INTERNATIONAL STANDARD

ISO 24253-2

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Crop protection equipment — Spray deposition test for field crop —

Part 2: Measurement in a crop

Matériel de protection des cultures — Essais de dépôt de la pulvérisation sur les grandes cultures —

Partie 2: Mesurage dans une culture

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Foreword

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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).

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 6, *Equipment for crop protection*.

ISO 24253 consists of the following parts, under the general title *Crop protection equipment — Spray deposition test for field crop*:

— *Part 1: Measurement in a horizontal plane*

— *Part 2: Measurement in a crop*

Introduction

Efficacy of plant protection products (PPP), their safety to the crop and the environment may be much influenced by spraying efficiency. The dose of the active ingredient and its variation that is retained on target surfaces in a downward directed (boom) spray application such as ground surface need to be measured in a manner that is both accurate and precise.

The location, numbers, and sampling structures used to monitor sprayed depositions need to be defined in a standard manner to enable results from different experiments to be compared.

A test can be set up to quantify or to describe the in-field situation or for machine comparison.

A spray system can be compared with a reference system.

This International Standard does not deal with the deposition of spray outside the treatment zone, in crop canopy nor that lost as airborne spray drift. However, the combination of this part of ISO 24253 with the protocol for field measurements of spray drift as given in ISO 22866[4] when measured at the same time may result in a possible evaluation of spray mass balance. On the other hand, its combination with the measuring of sprayer boom movements in the field (see ISO 14131[2]) can also be used to evaluate the spray deposition and its variation in the field as a result of the boom movement.

Spray deposition from horizontal boom sprayers with downward directed application is affected by nozzle parameters, boom height, boom steadiness, sprayer speed, meteorological conditions, and other sprayer additional devices such as air assistance. These dynamic factors can all be elements of a test to determine the quantity and the variation in spray deposition.

Crop protection equipment — Spray deposition test for field crop —

Part 2: Measurement in a crop

1 Scope

This part of ISO 24253 specifies a method for field measurements to determine the quantity and distribution of spray in a field crop, treated by horizontal boom sprayers with downward directed application. This International Standard can be used for nursery trees and small size bush crops (young currants) when sprayed with boom sprayers.

NOTE When interested in the spray deposition over width of the crop canopy, it is advised to use ISO 22522.

This part of ISO 24253 allows flexibility in the arrangement of field tests, but specifies standardized measurement procedures that are useful to be able to compare the results from different field experiments or to compare with laboratory tests, such as that specified in ISO 5682-2.

This International Standard is not intended for use in or for a regulatory framework.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24253-1, *Crop protection equipment — Spray deposition tests for field crop — Part 1: Measurement in a horizontal plane*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24253-1 apply.

4 Test method

4.1 Principle

A spray deposition test comprises the measurement of spray deposition immediately available on all the target surfaces, on the top of such planting structures, at designated points within, and on the ground underneath the vegetation (crop or weed), represented by collectors. This spray deposition measurement can utilize a dye or other readily measurable tracer to simulate a plant protection product.

Spray depositions are assessed quantitatively (such as spray volume in µl/cm^2) and/or qualitatively (such as spray drop distribution, drops/cm^2, coverage, median drop size). The variation in spray deposition is quantified.

Spray deposition values used to quantify mean deposition and deposition variation of the spray liquid applied by the tested sprayer to quantify degree of penetration within, and over plant structures (crop canopy) are assessed using spray deposition collectors [artificial collector (see Annex A) or plant material, e.g. leaf, ear, fruit] at different heights.

4.2 Test area

The test shall be performed in a uniformly developed area of a cropped zone. There shall be a minimum distance of 1,5 m between the sampling place and the edge of the cropped zone. Since there are influences from boom movement (boom ends) and other disturbances such as, air turbulences around the tractor, and the sprayer (centre of the machine), measurements shall be taken on both sides of the sprayer and at different distances along the spray boom (see 5.3).

The length of the test area shall ensure the output of the intended spray volume over the sampling area. The test area shall therefore have a track length before and after the sampling area assuring that the sprayer has reached even intended output flow considering sprayer size and forward speed.

NOTE With rate control in manual mode, a minimum track length of 10 m is suggested for travelling speeds of up to 2 m/s and 20 m for travelling speeds up to 4 m/s. With the rate controller in automatic mode, the track length has to be adapted also considering the system reaction time.

Details of the spraying and sampling layout shall be fully reported with the test results.

In identifying the place of the test area, take notice of surrounding vegetation on the wind profile. The test area should be at least 10 times the height of the vegetation away from the surrounding vegetation or constructions.

Details of the test area and surroundings shall be specified in the test report (Figure 1).

4.3 Monitoring of meteorological conditions

Monitoring of the meteorological conditions shall be made at the time and the place of the test. The maximum error of measurements shall be as follows:

— for wind speed: 0,1 m/s for wind speed up to and including 1 m/s and 0,2 m/s for wind speed over 1 m/s;

— for temperature: 0,5 °C, recorded in the shade;

— for humidity: 5 % of the relative humidity.

