Foreword

The formulation of this National Standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) with support from the Department of Agriculture (DA).

This standard has been technically prepared in accordance with BPS Directives Part 3:2003 – Rules for the standard and from which no deviation is permitted.

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:

Regional Network for Agricultural Machinery (RNAM) Test Codes and Procedures for Farm Machinery. Technical Series No. 12:1983.

Richey, C.B., Jacobson P. and C.W. Hall. *Soil Classification Scheme Adopted by USDA*. Agricultural Engineers' Handbook. McGraw-Hill Book Company. 1961. pp. 792.

Smith, D.W., Sims B.G, and D.H. O'Neill. *Testing and Evaluation of Agricultural Machinery and Equipment – Principles and practices.* FAO Agricultural Services Bulletin 110. 1994.

Agricultural Machinery – Furrower – Methods of Test

1 Scope

This standard specifies the methods of test and inspection for furrowers used with four-wheel tractors. Specifically, it shall be used to:

1.1 verify the specifications submitted by the manufacturer;

1.2 determine the field performance of the furrower;

1.3 evaluate the ease of handling; and

1.4 prepare a report on 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 106:2000, Agricultural Machinery – Soil Tillage and Equipment – Terminology

3 Definitions

For the purpose of this standard, the following definitions shall apply:

3.1
furrower
lister
ridger
bedder
tillage implement resembling a double moldboard, one left wing and one right wing used to make ridges and beds for planting and trenches for irrigation and drainage purposes

3.2
furrowing
listing
ridging
bedding
tillage and land-forming operations using the furrower which lifts, inverts and throws laterally the layer of soil (furrow slice) in opposite directions

3.3
furrow
trench formed after the furrower bottom cuts and turns the furrow slices

3.4
row marker
toolbar mounted device used to guide the operator in setting the furrower for the next pass to ensure uniform furrow spacing

4 General Conditions for Test and Inspection

4.1 Furrower on Test

The furrower submitted for test shall be sampled in accordance with PAES 103.

4.2 Role of the Manufacturer/Dealer

The manufacturer/dealer shall submit to the official testing agency the specifications and other relevant information on the furrower. An official representative of the manufacturer/dealer shall be appointed to conduct minor repairs and adjustments and witness the test. It shall be the duty of the representative to make all decisions on matters of adjustment and preparation of the implement for testing. The manufacturer/dealer shall abide by the terms and conditions set forth by the official testing agency.

4.3 Termination of Test

If the furrower becomes non-functional during the test, the test shall be terminated by the test engineer.

4.4 Tractor to be Used

The tractor to be used shall be compatible with the furrower in accordance with the manufacturer's specification of required power.

5 Tests and Inspection

5.1 Verification of Manufacturer's Technical Data and Information

5.1.1 This investigation is carried out to verify that the mechanism, main dimensions and weight conform to the list of technical data and information submitted by the manufacturer.

5.1.2 The suggested minimum list of field and laboratory test equipment and materials are given in Annex A.

5.1.3 The items to be inspected and verified are given in Annex B.

5.2 Field Performance Test

5.2.1 This is carried out to test the field performance of the furrower.

5.2.2 The test shall be carried out on a dry field which has been previously plowed once and harrowed at least twice. The conditions of the field shall be recorded.

5.2.3 Test Conditions

5.2.3.1 Size of the Area per Trial

Furrowing operation shall be done in fields of not less than 1, 000 m^2 and shall be rectangular in shape with sides in the ratio of 2:1 as much as possible

5.2.3.2 Operational Pattern

Field capacity and field efficiency are influenced by field operational pattern which is closely related to the size and shape of the field, and the kind and size of implement. The non-working time should be minimized as much as possible using the recommended field operational pattern as shown in Figure 1. A marked row (illustrated in Figure 1) shall be located at a point equidistant to furrow units spacing. This will guide the operator during turning for the subsequent passes.

