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Equipment for harvesting — Forage harvesters —

Part 3: Test methods

Matériel de récolte — Récolteuses-hacheueses-chargeuses de fourrage —

Partie 3: Méthodes d'essai

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by ISO/Technical Committee TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 7, *Equipment for harvesting and conservation*.

This second edition cancels and replaces the first edition (ISO 8909-3:1994), which has been technically revised.

The main changes compared to the previous edition are as follows:

— updates to normative references

— modification of the specifications for the test report;

— deletion of Annex A.

A list of all parts in the ISO 8909 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Equipment for harvesting — Forage harvesters —

Part 3:
Test methods

1 Scope

This document specifies test methods for evaluations of forage harvester function and performance, covering forage harvesters which cut the crop directly at full width or from spaced-apart plant rows, or which pick up pre-cut crop.

It applies to forage harvesters with driven knives for chopping and which deliver the chopped crop into a container or a separate vehicle or trailer. The forage harvesters can be tractor-mounted, trailed or self-propelled.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 730, *Agricultural wheeled tractors — Rear-mounted three-point linkage — Categories 1N, 1, 2N, 2, 3N, 3, 4N and 4*

ISO 3600, *Tractors, machinery for agriculture and forestry, powered lawn and garden equipment — Operator's manuals — Content and format*

ISO 3965, *Agricultural wheeled tractors — Maximum speeds — Method of determination*

ISO 4254-7, *Agricultural machinery — Safety — Part 7: Combine harvesters, forage harvesters, cotton harvesters and sugar cane harvesters*

ISO 5675, *Agricultural tractors and machinery — General purpose quick-action hydraulic couplers*

ISO 5715, *Equipment for harvesting — Dimensional compatibility of forage harvesting machinery*

ISO 6489 (all parts), *Agricultural vehicles — Mechanical connections between towed and towing vehicles*

ISO 8909-1, *Equipment for harvesting — Forage harvesters — Part 1: Vocabulary (under revision)*

ISO 8909-2:2021, *Equipment for harvesting — Forage harvesters — Part 2: Specification of characteristics and performance (under revision)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8909-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
test machine
machine configuration whose performance is being assessed

3.2
reference machine
machine configuration of known performance required to be used alongside the *test machine* (3.1)

3.3
test series
all events and data comprising several test runs in one crop and set of conditions

3.4
catch
mass of the material processed and collected from the harvester during a test run

Note 1 to entry: The catch is expressed in kilograms.

3.5
capacity
continuous output (mass) on a wet and dry basis of chopped crop from the harvester per unit of time

Note 1 to entry: The capacity is expressed in tonnes per hour.

3.6
power requirement
time-averaged total power required to operate the harvester during a test run at rated operating speed, excluding the power for propulsion

Note 1 to entry: The power requirement is expressed in kilowatts.

3.7
no-load power requirement
time-averaged total power required to operate the harvester at the rated speed when stationary and with the attachments to be tested engaged

Note 1 to entry: The no-load power requirement is expressed in kilowatts.

3.8
specific energy requirement
total harvester energy required per unit of crop mass on a wet and dry basis

Note 1 to entry: Specific energy requirement is expressed in kilowatt hours per tonne.

3.9
theoretical length of cut
length of cut calculated from the number of knives and the speeds and effective dimensions of all relevant components

Note 1 to entry: The theoretical length of cut is expressed in millimetres.

3.10
length of cut analyser
apparatus for dividing a typical sample of the chopped forage harvested by the machine into particle length groups, to enable the percentage of cumulative undersize by mass to be determined from each group

3.11
length of cut distribution graph
logarithmic normal probability graph of percent cumulative undersize mass versus mean particle length data from the length of cut analysis for each sample

Note 1 to entry: See Annex A.

3.12
geometric mean length of cut
particle length calculated from the analysis data or taken from the *length of cut distribution graph* (3.11) at the 50 % level of cumulative undersized mass

Note 1 to entry: It denotes the fineness of chopped crop and is the most appropriate dimension for comparison with the theoretical length of cut.

