
**Agricultural irrigation equipment —
Sprinklers —**

Part 3:
**Characterization of distribution and
test methods**

Matériel agricole d'irrigation — Asperseurs —

Partie 3: Caractérisation de la distribution et méthodes d'essai

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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).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 18, *Irrigation and drainage equipment and systems*.

This third edition cancels and replaces the second edition (ISO 15886-3:2012), which has been technically revised. It also incorporates the Amendment ISO 15886-3:2012/Amd 1:2016.

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

- the definitions have been updated;
- the following test methods have been changed:
 - for the installation of sprinkles under test, the height of the top of the sprinkler riser has been modified;
 - for the pressure measurement, the test method for pop-up sprinklers has been modified;
- the radius of throw and water distribution curve tests have been added.

A list of all parts in the ISO 15886 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.

Agricultural irrigation equipment — Sprinklers —

Part 3: Characterization of distribution and test methods

1 Scope

This document specifies the conditions and methods used for testing and characterizing the water distribution patterns of irrigation sprinklers.

The term sprinkler is used in this document in a broad generic sense and is meant to cover a wide variety of products. The specific performance measurements addressed include distribution uniformity, wetted radius, and water jet trajectory height. This document applies to all irrigation sprinkler classifications for which those three performance measurements are required to verify the design objectives as defined by the manufacturer.

This document deals both with indoor and outdoor tests and with radial and full grid tests. It is organized so as to deal with conditions common to all tests first and then with conditions unique to indoor testing only and finally with conditions unique to outdoor testing only.

For any given sprinkler, a wide range of nozzle configurations, operating conditions, and adjustments generate at least a theoretical need for a correspondingly large number of tests. Testing agencies and manufacturers can use interpolation techniques to reduce the number of actual test runs provided accuracy standards are still being met.

This document does not address the specific performance testing required for sprinklers intended for use in frost protection.

This document does not address the topic of drop spectrum measurement and characterization and the related questions of soil compaction, spray drift, evaporative losses, etc., all of which can be considerations in the design of sprinkler irrigation systems.

This document is used for evaluating irrigation coverage of sprinklers that are identical and arranged in a fixed repeating geometric pattern. This document does not apply to moving systems.

This document applies to part-circle sprinklers provided that the testing agency can satisfy questions of potential anomalies in performance parameters.

NOTE [Annex A](#) addresses the procedures for the characterization of sprinkler pattern uniformity. [Annex B](#) addresses testing part-circle sprinklers.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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
ambient temperature**

temperature of the air surrounding a sprinkler

**3.2
area of coverage**

area within the wetted boundary from the sprinkler operated within the range of *effective application rates* (3.9) specified in the manufacturer's literature

**3.3
Christiansen's uniformity coefficient
UCC**

coefficient using deviations from the mean to characterize the uniformity of field-measured or simulated water application from a grid of sprinklers

**3.4
clean water**

water processed, if necessary, so as to contain suspended particles no larger than 74 µm (200-mesh equivalent) and to contain no dissolved chemicals known to have short-term effects on sprinklers materials

**3.5
collector**

receptacle into which water is deposited during a water distribution test

**3.6
critical dry area**

experience-based definition of the dry area size that defines uniformity of coverage objectives

**3.7
densogram**

areal map utilizing the density of dots representing water application depth at locations in the *area of coverage* (3.2) of a sprinkler or a grid of sprinklers

**3.8
distribution uniformity
DU**

coefficient using the lowest 25 % of water application depths to characterize the uniformity of field-measured or simulated water application from a grid of sprinklers

**3.9
effective application rate**

application rate equal to or exceeding 0,26 mm/h for sprinklers with *flow rates* (3.11) exceeding 120 l/h and 0,13 mm/h for sprinklers with flow rates equal to or less than 120 l/h

**3.10
effective radius of throw**

radius at which 95 % of the reconstituted volume of water discharged by a sprinkler, interpolated between points of measurement, is applied

**3.11
flow rate**

volume of water flowing through a device per unit time

**3.12
full grid collector array**

collectors (3.5) located at the intersections of a two-dimensional geometric grid pattern sufficient in number to give a desired statistical basis for determining water *distribution uniformity* (3.8)

3.13**inlet connection size**

numerical designation used to characterize the sprinkler which is identical to the size of the connection to the irrigation pipe

3.14**irrigation lateral**

branch supply line in an irrigation system on which distribution devices are mounted directly or by means of fittings, risers, or tubes