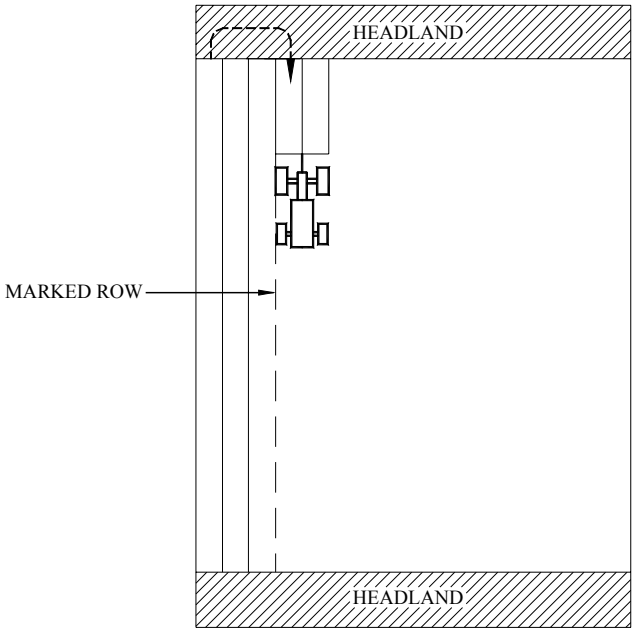


Figure 1 – Recommended Field Operational Pattern

5.2.3.3 Traveling Speed

A traveling speed of 7 kph to 8 kph shall be maintained during the operation.

5.2.3.4 Test Trials

The test shall be conducted with at least three test trials.

5.2.3.5 Headland

Depending on the tractor size, headland shall be at least 3 m in length.

5.2.4 Measurement of Performance Parameters

5.2.4.1 Field Capacity Determination

5.2.4.1.1 Effective Working Width

Effective working width is determined by dividing the total width of the field by the number of passes.

5.2.4.1.2 Depth of Furrow

It is determined by measuring the depth of the furrow using depth gauge. (see Figure 2)

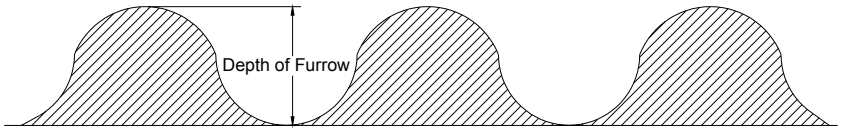


Figure 2 – Measurement of Depth of Furrow

5.2.4.1.3 Verification of Operating Speed

Outside the long boundary of the test plot, two poles 20 m apart (A, B) are placed approximately in the middle of the test run. On the opposite side also two poles are placed in similar position, 20 m apart (C, D) so that all four poles form corners of a rectangle, parallel to at least one long side of the test plot (see Figure 3). The speed will be calculated from the time required for the furrower to travel the distance (20 m) between the assumed line connecting two poles on opposite sides AC and BD. The easily visible point of the machine should be selected for measuring the time. The starting position shall be at least 2 m to 5 m from poles A and C to stabilize speed before measuring and recording data.

