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# Standardisation – One way for better protection of operators against pesticides

## Part 1: Personal protective equipment

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). Since November 2009 EN 15695, is in force defining cabs performance and testing. Concerning PPE, there exist EN and ISO standards for performance and testing respirators, gloves and partial body protection. For suits Germany created 2005 the DIN 32781, which was already revised in 2010. Since April 2011 ISO 27065 is in force. Some European countries are still critical because some important details do not follow their requirements sufficiently. Therefore writing an own CEN paper was agreed recently. In part 1, general information about exposure scenarios, risk assessment and protection by personally worn equipment is focused. Cabs performance and testing are in the scope of part 2.

**Keywords**
pesticides, risk management, user protection, personal protective equipment (PPE)

**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 herbicides or collecting varmints up to the use of plant protection products (PPP). These agents, mostly chemicals, shall keep clean the plant production. 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.

All possible loads must be diminished to acceptable levels by technical means or protective equipment to ensure most secure working conditions. Means of protection are cabs mounted on tractors or self propelled machinery and personal protective equipment (PPE).

The discussion to standardise protective suits for operators' protection on the CEN level was not really targeted. CEN didn't see any need to cover agriculture since a long time.

Therefore Germany created in 2005, revised in 2010, with DIN 32781 [1] a national solution, which was adopted by Portugal. To initiate progress, a work item at ISO level was launched. Now the concerned draft ISO 27065 [2] is in formal vote now. Some European countries are still critical because, for example, EU requirements are not considered sufficiently, and they are preparing a CEN solution. But in general all parties involved agree that at the end one standard only for CEN and ISO must be the target. In the following, scenarios of farmers' exposure, need of protection and the state of the art for standards with this concern are described. The main focus lies on dermal protection of the body. For respirators and gloves the situation is much more satisfying - with some exceptions. There are still some open questions for protection by cabs, with view to prescribed tests and performance requirements.

### Farmers' exposure and risk assessment

The use of pesticides implies a possible risk for farmers' health. Particular sources of load and danger against possible hazards may arise from different steps of work while handling pesticides or other agro-chemicals. It is to distinguish between

handling undiluted liquids - the concentrates - and the diluted spray ready concentrations.

Mixing and loading are the main work steps with concentrates. A possible high exposure is accompanied with a short duration of contact. Especially hands, face and eyes are endangered by splashes.

Spraying in the fields or in other cultivations causes less exposure than mixing and loading but within a longer time of work. Hand, face and the whole body are exposed to aerosols with more or less small droplets. In some cases respiratory exposure must be considered.

As the main source of possible hazards the PPP's themselves must be regarded. As chemicals these products must be labelled regarding toxic properties. **Table 1** gives the numbers of agents with possible effects to skin for Germany 2006 [3].

These classifications concern the active agent – the chemical – and not necessarily the spray ready solution.

Risk assessment gives the need and performance requirements of protective means. The need is given if the value of exposure $E$ becomes larger than 1 as given in the equation below:

$$E = \frac{D}{D^{tol}} + \frac{I}{I^{tol}} + \left(\frac{O}{O^{tol}}\right) \qquad \text{(eq. 1)}$$

$D$ and $I$ are effective or expected values of dermal and inhalative exposure which are limited in relationship with tolerable values (tol) prescribed by regulations. Oral exposure $O$ is caused by accidents and will be neglected in the following.

Risk assessment is done stepwise and shall lead to appropriate protection:

- Quantification of risk to all possible hazards for particular scenarios of exposure.
- Comparison with legislative considerations.
- Evaluation of need of protection.

For chemical protection the following must be known if protection is needed

- specific effects of present chemical depending on the way of uptake
- nature of chemical hazard → gases, liquids (jets or splashes)
- particles (solid or liquid (spray)
- exposure situation → level, duration, frequency, sudden events or long term

In case of dermal exposure → hand and body protection is required.

In case of inhalative exposure → respirator is required.

In the following **table 2** an overview is given to the most interesting exposure scenarios for the application of PPP spray ready solution.

For the applications given in **table 2** cabs and chemical protective clothing (suits and partial body) are the recommended respectively prescribed protective measures.

To complete the figure to dermal protection **table 3** shows additional work steps which require gloves for hand protection but no special suits.

