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Agricultural irrigation equipment — Centre-pivot and moving lateral irrigation machines with sprayer or sprinkler nozzles — Determination of uniformity of water distribution

Matériel agricole d'irrigation — Pivots et rampes frontales équipés de buses d'arrosage ou d'asperseurs — Méthode de détermination de l'uniformité de la distribution d'eau

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11545 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 18, *Irrigation and drainage equipment and systems*.

Annex A forms an integral part of this International Standard. Annex B is for information only.

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Introduction

The purpose of this International Standard is to specify a method of characterizing the uniformity of water distribution of agricultural irrigation machines by measuring distribution and then computing a coefficient of uniformity.

This coefficient of uniformity may assist in system design and/or selection, and for quantifying and verifying certain aspects of system field performance. The coefficient of uniformity is only one factor in evaluating total system performance: application rates, run-off, amount of water applied, pump performance, overall system management and wind conditions may, however, greatly affect the overall performance of an irrigation system.

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Agricultural irrigation equipment — Centre-pivot and moving lateral irrigation machines with sprayer or sprinkler nozzles — Determination of uniformity of water distribution

1 Scope

This International Standard specifies a method of measuring uniformity of water distribution in the field from centre-pivot and moving lateral agricultural irrigation machines equipped with sprayer or sprinkler nozzles. The method of computing the coefficient of uniformity from the data produced is also laid down.

This International Standard applies to irrigation systems where the water application device is more than 1,5 m above the soil surface and where the water distribution from successive devices overlaps.

This International Standard does not apply to the evaluation of centre-pivot irrigation machines equipped with various corner application devices.

2 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1 centre-pivot: Automated irrigation machine consisting of a pipeline rotating around a pivot point and supported by a number of self-propelled towers. The water is supplied at the pivot point, flows outwards through the pipeline and is distributed by sprayer or sprinkler nozzles located along the pipeline.

2.2 moving lateral: Automated irrigation machine consisting of a pipeline supported by a number of self-propelled towers. The entire unit moves in such a way that the pipeline remains generally in a straight line, traversing the field in a straight path, irrigating basically a rectangular area. The water may be supplied to the machine at any point along the pipeline and is distributed by individual sprayer or sprinkler nozzles located along the pipeline.

2.3 sprinkler package: Collection of devices fitted to the outlets of either centre-pivot or moving lateral machines. The devices may consist of sprayers or sprinklers, and may include piping, pressure or flow control devices, and supporting plumbing designed for a specific machine and set of operating parameters.

2.4 endgun: Set of one or more sprayer or sprinkler nozzles installed on the distal end(s) of a centre-pivot or a moving lateral machine to increase the irrigated area. The endgun(s) usually operate(s) for only a portion of the time to conform to system boundaries.

2.5 test pressure: Pressure of the centre-pivot or moving lateral machines, as measured at the first available outlet downstream of the elbow or tee, at the top of the inlet structure.

2.6 effective radius of centre-pivot machine: Radius of the circular field area to be irrigated, which is conventionally calculated as the distance from the pivot point to the terminal sprinkler on the pipeline plus 75 % of the wetted radius of the terminal sprayer or sprinkler.

NOTE 1 If an alternative effective radius is used, this needs to be clearly stated in the test results.

2.7 effective length of moving lateral machine: Dimension parallel to the pipeline of the area to be irrigated, which is conventionally calculated as the distance between the two most distant sprayer or sprinkler nozzles on the pipeline plus 75 % of the wetted radius of each end sprayer or sprinkler.

NOTES

2 If a portion of the area under the pipeline is used for the water supply system, and not for crop production, that distance is not included in the effective length. In this case, the effective length is the distance between the two most distant sprayer or sprinkler nozzles, plus 75 % of the wetted radius of each nozzle, minus the distance used for the water supply system.

3 If an alternative effective length is used, this needs to be clearly stated in the test results.

2.8 wetted radius: Distance measured from the sprayer or sprinkler centreline to the most remote point at which the application rate of the individual nozzle declines to approximately 0,25 mm/h. The wetted radius is based on tests that were conducted when there was no wind.

