ISSN 2364-7574

SPISE

Standardized **P**rocedure for the **I**nspection of **S**prayers in **E**urope

ADVICE

February
01/2023

compiled by :
SPISE Technical Working Group 1

What to be considered when you buy a new sprayer?

Guideline for stakeholders – demands on a modern environmental sprayer

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Guideline for stakeholders – demands on a modern environmental sprayer

This document has been compiled by the SPISE Technical Working Group 1

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Content

1. Introduction

The amendment to the Machinery Directive 2006/42/EC for Pesticide Application Equipment (PAE) set out in Directive 2009/127/EC will make a significant contribution to the protection of the environment and human health. It will help European farmers and gardeners to reduce the quantity of pesticides used, due to better more accurate application technique. The sprayer must be designed so that pesticides can be applied only where they are needed. At the same time, the use of the Machinery Directive avoids creating new burdens for the machinery manufacturers, since existing procedures can be used. The Machinery Directive already fixes harmonized health and safety requirements for all new machinery sold in the EU.

According to the European Directive, sprayers can then be placed on the market only if they are provided with self-certification protocol by manufacturer. This means that the sprayer has to fulfil all the requirements, not affecting safe and health of humans, animals, property and environmental contamination by plant protection products and that have been taken all measures necessary to reduce the risk. This process leads to Declaration of Conformity (including CE marking) which officially can be considered as an official guarantee of the accomplishment of all the requirements mentioned in the Machinery Directive.

This document has been developed by SPISE community with the main objective to serve as a guide for potential customers of PAEs, giving practical information about the main features which shall be on a new modern sprayer. He must know what his new sprayer must have when to buy it. However, it must be considered that this document represents just a practical guideline, and its following will never substitute the complete accomplishment of the Directive 2009/127/EC.

2. Environmental and safety requirements for brand new sprayers

The accomplishment of all requirements established in Directive 2009/127/EC can be supported by a complete following of specific harmonized international standards. EN ISO 16119 series establishes the specific environmental requirements to be fulfilled by a new sprayer.

Part 1 of this ISO series includes the minimum requirements for brand new sprayers in order to avoid environmental problems during the pesticide application process. For that reason, a list of requirements has been defined as mandatory for new sprayers prior its placement into the market. Table 1 shows a resume of the principal requirements for new sprayers.

Table 1. Main requirements of sprayers

Aspect	Requirements according ISO 16119-1
Inspection of sprayers	Sprayers shall be provided by adequate devices in order to facilitate the connection of special devices for the mandatory inspection of sprayers in use (ISO 16122 series)
Adjustment of sprayer	It shall be possible to adjust the sprayers for the intended volume application rate. The sprayer shall be delivered with adequate and reliable measuring systems.
Spray distribution	Characteristics of the sprayer shall allow to obtain a uniform distribution of the sprayed liquid according the intended target, while minimizing losses and drift and avoid contamination of non-target areas.
Information	The sprayer shall contain a specific placement where operator will write the name and specifications of PPP in use
Filling, emptying and cleaning	All the sprayers shall be provided with reliable and safe systems for filling and emptying the tank without environmental risk. Sprayers shall incorporate devices for cleaning the whole machine (inside and outside) after the application process.
Marking	Specific spare parts as nozzles and filters shall be clearly identified (manufacturer, size, type…)
Instruction handbook	It is mandatory to provide a clear, precise and useful instruction book with all the sprayers. Information about calibration, cleaning and maintenance shall be provided.

3. Main aspects to be required to new sprayers

3.1 Required characteristics of the spray tank

Figure 1 shows the main characteristics to be requested on the tank of a new sprayer. Roughness of the tank walls (inside and outside) shall be as minimum as possible in order to facilitate the cleaning process.

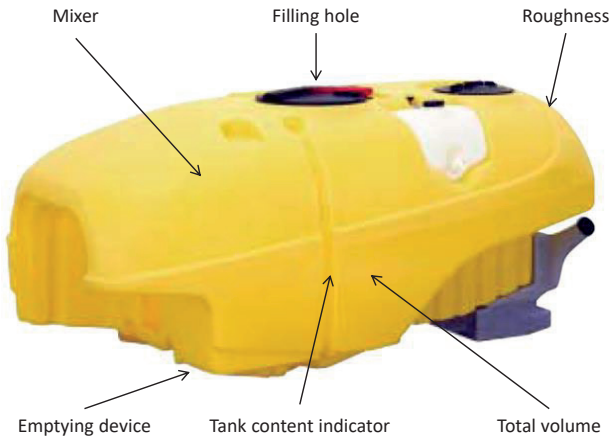


Figure 1. Main aspects to be considered on a sprayer tank

The tank shall be provided with an adequate filling hole. Dimensions shall be according to the tank size. A lid shall be provided to prevent leakages or spillages when the tank is closed. Diameter of filling hole shall allow a complete filling of the tank in a reasonable time.

