First results from the inspection of soil-disinfection equipment in Belgium.

J. Declercq¹, G. Defays², D. Nuyttens¹, B. Huyghebaert²

¹Institute for Agricultural and Fisheries Research (ILVO), Technology & Food Science Unit - Agricultural Engineering – Burg. Van Gansberghelaan 115 – 9820 Merelbeke - BELGIUM
²Agricultural Research Centre (CRA-W) – Agricultural Engineering Department Chée de Namur 146 – 5030 Gembloux – BELGIUM

Contact: johan.declercq@ilvo.vlaanderen.be

Summary

In Belgium, the mandatory inspection of field and orchard sprayers was already started up in 1995[1]. At that time there were only inspection protocols available for those two types of sprayers. From 2008 on, two new inspection protocols were developed: one for greenhouse sprayers and an in-house developed one for soil-disinfection machines[8]. Those inspection protocols were added to the Belgian legislation and implemented from 2011 on[7]. The new protocol for soil-disinfection equipment was developed after an evaluation of existing soil-disinfection machines and was mainly based on the existing Belgian protocols. Due to some safety aspects, the inspection from soil disinfection machines was finally started up in 2014. At this moment, all known soil disinfection machines used on the Belgian territory have been inspected once. Following the inspection of those machines, Belgium felt the need to make some additional changes to the existing first protocol. Some inspection limits were too narrow, some items were inapplicable and new inspection items were added. Those changes were implemented and at this moment, the updated inspection protocol is ready for publication and will be implemented from 2017 on. Based on this new adapted inspection protocol, Belgium also prepared a SPISE advice. The first inspection results and problems encountered during the first inspections will be presented in this paper.

Key words: sprayers, soil-disinfection, safety, inspection, results, defects

Introduction

Since 1995 sprayer inspection is mandatory in Belgium which makes it one of the forerunners in Europe[2]. At that time, the bad technical condition of the sprayers, the excessive supplementary costs for the farmer arising from an inefficient pesticide use, the negative impact on the environment and the necessary restructuring of the European Agriculture to keep it competitive after the CAP reform and GATT negotiations, were the main reasons for the implementation of the sprayer inspection[3]. Now, the Framework Directive for a sustainable use of pesticides introduces the inspection of all pesticide application equipment in professional use in Europe.

In many ways, the mandatory inspection of sprayers in Belgium differs from inspections in other European countries. The FAVV/AFSCA (Federal Agency for Food Security) is responsible for the inspection but it delegates the inspection to two regional bodies: ILVO (Flemish region) and CRA-W (Walloon region). Both official inspection bodies are BELAC accredited according to ISO 17020 which guarantees a maximum quality of the performed inspections. The inspection teams (3 in the Flemish region and 2 in the Walloon part) are equipped with a test van that contains all necessary equipment to perform the inspections according to the Belgian federal legislation. The inspections are carried out at a neutral location where farmers/contractors are invited at an exact date and time to present their sprayer for testing. All over the country, test locations are hired so that farmers/contractors don’t need to
travel distances above 15 km. On demand inspection teams also perform inspections at the farmyard, but therefore an extra fee is charged. The inspection procedure is based on the analytical principle which means that all parts of the machine are tested separately. After the inspection the farmer/contractor receives a certificate confirming the approval of the sprayer for the next three years or specifying all the items that need to be repaired in case of a rejection. No repairs are made to the sprayer during the inspection. Consequently, the repaired sprayer has to be represented for a second passage. The inspection of soil disinfection machines was started up in 2014[7]. This paper describes the working principle, the inspection protocol and the first inspection results.

**Working principle of a common soil-disinfection machine.**

Figure 1 shows a picture of a typical soil-disinfection machine while Figure 2 shows the corresponding hydraulic scheme containing all elementary parts[7].

![Fig. 1 Typical soil-disinfection machine.](image)

![Fig. 2 Hydraulic scheme of a soil-disinfection machine.](image)
Briefly one could divide the scheme into two main parts. On the one side you have the air pressure part (parts 1-8) and at the other side the liquid pressure part (parts 9-17).

As concerns the air pressure part, in most cases, a battery or hydraulically powered compressor (1) is used to pressurise the air-pressure tank (2), but it has to be mentioned that some specialised companies use a scuba tank for pressurising the pesticide tank (10). A pressure gauge (3) on the air pressure tank indicates the available air pressure. A valve (4) between the air pressure tank and the pesticide pressure tank (10) is available to shut off the air pressure between both tanks. Between the air pressure tank and the pesticide pressure tank, a pressure valve (5) makes it possible to adjust the air pressure in the pesticide pressure tank (10) based on a pressure gauge (6). There is also a safety pressure valve (7), and a pesticide tank depressurizing valve (8) to safely depressurize the pesticide tank.