Measurements shall be made at (2 ± 0,1) m height above ground surface or at (1 ± 0,1) m above crop canopy when crop canopy is higher than 1 m. Measurements of wind (direction and velocity) shall be made at a frequency of at least 1 Hz (every 1 s) sampling rate.

The instruments should be calibrated prior to their use according to instrument instructions.

4.4 Acceptable meteorological conditions for field measurement of spray deposition

Average wind speed during spraying shall not be higher than local recommendation or practice and preferably below 2 m/s, at the measuring height specified in 4.3. The wind speed shall be stable during the test (the standard deviation shall not exceed ±1 m/s).

For wind speeds above 2 m/s, the wind direction should be within ±30 ° of the mean wind direction.

Temperature shall be between 5 °C and 35 °C.

Temperature inversions affect deposition measurements and need to be reported (preferably by using of 3D anemometer alternatively by cloud cover or measurements of temperature at two heights).

4.5 Tracers

Tracers shall be safe for their intended use. See the environmental and operator safety data sheets for the suitability for this purpose.

NOTE 1 Local Pesticide Regulatory Bodies ought to be able to comment on the use of suitable candidate products and their restrictions for this purpose.

NOTE 2 Spray deposition measurement on plant material is influenced by the outside structure (hairiness, waxy layer, etc.) or the penetration of the spray liquid into the plant tissue.

The tracers shall be stable in field conditions and with a good recovery (at least >90 %; preferably >95 %) from all kind of collectors (see Annex A and 4.6) used in the test.

NOTE 3 For further information on sunlight stability of fluorescent tracers, see Herbst, 2006 and Stallinga et al., 2012.[4][5]

Examples of usable tracers are the following:

— metal ions (recommended for several applications on the same target);

— food dyes:

  — tartrazine (E102);

— fluorescent dyes:

  — brilliant sulfo flavine;

  — sodium fluorescein.

4.6 Collectors

Collectors are used to sample spray deposition on ground surface. The recovery of the sprayed tracer from the collectors shall be determined prior to the experiment.

The artificial collectors used shall provide for a good recovery (at least >90 %; preferably >95 %). Examples of artificial collectors which can be used are given in Annex A. How to quantify tracer recovery from the collector is described in Annex B.

Background emission from the artificial collectors is to be determined (see Annex B). The average reading of the blank artificial collectors should not be higher than 0,1 % of the average reading of the sprayed collectors. Accuracy of the measuring device, artificial collector types, and background emission from artificial collectors shall be recorded and chosen to obtain a coefficient of variation of the background emission lower than 10 % (of at least 10 collectors; see Annex B). This can be determined by analysing with the procedure (diluting volume, shaking time, fluorimeter settings) 10 clean collectors for background value and calculate the mean and the coefficient of variation of the measured values of the collectors.

Care shall be taken to ensure that the sampling collectors used to verify the applied dose and volume rate do not saturate. This shall be checked before the tests.

4.7 Spray liquid

The spray liquid shall be representative of liquids typically used in the application of plant protection products. Tap water or standard tank mix is often used in spray drift measurements (see ISO 22866). A standard tank mix can be achieved by the addition of a water-soluble non-ionic surfactant at rates typically from 0,005 % to 0,5 % v/v, following manufacturers recommendation.

The type and concentration of additives shall be specified in the test report.

5 Test procedure

5.1 General

A test can be set up to quantify or to describe the in-field situation, or it can be a defined situation (specific track) for machine comparison. In a comparison test if mounted or trailed sprayers are used, preferably the same tractor configuration shall be used. Tractor type should be reported in the test report.

