

## A test method to assess operator safety using Closed Transfer Systems

Jens Karl Wegener, Matthias Kemmerling, Jan-Philip Pohl, Eckhard Immenroth

Institute for Application Techniques in Plant Protection, Julius Kühn-Institute, Federal Research Center for Cultivated Plants, Messeweg 11/12, 38104 Braunschweig.

### Summary

Closed transfer systems (CTS) are devices for the contactless transfer of plant protection products (PPP) into pesticide application equipment (PAE). They are intended to protect the operator against contamination with undiluted PPP during filling of the sprayer. CTS are universal and can be mounted on a wide range of different types and sizes of PAE. They are able to transfer the PPP from container of diverse sizes, enable also partial draining and containers can be easily rinsed after complete emptying.

At the moment there is no reliable information about the contribution of CTS to operator safety. For this reason a test method was established in order to compare the operator's contamination after the dosing process using CTS and conventional filling into the PAE. Aim of the project was to quantify the dermal exposure at different parts of the operator's body.

Instead of PPP a mixture of water and a fluorescent tracer (Pyranin) was used. It was filled into 10-Liter-containers and sealed. The operator was equipped with Personal Protective Clothing which was washed after the filling process in order to determine the amount of contamination on different parts of the body by using fluorometry. The different filling processes were performed by 3 different persons with 5 repetitions per setting using an attached field crop sprayer (RAU D2) with a CTS mounted on the induction hopper and also on the dome shaft.

The results show that CTS can significantly help to minimize operator exposure in comparison to conventional filling and that the test procedure established is able to fulfil the defined aims of testing CTS.

### Introduction

In a draft paper (EU 2015) the European Commission demands the assessment of negligible exposure to an active substance in a plant protection product (PPP) under realistic conditions of use. Among other things this applies for the exposure of humans in particular during the filling process of pesticide application equipment (PAE) when the operator is exposed to contamination by undiluted PPP. These new requirements concerning negligible exposure can have an impact on the future capability for the approval of PPP. Against this background Closed Transfer Systems (CTS) can due to their working principle contribute to operator safety and could be a technical solution to fulfill the requirements of negligible exposure.

CTS are devices for the contactless transfer of PPP into PAE. The working principle is based on a connection port which can be mounted on the sprayer and an adaptor on the sealed PPP canister. Once both units are connected to each other the system is ready for filling and it protects the operator against contamination with undiluted PPP. The unsealing of the canister happens with an internal mechanism within the system. CTS are universal and can be mounted on a wide range of different types and sizes of PAE. They are able to transfer the PPP from containers of diverse sizes, enable also partial draining with precise dosing and allow an easy rinsing of the containers within the closed system once they have been emptied. Before the connection between port and adaptor is unlocked the contact surfaces can be rinsed, too. The adapter remains on the container until it has been completely emptied.

At the moment there is no reliable information about the contribution of CTS to operator safety. In order to consider the advantages of CTS within the process of authorization of PPP it is necessary to make an assessment comparing the operator exposure based on conventional filling against those using a CTS under realistic conditions of use. Aim of this work was to develop a testing routine for the assessment of operator exposure using CTS in comparison to conventional fillings.

## Materials and Methods

In order to determine the operator exposure different varieties of fillings of a field crop sprayer (RAU D2) were simulated by different persons wearing protective clothes. Instead of PPP, water and a fluorescent tracer (Pyranin from Lanxess company, concentration of 5g/l) was filled into PPP-canisters of different sizes (1, 5, 10 liters) which have been sealed afterwards. After the filling routine of PAE done by a person in protective clothes the protective clothes were rinsed off by hand or washed separately in a washing machine (Miele W1 classic). Afterwards, the collected rinsing/washing water was analyzed using fluorescence spectroscopy (Kontron Instruments SFM 25).