NOTE 4 For the purpose of the test, the wetted radius of the sprayer or sprinkler may be estimated from manufacturer's catalogue data or by observation of the machine operating in the field.

2.9 applied depth, d_1**:** Adjusted volume of water caught in each collector plus the average amount of water that evaporated while the water was in the collector, divided by the area of the collector opening.

2.10 collector: Receptacle into which the water discharged by the sprinkler is deposited during the test for distribution uniformity.

2.11 client: Person, persons or organization for whom the test is to be performed.

2.12 tester: Person, persons or organization who conducts the test.

3 Test conditions and equipment

3.1 All collectors used for a test shall be identical and shaped such that water does not splash in or out. The lip of the collector shall be symmetrical and without depressions. The height of the collectors shall be at least 120 mm. The entrance diameter of the collector shall be one-half to one times its height, but not less than 60 mm.

3.2 The collectors shall be spaced uniformly along two or more straight lines perpendicular to the direction of travel of the machine. The collector spacing within each line shall not be more than 3 m for sprayers and 5 m for sprinklers (see figures 1 and 2 for collector layout detail). The distance between the collectors shall not be a multiple of the distance between the sprayers or sprinklers. Collectors should be moved to avoid wheel tracks. The location of the collectors shall be recorded.

3.3 The collectors shall be located so that obstructions, such as the crop canopy, do not interfere with the measurement of water application. When an obstruction is higher than the elevation of the collector, but below the nozzle height, a horizontal unobstructed distance of at least twice the height of the obstruction shall be maintained on both sides of the collector rows (figure 3, case A). For systems with nozzles that operate below the crop canopy height, a horizontal unobstructed distance of at least 1,25 times the wetted radius of the nozzle shall be maintained on each side of the collector rows (figure 3, case B).

3.4 The entrance portion of the collectors shall be level. When wind velocities during the test are expected to exceed 2 m/s, the entrance of the collectors should be no more than 0,3 m above the ground or crop canopy. The discharge height of the sprayer or sprinkler shall be at least 1 m above the elevation of the collector. The height of the sprayer or sprinkler nozzles and the entrance to the collectors shall be recorded.

3.5 Wind velocity during the test period shall be measured with a rotating anemometer or equivalent device.

3.5.1 The wind direction, relative to the line of collectors, shall be determined with a vane indicating at least eight points of the compass.

3.5.2 The wind velocity measuring equipment shall be located at a height of 2 m and within 200 m of the test site, in a location that is representative of the wind conditions at the test site.

3.5.3 The anemometer shall have a threshold velocity which does not exceed 0,3 m/s and be capable of measuring the actual velocity within ± 10 %.

3.5.4 The accuracy of the test procedure begins to decrease when the wind velocity exceeds 1 m/s. The test should not be used as a valid measure of the uniformity or performance of the sprinkler package if the wind velocity exceeds 3 m/s. To test at wind velocities greater than 3 m/s, the client and tester must understand the limitations of the test results. The wind velocity and direction prevailing at the time of the test shall be measured and recorded at intervals not longer than 15 min.

3.6 It is recommended that the test be conducted during periods that minimize the effect of evaporation, such as at night or during early daylight hours. Dry bulb temperature and either wet bulb temperature, relative humidity or dew point temperature shall be measured upwind of the machine and recorded near the beginning and end of the test. The time of day for the measurement shall be recorded.

3.6.1 To minimize the effect of evaporation from collectors during the test, the volume of water in each collector shall be measured and recorded as soon as possible after the collector is no longer within the range of the water pattern. If the volume caught in each collector is to be adjusted for evaporation loss, the time that each collector contains water, i.e. from the time the collector is first within the range of the water pattern until the collector volume is measured, shall be estimated.

3.6.2 If an adjustment is made on the collected data to account for evaporation from the collectors, a minimum of three control collectors containing the anticipated catch shall be placed at the test site and monitored to determine the rate of evaporation. These control collectors shall be located where the microclimate is essentially unaffected by the operation of the machine. This is normally upwind of the test area. The time of day when control collectors are measured shall be recorded.