Note 2 to entry: Geometric mean length of cut is expressed in millimetres.

3.13
geometry length of cut standard deviation
particle length taken from the *length of cut distribution graph* (3.11) at the 84 % level of cumulative undersized mass divided by the mean length at the 50 % level of cumulative undersized mass

Note 1 to entry: Alternatively, it may be calculated mathematically from the analysis data.

Note 2 to entry: The geometry length of cut standard deviation is an index of the uniformity of cut.

3.14
whole-grain fraction
percentage, to the nearest 0,5, of all undamaged grains or maize (corn) kernels present in samples of chopped forage, relative to the whole catch mass (or optionally to the calculated field grain population)

Note 1 to entry: Dye penetrants may be used to determine invisible grain surface damage.

4 General requirements

4.1 The test report (see Clause 7) shall state how the forage harvester was selected or obtained for testing and the extent of any use prior to the test.

4.2 The forage harvester shall be operated in accordance with the manufacturer's instructions given in the operator's manual. The test report shall record, and give reasons for, any significant departures from them.

4.3 Commercially available accessories, as necessary or desirable for the various crops in which the forage harvester is to be used, shall be provided.

4.4 Setting and adjustments of the machine shall be in accordance with the manufacturer's instruction manual. Any necessary significant departures shall be reported.

4.5 A manufacturer's representative shall be invited to observe testing of the forage harvester.

5 Machine requirements for test

5.1 All significant details of the forage harvester shall be established and verified, using applicable terminology and measuring methods as indicated.

5.2 For self-propelled machines, measure the speed of any component at "no-load", with the engine governor control lever set to given rated engine speed. For power take-off (PTO) driven machines,

measure these speeds at the standard PTO speed (540 min^{-1} or 1 000 min^{-1}). Measure forward speeds of self-propelled forage harvesters on a hard, horizontal surface, with the governor control lever set to give rated engine speed and the harvester mechanism engaged; report the size of tyres fitted; the inflation pressure shall be as recommended by the manufacturer.

For machines with stepless speed change mechanisms, determine the maximum and minimum speeds in each speed range. Otherwise, measure speeds obtained for all combinations of gears in accordance with ISO 3965.

5.3 Assess the suitability of construction and the geometry of the forage harvester in accordance with ISO 730, ISO 5675, ISO 5715, ISO 6489 (all parts).

5.4 Assess the comprehensiveness and clarity of instructions in the operator's manual in accordance with ISO 3600.

5.5 Where applicable, check and report on compliance with safety and ergonomic requirements with particular reference to ISO 4254-7.

5.6 With self-propelled forage harvesters, measure the left-hand and right-hand turning diameters without the turning brakes engaged in accordance with ISO 8909-2:2021, 4.2.8.

6 Specific performance tests

6.1 General

These shall be carried out in crops and conditions specifically selected to determine and define by physical measurement the principal performance aspects of the harvester. On each occasion a reference machine of already defined performance characteristics shall be tested alongside the test machine(s) in like manner to provide a reference for each type of performance measurement, especially with regard to machine setting, crop condition and characteristics, and seasonal differences.

6.2 Selection of crops

6.2.1 Only crops of uniform appearance, reasonably free from disease and weeds, and of at least average yield, shall be selected. The ground surface shall be as level and even as practicable, unless special tests are being conducted. The crops shall in general be standing well and shall be free of surface moisture. Any deviations from the prescribed conditions shall be recorded and stated in the test report.

6.2.2 Crops for performance tests should cover the range of greatest interest, nationally or regionally. With multi-purpose machines, at least two types of crop of the following should be harvested:

— grass: single species or mixtures, fresh and wilted, first growth;

— legumes: single species, fresh and wilted, first or second growth;

— row crops, for example, maize (corn), sorghum or kale:

  — single species

  — direct cut

— forage cereals: single species or mixtures, fresh or wilted.