Operator shall be able to empty completely the tank by acting a dedicated device placed on the bottom part (Fig. 2) without any risk of contamination (environmental contamination or other equipment parts e.g. stays). This device shall be protected in order to avoid unintentional contamination

Figure 2. Emptying device examples

Tank content indicator

A durable level indicator shall be included in the tank. This device shall be easily readable from the driver's position and from the filling place where the sprayer is filled (Fig. 3). The acceptable tolerances are indicated in the figure.

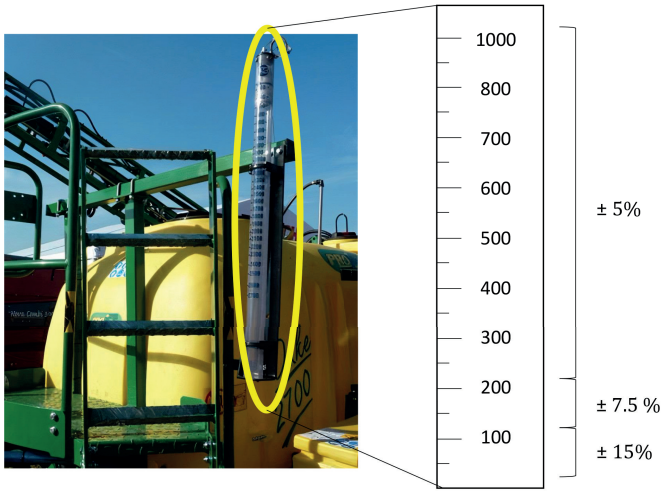
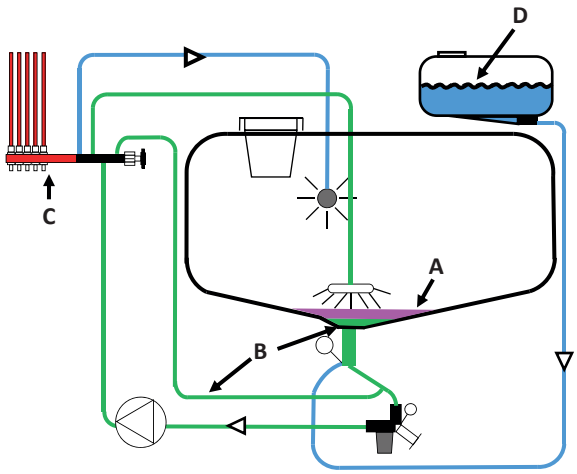


Figure 3. Example of lever indicator in the tank and minimum requested tolerances

Residual volume

In order to avoid cross contamination and to easy the cleaning process, the residual volume of the tank shall be limited (Fig. 4). For boom sprayers the maximum value shall not exceed 0.5% of the nominal tank volume plus 2 l/m of the boom. For orchard sprayers, the maximum value of residual volume is calculated according table 2. Detailed information about residual volume shall be included by the sprayer manufacturer in the instruction handbook.



A *Exceed volume*: produced by an inadequate calibration process or due to an excessive filling of the tank.

B *Diluted Volume*: amount of liquid that can be returned to the main tank and, as a consequence, can be diluted.

C *Dead Volume*: amount of liquid that cannot be returned to the main tank.

D *Clean water tank*: device for cleaning the sprayer

Figure 4. Definition of residual volume and other concepts, as established in ISO 13440

Table 2. Maximum value of residual volume for orchard sprayers

Tank nominal volume N (l)	Maximum residual volume (l)
N < 400	4% of the nominal volume (4% N)
400 ≤ N ≤ 1000	3% of the nominal volume (3% N)
N > 1000	2% of the nominal volume (2% N)

Following the previous requirements, tables 3 and 4 indicate some examples of how to calculate the maximum residual volume for boom sprayers and orchard sprayers, respectively.

Table 3. Examples of calculation of maximum residual volume for boom sprayers

Maximum residual volume (l)				
Tank		**boom**		**Total (l)**
Capacity (l)	**0.5%**	**Length (m)**	**2 l/m**	
400	20	12	24	44
600	30	15	30	60
800	40	18	36	76
1000	50	24	48	98
2000	100	36	72	172

Table 4. Examples of calculation of maximum residual volume for orchard sprayers

Tank capacity (l)	Maximum residual volume (l)
400	12
600	18
1000	30
1500	30
2000	60

The nominal tank volume is the volume indicated by the maximum filling level marked on the sprayer tank of level indicator when placed on a level horizontal surface; it is different than total volume, that should be at least 6% higher (additional volume) than the tank nominal volume (Fig. 5).