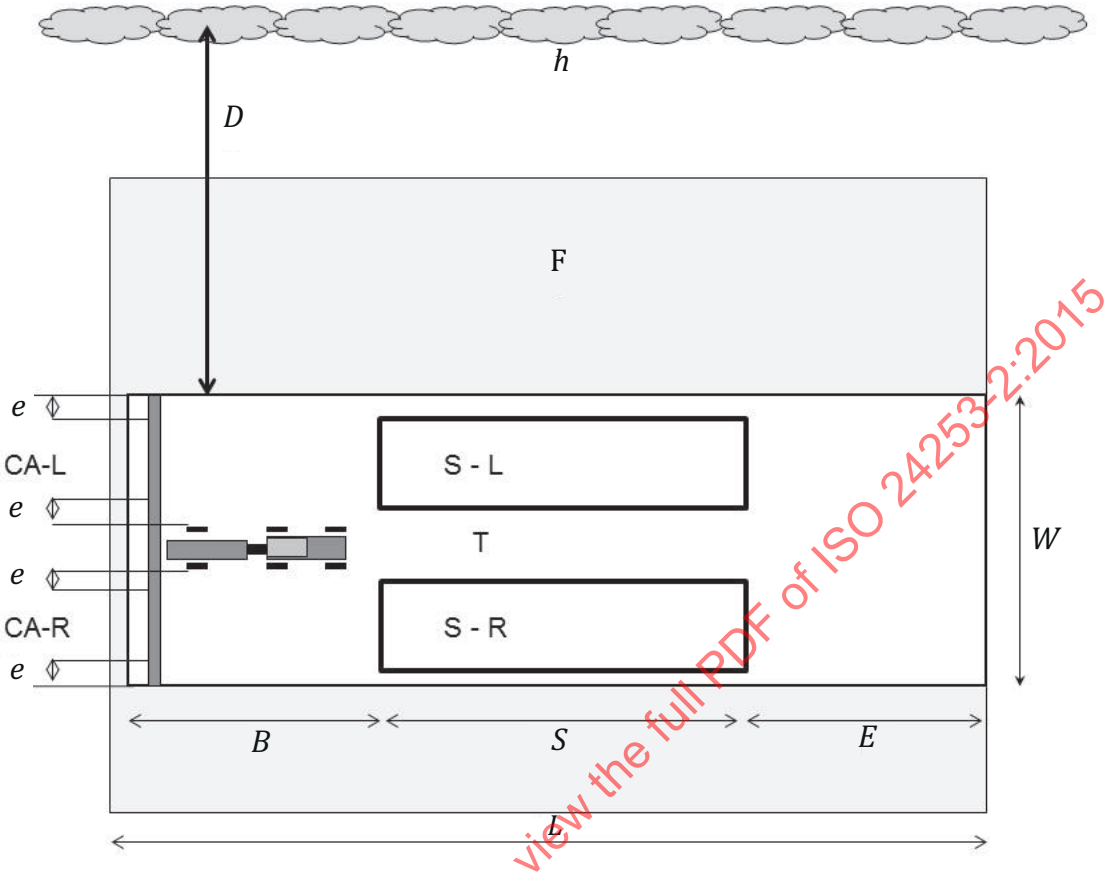
The test area for the deposition measurement is to be marked in the field. To quantify the amount and the variation of total spray deposition coming onto crop canopy and ground surface underneath the crop canopy, spray deposition is to be measured

— on top of the canopy (flux coming into the canopy),

— inside the canopy, and

— on ground surface underneath the canopy.

The collectors are placed generally in the centre area at each side of the spray boom between 1,5 m from the end of the boom and the sprayer (vehicle wheel), at least at three places according to Figure 1. For special purposes like sprayer boom movement effect, place collectors underneath the tip of the boom; for the wake effect, place collectors, e.g. close to the sprayer. When placing collectors across the boom, the place of the collectors shall represent both the area “under” the nozzle positions and ‘between’ the nozzle positions.

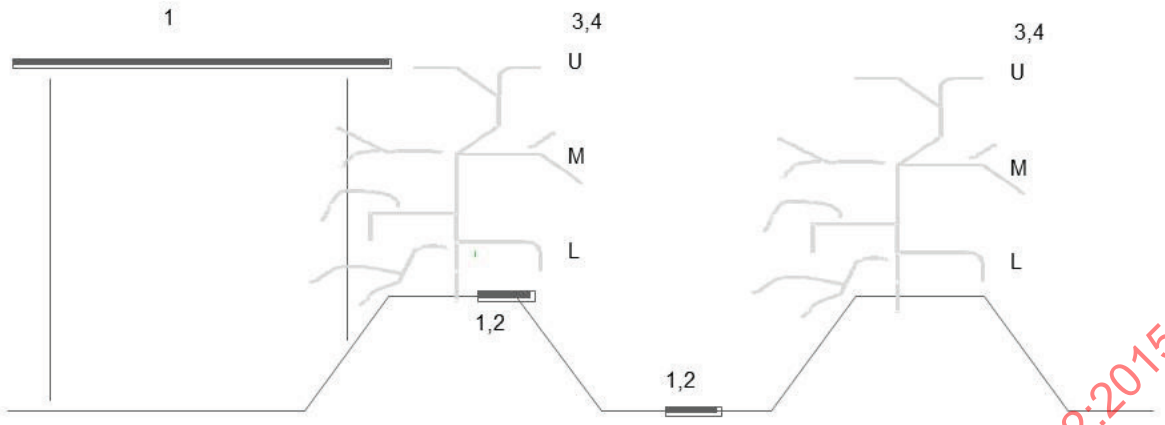


Key

W	working width
h	height of the surrounding vegetation
e	edge distance from end of boom or sprayer
CA-L	central area under left half boom
CA-R	central area under right half boom
F	field
D	distance between vegetation and test area, $D > 10 \times h$
T	test area
S – L	left sampling area
S – R	right sampling area
L	track length
B	start length
S	sampling area length
E	stop length

Figure 1 — Schematic presentation of field layout, test area and sampling areas under the (left and right) centre of the spray boom.

Each measurement shall involve sampling spray depositions quantitatively (5.2, 5.3) or qualitatively (5.4) on top of the canopy (5.2.1), within the canopy (5.2.2) and on the ground (5.3) underneath (Figure 2). Make at least three measurements at the same collector positions or at different places after each other.