6.2.3 With machines specifically designed for row crops, at least two test series shall be carried out, if possible, in dissimilar crops. The row spacing shall coincide with the recommended working widths of the gathering units. The average dry matter content of each crop as harvested shall be determined.

6.3 Reference machine

The reference machine shall be functionally sound, and fully identified by make, model, type, year of manufacture and other pertinent information. It shall be of similar design and capacity to the test machine and be operated at comparable settings.

6.4 Operator competence

The operator shall be adequately experienced with the type of test machine and with the reference machine.

6.5 Preparations for performance tests

6.5.1 At the time of the test, both the test and reference machines shall be in good order, the working components and crop-engaging surfaces shall have adequate run-in, and the knives shall have been newly sharpened. If a recutter screen or other chopping aid is fitted, this shall be stated in the test report.

6.5.2 Immediately prior to their testing, both machines shall be adjusted in accordance with the manufacturer's recommendations to give required performance under the prevailing conditions in the same area of crop to be used for the test. A theoretical length of cut shall be used which is most appropriate for the test crop and typical in the geographic region. After the commencement of the tests, no further adjustment of settings shall be permitted in any single test series. Important settings, like those governing the length of cut, shall be recorded in the test report.

6.6 Instrumentation and test apparatus

6.6.1 The following items of instrumentation and equipment shall be available in addition to normal test aids and measuring apparatus:

a) equipment for accurately determining the mass of the catch, such as a trailer and weighbridge or wheel weighing units, or self-emptying trailer fitted with load cells between the trailer body and running gear;

b) length of cut analyser for classifying samples of chopped forage;

c) device for taking representative crop samples safely from the delivery spout of the harvester;

d) device for determination of the moisture content.

6.6.2 For tractor-operated harvesters, PTO torque and rotational frequency measuring instrumentation shall be provided.

6.5.3 For self-propelled machines the total power to drive the forage harvester components shall be determined using torque and rotational frequency sensors.

6.7 Test procedure

6.7.1 Output and specific energy requirement tests

6.7.1.1 All tractors designated to operate a test and reference machine shall provide ample power at all times. With the tractor-operated test or reference machine attached and driven at recommended PTO speed, but with the outfit stationary, note the no-load power requirement. Then, with a container

or trailer equipped for collecting the catch attached to the harvester, or pulled alongside by a separate tractor, drive the outfit into the crop at constant forward speed.

With self-propelled harvesters, the no-load power requirement shall be measured at rated engine speed with the outfit stationary and all other drives engaged. Then with a container or trailer attached to the harvester, or pulled alongside by a tractor, drive the outfit into the crop at constant forward speed.

With direct-cutting harvesters, use the full working width.

6.7.1.2 During the run-in, in other words, at least the first 5 s of harvester operation, allow the crop flow through the machine to stabilize, without the crop stream from the delivery spout being directed into the collecting device. Thereafter, start the test run during continuing work by directing the crop from the spout of the harvester into the catch-collecting trailer or container and simultaneously commence timing of the catch period. During the test run, take records of harvester power, or torque and rotational frequency. Take at least one sample for length of cut analysis from the crop stream emanating from the delivery spout of the machine.

6.7.1.3 The catch period shall extend for at least 60 s or until a minimum of 1 t of material has been collected. On completion of the test run, measure the test length, weigh the catch, take two samples from the catch for dry matter content analysis by recognized methods, and determine the effective working width. Periodic checks of soil contamination may be made by applying a recognized laboratory procedure to the ashing of two further harvested samples, alongside a sample taken from the unharvested crop, for the comparison of silica content. From the data collected during each test run calculate the following:

a) forward speed, in kilometres per hour;

b) yield of crop harvested, wet and dry basis, in tonnes per hectare;

c) capacity on a wet and dry basis, in tonnes per hour;

d) no-load power requirement, in kilowatts;

e) power requirement, in kilowatts;

f) specific energy requirement, wet and dry basis, in kilowatt hours per tonne.

