

## **Foreword**

The pursuance 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 Structure and Drafting of International Standards.

The word “shall” is used to indicate mandatory requirements to conform to the standard.

The word “should” is used to indicate that among several possibilities one is recommended as particularly suitable without mentioning or excluding others.

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

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.

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**Agricultural Machinery – Disc Harrow – Methods of Test**

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**1 Scope**

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

- 1.1 verify the requirements specified in PAES 120 and the specifications submitted by the manufacturer;
- 1.2 determine the field performance of the harrow;
- 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 120:2001, Agricultural Machinery – Disc Harrow – Specifications

**3 Definitions**

For the purpose of this standard, the definitions given in PAES 120 and the following definitions shall apply:

**3.1****disc harrow**

implement consisting of two or four gangs of concave steel discs used for additional pulverization, mixing of pesticides and fertilizers into the soil, leveling and firming the soil, closing of air pockets and eradication of weeds

**3.2****gang**

set of concave discs, which is mounted on a common shaft and separated by a spool

## **4 General Conditions for Test and Inspection**

### **4.1 Disc Harrow on Test**

The disc harrow 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 of the harrow. An official representative of the manufacturer/dealer shall be appointed to conduct minor repair, adjust 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 harrow 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 harrow 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 and specifications 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 equipments and materials are given in Annex A and 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 harrow.

**5.2.2** The test shall be carried out on a dry field as specified by the manufacturer where the conditions of the field are to be recorded.

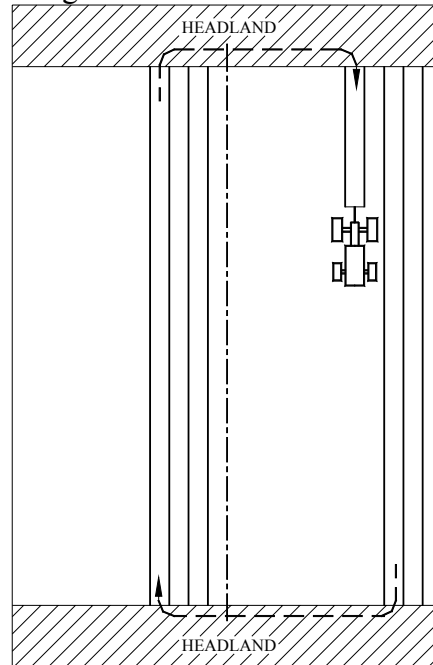
#### **5.2.3 Test Conditions**

##### **5.2.3.1 Size of the Area per Trial**

Harrowing operation shall be done in fields of not less than 1, 000 m<sup>2</sup> 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.



**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. For each test trial, two passes perpendicular to each other shall be done. Test data shall be measured for each pass.

### 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

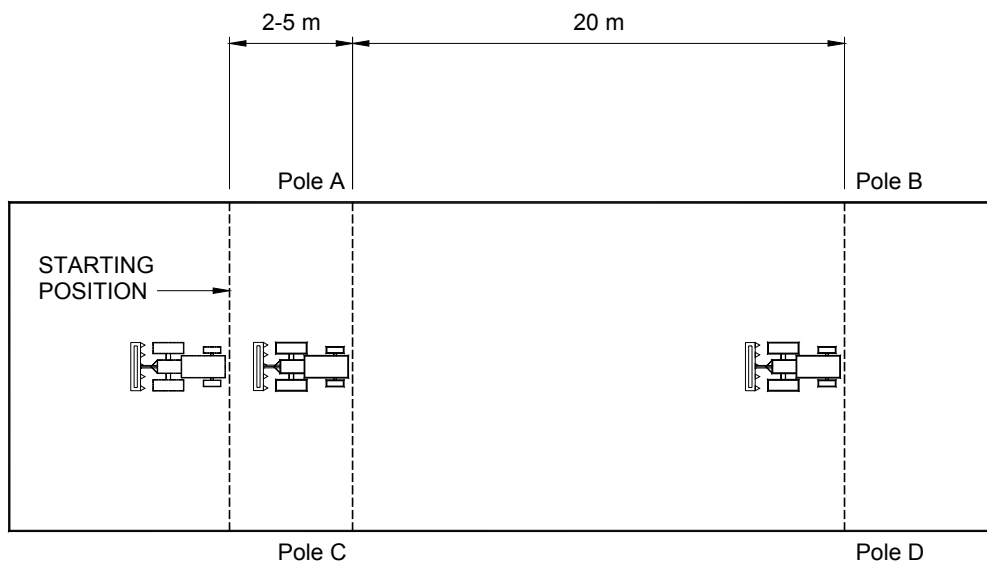
### 5.2.4.1 Field Capacity Determination