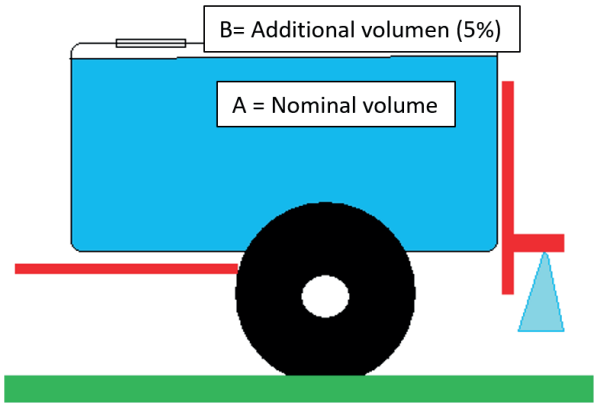


Figure 5. Main tank of the sprayer must be provided with an extra capacity for environmental reasons (spillage, overfilling…).

Agitation system

Agitation system on sprayers is one of the most important devices and its functioning affects directly the quality of deposition of PPP during the spraying process. In general, the agitation system installed on the sprayers is linked to a hydraulic circuit fed by the main pump of the sprayer (Fig. 6). A maximum of 15% of deviation in the concentration is admitted (ISO 5682-2). The system must guarantee a uniform concentration of the tank content along the whole spraying process. Consequently, the capacity of the main pump of the sprayer should be checked to be able to guarantee the maximum flow rate at the maximum working pressure recommended by the sprayer's manufacturer, plus the requested flow rate for feeding the agitation system.

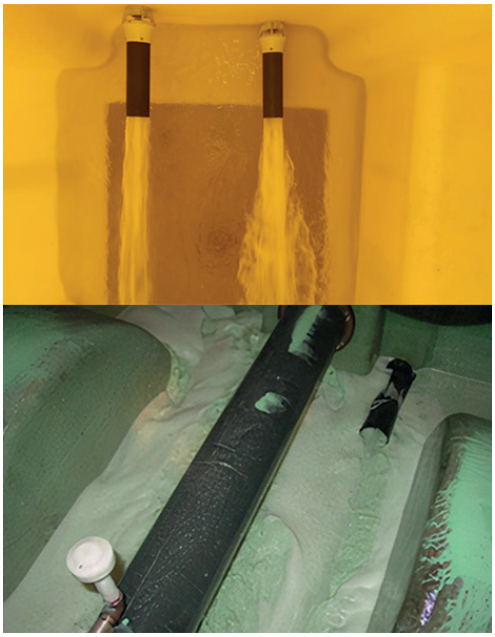


Figure 6. Agitation system is an important device to guarantee the quality during the spray application process, by assuring a uniform concentration of the liquid during the whole process.

3.2 Pump

The capacity of the main pump of the sprayer should be large enough to be able to guarantee the maximum flow rate at the maximum working pressure recommended by the sprayer's manufacturer, plus the requested flow rate for feeding the agitation system. During filling and mixing no pump capacity for spraying is needed.

3.3 Spray boom (field crop sprayers)

In this section are included the most important technical characteristics that shall accomplish the boom (Fig. 7)

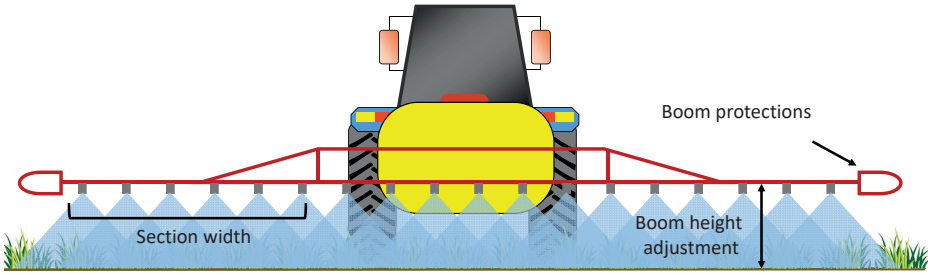


Figure 7. Boom sprayer's main characteristics to be evaluated

For boom sprayers, the maximum spraying section widths will be designed according the total boom length. Requirements are presented in table 5.

Table 5. Maximum spraying section widths

Boom length L (m)	Maximum boom section length (m)
L < 24	4.5
L ≥ 24	6.0

Adjustment of boom height shall be possible within a range of at least 1.0 m. This adjustment can be executed either continuously or step by step, with intervals lower that 0.1 m. Also, the minimum boom height shall be 50 cm.