3.15**nozzle**

aperture of a sprinkler through which water is discharged

3.16**part-circle sprinkler**

sprinkler with an adjustable feature that enables it to irrigate a sector of a circular area either with or without an attachment which enables it to be adjusted to irrigate another sector or the entire circular area

3.17**pop-up sprinkler**

sprinkler designed for installation so that the sprinkler nozzle automatically raises from below ground when the system is pressurized and automatically lowers to its original position when the system is depressurized

3.18**pressure tap**

precisely fabricated connection for communicating internal conduit pressure to an external pressure-measuring device

3.19**radial collector arrays method**

collectors (3.5) located only on a radial axis projected from the centreline of a sprinkler sufficient in number to characterize the water distribution curve

3.20**radius of throw****wetted radius**

distance measured from a centreline of a continuously operating sprinkler to the most remote point at which the sprinkler deposits water at the minimum *effective application rate* (3.9), measured at any arc of coverage except near the arc extremes for part-circle sprinklers

3.21**range of working pressure**

pressures between the minimum working pressure and the maximum working pressure

3.22**rotating sprinkler**

distribution device which, as a result of rotating motion around its axis, distributes water over a circular area, part of a circular area, or a non-circular area

3.23**scheduling coefficient****SC**

coefficient used to characterize the water application uniformity of sprinklers employing an analysis of full-grid test data based on a definition of *critical dry area* (3.6)

3.24**sprinkler spacing**

conventional designation including the distance between the sprinklers along an *irrigation lateral* (3.14) and the distance between consecutive irrigation laterals

3.25

statistical uniformity coefficient

UCS

coefficient using standard deviation as a measure of dispersion in statistical theory to characterize the uniformity of field-measured water application from a full grid of sprinklers

3.26

test pressure

pressure at the inlet of a sprinkler declared by the manufacturer as the pressure to be used for test purposes

3.27

maximum trajectory height

maximum height above a sprinkler of the trajectory of the water stream discharged from the sprinkler nozzle operating under the nominal *test pressure* (3.27)

3.28

water application rate

mean depth of water applied per unit time

3.29

distribution curve

graphical plot of water application depth as a function of distance from a sprinkler along a specified radius

3.30

wind speed

speed of the wind at a test site averaged over the time required for a sprinkler *distribution uniformity* (3.8) test

3.31

working pressure

water pressure recommended by the manufacturer to ensure proper operation of a sprinkler

4 Collectors

4.1 Collector design

All collectors used for any one test shall be identical. They shall be designed to minimize water splashes in or out and distortions of the catchment volume as may be caused by wind currents.

The height of a collector shall be at least twice the maximum depth of the water collected during the test, but not less than 150 mm.

The collectors shall have a circular opening with sharp edges free from deformities. The diameter shall be between 1/2 to 1 times the height, but not less than 85 mm.

Alternative collector designs may be used, provided that their measuring accuracy is not less than of those described above.

The catchment from a collector shall be quantified from a direct reading of mass, depth, or a volumetric determination provided that the required accuracy standard is met.

4.2 Collector orientation

The openings of all collectors shall be in a common horizontal plane with a slope not exceeding 2 % in any direction. The difference in height between any two adjacent collectors shall not exceed 20 mm.

For indoor testing, collector height is not critical. For outdoor testing, the collector height shall be sufficient to ensure that vegetation does not interfere with jet access to the collectors.

5 Installation of sprinklers under test

The sprinkler selected for testing shall be representative of general production capabilities particularly as relates to the speed of rotation. New sprinklers shall be operated before the test for a period sufficient to demonstrate that the time per revolution has stabilized to $\pm 5\%$.

Mount the sprinkler on a riser with the same nominal size designation as the sprinkler inlet connection size. Ensure that the riser is fixed rigidly vertically, and that it does not vibrate sufficiently to cause a visual effect on the sprinkler operation, bend or deviate from the vertical during the test. The maximum allowable deviation from the vertical during the test shall not exceed 2° .

A steel pipe riser is recommended to provide the required mechanical strength and facilitate the installation of a standard pressure tap.

The sprinkler nozzle height above the collectors should simulate the conditions under which the sprinkler is normally used. For example, with the turf sprinklers the top of the sprinkler body should coincide with the top of the collectors.

For agricultural sprinklers used under a variety of field conditions, the following height requirement applies:

- The height of the top of the sprinkler riser above the openings of the collectors shall be according to the manufacturer's specifications.
- If the manufacturer does not provide specification, the relevant data shall be selected from [Table 1](#), with a tolerance of $\pm 0,05$ m.

