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Standardisation – one way for better protection of operators against pesticides

Part 2: Cabs on tractors and self propelled sprayers

The use of pesticides is possibly connected with risks for the environment and for the bystanders, but also for the farmer himself. All possible risks must be diminished to acceptable levels by active technical means of reduction or ultimately protective equipment must secure the working conditions. Means of protection are machinery bound cabs or personal protective equipment (PPE). Classification and definition of types or categories of protection are classical tasks for standardisation. Since November 2009, EN 15695 with two parts is in force defining four categories of cabs and introducing methods for testing.

Keywords
pesticide, operators' protection cabs, cabs on tractors, performance, leakage flow, cabs efficiency

Abstract
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To secure human nutrition cultivated plants or fruits must be protected against all possible diseases to minimize losses, world wide. Therefore different means are undertaken, starting from mechanical removal of weeds or collecting varmints up to the use of plant protection products (PPP). Unfortunately chemicals are possibly connected with a risk potential for the environment and human beings. With view to a holistic approach all kinds of possible ways of uptake or exposure must be considered – inhalative, respiratory and dermal - for all cultivations and steps of work. Machinery bound the installation of a cab is the most comprehensive solution. **Figure 1** shows an example of a boom sprayer in the field.

On September 30, 2006, CEN received the mandate by the Commission to create standards of performance and for testing of cabs used in agriculture with focus on pesticide application. After the prescribed limited 36 months since November 2009 the two parts of EN 15695 (part one deals with cabs [1], part two deals with filters [2]) are in force: four categories of cabs are defined and test methods installed, to ensure a required efficiency of a cab. According to the European directive for spraying pesticides category 4 cabs are prescribed.

In the following EN 15695 [1] is presented defining the categories and describing the two performance test methods. First results concerning the application of the tests are given for two cabs of different manufacturers.

Performance of cabs

To ensure the same quality of protection due to PPE by a cab, in the end the reduction coefficients of PPE must be kept by the full system of the enclosure. In detail this implies the following performance requirements on a cab:

- fully closed structure
- force-ventilated (air-conditioned)
- over pressurized - tight against leakages
- tight against particles
- tight against gases and vapours

The new European Standard is divided into two parts which either target the manufacturers of cabs (part 1) or the manufacturers of filter elements (part 2):

Fig. 1

Cab equipped tractor with boom sprayer

EN 15695 Agricultural tractors and self-propelled sprayers, Part 1: Cab classification, requirements and test procedures,

EN 15695 Agricultural tractors and self-propelled sprayer Part 2: Filters, requirements and test procedures.

The following mainly deals with part 1, the categories of cabs and test procedures concerned.

In clause 4 of part 1 the four categories of cabs are defined:

- Category 1: no defined level of protection against hazardous substances.
- Category 2: protection against dust.
- Category 3: protection against dust and aerosols.
- Category 4: protection against dust aerosols and vapour.

While category 1 cabs are more or less open structures without forced ventilation systems, all other categories require enclosures in which filters can be mounted and which prevent entrance of unfiltered air into the cab. A minimum flow of 30 m³/h is demanded. Additionally the cabs must be over-pressurized with a minimum of 50 Pa pressure under test conditions. If a reading of pressure is foreseen or prescribed in the two higher categories 20 Pa must be ensured. All these cabs must be equipped with filters depending on the categories given above.

Category 4 cabs must be equipped with an aerosol filter with a separation efficiency of 99.95 % and an additional charcoal filter to separate volatile components of the sprayed pesticide. Only this specification with the demand of a charcoal filter distinguishes category 4 from category 3.

Test methods for detection leakage flow and cabs efficiency

The protection efficiency of a cab depends on its tightness against penetrating loaded ambient air through wanted or needed and non wanted openings in the cab's structure. **Figure 2** shows possible ways of air flows into the in-cab room, the drivers working environment.

