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**Agroprocessing machines — Test  
methods —**

**Part 4: Heated air mechanical grain dryer**

ICS 65.060.01

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Reference number

DRS 269-4: 2020

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## Foreword

Rwanda Standards are prepared by Technical Committees and approved by Rwanda Standards Board (RSB) Board of Directors in accordance with the procedures of RSB, in compliance with Annex 3 of the WTO/TBT agreement on the preparation, adoption and application of standards.

The main task of technical committees is to prepare national standards. Final Draft Rwanda Standards adopted by Technical committees are ratified by members of RSB Board of Directors for publication and gazettment as Rwanda Standards.

RS 269-4 was prepared by Technical Committee RSB/TC 047, *Steel aluminium and related*.

This second edition cancels and replaces the first edition (RS 269-4:2015) which has been technically revised.

DRS 269 consists of the following parts, under the general title *Agroprocessing machinery— Test methods*:

- *Part 1: Price thresher*
- *Part 2: Power operated maize sheller*
- *Part 3: Rice mill*
- *Part 4: Heated air mechanical grain dryer*
- *Part 5: Maize mill*

## Committee membership

The following organizations were represented on the Technical Committee on Steel aluminium and related products (RSB/TC 047) in the preparation of this standard.

University of Rwanda/college of science and technology

University of Rwanda/College of agriculture animal science and veterinary medicine

Kabizu business group

Rwanda Polytechnic/IPRC Kigali

Rwanda Polytechnic/IPRC Ngoma

Rwanda Polytechnic/IPRC Musanze

RWANTECH Boilers

Rwanda Inspectorate and competition authority

Rwanda Institute for Conservation Agriculture

ACER Ltd

Rwanda Standards Board (RSB) – Secretariat

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# Agroprocessing machines — Test methods — Part 4: Heated air mechanical grain dryer

## 1 Scope

This Draft Rwanda Standard specifies the methods of sampling, testing and inspection for heated – air mechanical grain dryer.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

DRS 268-4, Agroprocessing machines — *Specification — Part 4: Heated air mechanical grain dryer*

RS 241, Agriculture machinery — *Methods of sampling.*

## 3 Terms and definitions

For the purposes of this standard, the terms and definitions given in RS 268-4 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**

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

### 3.3

#### **drying air temperature**

mean 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

**3.4****drying system efficiency**

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

**3.5****grain holding capacity (syn: load capacity continuous flow dryer)**

weight of grain in the dryer after a period of stable operation batch type dryer: weight of grain required to fill the dryer at the input moisture content

**3.6****purity**

percentage of grains free of foreign matter

**3.7****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

**3.8****tempering**

temporarily holding the grain between the drying passes, allowing the moisture content in the centre 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**

**4.1.1** The machine on test shall be commercially produced or prototype unit or slightly used machine depending upon the test objective.

**4.1.2** In case of testing commercially manufactured dryers, the dryer sampled for acceptance, lot, routine, and type tests in accordance with RS 241 shall be submitted for test.

**4.2 Role of manufacturer/dealer**

The manufacturer/dealer shall comply with the test procedures of national testing authority.

### 4.3 Test site conditions

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

### 4.4 Measurement of dryer holding capacity

4.4.1 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.

4.4.2 The holding capacity shall be measured in terms of weight and other accompanying information such as moisture content and purity.

### 4.5 Indication of damage

4.5.1 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.

4.5.2 Milling test of the samples obtained during drying test shall be conducted at least 48 h after the drying test while air-dried samples shall be milled when its moisture content reaches 13.5%

### 4.6 Suspension of test

4.6.1 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.

4.6.2 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 and comply with Rwanda standards on petroleum product

#### 5.1.2 Grain

The grain to be used shall be single variety and the moisture content shall be 20% and above for rice and corn with the highest available moisture content to be used in the test.

#### 5.1.3 Measuring instruments

The measuring instruments for performance testing shall be calibrated prior to the tests.



