PHILIPPINE NATIONAL STANDARD

PNS/PAES 202:2015
(PAES published 2015)
ICS 65.040.20

Agricultural machinery – Heated air mechanical grain dryer – Methods of test

BUREAU OF PRODUCT STANDARDS*

Member to the International Organization for Standardization (ISO)
Standards and Conformance Portal: www.bps.dti.gov.ph

***BUREAU OF PHILIPPINE STANDARDS**

National Foreword

The Philippine Agricultural Engineering Standards PAES 202:2015, Agricultural machinery – Heated air mechanical grain dryer – Methods of test was approved for adoption as Philippine National Standard by the Bureau of Philippine Standards upon the recommendation of the Agricultural Machinery Testing and Evaluation Center (AMTEC) and the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development of the Department of Science and Technology (PCAARRD-DOST).

This standard cancels and replaces PNS/PAES 202:2003 (PAES published 2000).

Foreword

The revision of this national standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project entitled "Development of Standards for Rice Production and Postproduction Machinery" which was funded by the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) of the Department of Science and Technology (DOST).

This standard has been technically prepared in accordance with PAES 010-2 – 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 preparation of this standard, the following documents/publications were considered:

ASAE S248.3 MAR1976 (R2005) – Construction and Rating of Equipment for Drying Farm Crops

Bakker-Arkema, F.W. 1999.CIGR Handbook of Agricultural Engineering Volume 4.Agro-Processing Engineering. USA

Brooker, D.B. Bakker-Arkema, F.W. and Hall, C.W. 1974.Drying Cereal Grains. The AVI Publishing Company, Inc. Westport Connecticut, p. 166-176

Hall, C. W. 1980. Drying and Storage of Agricultural Crops. AVI Publishing Company, Inc. Westport Connecticut

Paddy Drying. IRRI Rice Knowledge Bank (http://www.knowledgebank.irri.org/rkb/index.php/drying)

Primer on Philippine Grains Standardization Program. 2002. National Food Authority. Quezon City, Philippines

CONTENTS **Page**

FIGURE

ANNEXES

1 Scope

This standard specifies the methods of test for heated-air mechanical grain dryer to determine the following performance characteristics.

1.1 Heating System

1.1.1 Heating system efficiency

1.1.2 Combustion efficiency

1.1.3 Burner/Furnace efficiency

1.1.4 Fuel consumption

1.2 Drying System Performance

1.2.1 Drying capacity

1.2.2 Moisture reduction per hour (per pass)

1.2.3 Heat utilization

1.2.4 Drying efficiency

1.2.5 Drying system efficiency

1.2.6 Electric power consumption

1.3 Quality of Dried Grains

1.3.1 Cracked grain (for rice and corn)

1.3.2 Milling quality (for rice only)

1.3.3 Hulled/Damaged grain (for rice)

1.3.4 Brokens/Split kernel (for corn)

1.3.5 Moisture content gradient

1.4 Others (e.g. Scattered grains)

2 References

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

PNS/PAES 102:2000 Agricultural Machinery – Operator's Manual – Content and Presentation

PNS/PAES 103:2000 Agricultural Machinery – Method of Sampling

PNS/PAES 201:2015 Agricultural Machinery – Heated-Air Mechanical Grain Dryer – Specifications

3 Definitions

For the purpose of this standard the definitions given in PNS/PAES 201:2015 – Agricultural Machinery – Heated-Air Mechanical Grain Dryer – Specifications and the following shall apply:

3.1
airflow rate
volume of air in cubic meters delivered to the mass of grains per second

3.2
burner efficiency
ratio of the heat supplied by the burner, to the heat released by the fuel

3.3
combustion efficiency
ratio of the heat released by the fuel, to the theoretical heat available from the fuel

3.4
damaged grains
grains which are heat damaged, weather damaged, ground damaged, moldy, diseased, insect bored, sprouted or distinctly damaged by insects, water, fungi and/or any other means as seen by the naked eye

3.5
drying air temperature
average temperature of the air to be used for drying the grain, measured at a number of points as close as practicable to its entry to the grain bed

3.6
drying rate
amount of water removed per unit of time, expressed in kilogram per hour

3.7
drying system efficiency
ratio of the total heat utilized for drying, to the heat available in the fuel expressed in percent

3.8
foreign matter
all matters other than rice/corn grains such as sand, gravel, dirt, pebbles, stones, lumps of earth, clay, mud, chaff, straw, weed seeds and other crop seeds

3.9
fuel consumption
total amount of fuel consumed divided by the total drying time

3.10
grain holding capacity
load capacity
continuous flow dryer: weight of grain that could be contained in the dryer
batch type dryer: weight of grain required to fill the dryer at the input moisture content