Table 1 — Sprinkler height

Sprinkler flow rate (l/h)	Top of the sprinkler riser height above the collector (m)
Pop-up	0 (in a non-pressurized state)
0 to 300	0,3
301 to 1 500	0,5
1 501 to 2 500	1,0
>2 500	1,5

If the manufacturer specifies any special test-related conditions, for example, testing with straightening vanes, they shall be used if such items are provided as standard equipment with the sprinkler.

For a sprinkler that is not riser-mounted as described in above, the test mounting shall be as specified by the manufacturer.

For single leg distribution patterns, a shelter may be used around the sprinkler to contain jet action provided the following conditions are met:

- The shelter is large enough and so constructed as to trap the water jets and not let them interfere with the sprinkler's operation or contribute to the collector catchment.
- The shelter is designed to allow air circulation to develop around the jets.
- The shelter provides a minimum sector for unrestricted jet operation of 45° centred on the collector radius. If the testing agency uses an angle less than 45° , it shall demonstrate that the integrity of the results is not compromised. Special attention shall be put to sector size, to avoid interception of projections (spoon spit) generated by the impact arm.
- The shelter is designed so that no jet deflection or splash is directed into the collectors.

6 Measurements

6.1 Accuracy of measurements

The accuracy required for all measurements not specifically addressed in this document is $\pm 3\%$.

Water depths within collectors shall be measured with an accuracy of $\pm 3\%$.

Pressure shall be measured with an accuracy of $\pm 1\%$.

Flow rate through the sprinkler shall be measured with an accuracy of $\pm 2\%$.

Time shall be measured with stop watches accurate to $\pm 0,1$ s.

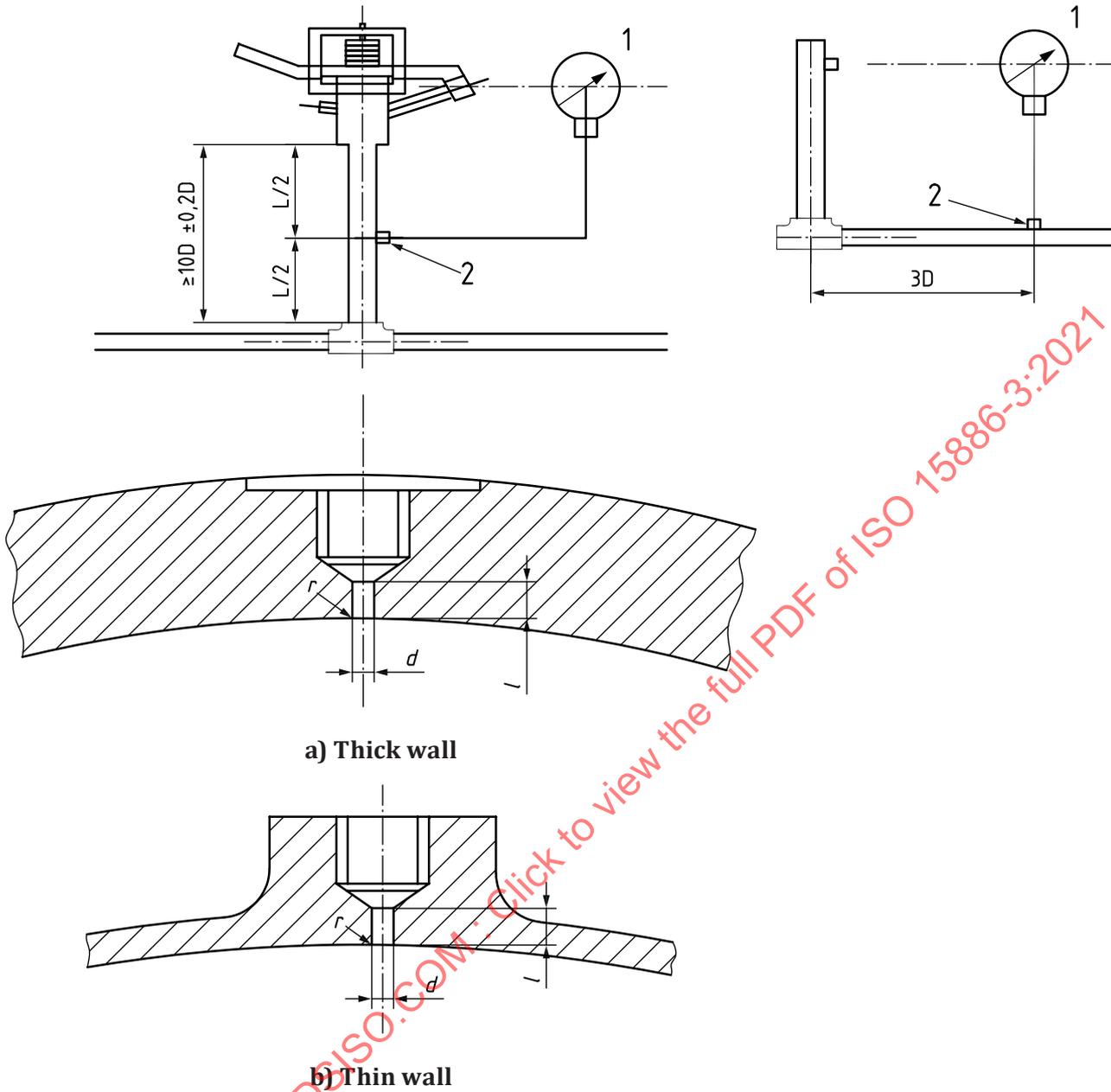
Temperature shall be measured with an accuracy of $\pm 0,5$ °C.

