

## Advice for the functional inspection of plot sprayers with compression tanks

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# SPISE

Standardized Procedure for the Inspection of Sprayers in Europe

# ADVICE

compiled by :  
SPISE Technical Working Group15

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This document has been compiled by the SPISE Technical Working Group 15

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## FOREWORD

The SPISE Working Group was established in 2004 during the first SPISE workshop. There the participants welcomed the thought of Dr. Eng. Ganzelmeier (JKI) that a working group should work on further steps for the harmonization and mutual acceptance of equipment inspections. In the following years, thanks to SPISE engagement, a constant exchange of information has been made possible within the working group and consultations went on between the EC and MS on improving the sustainability of plant protection.

The founding members of the SPISE working group came from Belgium, France, Germany, Italy and the Netherlands.

In the ambit of SPISE working Group several Technical Working Groups (TWG) have been recently created with the aim to prepare **advice** about the items taken into account by the EU Directive 128/2009/EC but still not considered in the actual ISO/CEN Standards. SPISE TWG 8 in particular, has defined **advice** on what are the parts and the requirements of equipment and the criteria to use for the functional inspection of dusters.

The present document is intended to provide technical indications about the steps to follow for making the correct inspection of this equipment.

## **INTRODUCTION**

Plot sprayers are used in most European countries in trials for testing of plant protection products in various crops. They are designed to apply one specific product and/or dose in a plot in field trials. They are designed for one treatment only as manually driven or with multiple units as tractor mounted or self-propelled sprayers.

Each treatment in a trial needs cleaning of equipment or change to another separate unit with tank, valves, regulations and nozzles.

The plot sprayers are used as horizontal booms or on sprayers for bush and tree crops.

This SPISE Advice is focusing on plot sprayers with compression tanks. Other types of plot sprayers with pump, tanks, agitation are considered as sprayers that can be inspected according to EN ISO 16122 parts 1 plus 2 or 3.

The advise is based on methods described in EN ISO 16122 and ISO/DIS 19932:3 plus specific parts relevant for this specific type of sprayers

## **PRE-INSPECTION**

### **3.1 Cleaning**

The sprayer shall be clean externally and internally. Shall not be there any pesticide residues into the tank or on the external surface that can be a source of contamination for the inspector or the environment.

Method of verification: visual check.

### **3.2 Power transmission parts and moving parts of the equipment**

The power take-off (PTO) drive shaft, the power input connection (PIC) and the universal joints shall be equipped with suitable and undamaged guards and protective devices, that shall work properly

Method of verification: visual check.

### **3.3 Structural parts and framework**

Structural parts and framework of the equipment shall be without permanent deformation, significant corrosion or considerable defects.

The hitching device shall be in good condition and shall work properly.

Method of verification: visual check.

### **3.4 Lockable foldable parts**

Locking of foldable parts of the equipment, if present, shall works properly and without defects.

Method of verification: visual check.

### **3.5 Blower**

#### **3.5.1 General**

The blower (fan, casing) shall be without mechanical deformations, excessive wear and corrosion that could be able to significant vibration or malfunctions.

Moreover it shall be verified that:

- all blades are present and without damages;
- guarding to prevent access to the fan is present and in good conditions.

Method of verification: visual and functional check.

#### **3.5.2 Clutch**

If the blower is provided with a clutch to switched off it separately from other driven parts of the sprayer, this device shall function properly.

Method of verification: visual and functional check.

**3.6** The sprayer shall be depressurised, empty (no visible puddles in the spray tank) and internally and externally clean to allow safe inspection.

Compliance shall be checked by inspection

**3.7** The sprayer shall have no obvious serious damage that would cause failure (e.g. holes or cracks in the tank, severely abraded hoses).

Compliance shall be checked by inspection

### **3.8. Pressurising system**

**3.8.1** Tanks and regulators for compressed air shall have valid certificate of approval in national control system.

Compliance shall be checked by inspection.

NOTE: National regulations according to Pressure Equipment Directive 2014/68/ EU shall be regarded

**3.8.2** Power take off and v-belts for air compressor, if present, shall be equipped with suitable and undamaged guards and protective devices, that shall work properly

Compliance shall be checked by inspection.