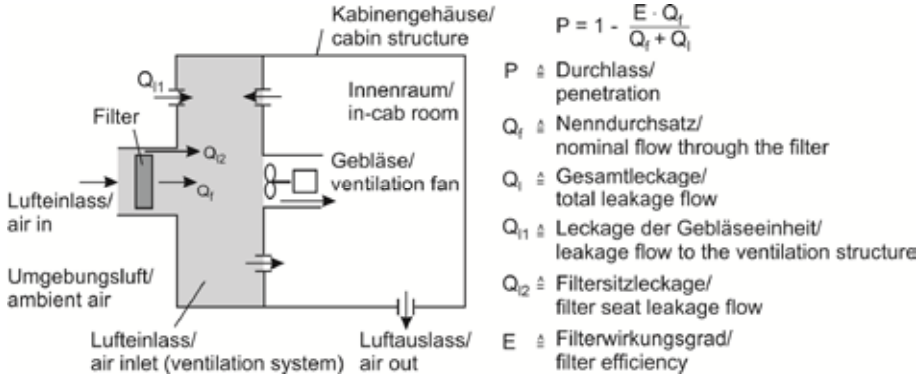
The protection efficiency is mainly a function of filter efficiency, which takes care that loaded intake air will be cleaned to a required level. But the filter efficiency is not always the efficiency of the cab. By leakage flows hazardous substances can be carried into the cab with the unreduced concentration of the surrounding atmosphere. Leakage flows are driven by pressure and are most effective at the use of highly efficient filters. To estimate the effect of leakage flows the EN 15695-1 defines two possible methods, Annex B, measuring leakage flow, and Annex C, determination of cabs efficiency.

Measuring leakage flow with the blind filter method

In **Figure 3** the detection of leakage flow with the so called blind filter test is shown.

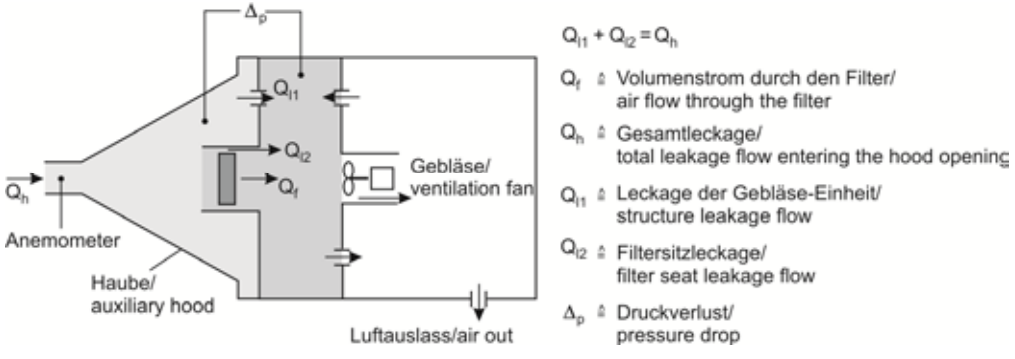
The air inlet of the air intake system is equipped with an auxiliary hood with a defined opening. In this opening the air