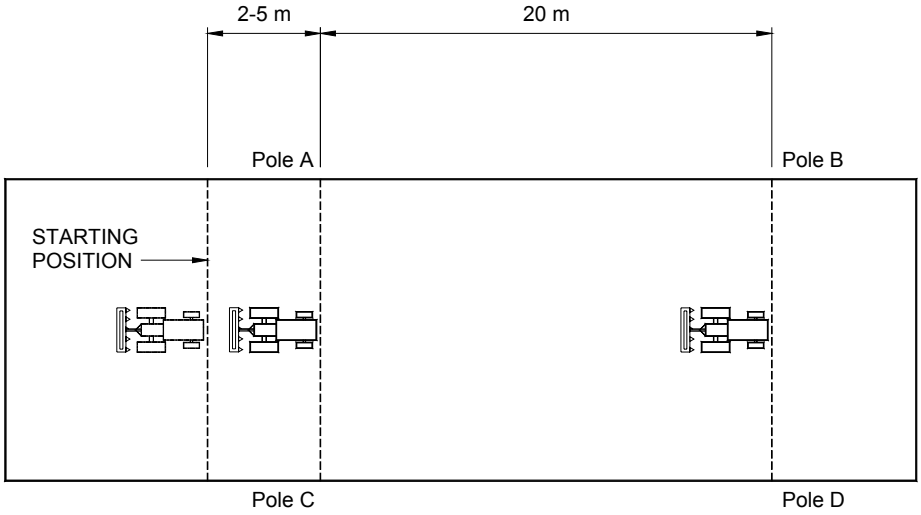


Figure 3 – Measurement of Operating Speed

5.2.4.2 Wheel Slip or Travel Reduction

The tractor drive wheel is marked with colored tape. For a given distance, the number of revolutions of the driving wheels with load (N_1) and without load (N_0) shall be recorded. (refer to Annex E for the formula used in calculating wheel slip).

5.2.4.3 Fuel Consumption (Optional)

The tank is filled to full capacity before and after each test trial. The volume of fuel refilled after the test is the fuel consumption during the test. When filling up the tank, careful attention should be taken to keep the tank horizontal and not to leave empty space in the tank.

5.3 Power Requirement Determination (Optional)

5.3.1 Draft Measurement

A strain-gauge type dynamometer is attached to the front of the tractor on which the implement is mounted. Another auxiliary tractor will pull the implement-mounted tractor through the dynamometer in neutral gear but with the implement in the operating position as shown in Figure 4. The draft in the measured distance of 20 m as well as the time it takes to traverse it shall be read and recorded. On the same field, the draft in the same distance shall be read and recorded while the implement is lifted above the ground. The difference gives the draft of the implement.

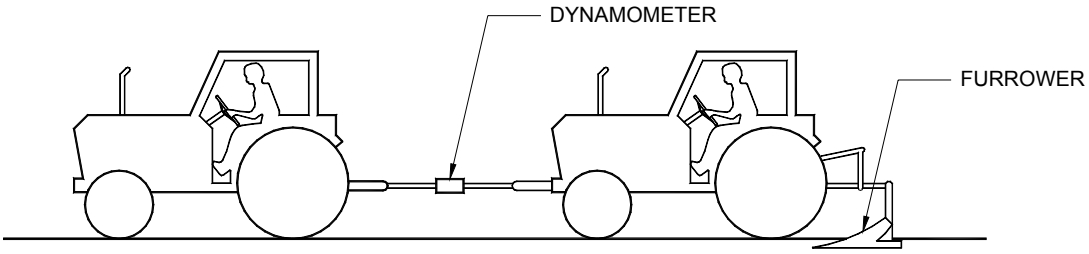


Figure 4 – Draft Measurement

5.3.2 Calculate the power using the following formula:

$$P = \frac{D\ v}{100.5}$$

where: P is the power requirement of the implement, kW
D is the draft of the implement, kg
v is the speed of the tractor, m/s

5.4 The items to be measured, investigated and recorded during the field tests are given in Annex C.

5.5 Soil Analysis (Laboratory Method)

The soil texture and moisture content of the test area shall be determined by the recommended methods given in Annex D and shall be recorded in Annex C.

6 Data Analysis

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

7 Test Report

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

7.1 Name of Testing Agency

7.2 Test Report Number

7.3 Title

7.4 Summary

7.5 Purpose and Scope of Test

7.6 Methods of Test

7.7 Description and Specifications of the Furrower

7.8 Results of Field Test

7.9 Name and Signature of Test Engineers

Annex A

Suggested Minimum List of Field and Laboratory Test Equipment and Materials

Items	Quantity
A1 Equipment	
A1.1 Field equipment	
A1.1.1 Timers Range: 0 to 60 minutes Accuracy: 1/10	2
A1.1.2 Steel tape, 50 m	1
A1.1.3 Graduated cylinder, capacity: 1,000 mL	1
A1.1.4 Width and depth gauge	1
A1.1.5 Digital video camera	1
A1.1.6 Four-wheel tractor, minimum: 65 kW	1
A1.2 Laboratory equipment (soil analysis and verification of specifications)	
A1.2.1 Convection oven or soil moisture meter	1
A1.2.2 Electronic balance**,** capacity: 1 kg	1
A1.2.3 Sieve Sizes: 2 mm, 0.05 mm, and 0.002 mm	3
A1.2.4 Vernier caliper	1
A2 Materials for field test	
A2.1 Marking pegs	10