The large variations of parameters and number of pesticides make nearly impossible a detailed risk assessment and definition of appropriate protection means for each single situation nearly impossible. It becomes more difficult to get a holistic approach for protection with view to standardization. The structures of most national bodies, but also within CEN and ISO have resulted in separate standards for respiration, dermal protection of gloves and suits with view to PPE and do not allow a standard covering all components of protection. But the solution is given in some national reports [4,5] and a CEN Technical Report [6]. For the future it is suggested to write a special SUCaM paper for agricultural and horticultural use of pesticides (SUCaM = Selection, Use, Care and Maintenance).

Under consideration of these facts in the following the standards for applicators' protection are introduced with view to CPC against dermal exposure. The mainly concerned exposure scenarios are those with handheld sprayer e.g. in bush cultures, vineyards, fruit gardens and orchard crops according to **table 2**. **Figure 1** shows a typical exposure situation with a handheld sprayer.

Table 1

*Skin related classification of PPP, Germany 2006*

| **R-Sätze** ***Risk phrases*** | **Gefahrenmerkmal – Haut** ***Hazard designation*** | **Anzahl der zugelassenen PSM** ***Number of authorised PPP*** |
|---|---|---|
| R 21 | gesundheitsschädlich *harmful in contact with skin* | 17 |
| R 24 | giftig/*toxic in contact with skin* | 1 |
| R 27 | sehr giftig/*very toxic in contact with skin* | 0 |
| R 34 | verursacht Verätzungen/*causes burns* | 2 |
| R 35 | verursacht schwere Verätzungen *causes serious burns* | 0 |
| R 38 | reizt die Haut/*irritating to skin* | 81 |
| R 43 | Sensibilisierung möglich *may cause sensitisation by skin contact* | 154 |
| R 66 | kann zu spröder und rissiger Haut führen *repeated exposure may cause skin dryness or cracking* | 16 |

## Standards for applicators' protection

As mentioned above standardisation of respirators [7, 8] and gloves [9, 10] fully cover the requirements of agriculture. In some cases of testing different or additional chemicals are prescribed in national regulations.

### CPC Chemical Protective Clothing

At the present time for performance and testing suits are in force: the DIN 32781 [1] (adapted by Portugal) and at international level the ISO FDIS 27065 [2] which is just in the formal vote procedure.

Table 2

*Exposure scenarios handling PPP*

| **Expositionsszenarien** ***Usual scenarios of exposure*** | **Produkt** ***Product*** | **Gefahren durch Drift Tröpfchen (dp) oder direkten Kontakt (dc)** ***Hazards by drift droplets (dp) or direct contact (dc)*** | **Risikoabschätzung** ***Exposure/ risk estimation*** **+, ++ , +++** | **Mögliche Schutzmaßnahmen** ***Proposed means of protection*** | **Kommentar** ***Comments*** |
|---|---|---|---|---|---|
| Spritzen mit Traktor oder Selbstfahrer *Spray application tractor bound or self-propelled* | Feldkulturen Getreide, Wein, Gemüse, Obst *field crops, viniculture, vegetable gardening* | dp | +/++ | Kabine/*cab* PSA/*PPE* | Kategorie 4 Gas? *depending on the cab category Vapour?* |
| Spritzen mit Traktor oder Selbstfahrer *Air-assisted spray application, tractor bound or self-propelled* | Raumkulturen, Feldfrüchte, Wein, Gemüse, Obst, Gartenbau *bush and tree cultures, field crops, viniculture, gardening, orchard crops* | dp | +/++ | Kabine/*cab* PSA/ *PPE* | Kategorie 4 Gas? *depending on the cab category Vapour ?* |
| Tragbare Spritzgeräte *Spray application hand-held with knapsack lance* | Feldkulturen, Gemüse, Gartenbau *field crops, vegetable gardening* | dp,dc | ++ | Anzug/*Suit* Teilschutz/*PB* | Durchnässen am Nacken und Rücken *wetting especially neck and back* |
| Tragbare Spritzgeräte, Motorrübenspritze *Air-assisted spray application hand-held, motorised knapsack mistblowers* | Raumkulturen, Wein, Feldkulturen, Gartenbau Obst *bush, tree cultures, viniculture, field crops, gardening, orchard crops* | dp, dc | ++/+++ | Anzug/*Suit* Teilschutz/*PB* | Durchnässen am Nacken und Rücken *wetting especially neck and back* |
| Hydraulische Spritzgeräte im Gewächshaus *Application in greenhouses with hand-held hydraulic or CDA sprayer* | Hohe und niedrige Pflanzen, Gemüse, Obst *low and tall plants, vegetables, orchard crops* | dp, dc | +/+++ | Anzug/*Suits* Teilschutz/*PB* | Gas? *Vapour?* |
| Nachgeordnete Arbeiten *Follow-up work with plant contact* | | dc | +/++ | Anzug/*Suits* Teilschutz/*PB* | |