Fig. 2



Ways of air flow into an in-cab room, scheme

Fig. 3

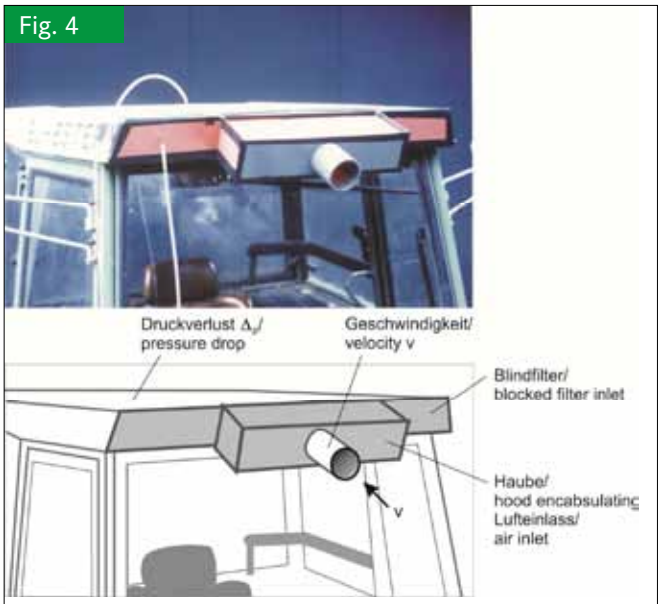


Test assembly for determination of leakage flow

velocity is measured using an anemometer for nominal flow with the open filter. After this the filter will be blocked. The measured air velocity arises from leakage flow through the whole air inlet system. The ratio of the both velocities is given as relative leakage and should be below 2 % of nominal flow. This method was developed in a previous stage of standardization on ISO level and was also introduced for testing automotive filters.

Less leakage means low velocity. Commonly used fan wheel or hot wire anemometers are not able to detect velocities below 0.2 m/s and by this a limit is given for the procedure apart from the use of e. g. Laser Doppler anemometer (LDV). An increasing velocity needs smaller openings with higher pressure drops which means higher driving force than in nominal work of the system. **Figure 4** shows an example for a blocked filter unit with a hood encapsulating nominal air inlet and the array to measure air flow velocity and pressure drop.

Fig. 4



Practical example for determination of leakage flow

Determination of cabs efficiency - aerosol test

In case that the blind filter method does not work or cannot be applied due to design of the ventilation system of the cab the additional method according to Annex C is introduced to calculate the efficiency of a cab by the ratio of inside and outside concentration of tracer particles. A minimum value of 98 % cabs efficiency is requested. **Figure 5** gives a schematic view to the test procedure.

For the test the cab is situated in a large closed room in with a homogeneous field of salt-particles. Samples are taken from the air inlet and the breathing zone of the driver inside the cab. The samples are analysed with optical particle counters simultaneously.

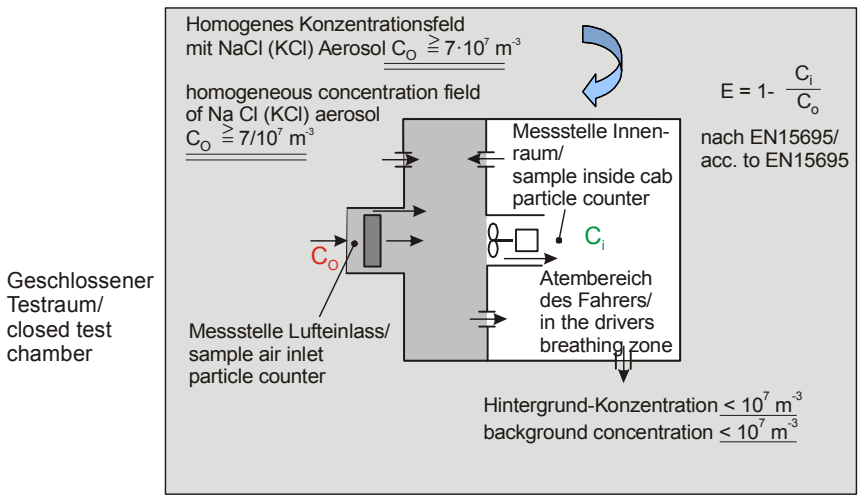
Unfortunately the standard does not specify the large room compared to the dimensions of the cab situated inside and how it will be possible to get the requested homogeneous field of salt particles and how to check it. Also information about types of appropriate aerosol generators and how to feed the aerosol is missing in the instructions for this test.

Detection of leakage flow and cabs efficiency, first experiments and results

To get a feeling how to implement the EN 15695 into practical use first tests were made to detect leakage flow and to determine the efficiency of a cab. Two different cabs were available as candidates for category 4. Correspondingly the maximum allowable leakage flow is 2 % from nominal flow and the efficiency must be not less than 98 %.