Key

1 filter collector; on top of crop canopy, on ground surface underneath the crop (top of ridge) and between ridges

2 water sensitive paper: on ground surface underneath the crop (top of ridge) and between ridges

3 water sensitive paper: on top and bottom side of leaves at three leaf levels

4 chromatography paper: on top and bottom side of leaves at three leaf levels

U upper

M middle

L lower

Figure 2 — Example of layout of the collectors for the measurement of spray deposition in a potato crop

Depending on height, the canopy may be divided in segments such as upper, middle, and lower part of the canopy (Figure 2). To quantify spray depositions, samples such as, leaves, stems, or appropriate collectors (Annex A) can be used and shall be carefully sampled after spraying. Typical sampling strategies for cereals are e.g., flag leaf, second leaf, third leaf, head, stem upper part, and stem lower part. Whereas for e.g., potatoes top leaves, middle of plant height leaves, and near soil surface height leaves can be taken and for strawberries the whole pant leaf area, the flowers, and the fruits are often sampled.

The leaf surface area of single leaves can be measured using leaf area scanners or special measuring devices quantifying the projected leaf tissue area (flat surface area). The total leaf tissue surface area is the upper and bottom side of the leaf together, so measured projected leaf area shall be doubled to present total surface of the leaf. The total leaf area is the sum of all the leaves in the upper, middle, or lower leaf level. To characterize a crop canopy in the field in general, a square meter of plants is cut above ground surface and taken to the laboratory to measure leaf area. The amount of leaf area is presented as unit area leaf per leaf level (upper, middle, lower) and as sum of all leaf levels per unit area ground (general m^2/m^2). The one-sided leaf tissue area per unit of ground area is called the Leaf Area Index[6] (LAI, m^2/m^2). The total amount of single sided leaf area can also be expressed relative to the total dry weight [after drying at (60 to 80) °C for 48 h] of leaf (m^2/kg) and is called the Specific Leaf Area (SLA). The total one-sided leaf area per unit of leaf layer volume (upper, middle, lower) can also be presented and is called the Leaf Area Density (LAD). The sum of the leaf areas of the LADs per leaf layer per unit of ground area is the LAI.

Note that due to variation of crop stand in the field, the sampling of leaf area from only one square meter may lead to wrong estimates of the total leaf area in the field and therefore in mass balance of spray deposition.

The test shall be performed with the rate control in manual mode unless the rate control in itself is being tested. Sprayer speed and nozzle output (l/min) over the test area shall be directly measured and recorded in the test report. Information from the rate control (such as volume, speed, pressure) shall preferably be recorded or visually checked and specified in the test report.

The presentation of spray deposition result can be done on

— a relative basis e.g. as percentage of dose applied (comparing distribution on leaf to on a collector placed on the ground), or

— an absolute basis, e.g. µl (spray liquid)/cm^2 or l (spray liquid on the total crop canopy)/ha.

NOTE 1 Scaling up limited number of sample values to a complete 'mass balance' makes it critical to know target structure factors, e.g. leaf area index, although scaling up will always result in some error.

Spray deposition measurements shall be differentiated between natural collectors (leaves, stems, fruits) and artificial collectors attached to the areas of interest.

Natural collectors can be a cluster of leaves or fruitlets, but area of interest can also be the stem and flowers of the plant. The number of leaves or fruitlets of each sample shall be that to allow a representative random sampling from the whole zone. The positions and the number of leaves or parts of the different sample zones shall be reported. For fruitlets spray, deposition can also be related to the weight of the fruit. A sample shall be of at least four leaves per measuring place, at least three measuring places shall be identified per sample area of interest. The single leaf is the smallest unit for analysis.

Artificial collectors (4.6 and Annex A) shall be used to determine the ground depositions and in addition, can be used for assessments of the spray liquid that is sprayed onto the natural collectors. Other structures such as horizontally presented pipe cleaners can be more appropriate for air assisted methods, as vertically placed pipe cleaners are more appropriate to mimic grassy weeds and tend to catch smaller drops better. Care will be needed to ensure that the artificial collectors do not saturate, especially when used to verify the applied dose and volume rate (at the top of crop canopy 5.2.1).

NOTE 2 Beware of differences in results from natural and artificial collectors because of differences in nature of the surface (waxiness, roughness, etc.).

Procedures for handling samples from the plant(s) or collectors prior to and post exposure to spray that minimize the risk of cross-contamination shall be established. It might therefore be necessary to use other types of collectors to be placed on ground level (5.3) between the plants than on top of the crop canopy structure (5.2.1). The potential for cross-contamination of collectors is especially to be taken account of for collectors placed on ground level in the crop canopy structure both when placing and removing collectors.

The potential for tracer degradation shall be monitored during a trial using clean samples from the plant(s) or collectors and those loaded with a measured volume of the tracer solution.

The results of all deposition measurements shall be statistically evaluated in accordance with the analysis of variance, ANOVA, 10 %.