3.11
heat utilization
total amount of heat utilized to vaporize moisture in the material, expressed in kJ/kg of H_2O

3.12
immature grains
kernels, whole or broken, which are light green and chalky with soft texture

3.13
moisture reduction rate
drying rate
average percentage point moisture content removed from the grain per drying time

3.14
non-renewable energy source
source of energy which includes petroleum-based fuels such as kerosene, gasoline, diesel oil and bunker fuel oil

3.15
purity
percentage of grains free of foreign matter

3.16
renewable energy source
source of energy that includes non-petroleum based fuels such as biomass and solar energy

3.17
scattered grains
ratio of the weight of grains that fell out from the machine during the drying operation, to the weight of the total grain input to the dryer, expressed in percent

3.18
static pressure
pressure in the plenum chamber to maintain uniform distribution of air flow through the grain mass, expressed in Pascal

3.19
suction system
air movement through the drying chamber wherein air is moved through the product at a pressure lower that the atmospheric condition, expressed in Pascal

3.20
tempering
temporarily holding the grain between the drying passes, allowing the moisture content in the center of the grain and that on the surface of the grain to equalize

4 General Conditions for Test and Inspection

4.1 Machine on test

The machine on test shall be commercially produced or prototype unit machine depending upon the test objective. In case of testing commercially manufactured dryers, the dryer sampled for acceptance, lot, routine, and type tests in accordance with PNS/PAES 103:2000 – Agricultural Machinery – Method of Sampling shall be submitted for test.

4.2 Role of manufacturer/dealer

The manufacturer/dealer shall make the dryer for testing available to an authorized testing agency together with its specifications and other relevant information (Annex B or C). An authorized manufacturers/dealer's representative shall be appointed to repair, handle, adjust and witness the test. Manufacturers/dealers should provide appropriate authorization documents. It shall be the duty of the representative to make all decisions on matters of adjustment and preparation of the machine for testing and shall have related experience in all aspects of troubleshooting of the dryer. The manufacturer shall abide with the terms and conditions set forth by the authorized testing agency. The interested party shall provide testing materials and other variable cost as cited in the next section.

4.3 Site of test

The dryer shall be tested as installed for normal operation but it is important for testing that the site should have adjacent to its premises suitable space for storing and turning a sufficient quantity of grains for drying during the test.

4.4 Operation of the dryer

During the test, the dryer shall be operated by the manufacturer's authorized representative(s) in accordance with the manufacturer's published instructions (published manual) and verified by the testing authority. The testing authority shall make all measurements, which form part of the test and take the prescribed samples. An instruction manual which conforms to

PNS/PAES 102:2000 – Agricultural Machinery – Operator's Manual – Content and Presentation shall be provided.

4.5 Measurement of dryer holding capacity

The maximum amount of grain required to fill the dryer for proper operation shall be verified when filling the dryer at the beginning of the test. The holding capacity shall be measured in terms of weight and other accompanying information such as moisture content and purity.

4.6 Indication of damage

Samples of grain used for the test shall be subjected to laboratory analysis by test milling and presence of cracked grains before and after drying. Milling test of the samples obtained during drying test shall be conducted at least 48 hours after the drying test while air-dried samples shall be milled when its moisture content reaches 14%.

4.7 Suspension 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 shall be suspended. The decision to suspend or to continue the test is at the discretion of the test engineer and concurred by the company representative.

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. The initial condition of the fuel shall be determined.

5.1.2 Grain

The grain to be used shall be homogeneous and the moisture content should be at least 22% for rice and corn.

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.The suggested list of minimum field and laboratory test equipment and materials needed to carry out the test is shown in Annex A.

5.2 Preparation of the dryer for testing

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

5.3 Test set-up

Thermometers 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 grain plenum interface, middle section of the total length of the plenum (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. A schematic diagram shall be made of the dryer, showing a numbered location for each sensor.

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

The control of drying air condition shall be by adjustment of the setting of an automatic control forming part of the dryer, or by manual adjustment of the furnace by the manufacturer's representative if automatic temperature control mechanism is not fitted.

Adjustments for the purpose of maintaining a steady temperature of the drying air may be made at any time but any adjustment of an automatic control shall have been sanctioned by the Testing Center.

5.4 Running-in and preliminary adjustments

The dryer shall be run-in in accordance with manufacturer's operating manual before the start of actual test. The manufacturer may take any adjustment during the test period, in case of breakdown of any parts and components.

6 Procedures of Test

6.1 Verification of the specifications

6.1.1 This inspection is carried out to verify the mechanism, main dimensions, material and accessories of the dryer conform to the lists of specifications submitted by the manufacturer.