## **INSPECTION**

### **4.1 Leaks and dripping**

#### **4.1.1 Static leaks**

There shall be no visible leakage when the sprayer shall be filled with water to its nominal capacity.

With the sprayer parked on a level horizontal surface, a visual inspection for any leakage from the tank, pump and associated pipes shall be carried out.

Compliance shall be checked by inspection.

#### **4.1.2 Dynamic leaks**

##### **4.1.2.1 Leak test when not spraying**

With a pressure which is equal to the maximum obtainable pressure for the system, with the section valves closed, there shall be no leakage from any part of the sprayer.

Compliance shall be checked by inspection.

##### **4.1.2.2 Leak test while spraying**

While spraying at a pressure that is equal to the maximum working pressure recommended by the sprayer manufacturer, or the nozzle manufacturer for the nozzles mounted on the sprayer if lower, there shall be no leakage from any part of the sprayer or spray boom/-s.

Compliance shall be checked by inspection.

##### **4.1.3 Spraying and dripping on parts**

Regardless of the height of the boom above the ground, in the height range between the nozzles and the target surface, no liquid shall be sprayed directly on to the sprayer itself (e.g. parts of the sprayer, hoses).

This does not apply if needed by function (e.g. sensors) and if dripping is minimised.

Compliance shall be checked by inspection and function test.

#### **4.2 Spray liquid tank/-s**

4.2.1. The spray tank filling opening shall be fitted with a lid that does not leak air or liquid.

Compliance shall be checked by inspection and function test.

##### **4.2.3 Filling hole**

The diameter of the tank filling hole should allow a safe and easy introduction of liquid into the tank without spillage

A funnel with a strainer shall be available to fill the sprayer tank/ -s.

Compliance shall be checked by inspection.

#### **4.3 Tank emptying**

In case tank/-s are permanently mounted on machine it shall be possible to

— empty the tank/-s e.g. using a tap, and

— collect the liquid without contamination of the environment and without potential risk of exposure of the operator.

Compliance shall be checked by inspection

#### **4.4 Tank agitation system (if present)**

The agitation system in the tank, if present, shall guarantee a good agitation.

Compliance shall be checked by inspection.

#### **4.5 Pressure release device**

The spray tank/-s shall be equipped with a pressure relief device that prevents over pressurization of the spray tank. The device shall reseal to allow normal operation of the sprayer without leakage.

Compliance shall be checked by inspection and function test

#### **4.6 Measuring systems, controls and regulation systems**

##### **4.6.1 General**

All devices for measuring, indicating and/or adjusting the operating pressure of spray liquid and/or flow rate shall function.

The valves for switching on or off the spray shall function.

Switching on and off of all nozzles shall be possible simultaneously.

The controls to be operated during spraying shall be operable from the operator's position and the instrument displays shall be readable from this position.

NOTE Turning of the head and the upper body is acceptable to achieve these requirements.

Switching on and off individual boom sections shall be possible.

Compliance shall be checked by inspection and function test.

##### **4.6.2 Pressure indicator for spray liquid**

###### **4.6.2.1 Scale and dimension of pressure indicator**

At least one digital or analogue pressure indicator shall be fitted at a position where it is clearly readable from the operator's position. Pressure indicators shall be suitable for the working pressure range used.

Compliance shall be checked by inspection.

###### **4.6.2.2 Scale of analogue pressure indicator**

The scale of analogue pressure indicators shall provide graduations:

- at least every 0,2 bar<sup>1)</sup> for working pressures less than 5 bar;
- at least every 1,0 bar for working pressures between 5 bar and 20 bar;
- at least every 2,0 bar for working pressures more than 20 bar.

Compliance shall be checked by inspection.

###### **4.6.2.3 Accuracy of pressure indicator**

The accuracy of the pressure indicator shall be

- $\pm 0,2$  bar for working pressures at 2 bar and below,
- $\pm 10$  % of the real value for pressures at 2 bar and above.