5.2 Sampling spray deposition on the canopy

5.2.1 Spray flux on top of crop canopy

On the top of the crop canopy, horizontal flat collectors with a total collecting area of at least 1000 cm^2 shall be placed in each end of test area (Figure 2) for measuring sprayer output and total spray flux (spray dose or spray volume) coming into the canopy.

NOTE 1 The measured spray deposition is presented as % of sprayed volume or µl/cm^2 per unit ground area.

NOTE 2 Measurements from air-assisted sprayers might not produce an accurate result and measurements are not appropriate for spray released within the canopy, e.g. drop legs.

5.2.2 Inside canopy

5.2.2.1 General

After spraying, spray deposition inside the canopy can be measured by sampling the leaves and stems or by picking artificial collectors attached before spraying between the leaves and stems at different levels (upper, middle, lower heights).

5.2.2.2 Leaves and stems

Leaves and stems are collected and put in suitable container and stored cool and in the dark until they are analysed. To determine the spray deposition, the samples are washed with a known amount of solvent (e.g. demineralised water) and the projected surface area of the leaves are measured (fluorimetry, etc., see Annex B). To calculate the deposition per unit area of leaf, the surface area is taken as twice the projected surface area.

When leaves are picked, information on top and bottom side deposition cannot be easily separated and indicates the sum of top and bottom side deposition when the whole leaf is put into a pot. A differentiation in top and bottom side leaf spray deposition can be made by adhering artificial collectors folded around the top and bottom side of the leaf and separate the top and bottom part afterwards.

NOTE 1 Special small jars are available, which can be clipped around the picked leaf both on top and bottom side of the leaf to wash the opening surface with a filled amount of rinsing water. This is however very laborious work but can be very important for particular pest and diseases.

In case of special interest to fruits, flowers, and seeds, these can be picked also from the crop and analysed separately. Analysis procedures are similar as for leaves and stems. Spray deposition results on fruit, flowers, and seeds can be presented on a spray volume per fruit mass base (e.g. µl/g).

NOTE 2 The measured spray deposition on the leaf is presented as % of sprayed volume or µl/cm^2 per unit leaf area when measured as a whole leaf, or per unit area of a top or bottom side of the leaf when such discrimination is made. The sum of the top and bottom side spray deposition is the presentation per unit leaf area (as if the whole leaf was sampled).

5.2.2.3 Artificial collectors

Artificial collectors should be of similar size and shape as part of the plant being sampled (Annex A) to measure deposition in the canopy (e.g. chromatography paper strips 20 cm long × 2 cm wide). Collectors can be folded around and attached to the leaves at the upper, middle, and lower leaf levels or other parts of the plant (e.g. with paper clips, needles, cramps). Artificial collectors can also be placed in crop canopy on special holders arranged between the leaves not damaging canopy structure. The artificial collectors are to be placed systematically at different leaf levels (e.g. upper, middle, and lower, depending on canopy height and structure) or stem heights, with a minimal of four artificial collectors at each height (Figure C.1).

The architecture of the crop canopy needs to be taken into account when placing the collectors. Also the shape and orientation of the leaves should not be changed by attaching collectors. The weight of collectors and paperclips should not change crop canopy architecture. The collector size should be adapted to the leaf size or part of plant of interest.

After spraying, gather the collectors as soon as possible, following the tracer requirements or at least within 30 min after spraying. Code the collectors and store them in a dark, dry, and depending on substance, cool place. Extract the tracer from the collectors and determine the spray deposition, e.g. by fluorimetry as described in Annex B.

For any sprayer and crop combination for which the spray deposition is to be quantified, a minimum of three measurements shall be made in crop canopy and weather conditions that are similar.

Details on the accuracy of the measuring system, collector efficiencies, and recoveries shall be recorded.

5.2.2.4 Reference collector system

A reference collector setup (Annex C) is to be used in order to make spray deposition measurements transferable from one measurement to another. The reference collector system consists of two horizontally placed filter paper positions and two vertically placed filter papers (Figure C.1) positioned at three leaf levels (Figure C.2; upper, middle, and lower). At each of these leaf levels, there shall also be one pipe cleaner attached in a vertical position. At each filter paper position, the two filter papers (Ø 48 mm) are attached with a discriminator plate in between. The reference collector system is placed in the test area with the vertical collectors at crop height just below crop canopy height and the horizontal collectors just 10 cm lower. The direction of the vertical filter papers is cross to the driving direction for which spray deposition in the driving direction on the front and the back side of the vertical filters is ensured. For the horizontal collectors, sampling of the upper and the lower spray deposition is guaranteed. See Annex C for a presentation of the reference collector system.

5.3 Sampling spray deposition to the ground underneath canopy

Horizontal, flat artificial collectors with a total collecting area of at least 1 000 cm^2 can be used to measure spray deposition on the ground. Minimal number of artificial collector locations, oriented on the ground around the plants used for canopy deposition, is two per measuring place. In typical row crops (e.g. potatoes, sugar beet, cotton etc.), artificial collectors can be placed both in (next to) and between the crop rows (Figure 2). Care is to be taken when positioning collectors before spraying and taking out collectors after spraying for cross contamination with plant material.