## 5.2 Test set-up

5.2.1 Thermometers shall be mounted on or inside the dryer for temperature sensing.

5.2.2 Thermometers shall be mounted at least at the following locations:

- a) near the dryer to sense ambient temperature;
- b) at the grain plenum interface;
- c) after the plenum; and
- d) immediately outside the dryer to sense exhaust air temperature.

5.2.3 Temperature sensors shall be partially shielded to minimize errors from heat radiation effects.

5.2.4 A schematic diagram shall be made of the dryer, showing a numbered location for each sensor.

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

5.2.6 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 if automatic temperature control mechanism is not fitted.

5.2.7 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 authority.

5.2.8 Fire protection complying with requirement of Rwanda standards on fire safety shall be provided

## 5.3 Running-in and preliminary adjustments

5.3.1 The dryer shall be run-in in accordance with manufacturer's operating manual before the start of actual test.

5.3.2 The manufacturer may take any adjustment during the period of run-in. Adjustments shall be within the limits specified by the manufacturer.

## 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:

- a) quality of manufacture;
- b) adequacy of protection of components (e.g. bearings, shafting, belts, etc.);
- c) presence of safety controls;
- d) presence of dust collection systems; and
- e) instruction manual and spare parts catalogue, and mechanical tool kit required.

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

## **6.2 Performance test**

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

**6.2.2** Three test trials shall be carried out with the same operational setting.

**6.2.3** The length of the test shall be such that one full capacity of grain has been dried to a final moisture content of the grain as specified in the concerned product standard.

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

**6.2.5** 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 for at least four (4) hours before reloading to the dryer for another pass.

**6.2.6** For a continuous drying operation, the minimum amount of test material to be used shall be equal to twice the rated capacity.

**6.2.7** The following shall be measured at least 30-min intervals or as necessary:

- a) air velocity: Measurement of air velocity shall be made at the air duct or at the heat exchanger, whichever is applicable;
- b) temperatures: Grain temperature, drying air temperature, ambient and exhaust air wet bulb and dry bulb temperatures shall be recorded;
- c) static pressure: This shall be taken at the plenum/transition duct;
- d) moisture content reduction per pass: In case of continuous flow dryer, the percentage of moisture removed for each drying pass shall be recorded;
- e) sound level: This shall be measured with the dryer full of grain, operating at recommended settings of different components, with burner on.;

- f) 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;
- g) power and fuel: Measurement shall be made of the power and fuel used during each test run; and
- h) 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 C.

## **7 Ease of handling and safety feature**

**7.1** The ease of loading and unloading of grain operation, setting and adjustment shall be observed during the test and reported.

**7.2** 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 A or Annex B.

## **8 Laboratory analysis of dried samples**

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

**8.2** The quality of dried grain samples from the dryer shall be compared to the quality of dried grain using shade drying.

**8.3** The grain samples taken before and after the test shall be subjected to quality analysis in the laboratory.

**8.4** The following shall be determined:

- a) Variety;
- b) moisture content;
- c) purity;
- d) cracked grains;
- e) broken /split kernels;
- f) immature grains;
- g) fermented grains;
- h) damaged grains;

- i) foreign matter; and
- j) weed seeds

**8.5** Items to be determined shall be recorded in Annex D

## **9 Formula**

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

Test report

The test report shall include the following information:

- a) title;
- b) summary;
- c) scope of test;
- d) method of test;
- e) condition of machine;
- f) description of the machine;
- g) results and discussion;
- h) observations (include pictures); and
- i) names and signatures of test Engineers

## Annex A (normative)

### Specification of grain dryers (Continuous flow types)

Name of Applicant (or Distributor): \_\_\_\_\_

Address: \_\_\_\_\_

Tel. No.: \_\_\_\_\_

Name of Manufacturer: \_\_\_\_\_

Address: \_\_\_\_\_

Tel. No.: \_\_\_\_\_

General information:

Mark: \_\_\_\_\_ Model: \_\_\_\_\_

Serial No.: \_\_\_\_\_ Classification: \_\_\_\_\_

Production date of dryer to be tested: \_\_\_\_\_

Testing Authority: \_\_\_\_\_ Date of Testing: \_\_\_\_\_

Test Engineer: \_\_\_\_\_

**Table A 1 — Grain dryer specification**

Items	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Authority
A.1 Grain flow rate (t/h)*		
A.2. Drying chamber		
A.2.1 Drying and cooling section		
A.2.1.1 Overall dimensions (mm)		
Length		
Width		
Height		

A.2.1.2 Grain holding capacity		
Volumetric (m3)		
Weight (kg.)		
A.2.1.3 Materials of construction		
A.2.2 Grain discharge section		
A.2.2.1 Metering device		
Type		
Number of elements		
Control drive arrangement		
Drive unit (kW)		
A.2.2.2 Materials of construction of discharge hopper		
A.3 Air distribution system		
A.3.1 Drying and cooling section		
A.3.1.1 Plenum		
a. Intake manifold		
Material (s) of construction		
b. Exhaust manifold		
Material (s) of construction		
A.3.1.2 Ducting		
Material (s) of construction		
A.3.2 Fans		
A.3.2.1 Drying and Cooling Section		
a Number		
b Type		
c Make and Model		
d Electric Motor		
d.1 Number and Type		
d.2 Total Rated Power (kW)		
d.3 Rated speed (rpm)		
d.4 Phase		
d.5 Voltage (V)		
d.6 Frequency (Hz)		
e Fan shaft speed (rpm)		
f Air flow rate (m3/min)		
A.4. Heating system		
A.4.1 Main		
A.4.1.1 Type (direct or indirect)		
A.4.1.2 Type of fuel		

A.4.1.3 Temperature control		
A.4.1.4 Fuel consumption (L/h)		
A.4.1.5 Other feature(s)		
A.4.2 Supplementary		
A.4.2.1 Type (direct or indirect)		
A.4.2.2 Fuel		
A.4.2.3 Temperature control		
A.4.2.4 Other feature(s)		
A.5. Tempering bin(s)		
A.5.1 Number		
A.5.2 Holding capacity (m3)		
A.5.2.1 Type		
A.5.2.2 Unloading rate (kg/h)		
A.5.3 Material(s) of construction		
A.5.4 Other feature (s)		
A.6. Material handling system		
A.6.1 Dump pit		
A.6.1.1 Pit dimension		
A.6.1.2 Material(s) of construction		
A.6.1.3 Feature (s)		
A.6.2 Elevator (s)		
A.6.2.1 Number and height (m)		
A.6.2.2 Capacity (t/h)		
A.6.2.3 Belt dimensions (w x t, mm)		
A.6.2.4 Elevator buckets		
A.6.2.4.a Dimensions (mm)		
A.6.2.4.b Material (s) of construction		
A.6.2.5 Drive Motor		
A.6.2.5.a Type		
A.6.2.5.b Rated power (kW)		
A.6.2.5.c Rated speed (rpm)		
A.6.2.5.d Phase		
A.6.2.5.e Voltage (V)		
A.6.2.5.f Frequency (Hz)		
A.6.2.6 Material (s) of construction		
A.6.2.7 Other Feature (s)		
A.6.3 Conveyor (s)		
A.6.3.1 Type		