At the liquid side the metal pesticide pressure tank (10) is sealed hermetically and there is a filling valve (9) to fill the tank with the soil-disinfectant. There is an optional pressure filter (11) and a main shutoff valve (13). A distributing block (15) with restrictor plates, small taps or narrow tubes distributes the liquid to the different injectors (17). Optionally an analogue or digital flowmeter (12) and an extra flow regulating valve (14) can be installed to fine-tune the flow. An extra pressure gauge (16) on the dividing block (15) is interesting to read out the pressure at the injector.

The Belgian inspection procedure for soil disinfection machines

In most of the EU countries the inspection is performed by workshops and sprayers can be repaired – if necessary- during the inspection. So finally each machine leaves the workshop with a valid inspection. In Belgium, no reparations are made during the inspection which involves that the owner needs a detailed description of each defect[7].

As a consequence the Belgian inspection methodology is based on the analytical principle which consists in checking separately and independently the performance of the different parts of the machine. Up to 33 criteria are checked in the updated protocol for soil disinfection machines. Some are checked visually (tank contents indicator, ploughshares, etc.) while others are measured (injector flow rate, pressure gauge, etc.). All observations are encoded and stored in a computer with tailor-written software. The analysis is done partly automatically and partly by the inspector, and the inspection report is printed on site. In this report, all dysfunctions are listed and classified according to their seriousness to disturb machine performance, together with advice on how to repair the defect. The combined analysis of the dysfunction and its cause allows to determine the weight of this dysfunction in the inspection results. The dysfunction leads to a rejection if it significantly disturbs injecting results or safety or if its origin is imputable to the user (lack of maintenance). Moreover, dysfunctions leading to a rejection always have to be determined in an objective way based on measurements. Thus, not all checked criteria can lead to a rejection of the machine. From the 33 checked criteria, and from 2017 on, only 9 can potentially lead to a rejection of the soil-disinfection machine[7].

The defects observed during the diagnosis are divided into three different categories[4]+[6]:

Category I are defects that automatically result in a rejection and must be repaired within four months. Within this period, the machine must be retested.

Category II defects do not result in rejection, but should be repaired before the next inspection. This means that the user has three years (= one inspection cycle) to repair these defects.
Defects of category III are only informative and aim at improving the general operation of the machine. The user is free to follow these recommendations.

**Overview of the defects of soil disinfection machines**

This overview is based on the inspection results obtained in the 7th inspection cycle (2014-2015-2016) in the Flemish region. In this period, only 16 machines were notified and also inspected. No machines were rejected because only four category I defects were defined and inspections were considered as “trial” inspections with a legal base.

**Defects of category I**

The first inspection protocol was considered as a “trial” one and rejections were only possible for four items:

- Bad attachment of the machine to the tractor;
- No pressure gauge;
- Major leaks;
- Worn nozzles and inhomogeneity of the nozzles.

No real problems were encountered for the first three items. All machines were well attached to the tractor, and there was a pressure gauge present on every machine. There were also no major leaks (>30ml/min).

For the last point, problems were found on a lot of machines. The original intention was to use the analytical method to inspect the injector flow by testing the nozzles or calibrated plates on a nozzle test bench, and measuring the injection pressure on the machine. The first inspections showed that it is difficult, and for some machines even impossible, to use the analytical principle to measure and evaluate the injector flow. Some soil disinfection machines use small tubes, others a section block with self-made calibrated plates, or calibrated plates per injector at injector height, and others use small taps to calibrate the flow for each injector. But even for machines using nozzles or calibrated plates, it was decided not to use the nozzle test bench inside the test van, because of contamination with the hazardous disinfectants. For the above reasons, it was decided to measure the injector flowrate on the machine for all soil-disinfection machines using buckets in combination with a stopwatch and weighing scale or using an orchard test bench, depending on the type of injector. This method results in individual flowrate values for each injector and the overall distribution pattern.

A lot of problems were encountered during those tests and 50% of the machines should have been rejected when following the protocol. However the use of the legal terminology “nozzles” was not correct and during those first inspections it became soon clear that the tolerance limit was quite narrow. It was therefore decided to move this item to a lower category II classification for this first inspection cycle.

**Defects of category II**

Figure 3 shows an overview of the category II defects encountered during the first inspection cycle. An uneven injection pattern was the main problem encountered (50% of the machines). The criterion used was that the flow rate at an individual injector should not differ more than 5% from the average flow rate from all injectors. This is what was legally applied for “nozzles” with unknown reference. This limit was quite narrow and after the
first inspections and discussions in the Belgian technical committee, the 5% limit was increased to 10% which will be used in future. Even with this 10% limit, 6 out of 16 machines did not fulfil this requirement! Main reasons are a bad design and a lack of maintenance.