In case of interest in deposition on small crops or weeds, artificial targets (such as pipe cleaners) can be placed in an upright position on a bare ground surface to mimic small crops.

5.4 Drop distribution/spray coverage (optional)

When more information is wanted on drop distribution and area covered with drops, this can be obtained by placing water sensitive papers (or similar papers) on the collector places specified above. Quantification of drop numbers and coverage from these papers can be done with image analysis systems. Proper calibration of the image analysis system is required (e.g. on pixel-size relation and background threshold/removal). Percentage of coverage or number of drops per unit of area on the different sample places is presented (see also Annex E).

NOTE Tracers and additives have an effect on the spread factor of the sprayed liquid on water sensitive papers. Also the angle, with which the droplets touch the paper, influences the spot at the paper. Very small drops will not show up and high spray volumes lead to total colouring of the water sensitive papers. Therefore, water sensitive papers are merely to be used on a comparative basis.

Quantification of drop numbers and coverage can also be directly made on the leaf if the colour of the tracer is appropriate. Drop sizes on leaves can also be visualized using an enlightening fluorescent dye with e.g. a black light. Drop distributions can be photographed using a digital camera and analysed with image analysis software afterwards.

The results of the drop distribution measurements can be statistically evaluated in accordance with the analysis of variance, ANOVA, 10 %.

6 Test report

6.1 Data related to the spraying system

6.1.1 Sprayer working condition

At least, the following items shall be described:

— manufacturer;

— sprayer type and model;
— tractor type, model, and configuration (if applicable);
— travel speed (km/h);
— electronic devices/spray computer;
— mounted/trailed/self-propelled;
— tires, pressure (sprayer + tractor);
— wheel suspension (yes/no).

6.1.2 Sprayer boom

At least, the following items shall be described:

— working width;
— height above target;
— number of boom sections;
— hydraulic/mechanic section operation;
— stabilization system;
— boom movement (see ISO 14131 for quantification else visual recording in a qualitative way).

6.1.3 Nozzles and liquid distribution

At least, the following items shall be described:

— nozzle type, size, and brand name;
— nozzle spray quality (e.g. fine/medium/coarse or D_{v10}, D_{v50} (VMD), D_{v90});
— working pressure (from sprayer pressure gauge, MPa);
— nozzles spacing and orientation and positions;
— number of nozzle sections on spray boom;
— spray volume (l/ha);
— liquid flow rate from the nozzles over the sampling areas (l/min; e.g. following ISO 5682-2).

6.1.4 Air flow distribution (for air-assisted sprayers)

At least, the following items shall be described:

— fan type;
— gear position;
— PTO speed (min^{-1});
— non-contact measurement fan speed (min^{-1});
— rotation direction: clockwise, counter-clockwise;
— characteristics of the air setting (e.g. direction);

— air speed at the air outlet and airflow rate of the sprayer (Annex D).

6.2 Data related to the field

At least, the following items shall be described:

— slope of the field (e.g. m elevation over 100 m field length);

— soil type (sand/clay/peat etc.);

— surface roughness (e.g. ploughed surface, seedbed prepared land, or Roughness Index from ground tillage studies);

— ground humidity conditions (e.g. wet/dry, dust from wheels).

6.3 Data related to the crop

At least, the following items shall be described:

— type of crop;

— development stage (e.g. BBCH, Zadoks, days after planting, according to Good Agricultural Practice);

— height;

— number of plants/m^2;

— plant ground coverage (%) specified over the target places in between rows, if relevant;

— leaf area (density Leaf Area Density or amount Leaf Area Index, Specific Leaf Area);

— height of different leaf levels;

— crop condition (for example, healthy/diseased, vigorous standing, or hanging);

— row spacing;

— plant spacing.

6.4 Data related to the spray liquid

a) All tank mix products shall be reported: tracers (ID, e.g. colour index number; batch), additives, chemicals used (see Annex B).

b) Spray volume (liquid, tracer additives) including specific rheological parameters, e.g. viscosity and surface tension at (20 ± 2)°C and preferably temperature during the test.

c) Tracer or plant protection product (PPP) concentration based on representative samples of the spray mixture liquid taken (preferably at the nozzle outlet) immediately before and after spraying.

If different tracers are used in the same test, they shall be allocated at random to each application.

7 Expression of results

Values of measured spray deposition may be indicated as the amount of spray per unit of area. Collector area may be determined if necessary. Normalization to a given application rate may be required to compare between different application conditions. Therefore, the tracer concentration in the sprayed liquid should be measured by taking samples out of the nozzle outlet before and after the treatment.

The uniformity of the spray deposition on the canopy can be reported as the coefficient of variation *CV* of the measured spray deposition values.

Spray deposition in crop canopy can also be presented as a function of penetration depth into canopy with accompanying certainty levels.