This requirement shall be achieved within the working pressure range suitable for the nozzles mounted on the machine under test.

Compliance shall be checked by measurement according to 5.2.2

#### **4.6.2.4 Diameter of analogue pressure indicator**

For analogue pressure indicators the minimum diameter shall be 63 mm, except for those mounted on spray guns and lances which shall have a minimum diameter of 40 mm.

Compliance shall be checked by measurement.

#### **4.6.3 Other measuring devices**

Measuring devices other than pressure indicators, especially flow meters and forward speed sensors used for controlling the volume/hectare rate, shall measure within a maximum error of  $\pm 5\%$  of the value read on the reference instrument within the range of the measuring device.

Compliance shall be checked by measurement according to 5.3 and 5.4.

#### **4.6.4 Pressure adjusting devices**

All devices for adjusting pressure shall maintain a constant pressure with a tolerance of  $\pm 10\%$  at constant setting and shall return within 10 s to the original working pressure  $\pm 10\%$  after the sprayer has been switched off and on again.

Compliance shall be checked by function test and measurement according to 5.9.

#### **4.7 Lines (pipes and hoses)**

Lines shall not show excessive bending, corrosion and abrasion through contact with surrounding surface. Lines shall be free from defects such as excessive surface wear, cuts or cracks.

Compliance shall be checked by inspection.

#### **4.8 Filters**

##### **4.8.1 Filter**

At least one filter on the pressure side shall be present. Nozzle filters are not to be regarded as pressure-filters.

The filter(s) shall be in good condition and the mesh size shall correspond to the nozzles fitted according to the instructions of the nozzle manufacturer.

Compliance shall be checked by examination of specification and inspection.

##### **4.8.2 Isolating device**

It shall be possible, with the tank filled to its nominal volume, to clean filters without any spray liquid leaking out except for that which may be present in the filter casing and the suction lines.

Compliance shall be checked by function test.

### **4.8.3 Filter insert changeability**

Filter inserts shall be changeable in accordance with the sprayer manufacturers' instructions.

Compliance shall be checked by inspection and function test.

## **4.9 Spray boom**

### **4.9.1 Stability/Alignment**

The boom shall be stable in all directions, i.e. no excessive movement caused by wear and/or permanent deformation.

The right and the left parts of the boom shall be of the same length except when the boom is intended for a special function, e.g. over beds in nurseries.

Compliance shall be checked by inspection and measurement.

### **4.9.2 Automatic resetting**

When provided, the automatic resetting of booms shall operate to move backwards and/or forwards, in case of contact with obstacles.

Compliance shall be checked by inspection and function test.

### **4.9.3 Nozzle spacing/orientation**

The nozzle spacing and their orientation shall be uniform along the boom.

The nozzle spacing (adjacent nozzle centre to centre distance) shall be within  $\pm 5\%$  of their nominal distance.

The verticality of the nozzle body shall be achieved with a maximum deviation of  $10^\circ$ .

In case of special design or applications (e.g. border spraying), nozzle body spacing, orientation and configuration shall correspond to the manufacturer's design specification.

It shall not be possible to modify unintentionally the position of the nozzles in working conditions, for example by folding/unfolding the boom.

Compliance shall be checked by inspection and measurement.

### **4.9.4 Boom deformation**

#### **4.9.4.1 Vertical position**

When measured with the sprayer stationary, the vertical distance between the lower edges of each nozzle and a horizontal reference line (e.g. on a level horizontal surface) shall not vary more than  $\pm 10$  cm or  $\pm 0,5\%$  of the working width, whichever is the highest.