Annex B

Inspection Sheet for Furrower

Name of Applicant: _____

Address: _____

Telephone No. : _____

Name of Distributor: _____

Address: _____

Name of Manufacturer: _____

Factory Address: _____

GENERAL INFORMATION

Brand: _____ Model: _____

Serial No. : _____Type: _____

Production date of furrower to be tested: _____

Items to be inspected

ITEMS	Manufacturer's Specification	Verification by Testing Agency
B1 Dimensions and weight		
B1.1 Overall length, mm		
B1.2 Overall width, mm		
B1.3 Overall height, mm		
B1.4 Weight, kg		
B2 Furrower bottom		
B2.1 Quantity		
B2.2 Size, mm		
B2.3 Material		
B3 Standard		
B3.1 Dimension, mm		
B3.2 Material		
B4 Toolbar		
B4.1 Dimension, mm		
B4.2 Material		
B5 Features		
B5.1 Recommended furrow spacing, mm		
B5.2 Type of crops		

Annex C

Field Performance Test Data Sheet

Items to be Measured and Inspected

ITEMS	Trials			Average
	1	2	3	
C1 Test conditions				
C1.1 Condition of the field				
C1.1.1 Location				
C1.1.2 Dimensions of field (L x W), m				
C1.1.3 Area, m^2				
C1.1.4 Soil type (clay, clay loam, sandy, etc)				
C1.1.5 Soil moisture content, %				
C1.1.6 Last crop planted				
C2 Draft measurement (optional)				
C2.1 Draft without load, kN				
C2.2 Draft with load, kN				
C2.3 Difference, kN				
C3 Field Performance				
C3.1 Date of test				
C3.2 Brand/model of tractor used				
C3.3 Tractor's gear shift lever setting				
C3.4 Traveling speed, kph				
C3.5 Depth of furrow, mm				
C3.6 Furrow spacing, mm				
C3.7 Time lost, min				
C3.7.1 Turning, min				
C3.7.2 Others (specify), min				
C3.8 Duration of test, min				
C3.9 Actual field capacity, ha/h				
C3.10 Theoretical field capacity, ha/h				
C3.11 Field efficiency, %				
C3.12 Wheel slip, %				
C3.13 Fuel consumption rate, L/h (optional)				
C3.14 Effective fuel consumption rate, L/ha (optional)				

C4 Observations

A minimum of three persons (test engineer, manufacturer's representative and the operator) shall rate the following observations.

Items	Rating*				
	1	**2**	**3**	**4**	**5**
C.4.1 Ease of handling and stability when machine is working					
C.4.2 Ease of making adjustments					
C.4.3 Straightness of furrows					
C.4.4 Evenness of spacing between furrows					
C.4.5 Uniformity of depth and width					
C.4.6 Non-adhesion of soil to furrower bottoms					
C.4.7 Durability of parts (based on wear of soil-working parts, visible deformation, etc)					
C.4.8 Other observations_____ _____ _____					

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

Annex D

Soil Analysis (Laboratory Method)

D1.1 Soil Texture Determination

D1.1.1 This test is carried out to analyze the soil samples taken during the performance test to determine the soil texture of the test area.

D1.1.2 Three soil samples shall be taken from the test area. Each soil sample shall be weighed and recorded.

D1.1.3 Each soil sample shall then be passed through series of sieves.