The distribution of the exposition on the operator was detected by using five different dosimeter: a whole-body counter consisting of an overall (65% cotton, 35% polyester) and long underwear (95% cotton, 5% elastane), one-way laboratory gloves (semper guard nitrile powder free) worn beneath nitrile protective gloves (KCL Camatril) and a protective visor (EKASTU k1 plus). The long underwear and the one-way laboratory gloves were used in order to determine the total body exposure even for the case that the protective clothes are not free of leakage.

The experimental setup was divided into two steps. First, seven different operators had to do a conventional filling using the induction hopper of the field crop sprayer using all different sizes of the PPP-canisters. The canister size leading to the highest operator exposure was then chosen as worst-case scenario for further experiments.

In a second step three operators did a conventional filling of PAE using a) the dome shaft and b) the induction hopper of the field crop sprayer which was then compared against a filling with a CTS mounted on top of c) the dome shaft and d) the induction hopper. Each setup was carried out with five repetitions. After each repetition the protective clothes were taken off and boxed for later analysis.

The washing of the overalls and underwear was carried out three times directly after each other for each piece by using the program "Express 20" at a water temperature of 30°C and a water volume of 17 liters. The water from the first and second washing was used for the determination of the tracer content, the water from the third washing for the definition of the blank value. In order to avoid measuring errors due to different water qualities the washing water was completely demineralized (AFT VE-Station 100 Mono) and the electrical conductivity was measured continuously for monitoring the quality. Cause of textiles fibers within the washing water influencing the working quality of fluorescence spectroscopy and its results the washing water was filtered before analysis using a stainless steel filter (Retsch test sieve) with a mesh size of 250µm.

The protective gloves, the one-way laboratory gloves and the protective visor were rinsed off by hand (protective and one-way laboratory gloves: 200ml; visor: 400ml) with distilled water.

In order to achieve reliable results it is necessary to calculate the detection limit and the determination limit. The detection limit is defined to be the sum of blank value plus triple standard deviation. Only if results of fluorescence spectroscopy are higher than the detection limit (LOD) it can be assured that there is tracer within the tested sample. A quantification of the tested sample is possible, when the result is above the quantification limit (LOQ). This is defined to be the sum of blank value plus nine fold the standard deviation. In terms of the results this means that all values beneath LOD are defined to be zero. Values measured between LOD and LOQ are considered to be at the average value between both limits. After calculating the concentration based on the aforementioned data the absolute tracer mass can be determined:

$$m = \frac{(x - B)}{a} \cdot V_{wf} = c_p \cdot V$$

with

m = mass of tracer

x = measured value (including limit definitions)

B = blank value

a = gradient of calibration curve

V = volume of rinsing/washing fluid

c<sub>p</sub> = concentration of probe

For the determination of tracer amount which could be found on the dosimeter the volume was calculated with the above mentioned tracer concentration (5g/l):

$$V_d = \frac{m}{c_0}$$

with

V<sub>d</sub> = volume of tracer on dosimeter

m = mass of tracer

c<sub>0</sub> = initial concentration of tracer within canister

Within pretests the retrieval rate was determined for all dosimeters, too. For this purpose an amount of 50µl tracer was dripped onto the specific dosimeter, washed out and analyzed as described before. The retrieval rate defines the analyzed amount of contamination compared to the amount of the known contamination:

$$R = \frac{V_d}{V_0} \cdot 100\%$$

with

R = retrieval rate

V<sub>d</sub> = measured volume of tracer

V<sub>0</sub> = initial volume of tracer

The statistical analysis was done by calculating mean value and standard deviation of the results. As usual for considerations of operator safety under long term conditions a 75-percentile evaluation was done afterwards (EFSA 2014).

## Results

The result of the first experimental setup is that the exposure for the operator is the highest using a 10-liter-canister (fig. 1). Against the background of conventional filling tracer was found predominantly on the protective gloves. Contaminations of the overall were detected in several cases but not with the 1-liter-canister. Furthermore, a small contamination of the underwear was found. These figures were all between the detection and determination limits. For this reason the diagram shows the average value between those two limits. But, pre-trials have shown that washing and drying the underwear had a small effect on the basic fluorescence of the material. Since the contamination of the underwear does not fit with the values found for the overall using a 1-liter-canister, and the values for the other canisters are at same level, the measured values are in all probability not due to contamination with tracer. Because of these results the 10-liter canister was chosen as worst-case scenario for the second experimental setup.