On leaf area or ground surface, it should be presented as µl/cm^2 or % dose (from sprayer output). It can also be presented as total percentage of spray deposited on compartments/segments/height levels of the crop canopy (upper, middle, lower leaf levels) or on the ground. Then, also the leaf area in the different height segments (upper, middle, lower leaf levels) and total leaf area should be quantified and presented.

At least, the following shall be reported:

a) total spray deposition on the crop or specific parts of the crop (target area);

b) penetration as the fraction of the spray deposition in all plant canopy compared to the spray deposition on the upper leaf layer;

c) fraction of the total deposition in the different leaf layers (e.g. upper, middle, lower or inner/outer leaves);

d) ground deposition amount as a fraction of the volume applied;

e) mass balance of spray recovered;

f) percentage covered with drops and number of spots/cm^2 (optional).

The spray deposition can be expressed in amount of spray liquid per unit of area (µl/cm^2) or percentage of volume applied on the different places in the crop canopy (see also Annex B).

The most essential result is on how the spray liquid is distributed on the leaf, because that is in most cases the essential link to biological efficacy. Therefore, percentage covered with drops and number of spots/cm^2 based on either leaf measurements or water sensitive paper is incorporated in this part of ISO 24253 as an option. Details of the spraying and sampling layout shall be given.

For mass balance of spray recovered (*MB*), multiply the specific amount (µl/cm^2) of the deposition on the different layers (*Du*, *Dm, Dl*) in the canopy (µl/cm^2) by the LAI (*Au, Am, Al*) of each different layer and add this value (*Dx*) to the specific ground deposition (µl/cm^2) (*S*) multiplied by the total area (*X*). Subtract this value (*T*) from the volume applied (*Va*) and multiply the result by 100.

$$Dx = (Du \times Au) + (Dm \times Am) + (Dl \times Al) \quad (1)$$

$$T = Dx + S \times X \quad (2)$$

$$MB = \frac{(Va - T)}{Va} \times 100\ \% \quad (3)$$

Penetration factor can be expressed with Formula (4):

$$P = \frac{Dl \times Al}{Dx} \times 100\ \% \quad (4)$$

In case of interest, homogeneity of the distribution in canopy can be expressed as the *CV* of the distribution of the deposition over the leaf layers, *Du, Dm, Dl*.

In this case, the mass balance is the relative mass balance quantified in this measurement, not of the total system.

Annex A
(informative)

Examples of collectors for canopy and ground measurements

A.1 Canopy

— filter paper

— chromatography paper (e.g. Whatman®[1)] no. 2)

— water sensitive cards

— leaves

— stems

Mixing collectors could give misleading results, therefore, preferably collectors of same size and type should be used.

A.2 Ground surface

— acetate sheets

— aluminium foil

— filter paper

— chromatography paper (e.g. Whatman®[2)] no. 2)

— filter material (e.g. Technofil®[2)] TF-290, Camfil®[2)] CM-360)

— water sensitive cards

— petri dishes

NOTE Mixing collectors could give misleading results.

A.3 On top of canopy

— filter paper

— chromatography paper (e.g. Whatman® no. 2)

— filter material (e.g. Technofil® TF-290, Camfil® CM-360)

— water sensitive cards

— pipe cleaners

— petri dishes

NOTE Mixing collectors could give misleading results.

1) Whatman®, Technofil®, and Camfil® are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

Annex B
(informative)

Fluorimetry and deposition calculation

In case of using a fluorescent dye as a tracer, it is important to optimize the excitation and emission wavelength of the fluorimeter to the tracer to maximize discrimination of tracer and background fluorescence. Noise or background fluorescence can come from the collector, the dilution liquid (e.g. fluorescence of tap or demineralised water can change in time) and the pollution of the capillary (measuring) cell in the fluorimeter. When collectors are stuck to leaves, care has to be taken about the background fluorescence from the leaves (plant juice).

Soak collectors with dilution liquid to get the tracer into solution. Minimize the volume of the dilution liquid to maximize fluorescent recovery, but it is dependent on the collection area and the spray content caught. The dilution volume and the amount of tracer on the collector also determine the recovery from the collector surface. Investigate in advance the optimal dilution volume and time necessary for the tracer to get in solution.

The reading of the fluorimeter is related to the amount of tracer in solution through a calibration curve. This curve, within limits of the scale, is a straight line (e.g. $10 < x < 950$ of 0-1 000), and determined through sampling known concentrations of the tracer.