#### 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 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 plot. 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 2) The speed will be calculated from the time required for the harrow 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. Tractor shall be operated at rated engine speed (rpm).



**Figure 2 – Measurement of Operating Speed**

#### 5.2.4.2 Soil Hardness (Optional)

The soil hardness shall be measured using cone penetrometer.

#### 5.2.4.3 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 ( $N_l$ ) and without load ( $N_0$ ) shall be recorded (refer to Annex E for the formula used in calculating wheel slip).

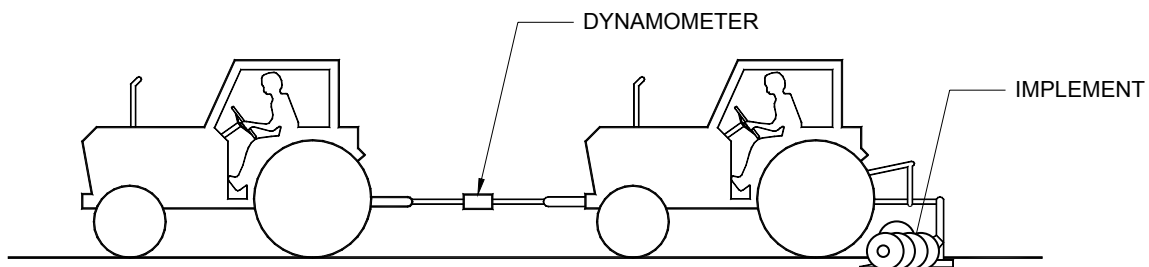
#### 5.2.4.4 Fuel Consumption (Optional)

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

#### 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 shall pull the implement-mounted tractor through the dynamometer in neutral gear but with the implement in the operating position as shown in Figure 3. 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 3 – 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 or draft animal, m/s |

5.4 The items to be observed, measured 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 Harrow
- 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 |
|---|----------|
| <b>A1 Equipment</b>   |          |
| <b>A1.1 Field equipment</b>   |          |
| A1.1.1 Timers<br>Range: 0 to 60 minutes Accuracy: 1/10                              | 2        |
| A1.1.2 Cone penetrometer  | 1        |
| A1.1.3 Steel tape, 50 m   | 1        |
| A1.1.4 Graduated cylinder, capacity: 1,000 mL                                       | 1        |
| A1.1.5 Width and depth gauge  | 1        |
| A1.1.6 Digital video camera   | 1        |
| A1.1.7 Four-wheel tractor, minimum: 65 kW   | 1        |
| <b>A1.2 Laboratory equipment (soil analysis and verification of specifications)</b> |          |
| A1.2.1 Convection oven or soil moisture meter                                       | 1        |
| A1.2.2 Electronic balance, capacity: 1 kg   | 1        |
| A1.2.3 Sieve<br>Sizes: 2 mm, 0.05 mm, and 0.002 mm                                  | 3        |
| A1.2.4 Vernier caliper  | 1        |
| <b>A2 Materials for field test</b>  |          |
| A2.1 Marking pegs   | 10       |



**Annex B****Inspection Sheet for Disc Harrow**

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 harrow to be tested : \_\_\_\_\_