6.2 Pressure measurement

The test pressure shall be measured at the height of the main nozzle. The pressure tap construction details are shown in [Figure 1](#). There shall be no flow obstructions between the pressure tap and the sprinkler base. The bore of the pipe containing the pressure tap shall be clean and smooth. The pressure tap shall be located at the medium point of the riser pipe.

For pop-up sprinklers the pressure shall be measured in the main pipe at a distance of 3D (main pipe) to the sprinkler base.

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Key

- 1 pressure gauge
- 2 pressure tap
- D riser pipe nominal diameter/ main pipe nominal diameter for pop-up sprinklers
- L riser pipe length

Figure 1 — Pressure tap location and construction details

[Figure 1 a\)](#), $l \geq 2,5d$, where $d = 3 \text{ mm to } 6 \text{ mm}$ or $1/10$ pipe diameter, whichever value is smaller.

[Figure 1 b\)](#), $l \geq 2d$; $r \leq d/10$.

6.3 Atmospheric conditions measurements

Relative humidity and ambient temperature shall be measured at the start, midpoint, and end of the test. For indoor testing, changes in temperature and humidity during the test shall not exceed $\pm 5,0$ % of the pre-test ambient conditions.

Air conditioning systems may be required to ensure that the testing facilities meet this requirement.

6.4 Corrections for evaporative losses within collectors

Under some conditions, evaporative losses within collectors are known to result in measurement errors that exceed the required accuracy of $\pm 3,0$ %. Under these conditions, a correction to the collector readings shall be made using the following procedure:

Place a volume of water approximately equal to the average volume to be collected during the test in each of three collectors. Locate the collectors near the test area but outside the area of water application. Measure the volume of water before and after the test and apply the difference to the volume of water in each collector.

7 Collector arrangement, spacing and number

7.1 Full grid collector array method

7.1.1 Method

This method refers to the use of a square grid of collectors with a sprinkler located inside the grid. It is especially useful in characterizing the impact of wind on sprinkler performance and characterizing sprinklers that do not produce symmetrical areas of coverage.

7.1.2 Collector spacing

The same collector spacing shall be used for both axes of the grid. Additional collectors can be located on the down wind edge of the collector array if required to cover the anticipated wetted area. Collector spacing as related to sprinkler radius of throw is specified in [Table 2](#).

Table 2 — Collector spacing

Sprinkler effective radius of throw (m)	Maximum collector spacing (centre to centre) (m)
1,0 to 3,0	0,25
3,0 to 6,0	0,50
6,0 to 12,0	1,00
12,0 to 17,0	2,00
over 17,0	3,00

A minimum of 80 collectors located within the area of coverage is recommended. If fewer than 80 collectors are located within the area of coverage, the testing agency shall attest to the statistical quality of results.

7.1.3 Sprinkler location relative to grid

The sprinkler shall be located midway between four adjacent collectors.

Alternatively, the sprinkler can be located at the intersection of the grid axes.

7.2 Radial collector array method

7.2.1 Method

This method refers to the use of collectors located along a radius or several radii (usually 4, spaced 90°) for the purpose of characterizing the sprinkler's water application rate as a function of radial distance from the sprinkler. It is especially useful for sprinklers with a symmetrical coverage pattern and under no wind conditions.