Calculate from the reading of the fluorimeter, the calibration line, the collector surface area, the tracer concentration in the spray liquid, the background fluorescence (collector and dilution liquid) and the volume of dilution liquid, the amount of spray deposition per unit area, e.g. in µl/cm^2 in accordance with Formula B.1. From this spray deposition the percentage of spray deposition on a collector can be calculated, by relating the spray drift deposition to the amount applied in the field on the same unit of area, in accordance with Formula B.2.

$$\beta_{\mathrm{dep}} = \frac{\left(\rho_{\mathrm{smpl}} - \rho_{\mathrm{blk}}\right) \times F_{\mathrm{cal}} \times V_{\mathrm{dil}}}{\rho_{\mathrm{spray}} \times A_{\mathrm{col}}} \qquad \text{(B.1)}$$

$$\beta_{dep\%} = \frac{\beta_{dep}}{(\beta_V/100)} \times 100\ \% \quad \text{(B.2)}$$

where

β_{dep} is the spray deposition, expressed in microlitres per square centimetre (µl/cm^2);

$\beta_{dep\%}$ is the spray deposition percentage (%);

β_V is the spray volume, expressed in litres per hectare (l/ha);

ρ_{smpl} is the fluorimeter reading of the sample;

ρ_{blk} is the fluorimeter reading of the blanks (collector + dilution water);

F_{cal} is the relationship between fluorimeter reading and tracer concentration [(µg/l)/fluorimeter scale unit];

V_{dil} is the volume or dilution liquid (e.g. tap or demineralised water) used to solute tracer from collector, expressed in litres (l);

ρ_{spray} is the amount of tracer solute in the spray liquid, sampled at the nozzle, expressed in grams per litres (g/l);

A_{col} is the (projected) area of the collector to catch spray, expressed in square centimetres (cm^2).

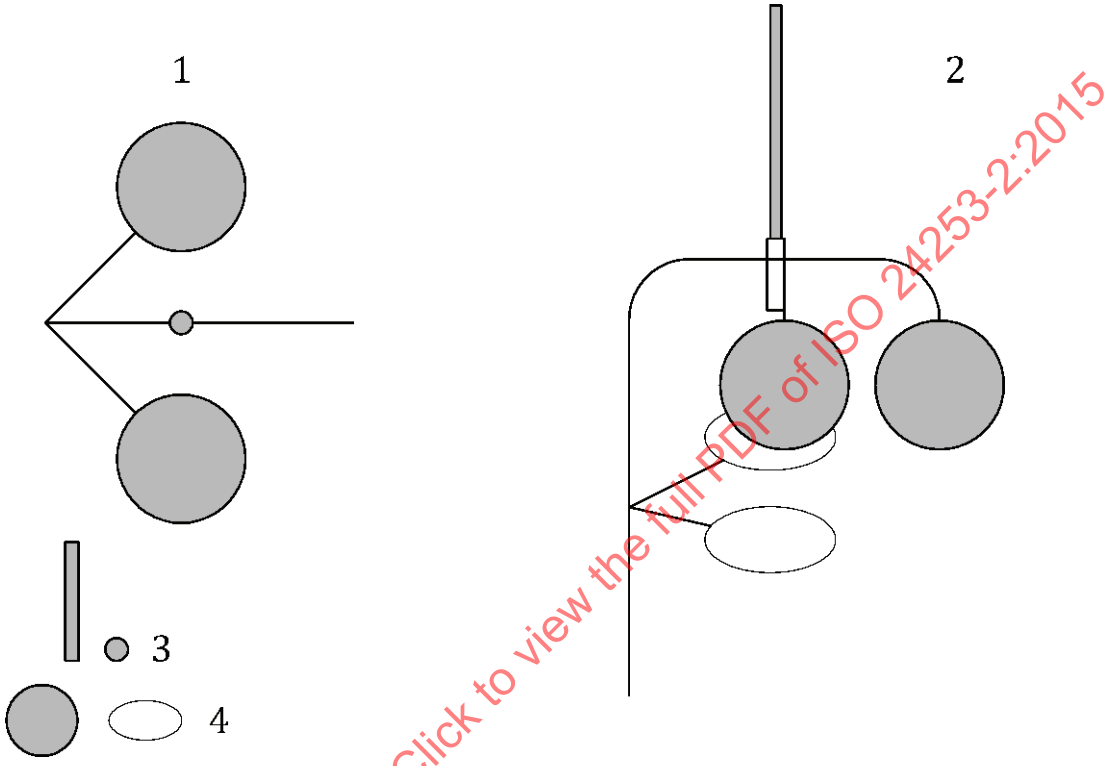
When the collector is leaf tissue, then the projected leaf area shall be measured.

The determination of the background reading from collectors can be obtained by taking at least 10 collectors; soak the collectors with the agreed dilution volume for the collector type and determine the fluorescence value according to the protocol. The mean background value is determined from the individual fluorimeter readings.

It is advised to take up in the standard analysis procedure of the collectors from the test area to put a blank water sample and a blank collector for background determination at the beginning and at the end of the series of samples.

Annex C
(informative)

Reference collector system



Key

1 top view
2 side view
3 pipe cleaner
4 filter collector

Figure C.1 — Reference collector system for one leaf layer height with two horizontal filter collector positions and two vertical filter collector positions and one pipe cleaner position

Per filter collector position, two filter collectors are fixed together (crocodile clamp) with a division plate in between to separate top and under side for the horizontal collector positions and front- and backside for the vertical collectors.

For three leaf layers (upper, middle, lower), three reference collector systems are fixed together to sample the three leaf layer heights.