6.7.1.4 Test runs shall be repeated at least once at each of several different forward speeds so that reliable performance relationships are established for the range of speeds which is practical in the prevailing conditions. At the highest acceptable forward speed, note the factors of circumstances preventing a further increase in speed and record them in the test report.

Carry out successive runs in adjacent strips of crop to minimize the effects of yield gradients in the field. Run the reference machine simultaneously in the same test area as the test machine. Unsuccessful test runs may be discarded only for valid reasons which shall be reported.

6.7.1.5 The data from a series of test runs may be used to plot the following graphs, using linear scales, with the independent and dependent variables as the *x* and *y* axes respectively:

— average total power requirement (*y*) versus out-put, wet basis and dry basis (*x*);

— specific energy requirement, wet basis and dry basis (*y*) versus output, wet basis and dry basis (*x*).

6.7.1.6 In at least one crop, make series of replicated test runs at the constant rate of approximately 80 % of maximum throughput and at progressively increasing dry matter contents of pre-cut crop, and also at similar dry matter contents but at a different theoretical length of cut. From the data collected, draw additional graphs of specific energy requirement (*y*) versus crop dry matter content, wet and dry basis, and theoretical length of cut (*x*).

6.7.2 Front end losses

When direct-cutting row crop heads are used, the pre-cut and front-end losses may be determined optionally in the test run areas. Lost cobs or other unharvested plant materials, where these are important, shall be collected and their mass related to the respective area. After deduction of pre-cut losses from front end losses, the results shall be expressed, in kilograms per hectare, of dry matter, or in terms of percentage dry matter yield.

6.7.3 Length of cut analysis

6.6.3.1 Analyse the samples taken from the harvester spout during the test runs by hand-sorting or by mechanical, pneumatic or other classification means. Permissible types of classification apparatus include stacks of actuated sieves and cascade separators. For any such device, a procedure giving good accuracy and repeatability needs to have been developed specifically. The minimum sample size is 1 l; the actual sample size shall satisfy the requirements of the length of cut analysis. For reducing the size of any sample taken, a recognized method of randomly dividing it shall be used.

6.6.3.2 Samples may be processed at harvest moisture content, or they may be dried prior to classification. The proven procedures for specific apparatus shall be adhered to, and the results obtained shall be checked periodically by hand-sorting or by mechanically classifying a sample of known length distribution.

6.6.3.3 Pertinent screening dimensions should be in geometry progression, with the smallest selected to be appropriate to the particle size spectrum of the sample. To provide a particle length for the 100 % undersize level, the mean length of the three largest pieces in each sample shall be determined.

6.6.3.4 From the results of each length of cut classification, determine the geometry mean length of cut and the geometry length of cut standard deviation by plotting a length of cut distribution graph, or by calculation (an example for crop divided into 10 length intervals is given in Annex A). In grain-bearing crops, particularly maize (corn), it is preferred that the whole-grain fraction is measured additionally.

7 Test report

7.1 Basic information

The test report shall contain the following information:

a) brief description, identification and photograph of the test machine, and statement on method of selection for test;

b) list of verified principal dimensions and specification;

c) lists of locations of test sites, crops, field, climatic conditions and machine settings including the description of the engine mode (for example, full power curve – eco mode), engine speed and other machine adjustments at each site;

d) brief descriptions of, or references to, test methods and procedures, including length of cut analysis;

e) the main data recorded during the test;

f) results, including any statistical analyses, of the test machine requirements and of the performance tests, in accordance with Clauses 5 and 6;

g) results of any optional measurements and observations, including a list of breakdowns with causes of all enforced stops due to mechanical faults, including wear, and with optional recommendations for functional and mechanical improvements;

h) brief summary of the comparative results of the tests conducted with the reference machine.