6.1.2 Besides gathering of technical data of the machine, observations on the following shall be made:

6.1.2.1 Quality of manufacture

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

6.1.2.3 Presence of safety controls

6.1.2.4 Presence of dust collection systems

6.1.2.5 Operation and maintenance manual and spare parts catalogue, and special tools required for adjustments and repair should be available and supplied to end-users.

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

6.2 Performance test

6.2.1 This is carried out to test the performance of the grain dryer.

6.2.2 Duration of test – Three test trials shall be carried out with the same operational setting. The length of the test shall be such that one full capacity of grain has been dried to a final moisture content of approximately 14% (for rice and corn). Unloading and loading time of the samples in the dryer shall also be recorded.

6.2.3 The dryer shall be operated at the drying air temperature as specified by the manufacturer.

6.2.4 In case of continuous flow type dryer, the dryer's discharge mechanism shall be set as specified by the manufacturer and the grains shall undergo tempering process as the case maybe for at least four (4) hours before reloading to the dryer for another pass. For a continuous drying operation, the minimum amount of test material to be used shall be equal to twice the rated capacity.

6.2.5 Measurements – The following shall be measured at 30-minute intervals or as necessary.

6.2.5.1 Air velocity

Measurement of air velocity shall be made at the air duct or at the heat exchanger, whichever is applicable.

6.2.5.2 Temperatures

Grain temperature, drying air temperature, ambient and exhaust air wet bulb and dry bulb temperatures shall be recorded.

6.2.5.3 Static pressure

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

6.2.5.4 Moisture content reduction per pass

In case of continuous flow dryer, the percentage of moisture removed for each drying pass shall be recorded.

6.2.5.5 Sound level

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

6.2.5.6 Moisture content

Samples for moisture determination shall be taken at the bottom, middle and top layer of the grain for batch type dryers and from the flow of grain from the discharge mechanism for the

continuous flow dryer. At least six (6) samples shall be taken from each layer. The samples gathered during testing shall be cooled down at ambient temperature before measuring the grain moisture content.

6.2.5.7 Power and fuel

Measurement shall be made of the power and fuel used during each test run.

6.2.6 Sampling – For determination of grain quality, such as cracked grain and for milling test (in case for rice), samples from the input and final output shall be taken during each test run.

6.2.7 The items to be measured, inspected and observed shall be recorded in Annex D.

6.2.8 The drying curve of the dryer shall be plotted with the drying time at the abscissa and the moisture content, grain temperature and drying air temperature at the ordinates.

7 Ease of Handling and Safety Feature

The ease of loading and unloading of grain operation, setting and adjustment shall be observed during the test and reported. The design from the point of view of safety for the operator and the different machine components/ assemblies shall be checked and reported. These shall be recorded in Annex B or C.

8 Laboratory Analysis of Dried Samples

This is carried out to have a comparative analysis of the grains used before and after the drying test.

8.1 The quality of dried grain samples from the dryer shall be compared to the quality of dried grain using shade or laboratory drying.

8.2 The grain samples taken before and after the test shall be subjected to quality analysis in the laboratory. The following shall be determined:

8.2.1 Variety

8.2.2 Moisture content

8.2.3 Purity

8.2.4 Cracked grains

8.2.5 Brokens/Split kernels

8.2.6 Immature grains

8.2.7 Fermented grains

8.2.8 Damaged grains

8.2.9 Foreign matter

8.2.10 Weed seeds

8.3 In case of rice grains, comparative analysis of the milling potential of the grain used as shown in Figure 1 shall be undertaken.