The objective of the test is to develop an accurate functional relationship between the water application rate and radius. If the sprinkler is known to have hydraulic discontinuities, sufficient collectors shall be used to adequately characterize these features and allow for a continuous functional characterization.

7.2.2 Collector spacing

A guide to collector spacing as related to sprinkler radius of throw is given in [Table 2](#).

7.2.3 Location of sprinkler

The sprinkler shall be located one collector spacing from the first collector and on the same radius.

7.2.4 Radius of throw

For a multiple array test, the wetted radius shall be the average of the results from all of the arrays used.

8 Additional tests

8.1 Time of rotation

The sprinkler time of rotation shall be measured only while the sprinkler is rotating from its own drive mechanism. It shall be measured at the beginning, the midpoint, and the end of the test. A minimum of three measurements shall be recorded for each position. In addition, at the midpoint of the test, the time shall be measured through each quadrant. A minimum of three measurements shall be recorded for each quadrant. The quadrant locations shall be indexed to the collector grid. Calculate the time of rotation required through each quadrant and the maximum deviation (percent, %) in relation to the time of rotation measured. Maximum deviation shall not exceed the time of rotation by more than $\pm 12\%$. This test is not applicable to a sprinkler with a time of rotation of less than 10 s.

8.2 Trajectory height

The measurement is taken from a horizontal plane through the main nozzle. As with the radius of throw definition, occasional drops that achieve a higher height shall be ignored in favour of some general representation of the top surface of the main jet. Care shall be taken to ensure that the sprinkler riser meets the 2° tolerance on verticality. The radial distance to the location of maximum trajectory height shall be noted. Both height and radius measurements require an accuracy of $\pm 5\%$.

9 Test operation

9.1 Rotation of sprinkler riser

During the radial collector array test (see [7.2](#)), the riser supporting the sprinkler shall be manually rotated by a quarter of a revolution (90°) about the axis three times at equal intervals of time. This rotation is to be performed during the periods when the jet of the sprinklers is not passing over the collectors.

For sprinklers with special operating modes, riser rotation requirements shall not bias the outcome of the test.

9.2 Test duration

Test duration shall be long enough to generally allow the standard for reading accuracy of the collectors to be met (± 3 %) for a minimum of 80 % of the collectors. The water applications accounted for in the collectors shall be a minimum of 90 % of the theoretically calculated amount based on the sprinkler flow calibration.

A minimum number of 30 passes shall be made over all collectors.

For sprinklers with programmed variations in operating characteristics, the duration of the test shall be long enough to subject all collectors to the same identical operation sequences.

9.3 Other test details

The test period shall begin after the sprinkler has run for a time period long enough to establish stable hydraulic conditions (for example: all air is evacuated). This can be accomplished by shrouding the sprinkler during unstable start-up periods and removing the shroud to start the test.

The test pressure shall be within the range of working pressure and shall not vary by more than ± 4 % during the test period; the water temperature shall not vary by more than $\pm 5,0$ °C during the test.

Care shall be taken in starting and stopping tests to avoid direct deposition in collectors by under-pressure jets or unstable rotational movement. This can be accomplished by using a manual lever action valve located at the base of the riser.

Care shall be taken also to avoid subjecting collector legs or portions of the grid to an unequal number of sprinkler rotations or cycles.

In general, test conditions not specifically covered by this document shall reflect, first, the reality of how and when the product is to be used, and second, how the manufacturer defines the product performance testing. Considerations that fall in this category include, for example:

- the sprinkler height in relation to crop canopy;
- the riser or drop tube length, configuration or construction;
- the sprinkler orientation (supply flow up or down).

All tests shall be performed using clean water, unless higher cleanliness of water is specified by the sprinkler manufacturer.

10 Test location specifications

10.1 Indoor testing building specifications

Indoor sprinkler testing is assumed to provide pattern results unaffected by wind. For test building conditions to represent no-wind conditions, there shall be no ventilating structures (doors, windows, etc.) that permit bulk air movement at velocities exceeding 0,10 m/s. The building shall be sized to permit unconfined jet development of the largest jet for which it is designed to test.

The test building design shall meet the following criteria.

- A floor slope not exceeding 1,0 % to provide surface drainage. (Reminder: collector ring inlet surfaces shall be in a common horizontal plane.)
- Minimum length equal to 125 % of the maximum sprinkler wetted radius of throw.

