ₂ O				
C.17 Fuel consumption rate of the furnace, kg/h				
C.18 Average power consumption during drying process				
C.18.1 Input power, kW				
C.18.2 Line voltage, V				
C.18.3 Load current, A				
C.19 Heating system efficiency, %				
C.20 Welding Acceptance Test (AWS D1.1:2000)				
C.20.1 Crack prohibition				
C.20.2 Weld/base-metal fusion				
C.20.3 Crater cross section				
C.20.4 Weld profile				
C.20.5 Time of inspection				

C.20.6 Undersize welds (if any)				
C.20.7 Undercut				
C.20.8 Porosity (presence of air holes on the welded parts)				

C.21 Evaluate the following observations

Items	Remarks
C.21.1 Ease of operation	
C.21.2 Ease of repairing of parts	
C.21.3 Ease of cleaning	
C.21.5 Availability of the switches needed	
C.21.7 Quality of manufacture	
C.21.8 Adequacy of protection of components (e.g. bearings, shafting, belts, etc.)	
C.21.9 Safety controls/devices	
C.21.10 Dust collection system	
C.21.11 Availability of manuals, brochure and standard and special tools for adjustments and repair	
C.21.12 Instrumentation	
C.21.13 Ease of loading and unloading	
C.21.14 Available settings and adjustments	

C.22 Other Observations (e.g. temperature stability, noise in dB(A), breakdown on any parts during operation):

Annex D

Laboratory Analysis of the Samples

Machine tested: _____
 Variety of corn used: _____
 Date of test: _____
 Laboratory Analyst: _____

D.1 General information of the machine dried dehusked corn samples brought to AMTEC laboratory for analysis

ITEMS	DATA
Variety	
Source	
Size, L x D, mm	
Kernel – Dehusked Corn Ratio	
Cracked Grains, %	
a) Before drying	
b) After drying	
c) Net percentage cracked	

D.2 Other observations (discoloration when using direct-fired heating system):

Annex E**Formula****E.1 Drying Capacity**

$$D_c = \frac{W_i}{T_d}$$

where:

$$\begin{aligned} D_c &= \text{drying capacity, kg/h} \\ W_i &= \text{initial weight of test material, kg} \\ T_d &= \text{actual drying time, h} \end{aligned}$$

E.2 Moisture Reduction Rate

$$MC_r = \frac{MC_i - MC_f}{T_d}$$

where:

$$\begin{aligned} MC_r &= \text{moisture reduction rate, \%/h} \\ MC_i &= \text{initial moisture content of test material, \%} \\ MC_f &= \text{final moisture content of test material, \%} \\ T_d &= \text{actual drying time, h} \end{aligned}$$

E.3 Heating system efficiency

$$HSE = \frac{Q_d}{Q_f} \times 100$$

$$Q_d = \frac{(h_2 - h_1) \times V_a}{V_{sp}} \times 60 \frac{\text{min}}{\text{h}}$$

$$Q_f = F_{FR} \times HV_F$$

where:

HSE	=	heating system efficiency, %
Q_d	=	heat supplied to the dryer, kJ/h
Q_f	=	heat available in the fuel, kJ/h
h_2	=	enthalpy of drying air, (see psychrometric chart)
h_1	=	enthalpy of ambient air, (see psychrometric chart)
V_a	=	airflow rate of drying air, m ³ /min
V_{sp}	=	specific volume of drying air, m ³ /kg dry air
F_{FR}	=	Fuel feed rate, kg/h
HV_F	=	Heating value of fuel, kJ/kg

Philippine Agricultural Engineering Standards

AMTEC-UPLB – PCARRD Project: “Development of Standards for Agricultural Production and Postharvest Machinery”

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Dr. Elmer D. Castillo
Philippine Society of Agricultural Engineers (PSAE)

your partner in product quality and safety



BUREAU OF PRODUCT STANDARDS

3F Trade and Industry Building
361 Sen. Gil J. Puyat Avenue, Makati City 1200, Metro Manila, Philippines
T/ (632) 751.3125 / 751.3123 / 751.4735
F/ (632) 751.4706 / 751.4731
E-mail : bps@dti.gov.ph
www.dti.gov.ph