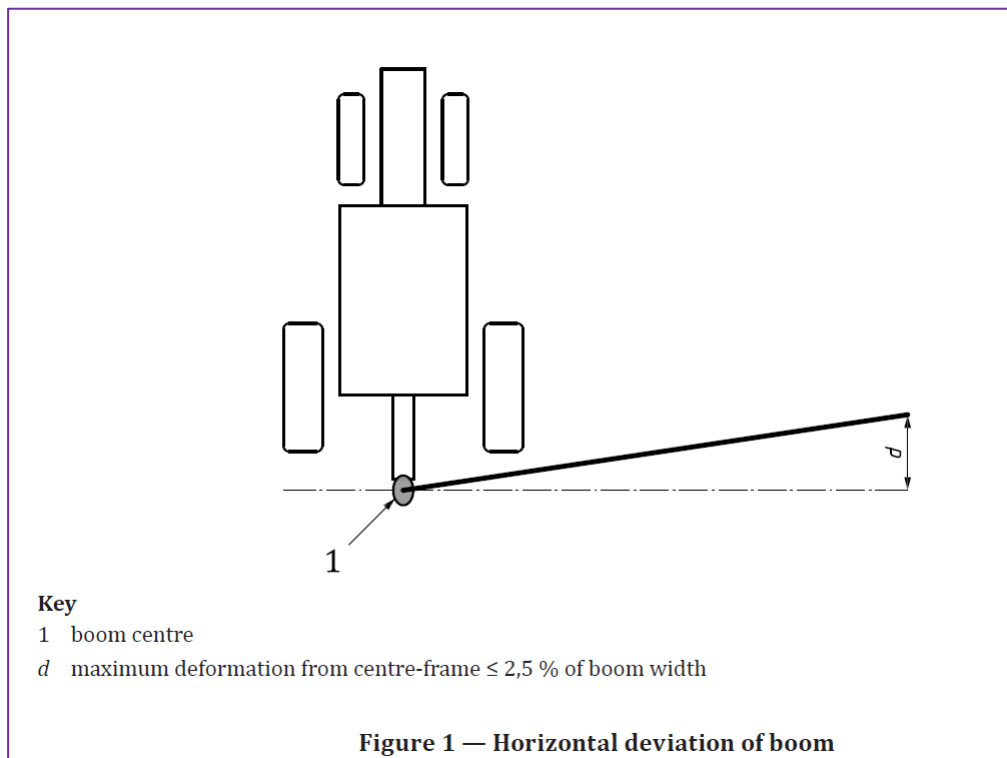
Compliance shall be checked by inspection and measurement.

#### **4.9.4.2 Horizontal position**

The boom shall not be bent in the horizontal plane: the maximum deformation  $d$  from the centre-frame to the boom end nozzle shall not exceed  $\pm 2,5\%$  of the boom width. See Figure 1.

Compliance shall be checked by inspection and measurement.





#### 4.9.5 Prevention of nozzle damage

Booms  $\geq 10$  m in working width shall have a device to prevent damage of the nozzles if the boom hits the ground.

Compliance shall be checked by inspection and measurement.

#### 4.9.6 Height adjustment

If provided, height adjustment devices shall function.

Compliance shall be checked by inspection and function test.

#### 4.9.7 Damping, slope compensation and stabilization

When provided, devices for damping unintended boom movements, slope compensation and stabilization systems shall function.

Compliance shall be checked by inspection and function test.

#### 4.9.8 Compensative returns

When measured at the inlet of each boom section or read on the sprayer pressure indicator, 10 s after a section has been closed, the pressure shall not vary more than 10 %, when the sections are closed one by one.

This requirement is only applicable for sprayers equipped with boom valves which can be set to return the same liquid volume to the tank when closed that would otherwise go through the nozzles on that boom section when the valve is open.

Compliance shall be checked by measurement according to 5.9.

#### **4.9.9 Pressure drop**

The pressure drop between the point on the sprayer where the indicated spray pressure is measured during working and the outermost end of each boom section shall not exceed 10 %.

In case of using measurement on a patternator (see 4.10.3.2), only one measuring point at one outer end of the boom is required.

Compliance shall be checked by measurement according to 5.8.

#### **4.10 Nozzles**

##### **4.10.1.1 Similarity for boom sprayers**

All nozzles fitted to the booms shall be of the same type, size, material and produced by the same manufacturer, except where they are intended for a special function (e.g. the end nozzles for border spraying, bed spraying or band spraying).

Other components (e.g. nozzle filters, anti-drip devices) shall be equivalent over the length of the boom.