- Minimum width equal to 25 % of the maximum sprinkler wetted radius of throw on each side of the radial collector array.
- Minimum clear ceiling height equal to 125 % of the maximum trajectory height anticipated.
- The building shall have no structural column or truss members that mechanically interfere with the jet when it is passing over the collector radial array.

10.2 Outdoor site specification

10.2.1 General

The test area where collectors are positioned shall be graded evenly in a horizontal plane with a maximum slope of 2,0 % in any direction. The surface shall be free of obstacles that could block the movement of airborne spray. Surface roughness, including vegetative cover, shall not exceed 150 mm in height so as to not interfere with spray droplet access to collectors.

There shall be no trees, buildings, or other obstructions in the vicinity of the test site that can alter the normal wind patterns. A minimum clear area upwind of the test site of six times the height of any wind break for each 0,45 m/s of wind speed up to a maximum of 30 times the height for winds of 2,24 m/s or greater is required. A minimum clear area downwind of the test site equal to five heights of any downwind windbreak is required.

10.2.2 Measurement of atmospheric conditions

Relative humidity and ambient temperature measurements shall be taken during the test at equal time intervals that give a minimum of 10 readings during the test.

Wind speed and direction measuring instruments shall be set at a height corresponding to the maximum sprinkler trajectory height ± 10 %. The actual height used shall be measured and recorded on the data sheets.

The sensing equipment shall be located a maximum distance of 45 m from the edge of the wetted area. The location shall be selected as most representative of the test site exposure.

Wind speed and direction shall be continuously recorded or measurements shall be taken at the beginning and end of the test and at regular time intervals not to exceed 10 % of the test period. Wind speed shall be recorded to the nearest 0,2 m/s and directions to the nearest 10°. Direction shall be referenced to one of the principal axes of the collector array layout. For single leg tests, the maximum allowable wind speed is 0,4 m/s. For four leg tests, the average allowable wind speed shall not exceed 1,3 m/s and, in no case, shall the maximum wind speed exceed 2,2 m/s.

11 Characterization of distribution

11.1 Overview

This clause refers to developing the results from the full grid test procedure to effectively characterize the sprinkler performance. The objective for specific characterizations is driven by the sprinkler design objectives as defined by the manufacturer.

11.2 Application pattern coverage and uniformity

Four methods of characterizing pattern uniformity are shown in [Table 3](#).

Table 3 — Pattern uniformity calculation methods

Name	Scientific notation	Reference in Annex A
1. Christiansen uniformity coefficient	UCC	A.2.2
2. Statistical coefficient of uniformity	UCS	A.2.3
3. Distribution uniformity	DU	A.2.4
4. Scheduling coefficient	SC	A.2.5

The method best suited to the design objectives of the sprinkler or its intended use shall be selected.

Patterns of coverage can be shown giving geometrically accurate representations augmented by densograms or contour graphs if required to compare the actual performance to the design objectives.

11.3 Generating performance measurements from radial arrays

If the testing agency decides to use the radial arrays method, it shall be able to satisfy questions of accuracy when compared to the full grid method. If wind is a factor in design, only the full grid method can be used.

Computer-generated full grid patterns may be developed from radial array data provided that the results are identified as based on simulated data and the sprinkler can be demonstrated to have a generally symmetrical pattern. The radial array data are analysed using a curve fit routine. The curve fit routine identifies a mathematical equation that gives water deposition as a function of radius from the sprinkler axis of rotation. This formula is used to calculate the deposition at the grid line intersections thereby simulating a full grid pattern.

11.4 Validation of test results

To be validated, a reconstituted flow rate (Q_{rel}) shall not deviate by more than 5 % from the flow rate measured by the water meter for sprinkler discharging 0,14 l/s or higher and 7 % for flow rates less than 0,14 l/s. The reconstituted flow rate is calculated from [Formulae \(1\)](#) and [\(2\)](#).

$$V_{rel} = \sum 2\delta r_i d_r x_i \tag{1}$$

where

- r_i is the radius at which x_i is measured;
- d_r is the measurement spacing;
- x_i is the depth of water within the collector.

$$Q_{rel} = \frac{V_{rel}}{t} \tag{2}$$

where t is the sprinkler run time.

12 Radius of throw and water distribution curve

12.1 General

Test 3 sprinklers of the same make, model and nominal size.

Perform the test along one radius at no wind conditions.