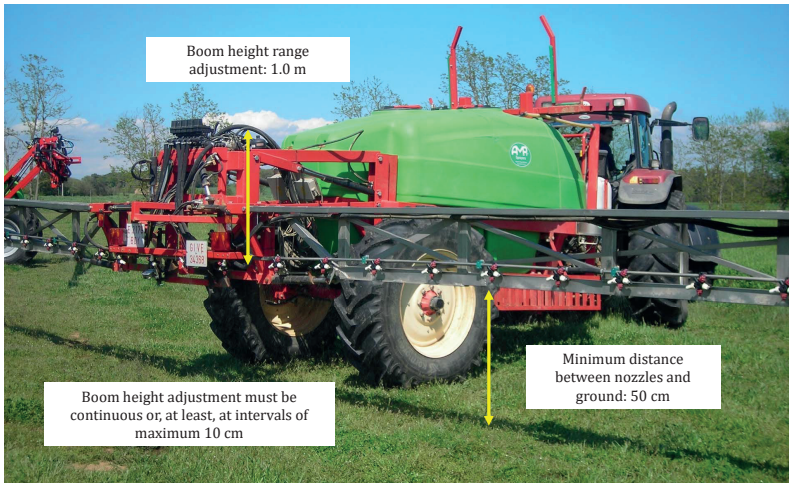


Figure 8. Main requirement/functionality for boom sprayer's adjustments

In order to avoid boom damages during accidental contact with obstacles, the sprayer's boom shall allow a backwards movement. In case of boom length larger than 10 m, that movement should be possible backward and forward. Also, boom shall be provided with a self-return system to avoid irreversible damages when touching with any obstacle. The movement shall be only backwards for booms up to 10 m width, and backward and forward for booms larger than 10 m (Fig. 9). Last nozzle on booms over 10 m shall be provided with a protection device to avoid damages in case of accidental hit on soil.

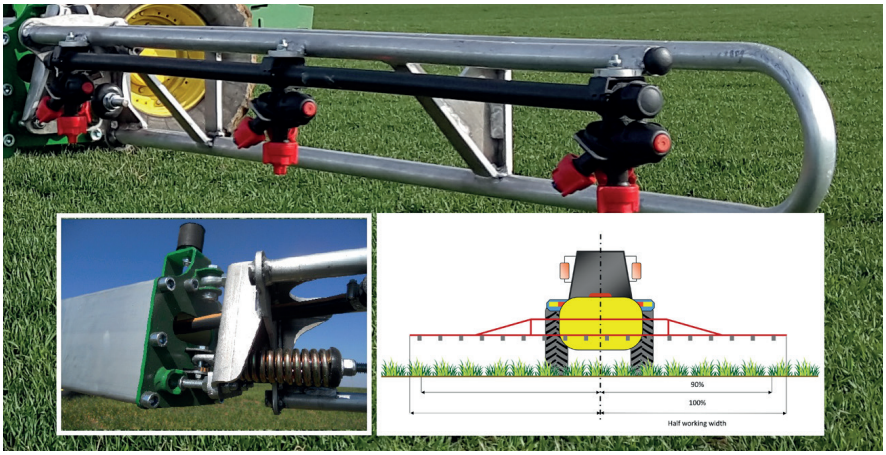


Figure 9. Boom must avoid irreversible damages when touching with obstacles

3.4 Filters

The sprayer shall be provided with a complete filtering system. Filters at the suction and pressure side of the pump must be provided. In this last case, either central filter or individual section filters must be installed in the sprayer. Only sprayers without positive displacement pump (pistons or membrane) could be used without suction filter. Main filter of the sprayer must be removable for cleaning and maintenance, even with the full main tank of the sprayer. For this purpose, an isolate device shall be included in the filter chamber (Fig. 10).

Mesh size shall be according the nozzle size. All the filters shall be mounted in an accessible placement, allowing the user to dismount for maintenance and cleaning.