3.6.3 Appropriate procedures for minimizing evaporation may be employed. These include the use of evaporation suppressants or specially designed collectors. The methods used to suppress evaporation including, if applicable, the type of suppressant, shall be recorded.

3.7 The test shall be conducted in an area which has elevation differences that are within the design specifications of the sprinkler package. Elevation differences shall be measured with an instrument capable of measuring an elevation change of ± 0,2 m in a 50 m distance. A sketch of the ground surface profile along each line of collectors should be included with the test results unless the ground surface is level.

4 Test procedures

4.1 General

4.1.1 Before testing a machine, the tester shall verify that the sprinkler package has been installed according to the design specifications, unless specified otherwise by the client.

4.1.2 The pressure of the water supplied to the machine shall be adjusted and maintained during the test to within ± 5 % of a test pressure mutually agreed upon by the client and tester. The pressure measurement device shall be capable of accurate measurement to within ± 2 % of the test pressure. The test pressure shall be recorded.

4.1.3 The machine shall be operated at a speed which will deliver an average depth of application of not less than 15 mm unless specified otherwise by the client.

4.1.4 The application depth data shall be recorded by measuring the volume or mass of water caught in the collectors. The measuring device shall be accurate to ± 3 % of the average amount of water collected.

4.1.5 Any obviously incorrect data points caused by such occurrences as leaking, tipped collectors or other explainable variances shall be eliminated from the water distribution analysis. The number of eliminated observations shall not exceed 3 % of the total number of depth measurements. All observations shall be reported. The number of eliminated observations with the reasons for their elimination shall be recorded.

4.1.6 Observations beyond the effective radius or length of the machine shall be eliminated from the analysis.

4.1.7 If the sprinkler package is designed with an endgun, the test shall be performed with the endgun operating. The number of sprayers or sprinklers should remain constant during the test. If desired, the test can also be performed with the endgun not operating to evaluate the water distribution for those conditions.

4.2 Centre-pivot

4.2.1 The collectors shall be located along lines extending radially from the pivot point. The distal ends of the radial lines shall be no more than 50 m apart (see figure 1 for collector layout detail).

4.2.2 The data from up to 20 % of the collectors on the inner portion of the total length of the machine can be eliminated from the water distribution analysis if mutually agreed upon by the tester and the client. Collectors need not be placed in the inner portion of the centre-pivot if the intent of the test is to determine the water distribution with the inner portion of the centre-pivot eliminated.

4.3 Moving lateral

The collectors shall be located along lines parallel to the pipeline. The lines of collectors shall extend across the effective length of the machine and shall not be more than 50 m apart (see figure 2 for collector layout detail).

5 Calculations

5.1 The coefficient of uniformity for a centre-pivot machine shall be calculated using the modified formula of Heermann and Hein[1].

$$C_{uH} = 100 \left[1 - \frac{\sum_{i=1}^{n} |V_i - \overline{V}| S_i}{\sum_{i=1}^{n} V_i S_i} \right]$$

where

C_{uH} is the Heermann and Hein uniformity coefficient;

n is the number of collectors used in the data analysis;

i is a number assigned to identify a particular collector, normally beginning with the collector located nearest the pivot point ($i = 1$) and ending with $i = n$ for the collector furthest from the pivot point;

V_i is the volume (or alternatively the mass or depth) of water collected in the ith collector;

S_i is the distance of the ith collector from the pivot point;

$\overline{V}$ is the weighted average volume (mass or depth) of water caught. It is computed as:

$$\overline{V} = \frac{\sum_{i=1}^{n} V_i S_i}{\sum_{i=1}^{n} S_i}$$

5.2 The coefficient of uniformity for a moving lateral machine shall be calculated using the Christiansen formula[2].

$$C_{uC} = 100 \left[1 - \frac{\sum_{i=1}^{n} |V_i - \overline{V}|}{\sum_{i=1}^{n} V_i} \right]$$

where

C_{uC} is the Christiansen uniformity coefficient;

n is the number of collectors used in the data analysis;

V_i is the volume (or alternatively the mass or depth) of water collected in the ith collector;

$\overline{V}$ is the arithmetic average of the volume (mass or depth) caught by all collectors used in the data analysis. It is computed as:

$$\overline{V} = \frac{\sum_{i=1}^{n} V_i}{n}$$

5.3 C_{uH} or C_{uC}, whichever is appropriate, shall be calculated for each line of collectors. A composite uniformity coefficient shall be computed using the data from both lines of collectors.