Compliance shall be checked by inspection.

##### **4.10.1.2 Symmetry for vertical booms**

The nozzle arrangement (e.g. nozzle types, sizes, material and production by the same manufacturer) shall be symmetrical on the left and right hand sides, except where they are intended for a special function (e.g. spraying on one side, fitting of nozzles to compensate the air distribution asymmetry, etc.).

Compliance shall be checked by inspection

##### **4.10.2 Dripping**

After being switched off there shall be no continuous dripping from nozzles 5 s after the spray jet has collapsed.

Compliance shall be checked by inspection.

##### **4.10.3 Liquid distribution**

###### **4.10.3.1 General**

**If hydraulic pressure nozzles are used on a horizontal boom to form a uniform spray, 4.10.3.2 or 4.10.3.3 applies; in other cases, 4.10.3.3 applies.**

###### **4.10.3.2 Measurement on a horizontal patternator**

a) The transverse distribution, within the total overlapped range, shall be uniform. The uniformity of the transverse distribution is evaluated on the basis of the coefficient of variation which shall not exceed 10 %.

b) The amount of liquid collected by each patternator groove within the overlapped range shall not deviate more than  $\pm 20$  % of the total average value.

Compliance shall be checked by measurement according to 5.6.

### **4.10.3.3 Flow rate measurements for horizontal and vertical booms**

#### **4.10.3.3.1 General**

For sprayers with only one spray liquid output, with adjustable flow rate nozzle, the flow rate has to be measured but no indication of wear can be provided.

Compliance shall be checked by measurement according to 5.7.

#### **4.10.3.3.2 Nominal nozzle flow rate**

The deviation of the flow rate of each nozzle of the same type and size shall not exceed —  $\pm 10$  % of the nominal flow rate indicated by the nozzle manufacturer for horizontal boom sprayers and  $\pm 15$  % for vertical booms, with a flow rate more than or equal to 1 l/min for the maximum working pressure given by the nozzle manufacturer, or —  $\pm 15$  % of the nominal flow rate indicated by the nozzle manufacturer with a flow rate less than 1 l/min for the maximum working pressure given by the nozzle manufacturer.

Compliance shall be checked by measurement according to 5.7

#### **4.10.3.3.4 Pressure distribution**

When the nozzle flow rate is measured according to 5.7.2 or 5.7.3:

— the pressure at each boom section inlet shall not exceed  $\pm 10$  % of the average pressure measured on all boom section inlets; — the pressure at the inlet and outer end of each boom section shall not drop more than 10 %, when spraying with the largest nozzle set mounted on the sprayer.

Compliance shall be checked by measurement according to 5.11.

### **4.11 Blower**

#### **4.11.1 Switching off**

If the blower can be switched off separately from other driven parts of the sprayer, the switching off system shall function.

Compliance shall be checked by function test.

#### **4.11.2 Adjustability**

Adjustable air guide plates on the blower and on an additional blower casing shall function.

Compliance shall be checked by inspection and function test

### **4.12 Spray guns and lances**

#### **4.12.1 Trigger**

The trigger shall function. It shall be lockable in the closed position.

The opening and closing system installed on the gun shall have a quick stop and opening. There shall be no continuous dripping when the trigger is "off" (closed position).

Compliance shall be checked by inspection and function test.

#### **4.12.2 Adjustment of flow rate and angle**

If the flow rate and/or spray angle of the spray gun is adjustable, the adjustment device shall function.

Compliance shall be checked by inspection and function test

## 5 Test methods

### 5.1 Test facilities

In complement to the test benches described below, the following test apparatus are needed for the inspection:

- tachometer (PTO) (with max error of  $\pm 10$  rpm);
- measuring tape (nozzle spacing and height);
- stop watch (flow rate; distribution);
- measuring cylinder (with measuring range 2 l; scale graduation 20 ml; error  $\pm 20$  ml);
- air pressure indicator (pressure pulsation damper).

Different test equipment and methods can be used, if at least the same measuring results and accuracy are achieved.