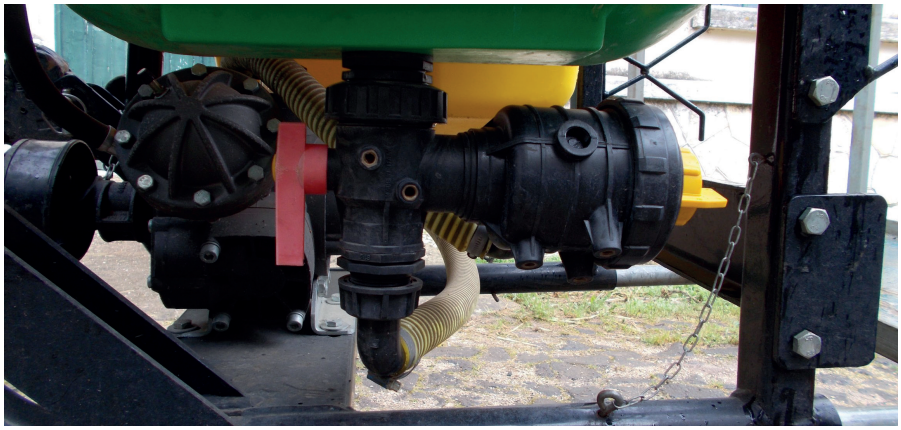
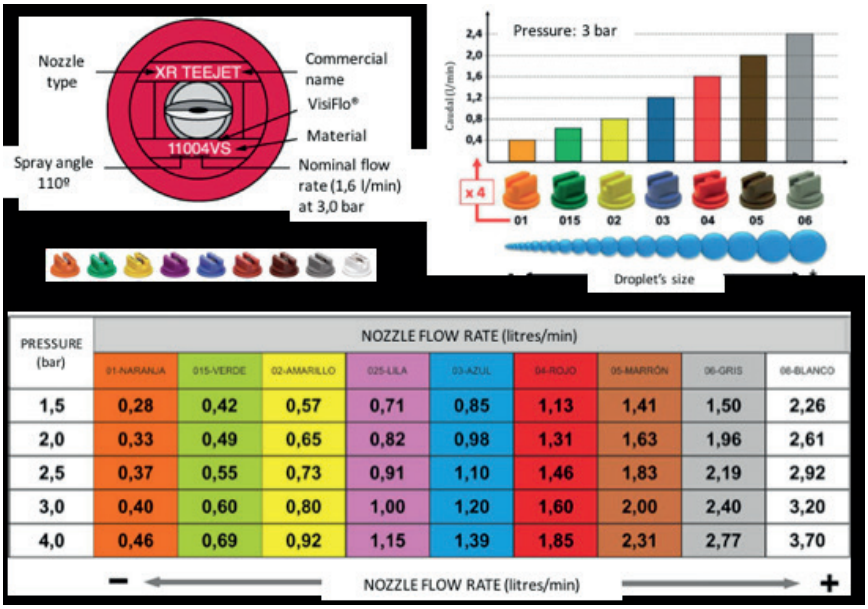


Figure 10. Isolated device allows to dismount the filter even with full tank

3.5 Nozzles

Nozzles shall be clearly identified (manufacturer, type, size and material) and its nominal flow rate shall be clearly defined (Fig. 11). Nozzle placement and its relative position with the boom shall be easily adopted. It shall be possible to measure the individual flow rate of every nozzle.



PRESSURE (bar)	NOZZLE FLOW RATE (litres/min)								
	01-NARANJA	015-VERDE	02-AMARILLO	025-LILA	03-AZUL	04-ROJO	05-MARRÓN	06-GRIS	08-BLANCO
1,5	0,28	0,42	0,57	0,71	0,85	1,13	1,41	1,50	2,26
2,0	0,33	0,49	0,65	0,82	0,98	1,31	1,63	1,96	2,61
2,5	0,37	0,55	0,73	0,91	1,10	1,46	1,83	2,19	2,92
3,0	0,40	0,60	0,80	1,00	1,20	1,60	2,00	2,40	3,20
4,0	0,46	0,69	0,92	1,15	1,39	1,85	2,31	2,77	3,70

− NOZZLE FLOW RATE (litres/min) +

Figure 11. Nozzles must be clearly identified. It is recommended the use of ISO colour code nozzles.

4. Devices to avoid drift

The sprayer shall be designed to reduce drift as far as practicable. National regulation and approvals in regard of drift reductions needs to be followed. In the case of mistflowers, it should be requested the possibility to adopt simple measures for drift control (use of anti-drift nozzles, possibility to adjust air stream, individual control of air outlets…) (Fig. 12).

Figure 12. Device for individual side control of air assistance in orchard sprayers. By closing the outer side drift can be reduced

For boom sprayers, the new equipment should be tested following the official standards for drift measurements (ISO 22866 or ISO 22401). In this case, drift values obtained through whatever of the previously mentioned international standards, should be equal or lower to that obtained with a reference boom sprayer at a reference working parameters, as defined in ISO 22369-3 (see table 6).

Table 6. Technical characteristics and working parameters for reference sprayer during drift tests, as established in ISO 22369-3

Technical characteristics of reference sprayer (ISO 22369-3)	
Type of sprayer	Lifted
Type of nozzles	Flat fan 110º
Nozzle distance	50 cm
Nozzle size	Fine/Media
Boom height	50 cm
Forward speed	6 to 8 km/h

5. Measuring systems

Pressure indicator shall accomplish the minimum requirements for a precise and profitable calibration. The scale, accuracy and other requirements of the manometer are shown in figure 13.

6. Provisions for connecting test equipment

The sprayer (field crop sprayers or orchard sprayers) shall allow a complete and easy mandatory inspection procedure according ISO 16122 (Fig. 14). Particularly, it shall be possible to connect a reference pressure gauge and it shall be possible to connect a flow meter between the pump and the pressure regulator. Those two devices will allow an easy and quick periodical evaluation of the manometer and the pump of the sprayer, respectively.