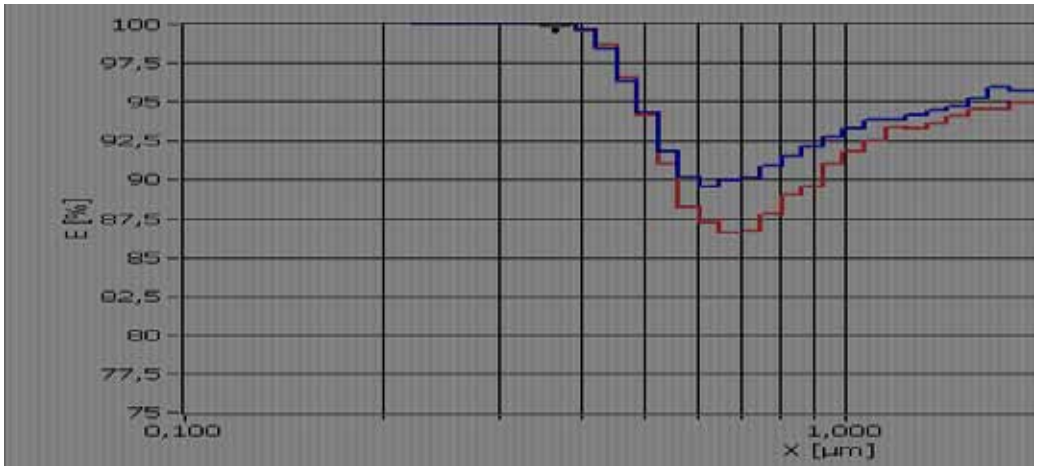
For measuring particle concentration inside and outside the cab a PALAS Promo system with 2 sensors type 2300 and 2070 was installed. From the quasi simultaneous downstream

Fig. 5



Test assembly to measure the protection efficiency of cabs

Fig. 6



Efficiency of a ventilated cab against salt particles

and upstream measurements the efficiency E was calculated directly by the internal software.

According to EN15695 the cab was mounted in a closed room with the dimensions 6,18 x 4,63 x 3,69 m and a volume of 105 m³. The salt aerosol was generated with a mist blower inside the test chamber.

Figure 6 gives an impression on the fractional separation efficiency of a cab.

The air inlet of the cab in **Figure 7** is one opening at the backside. An auxiliary extension is fitted to get a sufficient opportunity to measure air velocity on nominal run as well as leakage flow with a blocked filter. Air velocity was measured using a hot wire anemometer.

The clear and simple arrangement was also used for feeding the air supply directly with salt aerosol which was generated using a PALAS AGK 2000. For particle counting again the Palas equipment was used.

Fig. 7

Test assembly to measure the protection efficiency according to the aerosol test

The results showed that both method are compatible. At the end a leakage flow of less than 2 % of nominal flow rate and an efficiency of 98 % or more were measured for both cabs.

Conclusion

- It is agreed that pesticide applicators need protection by PPE or machinery bound cabs
- According to the rules of the EU, PPE must be tested and certified
- This rule must be also applied if cabs shall substitute PPE
- Performance requirements and tests for cabs are given in EN 15695-1/2
- Four categories of cabs have been introduced
- Category 4 must be equipped with HEPA filter (high Efficiency Particulate Air Filter) against particles and charcoal filter against gases
- European regulation only admits category 4 for the use in plant protection
- Performance tests by detection of leakage or determination of cabs´ efficiency are requested
- First trials showed that new cabs can fulfil the requirements of category 4
- Both tests, the blind filter and the aerosol test need a high degree of experience
- Clear rules for the aerosol test are needed
- The new standard is a necessary step for farmers protection, but especially part 1 should be revised as soon as possible

This paper is a revised version of a presentation at XXXIV CIOSTA & CIGR Section V, Conference, Vienna 29 June–1 July, 2011

Literature

[1] EN 15695-1:2009. Agricultural tractors and self-propelled sprayers - Protection of the operator (driver) against hazardous substances - Part 1: Cab classification, requirements and test procedures

[2] EN 15695-2:2009. Agricultural tractors and self-propelled sprayers - Protection of the operator (driver) against hazardous substances - Part 2: Filters, classification, requirements and test procedures

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