### 5.2 Sprayer's pressure indicators

#### 5.2.1 Specifications of pressure indicators used for verification

Analogue pressure indicators used for verification shall have a minimum diameter of 100 mm. Other minimum requirements on pressure indicators used for verification are given in Table 1.

Table 1: Characteristics of pressure indicators used for verification (values in accordance with EN 837-1)

Pressure measure to $\Delta p$ bar	Scale unit max. bar	Accuracy bar	Class required	Scale end value bar
$0 < \Delta p \leq 6$	0,1	0,1	1,6 1,0 0,6	6 10 16
$6 < \Delta p \leq 16$	0,2	0,25	1,6 1,0	16 25
$\Delta p > 16$	1,0	1,0	2,5 1,6 1,0	40 60 100
1 bar = 0,1 MPa = 0,1 N/mm <sup>2</sup> = 10 <sup>5</sup> N/m <sup>2</sup>				

#### 5.2.2 Verification method of the sprayer pressure indicator

The pressure indicator(s) of the sprayer shall be tested mounted on the sprayer or on a test bench by comparison with a calibrated test pressure indicator.

Measurements shall be carried out with both increasing and decreasing pressure. In each case the accuracy of the pressure indicator of the sprayer shall be checked at a minimum of 4 equally spaced points within the relevant working pressure range.

The pressure shall be stable during measurement, e.g. no influence from pump rotation or pulsations.

### 5.3 Flow meters for controlling the volume/hectare rate

#### 5.3.1 General

The error of the measuring instruments in the test equipment shall not exceed  $\pm 2$  % of the measured value with a minimum of 2 l/min.

During the test, the flow rate shall be steady, as indicated by the output of the flow rate sensor or the pressure indicator.

#### 5.3.2 Operating procedure No. 1: Verification by nozzle flow rate measurement

The inspection shall be conducted as follows:

— The spray control shall be set to the correct PTO speed and at a pressure within the working range of the sprayer.

— For each of the following three tests, the average flow rate of at least 5 nozzles shall be measured with a measuring cylinder, or the single flow rate values for each nozzle obtained from the test in 5.6 shall be used in order to calculate the average value of a single nozzle.

— One or more spraying section(s) shall be turned on to give a total flow rate representing 30 % to 50 % of the full flow. The pressure value and the value displayed on the flow meter and the number of nozzles in use shall be recorded.

— Additional spraying section(s) shall be turned on to give a total flow rate representing 50 % to 75 % of the full flow. The pressure value and the value displayed on the flow meter and the number of nozzles in use shall be recorded.

— Additional spraying section(s) shall be turned on in order to reach 100 % of the full flow. The pressure value and the value displayed on the flow meter and the number of nozzles in use shall be recorded.

The pressures shall be read at the level of the sections.

For each flow rate, the reference outflow,  $Q$ , corrected for the pressure applied during the test ( $P_1$ ), shall be calculated as follows:

$Q = \text{Number of nozzles} \times \text{average of single nozzle flow rates, l/min}$

The following formula can be used to calculate the adjusted single nozzle flow rate,  $d_1$ , for the applied pressure  $P_1$ :

$$d_1 = d_2 \cdot \sqrt{\frac{p_1}{p_2}}$$

where

$d_2$  is the single nozzle flow rate measured in 5.6 or with the measuring cylinder;

$P_2$  is the pressure during the measurement of the single nozzle flow rate  $d_2$ .

Each value of Q shall be compared with the corresponding value reading taken from the sprayer's flow meter. The deviation between the measured value of Q and the corresponding value reading taken from the sprayer's flow meter shall be expressed as a percentage of the reference value Q.

### 5.3.3 Operating Procedure No. 2: Verification by installing a calibrated flow meter in the circuit

#### of the sprayer

On the pump outlet side of the sprayer and as close as possible to the flow meter to be checked, a calibrated flow meter shall be installed.

The inspection shall be conducted as follows:

— The spray control shall be set to the correct PTO speed and at a pressure within the working pressure range of the sprayer.

— One or more spraying section(s) shall be turned on to give a total flow rate representing 30 % to 50 % of the full flow. The values displayed on the sprayer's flow meter and the calibrated flow meter shall be recorded.