Fig. 3 An overview of category II defects for soil disinfection machines during the first inspection cycle (2014-15-16).

Figure 4 shows a typical bad pattern from a bad designed soil disinfection machine, where individual flow rates range from 0.54 l/min (injectors 6 and 7) up to 0.72 l/min (injector 1). A decrease in flow rates can be observed from injector 1 to 7 probably caused by different lengths of the feeding tubes of the injectors, in combination with a dividing block that is dimensioned too narrow. The low flow rate on injector 3 can probably be solved by cleaning the calibration plate.

Fig. 4 Flow distribution and picture from machine number A13300016.
Figure 5 shows the pattern from a machine using a dividing block with calibrated plates where a low flowrate was observed at injector 7. The reason here is that the 7th injector is not always used and was therefore partially blocked.

Fig. 5 Flow distribution and picture from machine number A13300004.

Both examples show that a simple pattern test can show relevant problems on the machine. This test can also easily be performed by the owner himself. Furthermore all machines were equipped with one or more pressure gauges. In all cases, a pressure gauge was mounted on the pesticide tank to measure the air pressure. In some cases, another pressure gauge was present on the liquid circuit.

The pressure gauges are dismantled from the sprayer and tested on a pressure test bench. When the deviation is higher than 10% then the pressure gauge needs to be replaced. This was the case for 3 out of 16 machines. Two machines also showed minor leakages (< 30 ml/min).

With one machine there was a problem with the capacity of the compressor resulting in two remarks “repair or replace the bad working compressor” and “pressure instability”. This particular machine used a compressor driven by the tractor hydraulics (Figure 6). Even at the normal nominal working rpm of the tractor, the working pressure dropped after a certain time and could not be maintained, probably because the compressor of this self-made machine was malfunctioning or bad dimensioned.

Fig. 6 Machine with a hydraulically driven compressor.
Another remark given to a machine using nozzles and after separate testing on the nozzle test bench, was for a worn nozzle (Figure 7).

**Fig. 7 Machine using nozzles underneath a ploughshare.**

And at last a machine was given the remark bad state of the moving parts protection. This remark concerned a machine with no protection of the driving chain from the roller.

**Defects of category III**

Those defects are less important, but their reparation will improve machine performance or user comfort and safety.

**Fig. 8 An overview of category III defects for soil disinfection machines during the first inspection cycle (2014-15-16).**

These remarks can be grouped into two main categories: remarks concerning the tank contents indicator and remarks about the lack of filters.
Three machines did not have a tank contents indicator. In most other cases, the tank contents indicator was almost unreadable. Figure 9 shows two of these examples where it is difficult to read the tank level. For the right picture it would be better to put measuring marks on the tank.

![Bad tank contents indicators.](image)

At last, a lot of machines showed problems with the filters. For most of them, no filters at all were present in the liquid circuit. Despite the fact that the pesticide is putted in the tank in its pure form, there were some problems with blocked injectors. It should therefore be considered to mount at least one filter in the liquid circuit. Figure 10 shows a machine without any filtering. This machine was given the advice to use nozzle filters as the easiest solution, because the machine used standard nozzle holders.

![Machine without filters using standard nozzles.](image)
Remarks notified without a legal base

During the first inspections it became soon clear that there were some aspects which were not present in the first inspection protocol. The inspection from those items was performed -if relevant- and noted manually on the inspection reports. Most of them are now implemented in the updated inspection protocol.

Some important safety aspects were observed. For a lot of machines the main tank filling valve (Figure 11A) did not had a safety system to prevent unintended opening. This can cause dangerous situations because if the valve is opened with a pressurized tank, the air with hazardous vapours might be blown towards the operator or bystander. Other machines did not have a tank depressurising valve with a tube that leads the air-flow downwards (Figure 11B). And at last there were machines that missed a safety valve (Figure 11C).

Fig. 11 Pesticide tank with unsafe filling valve (A), safe depressurising valve (B) and safety valve (C).

Most machines are also equipped with a flow meter[5]. In those cases, fine tuning the liquid flow is based on the flow meter and not based on the pressure gauge. No testing was foreseen in the first inspection protocol. Because of its importance the actual measured flow was compared with the flow indicated by the flow meter. None of the flow meters showed inaccuracies above 10%. All these items were introduced in the new protocol.

Conclusions

Because of their specific construction and working principle, there was a need to develop a completely new inspection protocol for soil-disinfection machines. A first inspection protocol was established and implemented. The first inspections revealed some additional problems that needed to be solved. An updated and well balanced inspection protocol was developed and will be used from 2017 on.

The owners of the soil-disinfection machines are -as much as possible- involved in the actual inspection and they are given advice during the inspection. All test results are registered in an official test report.
References