D1.1.4 The type of soil (i.e. sand, silt and clay) that is retained in a particular sieve shall be weighed. (see Table D1)

Table D1 – Grain Size for Different Soil Types

Soil Type	Grain Size Mm	Remarks
Sand	2.0 – 0.05	Passed through the 2 mm sieve but retained by the 0.05 mm sieve
Silt	0.05 – 0.002	Passed through the 0.05 mm sieve but retained by the 0.002 mm sieve
Clay	< 0.002	Passed through the 0.002 mm sieve

D1.1.5 The relative composition of each soil type expressed in percent shall be computed as follows:

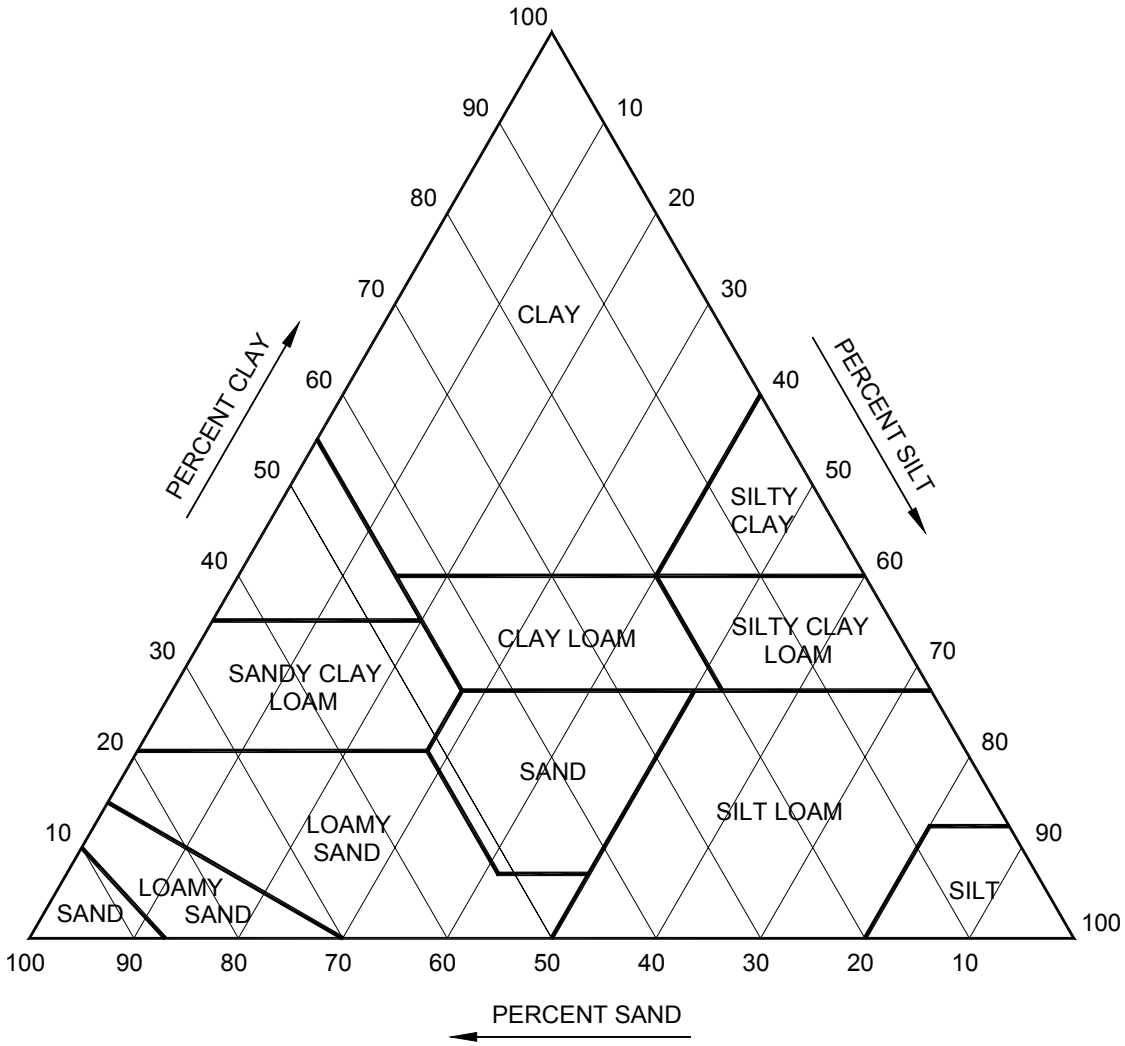
$$\%\ Sand\ =\ \frac{Weight\ of\ sand}{Total\ weight\ of\ soil}\ \text{x}\ 100$$