— Additional spraying section(s) shall be turned on to give a total flow rate representing 50 % to 75 % of the full flow. The values displayed on the sprayer's flow meter and the calibrated flow meter shall be recorded.

— Additional spraying section(s) shall be turned on in order to reach 100 % of the full flow. The values displayed on the sprayer's flow meter and the calibrated flow meter shall be recorded.

Corresponding recorded readings from the sprayer's flow meter and the calibrated flow meter shall be compared. The deviation between both values shall be expressed as a percentage of the reading from the calibrated flow meter.

### 5.4 System for controlling forward speed

The actual travel speed shall be measured with an error not exceeding  $\pm 2,5$  %.

The measurement shall be carried out continuously over a distance of at least 50 m located on a flat area.

The beginning and the end of the test distance shall be clearly marked. A reference point shall be marked on the sprayer to assist in the identification of the start and finish of the test.

— The tractor or self-propelled sprayer shall be pre-set to achieve a constant forward speed close to the operating speed. The hand accelerator can be used to set the speed of the engine.

— The set test speed shall be achieved before the 1st mark on the test track is reached.

— Timing shall start, by means of the stop watch, when the reference point on the sprayer aligns with the 1st mark on the test track.

— During travel, the speed indicated by the sensor shall be recorded.

— Timing shall stop when the reference point on the sprayer aligns with 2nd mark on the test track.

The measured forward speed shall be calculated using the following formula:

$$v = 3,6 \cdot \frac{d}{t}$$

where

v is the measured forward speed, expressed in kilometres per hour (km/h) and compared with the speed indicated by the sprayer' sensor;

d is the distance travelled, expressed in metres (m);

t is the duration, expressed in seconds (s).

## 5.5 Uniformity of the transverse volume distribution with a horizontal patternator

### 5.5.1 Specification of horizontal patternators used for verification

A patternator with grooves 100 mm wide and at least 80 mm deep, measured as a distance between the top and the bottom of the groove, shall be used to measure the uniformity of the transverse volume distribution of the spray.

The groove patternator shall be at least 1,5 m long. The groove width shall be 100 mm ± 2,5 mm. The groove width of a patternator working in steps with electronic data sampling (e.g. scanners) shall be 100 mm ± 1 mm.

Prior to the start of the test, the grooves to be used shall be checked by suitable means such as a pattern to see whether the above tolerance limits are met. The graduated spray liquid measuring cylinders shall be of the same type and size and have a capacity of at least 500 ml. Scale graduation shall be a maximum of 10 ml.

The error of measurement shall not be more than 10 ml or ± 2 % of the measured value whichever is greater.

When passing the measuring track, positioning in single steps shall be completed with an accuracy of ± 20 mm. The measuring error of the volume of the single grooves at a flow volume of 300 ml/min shall be less than ± 4 %. The adjustment and calibration of the patternator shall be in accordance with the patternator manufacturer's instruction handbook.

The size of the patternator shall be suited to the size of the boom to be tested and to the type of sprayer. The patternator shall also ensure that the overlapping range of the spray is measured completely.

### 5.5.2 Verification method of the uniformity of the transverse distribution

From all nozzle sets present on the sprayer the transverse distribution of spray shall be verified for the complete working width of the sprayer.

The test shall be carried out at a standard testing height (measured from the tip of the nozzle to the top of the grooves of the patternator) following the recommendations of the nozzle manufacturer and a standard test pressure, within the pressure range given by the nozzle manufacturer.

The verification shall be carried out from the midpoint between the centre of the outermost nozzle and the centre of the penultimate nozzle on one side of the boom to the midpoint between the centre of the outermost nozzle and the centre of the penultimate nozzle on the other side of the boom.

### 5.5.3 Calculation of Coefficient of Variation (CV)

The following formula shall be applied:

CV s

$$s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n - 1}}$$

$$\bar{x} = \frac{\sum x_i}{n}$$

$x_i$  is the volume of liquid in the tube;

$n$  is the number of grooves;

$s$  is the standard deviation of the volumes collected in the grooves;

$\bar{x}$  is the average/mean volume collected per groove.