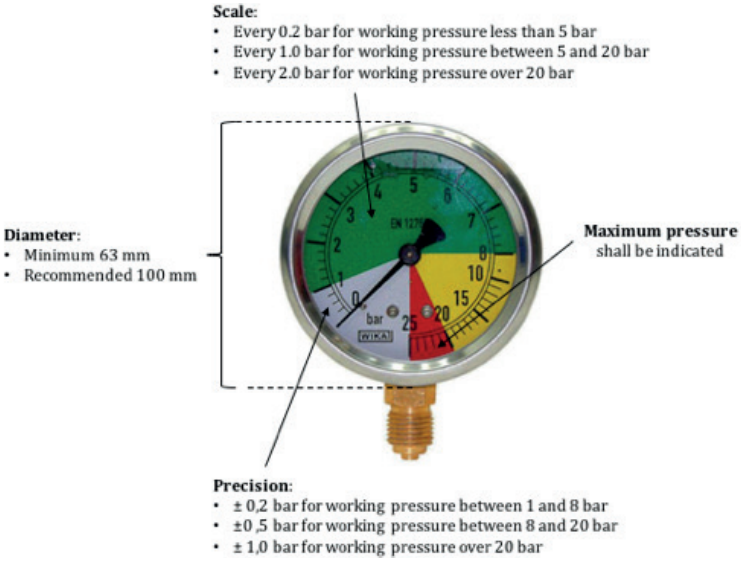


Figure 13. Minimum requirements to be accomplished by the pressure gauge installed in a new sprayer.

Figure 14. The sprayer shall be provided with a device for an easily connection of instruments used during the mandatory inspection of sprayers in use according ISO 16122. Left: easy adaptor for pump tester; right, easy plugging adaptor for testing manometer.

7. Air and liquid adjustment

It shall be possible to adjust in a proper way the intended volume rate according the canopy. For orchard sprayers, it shall be possible to open/close individually both sides of the sprayer. A calibration aids – jar of at least 1 l capacity and with a scale marked every 20 ml - shall be delivered with the sprayer (Fig. 15).

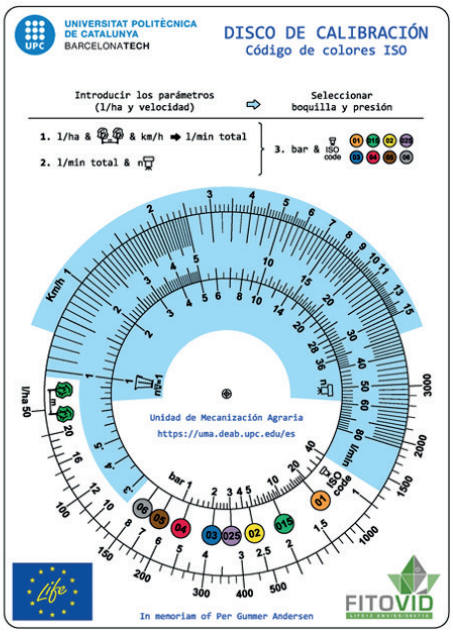


Figure 15. A simple but reliable calibration set shall be delivered with the sprayer

For orchard sprayers designed to apply symmetrically to both sides, air distribution generated by the fan shall be symmetrical and balanced.

8. Cleaning devices

The sprayer shall be provided with a rinsing water tank for cleaning purposes. The tank must allow the complete cleaning process (external and internal) and must be independent of the sprayer's main tank. The clean water tank shall be operative even with the main tank filled (Fig. 16) and shall be totally independent of the clean water tank for washing hands (see Fig. 18). Clean water tank for cleaning purposes is not mandatory for orchard sprayers with main tank volume lower than 400 l. The sprayer shall be provided also with a connection device for external cleaning purposes. It is also required an internal cleaning device (Fig. 17).

Figure 16. A rinse water tank for cleaning purposes is mandatory for all boom and orchard sprayers (except for orchard sprayers with a main tank of 400 l or lower).

Clean water tank for cleaning purposes must be complemented by several devices for the internal and external complete cleaning of the sprayer (Fig. 17). Either, dedicated spray guns for external pressure cleaning, or devices for a quick plugging of appropriate devices, shall be included in the sprayer. Those devices shall allow to clean the pesticide residues from the internal part of the tank in at least 80% of the total residues.

The manufacturer shall descript the procedure how to clean the sprayer in the instruction manual. Following this procedure, it shall be possible to clean the sprayer thoroughly. After the completion of the cleaning process following the procedure in the instruction manual, one of the following requirements, a) or b), applies:

a) The concentration of the residue shall be reduced by a factor of 400 (or 99,75 %), compared with the concentration before starting the cleaning process, tested in accordance with ISO 22368-1;
b) The concentration of the liquid drained from the main tank outlet shall have been reduced to 2 % of the original concentration in the tank.

Figure 17. Special tool for external cleaning of the sprayer (left); device for automatic internal cleaning of the sprayer's tank (centre); special nozzle for internal cleaning of the tank (right).

All sprayers must be provided with a clean water tank of minimum 15 l capacity (Fig. 18) for safety uses in case of spillage/contamination of the operator during the management process of PPP (Plant Protection Products).