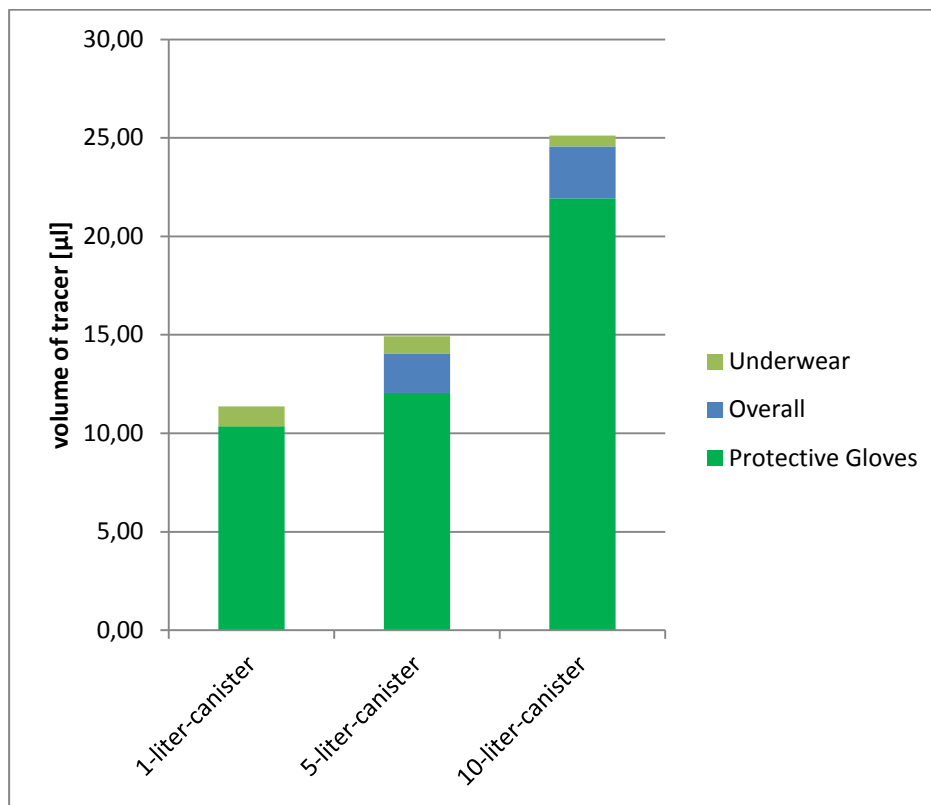


Figure 1. Exposure of different dosimeters by performing a conventional filling using the induction hopper of a field crop sprayer (RAU D2) in dependency of different canister sizes

Figure 2 shows the results of the second experimental setup. One can see that contamination on level of 75-percentile could only be found on the protective gloves and on the overall. A small contamination of the underwear between detection and determination limit was found in one case. This contamination is probably based on material effects as already mentioned above. There was no contamination on other dosimeters (visor, one-way laboratory gloves) used. From these results one can conclude that CTS can reduce the exposure of the operator significantly. If the CTS is mounted on the induction hopper instead on the dome shaft the expected exposure can be reduced further.