Operate the sprinkler for 1 h maintaining the test pressure at the inlet to the sprinkler.

Measure the quantity of water collected in each of the collectors to the most remote point at which the effective water application rate is obtained.

Repeat the test and calculate the radius of throw, the average of the two distances measured in the two tests.

12.2 Radius of throw

The radius of throw of the sprinkler is the average of four measurements of r_t , made when the sprinkler base is rotated a quarter revolution about its axis for each measurement, or by placing the collectors along four radii perpendicular to each other.

A single radius may be used when testing indoor under no wind conditions.

The radius of throw shall conform to the values supplied by the manufacturer within a permissible deviation of $\pm 10\%$.

12.3 Distribution curve

Calculate the water application rate, h (in mm/h), using [Formula \(3\)](#):

$$h = \frac{V}{A} \cdot \frac{1}{t} \quad (3)$$

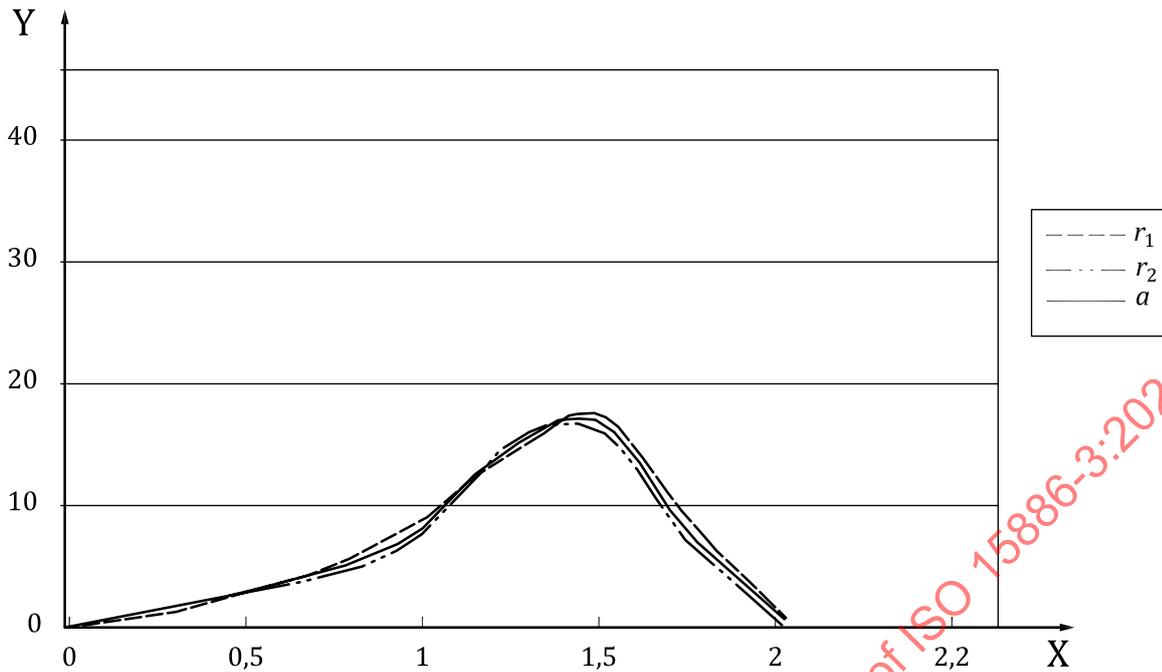
where

V is the volume, in litres, collected in each collector;

A is the area, in square metres, of the collector opening;

t is the test duration, in hours.

Plot the water distribution curve for all collectors measured as a function of the distance of the collector to the sprinkler along the radius, for each of the 3 sprinklers. Calculate and plot the average water distribution curve (see [Figure 2](#)).



Key

- X distance of each collector from the sprinkler (m)
- Y water application rate (mm/h)
- r_1 radius 1
- r_2 radius 2
- a average

Figure 2 — Water distribution curve

The sprinklers shall meet the following requirements.

- a) No point on the distribution curve of the tested sprinklers shall deviate by more than the greater of $\pm 0,25$ mm/h or ± 15 % from the corresponding point on the average distribution curve.
- b) No point on the average distribution curve shall deviate by more than the greater of $\pm 0,25$ mm/h or ± 15 % from the corresponding point on the distribution curve supplied by the manufacturer.

12.4 Uniformity of rotation (for rotating sprinklers intended to rotate in a uniform manner)

This test applies to sprinklers with a flow rate greater than 300 l/h and rotation speed lower than one revolution per 8 s.