8.4 Items to be determined shall be recorded in Annex E.

9 Formula

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

10 Test Report Format

10.1 Title

10.2 Summary

10.3 Scope of Test

10.4 Method of Test

10.5 Condition of Machine

10.6 Description of the Machine

10.7 Results and Discussion

10.8 Observations (include pictures)

10.9 Names and Signatures of Test Engineers

Annex A

Minimum List of Field and Laboratory Test Equipment and Materials

A.1	**Equipment**	**Qty.**
A.1.1	**Performance test**	
A.1.1.1	Thermometer (range: 0°C to 100°C) 4	**4**
A.1.1.2	Grain moisture meter (duly calibrated using the standard method) Range: 12% to 24% (for paddy)	**1**
A.1.1.3	Tachometer, contact type, range: 0-5000 rpm; or Photoelectric, range: 0-5000 rpm	**1**
A.1.1.4	Timers ; Capacity: 60 minutes ; Accuracy: 0.1 second	**2**
A.1.1.5	Measuring tape (capacity: 5m)	**1**
A.1.1.6	Noise level meter ; Range: 30 to 130 dB(A)	**1**
A.1.1.7	Weighing scale ; Capacity: 100 kg; scale divisions: 0.5 kg	**1**
A.1.1.8	Graduated cylinder (for engines) 500 mL capacity or watt-hour meter (for electric motors) ; 60 Hz, 220 V	**1**
A.1.1.9	Vernier Caliper Accuracy: 0.1 mm	**1**
A.1.1.10	Pitot tube	**1**
A.1.1.11	Manometer / Pressure gauge	**1**
A.1.1.12	Air velocity meter	**1**
A.1.1.13	Power meter (60 Hz, 220V)	**1**
A.1.1.14	Scientific Calculator	**1**
A.1.1.15	Marking pen and pencil	**1**
A.1.1.16	Camera	**1**
A.1.2	**Laboratory test**	
A.1.2.1	Weighing scale (Sensitivity: 0.1 g)	**1**
A.1.2.2	Air oven	**1**
A.1.2.3	Magnifying lens (minimum of 10 magnifications)	**1**
A.1.2.4	Grain sample cleaner	**1**
A.1.2.5	Whiteness meter	**1**
A.1.2.6	Grain sampler/Divider	**1**
A.1.2.7	Aluminum moisture can	**3**
A.1.2.8	Desiccator	**1**
A.2	**Materials**	
A.2.1	**Sample bags**	**50**
A.2.2	**Labeling tags which include:**	
A.2.2.1	Date of test	
A.2.2.2	Machine on test	
A.2.2.3	Sample source	
A.2.2.4	Variety	
A.2.2.5	Trial number	