$$\%\ Silt\ =\ \frac{Weight\ of\ silt}{Total\ Weight\ of\ soil}\ \text{x}\ 100$$

$$\%\ Clay\ =\ \frac{Weight\ of\ clay}{Total\ Weight\ of\ soil}\ \text{x}\ 100$$

D1.1.6 The relative composition of the sand, silt and clay shall be used to determine the soil type using the soil texture triangle as shown in Figure D1.

EXAMPLE: If you have a soil with 20% clay, 60% silt and 20% sand, it will fall in the "silt loam" texture class.



Source: Soil classification scheme adopted by USDA, Agricultural Engineering Handbook, 1961.

Figure D1 – Soil Texture Triangle Showing Relative Composition of Texture Class

D1.2 Soil Moisture Content Determination

D1.2.1 Oven Method

D1.2.1.1 This test is carried out to analyze the soil samples taken during the performance test to determine the soil moisture of the test area.

D1.2.1.2 Three core soil samples in at least three different locations of test plots shall be taken randomly from the test area. Each soil sample shall be weighed and recorded as initial weight.

D1.2.1.3 The samples shall be dried using a convection oven maintained at 150ºC for at least eight hours.

D1.2.1.4 The oven dried sample shall then be placed in a desiccator. Each soil sample shall be weighed and recorded as oven-dried weight.

D1.2.1.5 The soil moisture (% dry weight basis) shall be computed as follows:

$$Soil\ Moisture\ (\%\ dry\ weight\ basis) = \frac{W_i - W_f}{W_f} \text{ x } 100$$

where: W_i is the initial weight of the soil, kg
W_f is the oven-dried (final) weight of the soil, kg

D1.2.2 The soil moisture content can also be measured using a soil moisture meter.

Annex E

Formulas Used During Calculations and Testing

E1.1 Estimation of Effective Field Capacity

E1.1.1 Width of cut

$$S = \frac{W}{2n}$$

where: S is the width of cut, m
W is the width of plot, m
n is the number of rounds
2 is the number of trips per round

E1.1.2 Total distance traveled

$$D = \frac{A}{S} = 2nL$$

where: D is the total distance traveled, m
A is the area of the plot, m^2
L is the length of the plot, m

E1.1.3 Effective area accomplished

$$A_e = wD = 2nLw$$

where: A_e is the effective area accomplished, m^2
w is the width of furrower, m

E1.1.4 Actual field capacity

$$afc = \frac{0.006\ A_e}{t}$$

where: afc is the actual field capacity, ha/h
t is the time used during the operation, min

E1.2 Theoretical Field Capacity

$$tfc = \frac{w_e\ v}{10{,}000}$$

where: tfc is the theoretical field capacity, ha/h
w_e is the effective or theoretical width of furrow, m
v is the speed of operation, m/h

E1.3 Field Efficiency

$$\varepsilon_f = \frac{afc}{tfc} \quad \text{x} \quad 100$$

where: ε_f is the field efficiency, %

E1.4 Wheel slip

$$\textit{Wheel slip}, \% = \frac{N_1 - N_0}{N_1} \quad \text{x} \quad 100$$

where: N_1 is the number of revolutions of all driving wheels for a given distance with slip, rpm

N_0 is the number of revolutions of the driving wheels for the same distance without slip, rpm

E1.5 Fuel Consumption Rate

$$F_t = \frac{V}{t}$$

where: F_t is the fuel consumption rate, L/h

V is the volume of fuel consumed, L

t is the total operating time, h

E1.6 Effective Fuel Consumption Rate

$$F_e = \frac{10{,}000\ V}{A_e}$$

where: F_e is the effective fuel consumption rate, L/ha

V is the volume of fuel consumed, L

A_e is the effective area covered, m^2