## **5.6 Flow rate of the spray nozzles**

### **5.6.1 General**

This test shall be performed either with nozzles mounted on the boom (see 5.6.2) or removed from the boom (see 5.6.3). It shall be ensured that the spray jets are correctly formed when nozzles are mounted on the boom and before dismounting.

The error in the measured flow shall not exceed  $\pm 2,5$  % of the measured value or  $2,5 \times 10^{-2}$  l/min, whichever is greater.

The test shall be carried out at a pressure within the pressure range given by the nozzle manufacturer.

### **5.6.2 Measurement with nozzles fitted on the boom**

The flow rate of each nozzle shall be measured according to ISO 5682-2:1997, 8.1, except 8.1.1.

The pressure during flow rate test shall be measured at the nozzle position or as close as possible.

NOTE Specific methods for testing pneumatic nozzles are to be developed.

### **5.6.3 Measurement with nozzles removed from the boom**

The measurement of the flow rate of each nozzle shall be carried out on a test bench.

The test bench consists of a pump which pumps water with a certain pressure through the nozzle, a pressure regulator, a pressure indicator (analogue or digital) by which the actual pressure can be monitored and a flow meter by which the actual flow rate can be measured. The pressure indicator shall meet the requirements of 5.2.1.

The liquid system, adapters, etc. shall not influence the flow rate.

## **5.7 Pressure drop**

The test shall be carried out with the highest flow rate nozzle provided on the sprayer and at a pressure within the working pressure range given by the nozzle manufacturer.

A calibrated test pressure indicator (see 5.2.1) shall be fitted at the same position as a nozzle at the outermost end of each boom section.

Measurements shall be made at two pressures at the pressure indicator of the sprayer and the calibrated test pressure indicator.

The values indicated by the pressure indicator of the sprayer shall be compared with values measured by the calibrated test pressure indicator.

## **5.8 Pressure variation when the sections are closed**

Pressure variation shall be checked with a calibrated test pressure indicator (see 5.2.1) at the location of the sprayer's pressure indicator.



Variations in the value indicated by the calibrated test pressure indicator shall be observed and recorded as the sections are closed one by one, with all sections that have been closed kept closed until all measurements have been made.

The pressure shall be observed before and 10 s after each section is closed.

### **5.9 Pressure variation when the spray is switched off**

Pressure variation shall be checked with a calibrated test pressure indicator (see 5.2.1) at the location of the sprayer's pressure indicator.

Variations in the value indicated by the calibrated test pressure indicator shall be observed and recorded when the spray is switched off. The pressure shall be observed before and 10 s after the spray is shut off.

### **5.10 Pressure distribution**

The test shall be carried out with the highest flow rate nozzle provided on the sprayer and at a pressure within the working pressure range given by the nozzle manufacturer.

A calibrated test pressure indicator (see 5.2.1) shall be fitted at the same position as a nozzle at the inlet of each boom section.

The average inlet pressure from all sections shall be calculated and compared to individual inlet pressures.

A calibrated test pressure indicator shall be fitted at the same position as a nozzle at the outermost end of each boom section.

For each section, the pressure drop between the inlet and the outermost end shall be calculated using the following formula:

$$pressure\ drop = 100 \cdot \frac{(p_0 - p_1)}{p_0}$$

where

$P_0$  is the inlet pressure of the section;

$P_1$  is the outermost end pressure of the same section.

## **REFERENCES**

EN ISO 16122-1 (2015) - Agricultural and forestry machinery - Inspection of sprayers in use - Part 1: General.

EN ISO 16122-2 (2015) - Agricultural and forestry machinery - Inspection of sprayers in use - Part 2: Horizontal boom sprayers.

EN ISO 16122-3 (2015) - Agricultural and forestry machinery - Inspection of sprayers in use - Part 3: Sprayers for bush and tree crops.

ISO/DIS 19932:3 Equipment for crop protection — Knapsack sprayers —Part 3: Inspection of knapsack sprayers in use