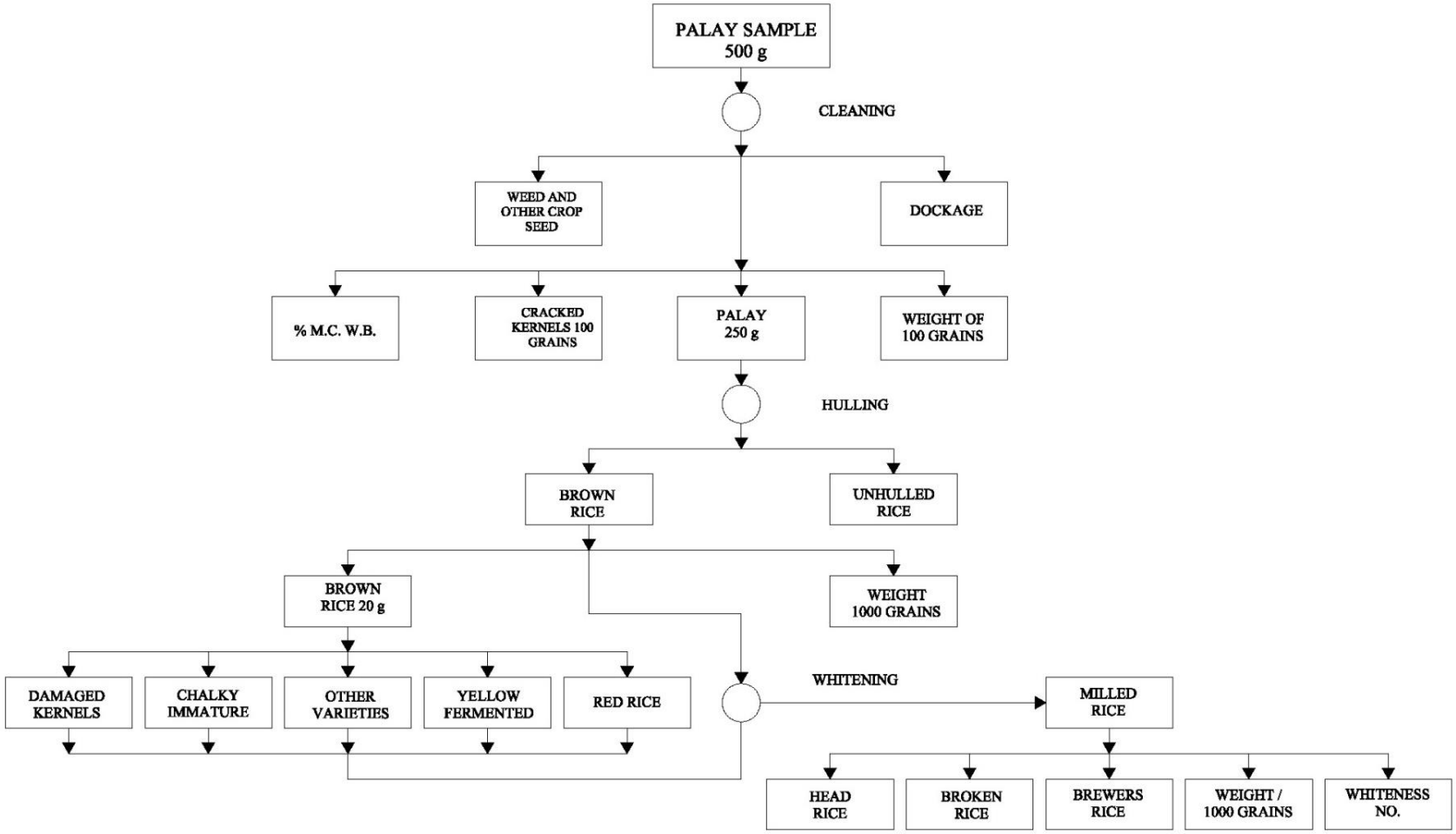

Figure 1 – Standard laboratory method in assessing milling quality of paddy

Annex B

SPECIFICATION OF GRAIN DRYERS
(Continuous-Flow Type)

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

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

General Information:

Make: _____ Model: _____
Serial No.: _____ Classification: _____
Production date of dryer to be tested: _____
Testing Agency: _____ Date of Testing: _____
Test Engineer: _____

ITEM	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Agency
B.1 Grain flow rate (t/h)*		
B.2. Drying chamber		
B.2.1 Drying and cooling section		
B.2.1.1 Overall dimensions (mm)		
B.2.1.1.a Length		
B.2.1.1.b Width		
B.2.1.1.c Height		
B.2.1.2 Grain holding capacity		
B.2.1.2.a Volumetric (m^3)		
B.2.1.2.b Weight (kg.)		
B.2.1.3 Materials of construction		
B.2.2 Grain discharge section		
B.2.2.1 Metering device		
B.2.2.1.a Type		
B.2.2.1.b Number of elements		
B.2.2.1.c Control drive arrangement		
B.2.2.1.d Drive unit (kW)		
B.2.2.2 Materials of construction of discharge hopper		
B.3 Air distribution system		
B.3.1 Drying and cooling section		
B.3.1.1 Plenum		

ITEM	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Agency
B.3.1.1.a Intake manifold		
Material (s) of construction		
B.3.1.1.b Exhaust manifold		
Material (s) of construction		
B.3.1.2 Ducting		
Material (s) of construction		
B.3.2 Fans		
B.3.2.1 Drying and Cooling Section		
B.3.2.1.a Number		
B.3.2.1.b Type		
B.3.2.1.c Make and Model		
B.3.2.1.d Electric Motor		
B.3.2.1.d.1 Number and Type		
B.3.2.1.d.2 Total Rated Power (kW)		
B.3.2.1.d.3 Rated speed (rpm)		
B.3.2.1.d.4 Phase		
B.3.2.1.d.5 Voltage (V)		
B.3.2.1.d.6 Frequency (Hz)		
B.3.2.1.e Fan shaft speed (rpm)		
B.3.2.1.f Air flow rate (m^3/min)		
B.4. Heating system		
B.4.1 Main		
B.4.1.1 Type (direct or indirect)		
B.4.1.2 Type of fuel		
B.4.1.3 Temperature control		
B.4.1.4 Fuel consumption (L/h)		
B.4.1.5 Other feature(s)		
B.4.2 Supplementary		
B.4.2.1 Type (direct or indirect)		
B.4.2.2 Fuel		
B.4.2.3 Temperature control		
B.4.2.4 Other feature(s)		
B.5. Tempering bin(s)		
B.5.1 Number		
B.5.2 Holding capacity (m^3)		
B.5.2.1 Type		
B.5.2.2 Unloading rate (kg/h)		
B.5.3 Material(s) of construction		
B.5.4 Other feature (s)		
B.6. Material handling system		
B.6.1 Dump pit		