A.6.3.2 Number		
A.6.3.3 Capacity (t/h)		
A.6.3.4 Drive motor		
A.6.3.4.a Type		
A.6.3.4.b Rated power (kW)		
A.6.3.4.c Rated speed (rpm)		
A.6.3.4.d Phase		
A.6.3.4.e Voltage (V)		
A.6.3.4.f Frequency (Hz)		
A.6.3.5 Control (s)		
A.6.3.6 Material (s) of construction		
A.6.3.7 Other feature (s)		
A.6.4 Other types of material handling		
A.6.4.1 Description		
A.7 Instruments and controls		
A.7.1 Temperature , moisture and pressure		
A.7.1.1 Air temperature		
A.7.1.1.a Type (s)		
A.7.1.1.b Location (s)		
A.7.1.2 Grain temperature		
A.7.1.2.a Type (s)		
A.7.1.2.b Location (s)		
A.7.1.2 Grain moisture content		
A.7.1.2.a Type (s)		
A.7.1.2.b Location (s)		
A.7.1.3 Pressure/ airflow indicator (s)		
A.7.1.2.a Type (s)		
A.7.1.2.b Location (s)		
A.7.1.4 Other feature (s)		
A.8 Pre-cleaner		
A.8.1 Type		
A.8.2 Capacity		
A.8.3 Fan		
A.8.3.1 Type		
A.8.3.2 Material (s) of construction		
A.8.4 Sieve		
A.8.4.1 Type		



A.8.4.2 Number		
A.8.4.3 Size of perforations (mm)		
A.8.4.4 Material (s) of construction		
A.8.5 Air Duct		
A.8.5.1 Diameter (mm)		
A.8.5.2 Material (s) of construction		
A.8.6 Electric Motor		
A.8.6.1 Type		
A.8.6.2 Rated power (kW)		
A.8.6.3 Rated speed (rpm)		
A.8.6.4 Phase		
A.8.6.5 Voltage (V)		
A.8.6.6 Frequency (Hz)		
A.8.7 Other feature (s)		
A.9 Dust emission control (s)		
A.9.1 Type (s)		
A.9.2 Location (s)		
A.9.3 Other feature (s)		
A.10 Safety feature (s)		
A.10.1 Product safety		
A.10.2 Machine safety		
A.10.3 Operation and maintenance safety		
* based on input to the dryer		

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

**A.12** Comments on the quality of manufacture

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

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**A.14** Comments on safety controls/devices

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**A.15** Comments on dust collection systems

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

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**A.17** Comments on instrumentation

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**A.18** Comments on ease of loading and unloading

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**A.19** Comments on settings and adjustments

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**A.20** Other comments/ observations

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## Annex B (normative)

### Specification for 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 Authority: \_\_\_\_\_ Date of Testing: \_\_\_\_\_

Test Engineer: \_\_\_\_\_

**Table B 1 — Grain dryer specification (batch type)**

Items	Manufacturer's Specifications	Actual Measurement/ Inspection by the Testing Authority
B.1. Machine Specifications		
B.1.1 Drying Rate ( kg/h)		
B.1.2 Machine Structure		
B.1.2.1 Overall Dimensions (mm) (installed)		
B.1.2.1.a Length		
B.1.2.1.b Width		
B.1.2.1.c Height		

B.1.3 Drying Bin		
B.1.3.1 Type		
B.1.3.2 Dimensions (mm)		
B.1.3.2.a Length		
B.1.3.2.b Width/ Diameter		
B.1.3.2.c Height		
B.1.3.3 Holding Capacity (kg)		
B.1.3.4 Maximum Grain Depth*(mm)		
B.1.3.5 Material		
B.1.3.5.a Frame		
B.1.3.5.b Holding Bin		
B.1.3.5.c Wall		
B.1.4 Fan		
B.1.4.1 Type		
B.1.4.2 Brand/Model		
B.1.4.3 Air Flow Rate (m <sup>3</sup> /min)		
B.1.4.4 Static Pressure (Pa)		
B.1.4.5 Material		
B.1.4.6 Prime mover		
B.1.4.7 Others (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.1.5.9 Materials of construction		
B.1.5.10 Others (specify)		
B.1.6 Material Handling System**		
B.1.6.1 Dump Pit		
B.1.6.1.a Pit Dimension,L x W x H mm		
B.1.6.1.b Material(s) of construction		
B.1.6.1.c Other Feature (s)		
B.1.6.2 Elevator (s)		
B.1.6.2.a Number and Height (m)		
B.1.6.2.b Capacity (t/h)		