While mounted on a vertical riser, operate the sprinkler at its nominal test pressure and measure the time required for each quarter revolution separately. Repeat the measurement five times.

Compute the average time required for a quarter revolution and the greatest deviations, expressed as a percentage, from the average.

To comply with this document, the extreme deviations from the average shall not exceed ± 10 %.

Annex A (informative)

Procedures for the characterization of sprinkler pattern uniformity

A.1 General

Testing for sprinkler performance is usually carried out to meet at least one of the following objectives.

- To provide a characterization of current levels of performance from which to judge the efficacy of changes in design or operating conditions. This is useful primarily to product engineers. Sprinkler mechanical and hydraulic changes can be evaluated for their potential contribution to product improvement.
- To provide data useful to manufacturers in the development of product specifications and performance literature. The data are used by system designers in designing system components, forecasting irrigation schedules, economic comparisons, product comparisons, and the characterization of system performance for a range of sprinkler spacing.
- To provide certified standards of performance that characterizes specific products. These data are useful in the development of specifications in contract documents. It ensures that products will perform at required design levels.
- To provide a standard for evaluating system field performance. This allows designers, engineers, and growers to evaluate existing installations in an “as-built” context. This is useful in determining if construction meets contract requirements and acceptance test conditions. It is also useful in auditing system performance. Auditing studies are commonly used as a basis for improving application uniformity and efficiency.

A.2 Methods for the characterization of the uniformity of sprinkler patterns

A.2.1 General

This document recognizes that there is no one best method of characterizing the “Uniformity of Distribution”. The diversity of intended uses, and the associated requirements for each use, preclude setting a single standard for characterizing uniformity of distribution. The testing agency, manufacturers, and users are free to use the procedure most appropriate for the intended sprinkler use. Four procedures are given in this annex. Of these, at least one procedure shall be used.

Other methods and calculating procedures may also be used as long as their logic is defensible in the context of the intended sprinkler use. This latitude in procedures presupposes that all sprinklers suited for a specific use will be evaluated by the same procedure as described in this document.

In some situations, the geometry of the test pattern grid does not correspond directly to the pattern grid being characterized. In this case, interpolation of catchment values shall be made. Interpolation procedures shall be used that do not unreasonably bias the results.

A.2.2 Christiansen uniformity coefficient (UCC)

Christiansen^[2] developed his uniformity coefficient (UCC) in 1942 to study sprinkler irrigation. UCC is one of the most common indicators of sprinkler uniformity, predominantly for historical reasons. See [Formula \(A.1\)](#):

$$UCC = 100 \cdot \left[1 - \frac{d}{m} \right] \tag{A.1}$$

where

UCC is Christiansen's uniformity coefficient;

m is the average value = $\frac{1}{n} \sum_{i=1}^n x_i$;

d is the average absolute deviation = average of individual absolute deviations = $\frac{1}{n} \left[\sum_{i=1}^n D_i \right]$;

D_i is the individual absolute deviation = absolute difference of individual values from *m* = $|x_i - m|$;

x_i is the individual value of depth of water within each collector in the array of values being analysed for uniformity;

n is the number of values in the array being analysed for uniformity.

A.2.3 Statistical coefficient of uniformity (UCS)

This coefficient was first proposed by Wilcox and Swailes in 1947^[3]. They preferred it to UCC because of the utility of the standard deviation as a measure of dispersion in statistical theory. It has also been called the Wilcox-Swailes coefficient, after its proposers. See [Formula \(A.2\)](#):

$$UCS = 100 \cdot \left[1 - \frac{s}{m} \right] \tag{A.2}$$

where

UCS is the statistical uniformity coefficient;

m is the average value = $\frac{1}{n} \left[\sum_{i=1}^n x_i \right]$;

s is the standard deviation = $\sqrt{\frac{1}{n} \left[\sum_{i=1}^n (x_i - m)^2 \right]}$;

x_i is the individual values of the depth of water within each collector in the array of values being analysed for uniformity;

n is the number of values in the array being analysed for uniformity.

A.2.4 Distribution uniformity (DU)

This uniformity concept that was originally proposed by the Soil Conservation Service of the US Department of Agriculture. At that time, it was called pattern efficiency (PE), Lower 25 % (the modifier referring to the Low Quarter - another version of PE was defined based on the upper quarter). Even though the word "efficiency" appeared in its name, PE is actually a uniformity coefficient, and not an