ITEM	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Agency
B.6.1.1 Pit dimension		
B.6.1.2 Material(s) of construction		
B.6.1.3 Feature (s)		
B.6.2 Elevator (s)		
B.6.2.1 Number and height (m)		
B.6.2.2 Capacity (t/h)		
B.6.2.3 Belt dimensions (w x t, mm)		
B.6.2.4 Elevator buckets		
B.6.2.4.a Dimensions (mm)		
B.6.2.4.b Material (s) of construction		
B.6.2.5 Drive Motor		
B.6.2.5.a Type		
B.6.2.5.b Rated power (kW)		
B.6.2.5.c Rated speed (rpm)		
B.6.2.5.d Phase		
B.6.2.5.e Voltage (V)		
B.6.2.5.f Frequency (Hz)		
B.6.2.6 Material (s) of construction		
B.6.2.7 Other Feature (s)		
B.6.3 Conveyor (s)		
B.6.3.1 Type		
B.6.3.2 Number		
B.6.3.3 Capacity (t/h)		
B.6.3.4 Drive motor		
B.6.3.4.a Type		
B.6.3.4.b Rated power (kW)		
B.6.3.4.c Rated speed (rpm)		
B.6.3.4.d Phase		
B.6.3.4.e Voltage (V)		
B.6.3.4.f Frequency (Hz)		
B.6.3.5 Control (s)		
B.6.3.6 Material (s) of construction		
B.6.3.7 Other feature (s)		
B.6.4 Other types of material handling		
B.6.4.1 Description		
B.7 Instruments and controls		
B.7.1 Temperature , Moisture and Pressure		
B.7.1.1 Air temperature		
B.7.1.1.a Type (s)		
B.7.1.1.b Location (s)		

ITEM	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Agency
B.7.1.2 Grain temperature		
B.7.1.2.a Type (s)		
B.7.1.2.b Location (s)		
B.7.1.2 Grain moisture content		
B.7.1.2.a Type (s)		
B.7.1.2.b Location (s)		
B.7.1.3 Pressure/ airflow indicator (s)		
B.7.1.2.a Type (s)		
B.7.1.2.b Location (s)		
B.7.1.4 Other feature (s)		
B.8 Pre-cleaner		
B.8.1 Type		
B.8.2 Capacity		
B.8.3 Fan		
B.8.3.1 Type		
B.8.3.2 Material (s) of construction		
B.8.4 Sieve		
B.8.4.1 Type		
B.8.4.2 Number		
B.8.4.3 Size of perforations (mm)		
B.8.4.4 Material (s) of construction		
B.8.5 Air Duct		
B.8.5.1 Diameter (mm)		
B.8.5.2 Material (s) of construction		
B.8.6 Electric Motor		
B.8.6.1 Type		
B.8.6.2 Rated power (kW)		
B.8.6.3 Rated speed (rpm)		
B.8.6.4 Phase		
B.8.6.5 Voltage (V)		
B.8.6.6 Frequency (Hz)		
B.8.7 Other feature (s)		
B.9 Dust emission control (s)		
B.9.1 Type (s)		
B.9.2 Location (s)		
B.9.3 Other feature (s)		
B.10 Safety feature (s)		
B.10.1 Product safety		
B.10.2 Machine safety		
B.10.3 Operation and maintenance safety		

* based on input to the dryer

B.11 Schematic diagram of the dryer set-up

The following are to be filled-up by the testing agency

B.12 Comments on the quality of manufacture

_____
_____
_____
_____

B.13 Comments on adequacy of protection of components (e.g. bearings, shafting, belts, etc.)

_____
_____
_____
_____

B.14 Comments on safety controls/devices

_____
_____
_____
_____

B.15 Comments on dust collection systems

_____
_____
_____
_____

B.16 Availability of manuals, brochure, and standard and special tools for adjustments and repair

_____
_____
_____
_____

B.17 Comments on instrumentation

_____
_____
_____
_____

B.18 Comments on ease of loading and unloading

_____
_____
_____
_____

B.19 Comments on settings and adjustments

_____
_____
_____
_____

B.20 Other comments/ observations

_____
_____
_____
_____

Annex C

SPECIFICATION OF GRAIN DRYERS
(Batch Type)

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

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

General Information:

Make: _____ Model: _____
Serial No.: _____ Classification: _____
Production date of dryer to be tested: _____
Testing Agency: _____ Date of Testing: _____
Test Engineer: _____

ITEM	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Agency
C.1. Machine Specifications		
C.1.1 Drying Rate (kg/h)		
C.1.2 Machine Structure		
C.1.2.1 Overall Dimensions (mm) (installed)		
C.1.2.1.a Length		
C.1.2.1.b Width		
C.1.2.1.c Height		
C.1.3 Drying Bin		
C.1.3.1 Type		
C.1.3.2 Dimensions (mm)		
C.1.3.2.a Length		
C.1.3.2.b Width/ Diameter		
C.1.3.2.c Height		
C.1.3.3 Holding Capacity (kg)		
C.1.3.4 Maximum Grain Depth*(mm)		
C.1.3.5 Material		
C.1.3.5.a Frame		
C.1.3.5.b Holding Bin		
C.1.3.5.c Wall		
C.1.4 Fan		