**Items to be inspected**

| <b>ITEMS</b>                             | <b>Manufacturer's Specification</b> | <b>Verification by Testing Agency</b> |
|--|-------------------------------------|---------------------------------------|
| <b>B1</b> Dimensions and weight          |                                     |                                       |
| <b>B1.1</b> Overall length, mm           |                                     |                                       |
| <b>B1.2</b> Overall width, mm            |                                     |                                       |
| <b>B1.3</b> Overall height, mm           |                                     |                                       |
| <b>B1.4</b> Weight, kg                   |                                     |                                       |
| <b>B1.5</b> Weight per disc, kg          |                                     |                                       |
| <b>B2</b> Gang                           |                                     |                                       |
| <b>B2.1</b> Quantity                     |                                     |                                       |
| <b>B2.2</b> No. of discs/gang            |                                     |                                       |
| <b>B2.3</b> Disc spacing, mm             |                                     |                                       |
| <b>B2.4</b> Angle, °                     |                                     |                                       |
| <b>B2.5</b> Size and shape of gang shaft |                                     |                                       |
| <b>B3</b> Disc                           |                                     |                                       |
| <b>B3.1</b> Brand                        |                                     |                                       |
| <b>B3.2</b> Make                         |                                     |                                       |
| <b>B3.3</b> Diameter, mm                 |                                     |                                       |
| <b>B3.4</b> Thickness, mm                |                                     |                                       |
| <b>B3.5</b> Concavity, mm                |                                     |                                       |

| ITEMS   | Manufacturer's Specification | Verification by Testing Agency |
|---|------------------------------|--------------------------------|
| <b>B4</b> Scraper (if applicable)               |                              |                                |
| <b>B4.1</b> Length, mm                          |                              |                                |
| <b>B4.2</b> Width, mm                           |                              |                                |
| <b>B4.3</b> Thickness, mm                       |                              |                                |
| <b>B5</b> Spool                                 |                              |                                |
| <b>B5.1</b> Length, mm                          |                              |                                |
| <b>B5.2</b> Shape and size of hole, mm          |                              |                                |
| <b>B5.3</b> Material                            |                              |                                |
| <b>B6</b> Main frame                            |                              |                                |
| <b>B6.1</b> Dimension, mm                       |                              |                                |
| <b>B6.2</b> Material                            |                              |                                |
| <b>B7</b> Transport wheels                      |                              |                                |
| <b>B7.1</b> Quantity                            |                              |                                |
| <b>B7.2</b> Size                                |                              |                                |
| <b>B8</b> Bearings                              |                              |                                |
| <b>B8.1</b> Type                                |                              |                                |
| <b>B8.2</b> Brand                               |                              |                                |
| <b>B8.3</b> Quantity                            |                              |                                |
| <b>B9</b> Additional weight, kg (if applicable) |                              |                                |