Figure 18. Clean water tank (minimum 15 l) shall be installed in the sprayers for safety purposes.

9. Mixing and agitation systems

An even concentration of mixture in the spray tank is important. Therefore, there shall be a good mixing system in the tank to guarantee an even concentration of plant protection products in the water. It is important that the products are solved proper and also that during spraying the concentration stays even.

A well-designed agitation system allows to maintain the concentration of pesticide constant during the whole application process, independently of the amount of liquid into the tank.

Figure 19. New sprayers shall be provided with a well-designed agitation system

10. Induction hopper

If the sprayer is provided with a device for a safe introduction of plant protection products (induction hopper), it shall function properly according the specifications provided in ISO 21278-2. It must be provided with a cleaning system, either for cleaning the empty PPP cans, and for cleaning the inner walls and hoses of the induction hopper itself. Protective net shall be installed at the bottom of the induction hopper in order to avoid inclusion of undesired objects over 20 mm through the feeding hole (Fig. 20). Then, devices for activation and control the whole process shall be placed in a correct and comfortable position considering the placement of the operator during the filling process.

Induction hopper is not mandatory for new sprayers. However, it is really recommended to avoid risk of contamination, both for the operator and for the environment, during the risky phase of mixing and feeding of PPP.

Figure 20. Induction hopper

11. Special requirements for band sprayers

Nozzles must be placed on a band sprayer must allow a uniform maintenance of the relative height over the target. Individual adjustment of every single nozzle must be possible. Nozzle height, nozzle distance and spray angling shall be adjustable according the specific requirements of the intended target (Fig. 21).

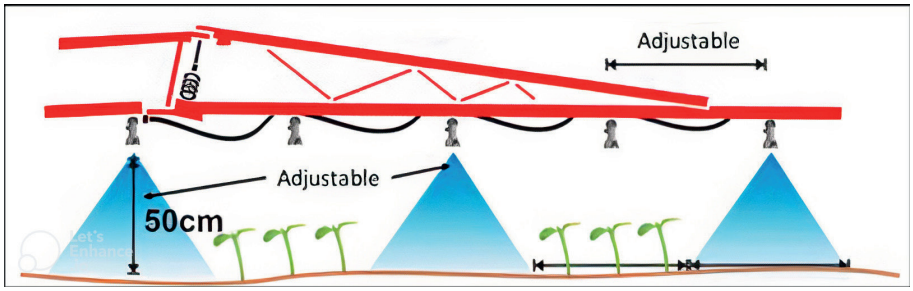


Figure 21. Nozzle height, nozzle distance and spray angle must be adjustable parameters in a band sprayer

The spray liquid distribution, measured according the sprayer's manufacturer, shall allow to obtain the desired working width. The maximum distance between the first point without liquid and the point with 100% of the expected volume shall be less than 50 cm (Fig. 22).

Figure 22. Method for measurement the horizontal distribution with a boom sprayer.

12. Instruction handbook

Manufacturer shall provide the customers with a complete instruction handbook. Clear information about calibration process, maintenance and adjustment, and safety aspects. For boom sprayers, information about residual volume, dilution process, cleaning process and recovery process shall be included. For orchard sprayers information about sprayer's adjustment according the canopy structure and air flow rate adjustment process shall be included as well. Table 7 shows the mandatory information to be included in the instruction handbook.

Other than the mandatory contents of the instruction's book that shall be delivered together with the sprayer, here is enclosed an additional list of information that the manufacturer should be include in the instruction's book.

Table 7. Main aspects to be included in the instruction handbook

Subject	Information to be included in the instruction handbook
Adjustment and calibration process	Detailed explanation about how to adjust the working pressure
	Complete calibration procedure information
	Folding/unfolding method of boom sprayer
	How to proceed in case of blocked nozzle, or other problems during the spraying process in the field.
Maintenance	Maintenance and updating process of the sprayer after the Winter break
	Practical information about how to prepare the sprayer for the winter break
	Precautions to be considered during the cleaning process, especially those concerning to environmental contamination
	Detailed information about maintenance procedure and safety measurements before dismounting pieces.
	Practical information concerning pump substitution
Safety	Practical recommendations to avoid direct contact with plant protection products, or inhalation dangerous vapours.
	Practical information about safe use of front spray boom (if applicable)
	Information about risk of a complete entry on the sprayer's tank
	Check the presence of other persons close to the sprayer before starting; special concerns must be indicated about blower
	Information about potential accident with high electrical lines.
	Information about maximal working pressure of the circuit

For boom sprayers, the additional information will include:

- Residual volume able to be diluted
- Practical method to clean the internal part of pipes/hoses of the boom, without any unintended dilution of the tank mix.
- Procedure for a complete dilution of residual volume in the tank.
- Procedure for recovery process of liquid from suction/pressure filters, without environmental contamination.
- Clear relationship between nozzle flow rate and the established marks for regulation purposes, in case of spray guns or lances.