5.4 If a machine with an endgun is tested, the procedure in 4.1.7 shall be used to measure the coefficient of uniformity when the endgun is on, and optionally when it is off. The operation of the endgun shall be characterized by recording in A.1 the approximate area of the field that is irrigated while the endgun operates and the area irrigated while the endgun is turned off.

5.5 A graph shall be prepared showing the volume (mass or depth) of water caught in each collector versus the distance from the pivot point or along the lateral together with the positions of the towers and sprayers or sprinklers. Data from each line of collectors shall be plotted separately.

6 Evaluation

6.1 The calculated coefficient of uniformity shall be used as an indication of sprinkler package performance with respect to the field, environment, and pressure conditions and variations prevailing during the test. The coefficient of uniformity of a new sprinkler package can be used for comparison of different types of sprinkler packages and as a reference

for similar machines that have been used for a period of time.

6.2 If the coefficient of uniformity for an installed machine deviates substantially from the value specified in the initial design, other investigations shall be conducted to determine the cause. A coefficient of uniformity smaller than the design value may indicate worn, broken or malfunctioning water application devices.

6.3 The graph of the depth applied along the lateral can help identify problems in the operation of the machine. Locations along the lateral where the depth applied is 10 % higher or lower than the average depth should be investigated to determine the cause of variation.

7 Reporting of test results

The data measured for this test shall be recorded on forms similar to the standard data presentation forms in A.1 and A.2, and the test summary form shown in A.3. Special arrangements between the client and the tester shall be explained. Justification of data inconsistencies shall be indicated on the data forms. Additional data not required by this International Standard should be included with the test results if the data will help characterize uniformity.

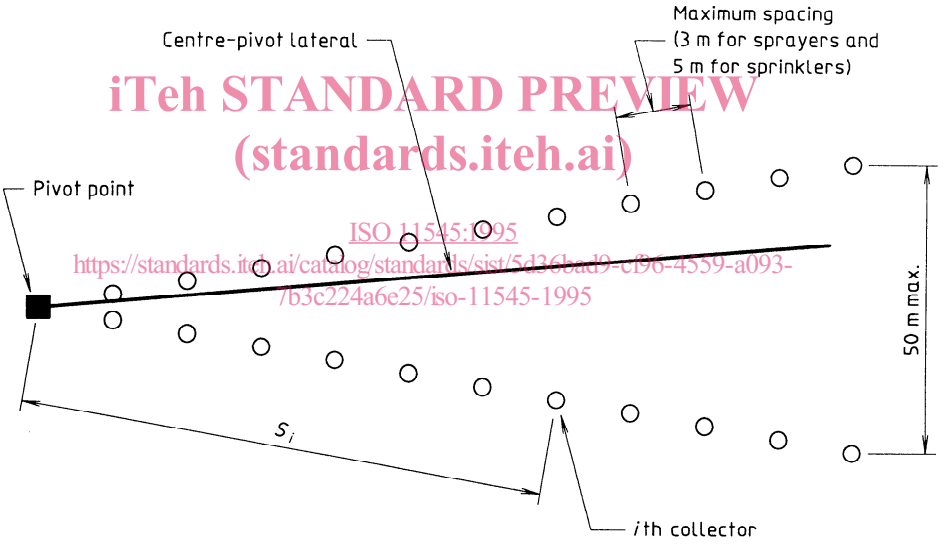

Figure 1 — Collector layout for determining water distribution of centre-pivot irrigation machines