ITEM	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Agency
C.1.4.1 Type		
C.1.4.2 Brand/Model		
C.1.4.3 Air Flow Rate (m^3/min)		
C.1.4.4 Static Pressure (Pa)		
C.1.4.5 Material		
C.1.4.6 Prime mover		
C.1.4.7 Others (specify)		
C.1.5 Heater		
C.1.5.1 Type		
C.1.5.2 Brand/Model		
C.1.5.3 Fuel		
C.1.5.4 Heat output (kJ/h)		
C.1.5.5 Fuel Consumption (kg/h or L/h)		
C.1.5.6 Capacity of fuel tank (L)		
C.1.5.7 Method of temperature control		
C.1.5.8 Materials of construction		
C.1.5.9 Others (specify)		
C.1.6 Material Handling System**		
C.1.6.1 Dump Pit		
C.1.6.1.a Pit Dimension,L x W x H (mm)		
C.1.6.1.b Material(s) of construction		
C.1.6.1.c Other Feature (s)		
C.1.6.2 Elevator (s)		
C.1.6.2.a Number and Height (m)		
C.1.6.2.b Capacity (t/h)		
C.1.6.2.c Belt dimensions (w x t, mm)		
C.1.6.2.d Elevator buckets		
C.1.6.2.d.1 Dimensions (mm)		
C.1.6.2.d.2 Material (s) of construction		
C.1.6.2.e Drive Motor		
C.1.6.2.e.1 Type		
C.1.6.2.e.2 Rated power (kW)		
C.1.6.2.e.3 Rated speed (rpm)		
C.1.6.2.e.4 Phase		
C.1.6.2.e.5 Voltage (V)		
C.1.6.2.e.6 Frequency (Hz)		
C.1.6.2.f Material (s) of construction		
C.1.6.2.g Other Feature (s)		
C.1.7 Safety Feature (s)		
C.1.7.1 Product Safety		

ITEM	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Agency
C.1.7.2 Machine Safety		
C.1.8 Operator Safety		

* maximum grain depth – air path distance from inlet to outlet
**for recirculating batch only

The following are to be filled-up by the Testing Agency

C.2 Comments on the quality of manufacture

_____
_____
_____
_____

C.3 Comments on adequacy of protection of components (e.g. bearings, shafting, belts, etc.)

_____
_____
_____
_____

C.4 Comments on safety controls/devices

_____
_____
_____
_____

C.5 Comments on dust collection systems

_____
_____
_____
_____

C.6 Availability of manuals, brochure, and standard and special tools for adjustmentsand repair

_____
_____
_____
_____

C.7 Comments on instrumentation

C.8 Comments on ease of loading and unloading

C.9 Comments on settings and adjustments

C.10 Other comments/ observations

Annex D

DRYING PERFORMANCE TEST

D.1 Crop conditions

D.1.1 Kind/Variety : _____

D.1.2 Initial grain moisture content (%) : _____

D.1.3 Total weight of grain (kg) : _____

D.1.4 Cracked grain (%) : _____

D.1.5 Damaged grain (%) : _____

D.1.6 Impurities (%) : _____

D.2 Ambient conditions

D.2.1 Temperature (°C) : _____

D.2.1.1 Dry bulb : _____

D.2.1.2 Wet bulb : _____

D.2.2 Relative humidity (%) : _____

D.2.3 Atmospheric pressure (Pa) : _____

D.3 Dryer performance

D.3.1 Drying rate (kg/batch or kg/hr) : _____

D.3.2 Drying air temperature (°C) : _____

D.3.3 Ave. ambient air temperature (°C)

D.3.3.1 Wet bulb : _____

D.3.3.2 Dry bulb : _____

D.3.4 Ave. ambient air relative humidity (%) : _____

D.3.5 Ave. exhaust air temperature (°C) : _____

D.3.5.1 Wet bulb : _____

D.3.5.2 Dry bulb : _____

D.3.6 Ave. exhaust air relative humidity (%) : _____

D.3.7 Ave. grain temperature (°C) : _____

D.3.8 Ave. air velocity (m/s) : _____

D.3.9 Ave. static pressure (Pa) : _____

D.3.10 Burner fuel consumption (L/h) : _____

D.3.11 Electrical power consumption (kW) : _____

D.3.12 Drying time (h) : _____

D.3.13 Moisture content reduction per pass or per batch (%/h) : _____

D.3.14 Drying system efficiency (%) : _____

D.3.15 Burner/furnace efficiency (%) : _____

D.3.16 Heating system efficiency : _____

D.3.17 Heat utilization (kJ/kg of H_2O) : _____

D.3.18 Dryer efficiency (%) : _____

D.3.19 Moisture content (% w.b.) : _____

D.3.20 Moisture content gradient (%) : _____

Annex E
LABORATORY ANALYSIS OF SAMPLES

E.1 Analysis of paddy samples

E.1.1 Before and after drying

Machine tested : _____ Date of test : _____

Variety : _____ Laboratory analyst : _____

Condition	Moisture Content (%)	Bulk Density (kg/m^3)	Purity (%)	Foreign Matter (%)	Cracked Grains (%)	Immature Grains (%)	Weed Seeds (%)	Fermented Grains (%)	Damaged Grains (%)	Remarks
Before Drying										
After Drying										