Additional information should be included in the instruction's book in case of orchard sprayers:

- Information concerning the calibration process of the mistblower, in order to adapt the spray distribution to the canopy characteristics (type, size and height of the trees), including information about fan adjustments, in order to avoid unintended drift or damages to the crop.
- Clear criteria to adjust the air assistance (fan) in order to achieve a symmetrical distribution (left and right).

This last information refers to certain specific adjustments that must be applied over certain sprayers in order to compensate the rotary sense of the fan, and the consequent asymmetrical distribution generated.

13. Look for a certified/inspected sprayer

Inspection sprayers in use became mandatory since the publication of the European Directive for a Sustainable Use of Pesticides. In order to avoid unexpected problems, it is recommended to check that new sprayer has been manufactured following the official requirements. So, it is important to guarantee a high-quality during manufacturing and assembling process.

This aspect is clearly identified in sprayers provided with "CEMA Inspection Seal" (Fig. 23). This sticker will never substitute the official sticker, but it will guarantee a high quality of the sprayer and of the single components. The Inspection Seal helps customers to save time and money: when seeing the Seal on a sprayer, they can rest assured that the machine – if properly used and maintained – will pass the in-use inspection (EN ISO 16122). Additional information is available at http://www.cema-agri.org/cema-inspected.

Figure 23. "CEMA seal" together with a regional/national official sticker guarantee the quality of the sprayer and the accomplishment of ISO 1622. The presence of the CEMA seal do not mean that the sprayer has pass the mandatory periodical inspection if not there is also the official……

14. ENTAM: guarantee for new sprayers

ENTAM, the European Network for Testing Agricultural Machines, is constituted by the official testing stations in several countries in Europe. The tests protocols for pesticide application equipment are based on national, European or international standards, and can provide the manufacturer with useful information on ways on which to improve its machinery. An ENTAM approval implies a complete fulfilling of the requirements for new sprayers. See additional information at https://www.entam.net/index.html.

Figure 24. ENTAM recognized sprayer. Sprayers with ENTAM logo will accomplish all the official requirements

15. STEP-WATER: on-line advice on sprayer technology

A new on-line advice, STEP-WATER (Fig. 22) has been developed by ECPA and CEMA with the objective to offer a practical and friendly tool to select the optimal sprayer's settings in order to achieve a safe and sustainable use of pesticides. Detailed information can be found at: https://step-water.org

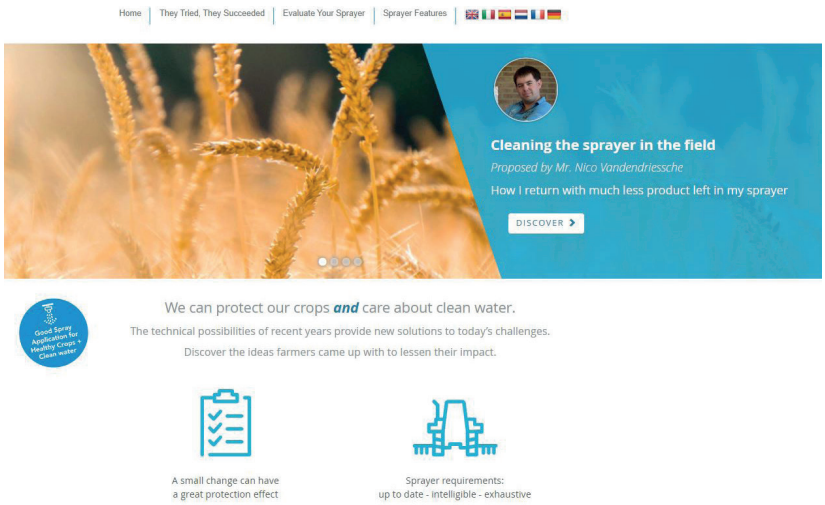


Figure 25. Main screen of STEP-WATER on line-tool, a useful platform to protect water during the spraying application process

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SPISE – Standardized Procedure for the Inspection of Sprayers in Europe

Established in 2004 by founding members from Belgium, France, Germany, Italy and the Netherlands, the SPISE Working Group aims to further the harmonisation and mutual acceptance of equipment inspections. In regular meetings, several Technical Working Groups (TWG) 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. The present document is intended to provide technical instructions and describes

a procedure which is not mandatory but can be voluntary adopted in the course of inspection or calibration.

Further information can be found at **https://spise.julius-kuehn.de**

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Publisher

Julius Kühn Institute - Federal Research Centre for Cultivated Plants
Erwin-Baur-Str. 27
06484 Quedlinburg (Germany)

ISSN: **2364-7574**
DOI: **https://doi.org/10.5073/20230112-112848**
February 2023