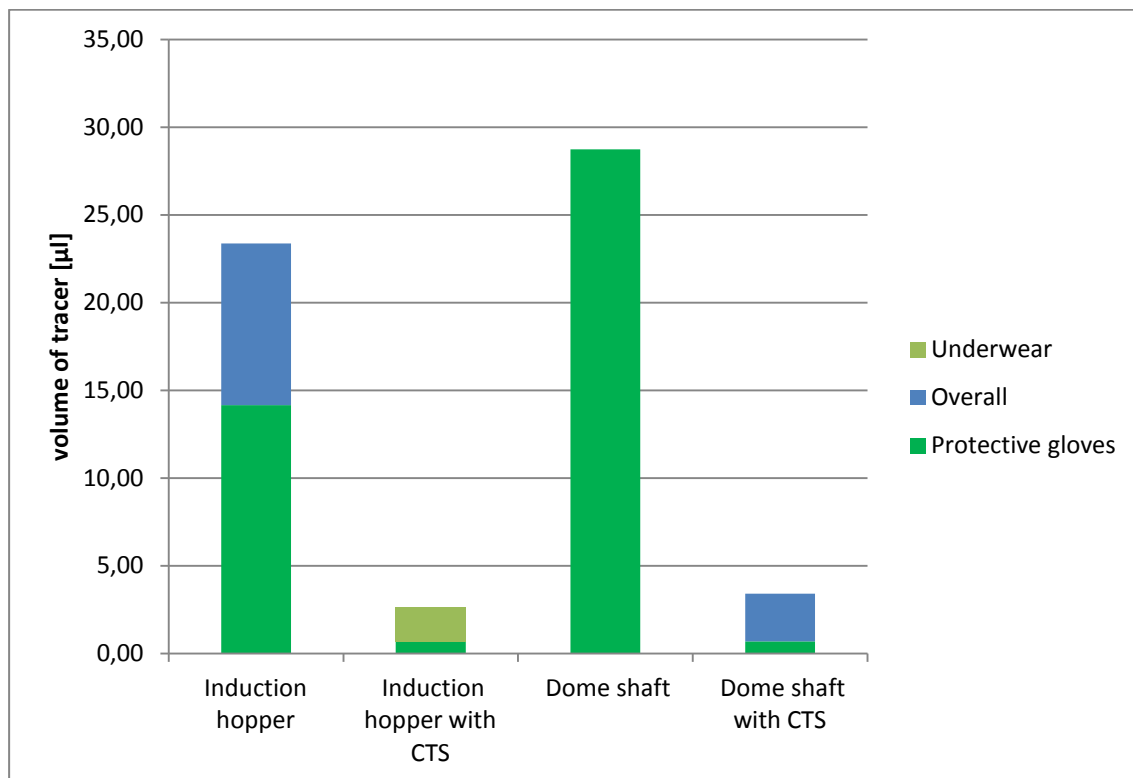


Figure 2. Total exposure of the operator performing different filling procedures on a PAE (RAU D2) with and without using CTS

The retrieval rate of the dosimeter was determined in separate experiments under field conditions. The mean retrieval rate was 83,22% for overall and 99.9% for the protective gloves.

## Conclusion

The method presented in our study is able to assess operator exposure when using CTS in comparison to conventional filling of a PAE. It can be shown which parts of the operator's body are endangered for contamination with PPP. Furthermore, the developed method is able to quantify the operator exposure in an ensured and reproducible way. Based on the results only protective gloves and overall are needed as dosimeters for future assessments of CTS performance.

## References

EU (2015): Commission Notice - Technical guidance on the interpretation of points 3.6.3. to 3.6.5, and 3.8.2 of Annex II to Regulation (EC) No 1107/2009, in particular regarding the assessment of negligible exposure to an active substance in a plant protection product under realistic conditions of use. DRAFT - May 2015, 17 pages.

Hilz, E., and Vermeer, A.W.P. (2013). Spray drift review: the extent to which a formulation can contribute to spray drift reduction. *Crop Protection*, 44: 75-83.

Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides. <http://eur-lex.europa.eu/eli/dir/2009/128/2009-11-25>

BS EN 13790-1:2003. Agricultural machinery. Sprayers. Inspection of sprayers in use. Field crop sprayers.

ISO 16119-1:2013. Agricultural and forestry machinery - Environmental requirements for sprayers - Part 1: General.

EFSA (2014): Guidance of EFSA – Guidance on the assessment of exposure of operators, workers, residents and bystanders in risk assessment for plant protection products. EFSA Journal 2014