E.1.2 Analysis of milled rice

Condition	Head Rice (%)	Broken Rice (%)	Milling Recovery (%)	Whiteness Index	Milling Degree	Date of Test	Moisture Content (%)	Remarks
Air Dried or Laboratory Dryer								
Dryer on Test								

Note: Laboratory milling of rice shall be conducted, minimum of 48 hours after drying.

E.2 Analysis of corn samples

Machine tested : _____ Date of test : _____

Variety : _____ Laboratory analyst : _____

Condition	Moisture Content (%)	Bulk Density (kg/m^3)	Purity (%)	Foreign Matter (%)	Cracked Kernels (%)	Damaged Kernels (%)	Remarks
Before Drying							
After Drying							

Annex F

Formula to be Used in the Computation of Drying Parameters

F.1 Drying capacity $\left(\frac{\text{kg}}{\text{h}}\right) = \frac{\text{Initial weight of test material (kg)}}{\text{Actual drying time (h)}}$

F.2 Final weight of test material, W_2 (kg)

$$W_2 = \frac{W_1(100\text{-}MC_1)}{(100\text{-}MC_2)}$$

where:

MC_1 is the initial moisture content of the test material (%)
MC_2 is the final moisture content of the test material (%)
W_1 is theinitial weight of the test material (kg)
W_2 is thefinal weight of the test material (kg)

F.3 Moisture reduction per hour

$$\text{By weight } \left(\frac{\text{kg}}{\text{h}}\right) = \frac{\text{Initial weight of test material (kg)- Final weight of test material (kg)}}{\text{Actual drying time (h)}}$$

F.4 Heating system efficiency (%)

$$\text{Heating System Efficiency (\%)} = \frac{\text{Heat supplied to the dryer}}{\text{Heat available in the fuel}} \text{ x } 100$$

where :

$$\text{Heat supplied} = \frac{[\text{Enthalpy } (h_2) - \text{Enthalpy } (h_1)]\text{x air flowrate}(m^3/\text{min})}{\text{specific volume}(m^3/\text{kg dry air})} \text{x } 60 \ \frac{\text{min}}{\text{h}}$$

$$\text{Heat available} = \text{Fuel feed rate (kg/h)xheating value of fuel (kJ/kg)}$$

Fuel feed rate (kg/h) = Fuel consumed (kg/h) x Moisture Content (dry basis)

F.5 Heat utilization $\text{(kJ/kg)} = \frac{\text{Heat supplied (kJ/h) x drying time (h)}}{\text{Amount of moisture removed (kg)}} \text{ x } 100$

F.6 Drying efficiency(%)= $\frac{\text{Total heat utilized (kJ/h)}}{\text{Heat supplied to the dryer (kJ/h)}} \text{ x } 100$

$$\text{Total heat utilized } \left(\frac{\text{kJ}}{\text{h}}\right) = \frac{[\text{LHV}_{\text{water}} \left(\frac{\text{kJ}}{\text{kg}}\right)]\text{x } (W_1 - W_2)}{\text{Actual drying time (h)}}$$

where:

LHV water = Latent heat of vaporization of water (kJ/kg)within the grain

Table 1 – Latent heat of water (kJ/kg) at different temperature.

Grain Temperature °C	**Latent Heat kJ/kg**
15.6	2465.8
26.7	2439.0
37.8	2399.5
48.9	2386.0
60.0	2358.9
71.1	2331.3
93.3	2274.6
100.0	2256.9
104.4	2245.3
115.6	2214.8
126.7	2183.2
137.8	2150.9
148.9	2116.7

Source : Hall, 1980.

F.7 Combustion efficiency(%) = $\frac{\text{Heat released by the fuel (kJ/h)}}{\text{Fuel feed rate (kg/h) x heating value of fuel (kJ/kg)}}$ x 100

F.8 Drying system efficiency(%)= $\frac{\text{Total heat utilized (kJ/h)}}{\text{Fuel feed rate (kg/h) x heating value of fuel (kJ/kg)}}$ x 100

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

***BUREAU OF PHILIPPINE STANDARDS**