B.1.6.2.c Belt dimensions (w x t, mm)		
B.1.6.2.d Elevator buckets		
B.1.6.2.d.1 Dimensions (mm)		
B.1.6.2.d.2 Material (s) of construction		
B.1.6.2.e Drive Motor		
B.1.6.2.e.1 Type		
B.1.6.2.e.2 Rated power (kW)		
B.1.6.2.e.3 Rated speed (rpm)		
B.1.6.2.e.4 Phase		
B.1.6.2.e.5 Voltage (V)		
B.1.6.2.e.6 Frequency (Hz)		
B.1.6.2.f Material (s) of construction		
B.1.6.2.g Other Feature (s)		
B.1.7 Safety Feature (s)		
B.1.7.1 Product Safety		
B.1.7.2 Machine Safety		
B.1.8 Operator Safety		

The following items are to be filled-up by the Testing Authority

**B.3** Comments on the quality of manufacture

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**B.4** Comments on adequacy of protection of components (e.g. bearings, shafting, belts, etc.)

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**B.5** Comments on safety controls/devices

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**B.6** Comments on dust collection systems

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**B.7** Availability of manuals, brochure, and standard and special tools for adjustments and repair

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**B.8** Comments on instrumentation

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**B.9** Comments on ease of loading and unloading

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**B.10** Comments on settings and adjustments

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**B.11** Other comments/ observations

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## Annex C (normative)

### Drying performance test

#### C.1 Crop conditions

C.1.1 Kind/Variety : \_\_\_\_\_

C.1.2 Initial grain moisture content (%) : \_\_\_\_\_

C.1.3 Total weight of grain (kg) : \_\_\_\_\_

C.1.4 Cracked grain (%) : \_\_\_\_\_

C.1.5 Damaged grain (%) : \_\_\_\_\_

C.1.6 Impurities (%) : \_\_\_\_\_

#### C.2 Ambient conditions

C.2.1 Temperature : \_\_\_\_\_

C.2.1.1 Dry bulb (°C) : \_\_\_\_\_

C.2.1.2 Wet bulb (°C) : \_\_\_\_\_

C.2.2 Relative humidity (%) : \_\_\_\_\_

C.2.3 Atmospheric pressure (Pa) : \_\_\_\_\_

#### C.3 Dryer performance

C.3.1 Drying rate (kg/batch or kg/hr) : \_\_\_\_\_

C.3.2 Drying air temperature (°C) : \_\_\_\_\_

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

C.3.3.1 Wet bulb : \_\_\_\_\_

C.3.3.2 Dry bulb : \_\_\_\_\_

- C.3.4** Ave. ambient air relative humidity (%) : \_\_\_\_\_
- C.3.5** Ave. exhaust air temperature (°C) : \_\_\_\_\_
- C.3.5.1** Wet bulb : \_\_\_\_\_
- C.3.5.2** Dry bulb : \_\_\_\_\_
- C.3.6** Ave. exhaust air relative humidity (%) : \_\_\_\_\_
- C.-3.7** Ave. grain temperature (°C) : \_\_\_\_\_
- C.3.8** Ave. air velocity (m/s) : \_\_\_\_\_
- C.3.9** Ave. static pressure (Pa) : \_\_\_\_\_
- C.3.10** Burner fuel consumption (L/h) : \_\_\_\_\_
- C.3.11** Electrical power consumption (kW) : \_\_\_\_\_
- C.3.12** Drying time (h) : \_\_\_\_\_
- C.3.13** Moisture content reduction per pass or per batch (%/h) : \_\_\_\_\_
- C.3.14** Drying system efficiency (%) : \_\_\_\_\_
- C.3.15** Burner/furnace efficiency (%) : \_\_\_\_\_
- C.3.16** Heating system efficiency (%) : \_\_\_\_\_
- C.3.17** Heat utilization (KJ/kg of H<sub>2</sub>O) : \_\_\_\_\_
- C.3.18** Dryer efficiency (%) : \_\_\_\_\_
- C.3.19** Moisture content (% w.b.) : \_\_\_\_\_
- C.3.20** Moisture content gradient (%) : \_\_\_\_\_



## Annex D (normative)

### Laboratory analysis of samples

#### D.1 Analysis of paddy samples

Laboratory milling of rice shall be conducted, minimum of 48 h after drying.