**Annex C**  
**Field Performance Test Data Sheet**

**Items to be Measured and Inspected**

| ITEMS  | Trials          |                             |                 |                             |                 |                             | Average |
|--|-----------------|-----------------------------|-----------------|-----------------------------|-----------------|-----------------------------|---------|
|  | 1               |                             | 2               |                             | 3               |                             |         |
|  | Passes          |                             | Passes          |                             | Passes          |                             |         |
|  | 1 <sup>st</sup> | 2 <sup>n</sup> <sub>d</sub> | 1 <sup>st</sup> | 2 <sup>n</sup> <sub>d</sub> | 1 <sup>st</sup> | 2 <sup>n</sup> <sub>d</sub> |         |
| <b>C1</b> Test conditions                                    |                 |                             |                 |                             |                 |                             |         |
| <b>C1.1</b> Type of field operation                          |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2</b> Condition of field                               |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.1</b> Location                                       |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.2</b> Dimensions of field (L x W), m                 |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.3</b> Area, m <sup>2</sup>                           |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.4</b> Soil type (clay, clay loam, sandy, etc)        |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.5</b> Moisture content, %                            |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.6</b> Weed density (low, medium, or high)            |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.7</b> Soil hardness, kg/cm <sup>2</sup> (optional)   |                 |                             |                 |                             |                 |                             |         |
| <b>C1.2.8</b> Last crop planted (optional)                   |                 |                             |                 |                             |                 |                             |         |
| <b>C2</b> Draft measurement                                  |                 |                             |                 |                             |                 |                             |         |
| <b>C2.1</b> Draft without load, kN                           |                 |                             |                 |                             |                 |                             |         |
| <b>C2.2</b> Draft with load, kN                              |                 |                             |                 |                             |                 |                             |         |
| <b>C2.3</b> Difference, kN                                   |                 |                             |                 |                             |                 |                             |         |
| <b>C3</b> Field performance                                  |                 |                             |                 |                             |                 |                             |         |
| <b>C3.1</b> Date of test                                     |                 |                             |                 |                             |                 |                             |         |
| <b>C3.2</b> Brand/model of tractor used                      |                 |                             |                 |                             |                 |                             |         |
| <b>C3.3</b> Tractor's gearshift setting                      |                 |                             |                 |                             |                 |                             |         |
| <b>C3.4</b> Traveling or operating speed, kph                |                 |                             |                 |                             |                 |                             |         |
| <b>C3.5</b> Width of tillage, mm                             |                 |                             |                 |                             |                 |                             |         |
| <b>C3.6</b> Depth of tillage, mm                             |                 |                             |                 |                             |                 |                             |         |
| <b>C3.7</b> Time lost, min                                   |                 |                             |                 |                             |                 |                             |         |
| <b>C3.7.1</b> Turning, min                                   |                 |                             |                 |                             |                 |                             |         |
| <b>C3.7.2</b> Others (specify), min                          |                 |                             |                 |                             |                 |                             |         |
| <b>C3.8</b> Duration of test, min                            |                 |                             |                 |                             |                 |                             |         |
| <b>C3.9</b> Actual field capacity, ha/h                      |                 |                             |                 |                             |                 |                             |         |
| <b>C3.10</b> Theoretical field capacity, ha/h                |                 |                             |                 |                             |                 |                             |         |
| <b>C3.11</b> Field efficiency, %                             |                 |                             |                 |                             |                 |                             |         |
| <b>C3.12</b> Fuel consumption rate, L/h (optional)           |                 |                             |                 |                             |                 |                             |         |
| <b>C3.13</b> Effective fuel consumption rate, L/h (optional) |                 |                             |                 |                             |                 |                             |         |
| <b>C3.14</b> Pattern of operation                            |                 |                             |                 |                             |                 |                             |         |
| <b>C3.15</b> Percent overlap or skip                         |                 |                             |                 |                             |                 |                             |         |

#### 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.3.1 Ease of handling and stability when machine is working                              |         |   |   |   |   |
| C.3.2 Ease of handling and stability when machine is turning                              |         |   |   |   |   |
| C.3.3 Quality of finished field:<br>C3.3.1 Tilth<br>C3.3.2 Level                          |         |   |   |   |   |
| C.3.4 Non-adhesion of soil to disc  |         |   |   |   |   |
| C.3.5 Ease of making adjustments  |         |   |   |   |   |
| C.3.6 Durability of parts (based on wear of soil-working parts, visible deformation, etc) |         |   |   |   |   |
| C.3.7 Other observations _____<br>_____<br>_____  |         |   |   |   |   |

- \* 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<br>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:

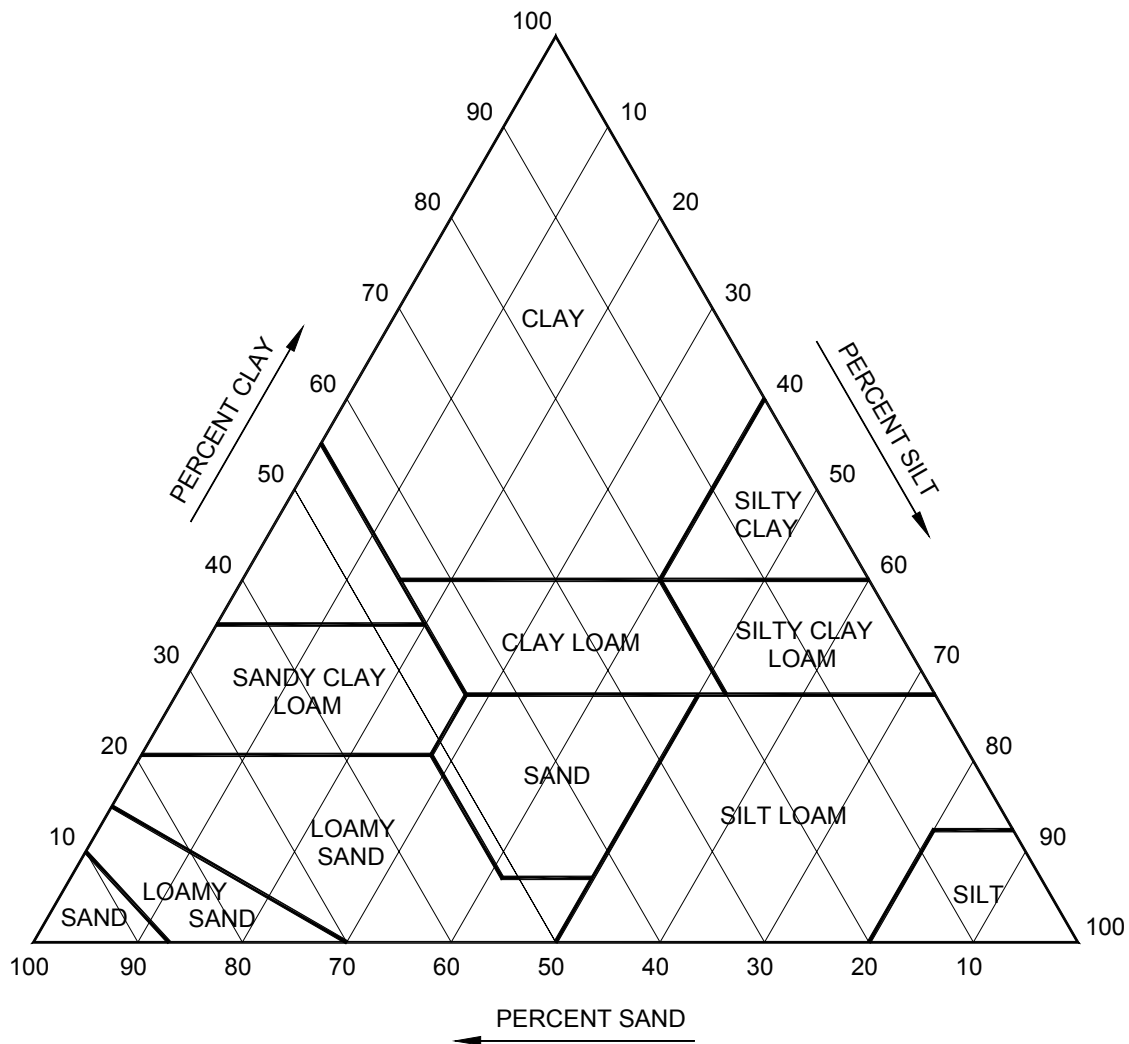
$$\% \text{ Sand} = \frac{\text{Weight of sand}}{\text{Total weight of soil}} \times 100$$

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

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

**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 105°C 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:

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

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<sup>2</sup>  
 $L$  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<sup>2</sup>  
 $w$  is the width of harrow, m

**E1.1.3.1** If width of cut is less than the harrow's width, the operator has passed over part of the area twice to secure better coverage, therefore:

$$A_o = |A_e - A|$$

where:  $A_o$  is the overlap (area which is harrowed twice), m<sup>2</sup>

**E1.1.3.2** If the width of cut is greater than the harrow's width, the operator has left part of the area unplowed, therefore:

$$A_u = A - A_e$$

where:  $A_u$  is the unharrowed area (area missed), m<sup>2</sup>



**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/theoretical width of tillage, m  
 $v$  is the speed of operation, m/h

**E1.3 Field Efficiency**

$$\varepsilon_f = \frac{afc}{tfc} \times 100$$

where:  $\varepsilon_f$  is the field efficiency, %

**E1.4 Wheel slip**

$$\text{Wheel slip, \%} = \frac{N_1 - N_0}{N_1} \times 100$$

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<sup>2</sup>