Machine tested: \_\_\_\_\_

Variety: \_\_\_\_\_

Laboratory analyst: \_\_\_\_\_

Date of test: \_\_\_\_\_

**Table D 1 — Analysis of paddy samples**

Condition	Moisture Content (%)	Bulk Density (kg/m <sup>3</sup> )	Purity (%)	Foreign Matter (%)	Cracked Grains (%)	Immature Grains (%)	Weed Seeds (%)	Fermented Grains (%)	Damage d Grains (%)	Remarks
Before Drying										
After Drying										

**Table D.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								

## D.2 Analysis of maize samples

Machine tested: \_\_\_\_\_

Variety: \_\_\_\_\_

Laboratory analyst: \_\_\_\_\_

Date of test: \_\_\_\_\_

Table D.3 — Analysis of maize samples

Condition	Moisture Content (%)	Bulk Density (kg/m <sup>3</sup> )	Purity (%)	Foreign matter (%)	Cracked Grains (%)	Damaged Grains (%)	Remarks
Before Drying							
After Drying							

## Annex E (normative)

### Formula to be used in computation of drying parameters

j) Drying capacity (kg/h) =  $\frac{\text{Initial weight of test material (kg)}}{\text{Actual drying time (h)}}$

k) weight of test material,  $W_2$  (kg)

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

l) Moisture reduction per hour

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

m) Heating system efficiency (%)

$$\text{HSE} = \frac{\text{Heat supplied to the dryer}}{\text{Heat available in the fuel}} \times 100$$

Where:

$$\text{Heat supplied} = \frac{[\text{Enthalpy (h}_2) - \text{Enthalpy (h}_1)] \times \text{air flow rate } \left(\frac{\text{m}^3}{\text{min}}\right)}{\text{specific volume } \left(\frac{\text{m}^3}{\text{kg dry air}}\right)} \times 60 \frac{\text{min}}{\text{h}}$$

$$\text{Heat available} = \text{Fuel feed rate } \left(\frac{\text{kg}}{\text{h}}\right) \times \text{heating value of fuel } \left(\frac{\text{kJ}}{\text{kg}}\right)$$

n) Heat utilization (kJ/kg) =  $\frac{\text{Heat supplied } \left(\frac{\text{kJ}}{\text{h}}\right) \times \text{drying time (h)}}{\text{Amount of moisture removed (kg)}} \times 100$

o) Drying efficiency (%) =  $\frac{\text{Total heat utilized } \left(\frac{\text{kJ}}{\text{h}}\right)}{\text{Heat supplied to the burner } \left(\frac{\text{kJ}}{\text{h}}\right)} \times 100$

p) Combustion efficiency (%) =  $\frac{\text{Heat released by the fuel } \left(\frac{\text{kJ}}{\text{h}}\right)}{\text{Amount of fuel } \left(\frac{\text{kg}}{\text{h}}\right) \times \text{heating value of fuel } \left(\frac{\text{kJ}}{\text{kg}}\right)} \times 100$

Drying system efficiency (%) =  $\frac{\text{Total heat utilized } \left(\frac{\text{kJ}}{\text{h}}\right)}{\text{Amount of fuel } \left(\frac{\text{kg}}{\text{h}}\right) \times \text{heating value of fuel } \left(\frac{\text{kJ}}{\text{kg}}\right)} \times 10$



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