Table 3

*Exposure scenarios with mainly exposure of the hands*

| | | | |
|---|---|---|---|
| Tauchverfahren *Dipping* | anbringen v. Stäbchen *placing sticks* | träufeln *drizzling* | kleben *gluing* |
| Sprühen *Spreading* | auslegen von Ködern *laying bait* | injizieren *injecting* | bemalen *painting* |

Fig. 1

*Handheld spraying in a fruit garden*

Base of the DIN was the previous guideline BBA 3-3 which defined a universal protective suit for applicators' protection, under the assumption of spraying under arable field conditions. The atomizer test EN 14786 was developed. Later on after the "Safer Use Initiative Southern Europe" requested water tight suits the DIN was revised and in force since July 2010. **Table 4** gives the main data of the new DIN 32781:2010 [1].

The main performance criteria are (1) a limited penetration rate of 5 % for atomized (sprayed) PPP with droplets in a size which is similar to those measured at the unprotected drivers' seat and (2) in cases of direct contact with a treated foliage a resistance of water penetration ≥ 8000 Pa. High attention is given to thermal comfort connected wearing time limitations in cases of very tight suits. Mechanical properties should meet minimum requirements only with lower limits for single use suits to select damaged suits very quickly.

The intentions of ISO 27065:2011 [16] are similar to those given in the DIN: suits with appropriate protection for agricultural and horticultural worker during the application of PPP. Four levels of protection are foreseen which are defined as follows:

Table 4

*Main data of the DIN 32781:2010 [2]*

| **Kriterium** *Criterion* | **Messgröße** *Measurement category* | **Grenzwert** *Limit value* | Testmethode *Test method* |
|---|---|---|---|
| Durchlass von Spray (PSM) *Penetration of atomised PPP* | Durchlassgrad degree of penetration | 5 % | EN 14786 [11] |
| Durchlass von Wasser Penetration of water | Wasserdruck *resistance to water penetration* | ≥ 8000 Pa | DIN EN 20811 [12] (ISO 811) |
| Festigkeit *Strength* | Maximale Zugkraft/*maximum tensile load* Weiterreißfestigkeit/*tear resistance* | 500 N (30 N)[1] 20 N (10 N)[1] | EN ISO 13934-1 [13] EN ISO 9073-4 [14] |
| Ergonomie *Ergonomics* | Wasserdampf – Durchgangswiderstand *water vapour – volume resistance* | $20\ \frac{m^2 \cdot Pa}{W}$ | EN 31092 [15] |
| Akzeptanz *Acceptance* | Design und Preis *design and price* | - | - |

[1] Die Werte in Klammern gelten für Einwegkleidung/*the values in brackets apply to the disposable suit.*

Level 1a garments are suitable when the potential risk of contamination is relatively low. The performance requirements for level 1a garments have been developed in view of low spray drift landing on the operator e. g. from tractor boom sprayers.

The performance requirements for Level 1b garments have been developed based on the performance of cotton and polyester/cotton garments, which are widely used for operator exposure studies.

Level 2 garments are suitable when the potential risk of contamination is higher but not so high as to require the use of liquid-tight materials.

Level 3 garments are suitable for use when the potential risk of contamination requires garments made with liquid-tight materials. This level is suitable for high-exposure scenarios where it has been determined that garments that prevent liquids from penetrating/permeating provide adequate protection."

Table 5

*Testing requirements according to table 1 of ISO 27065:2011 [16]*

| **Anforderungen an** *Requirements on* | **Absatz** *Subclause* | **Test** *Specific performance test* | **Level** | | | |
|---|---|---|---|---|---|---|
| | | | **1a** | **1b** | **2** | **3** |
| Textiles Material *Material* | 5.2.1 | Widerstand gegen Penetration von Flüssigkeiten/*liquid penetration resistance* (EN 14786, [11]) | X | | | |
| | 5.2.2 | Widerstand gegen Penetration von Flüssigkeiten/*liquid penetration resistance* (ISO 22608, [17]) | | X | X | |
| | 5.3 | Widerstand gegen Penetration von Flüssigkeiten unter Druck/*resistance to penetration by liquid under pressure* (ISO 13994, Methode/*method* E, [18]) | | | | X |
| | 5.3.1 | Permeationswiderstand/*resistance to permeation* (ISO 6529, Methode/*method* A, [10]) | | | | X |
| | 5.4 | bestimmen der Höchstzugkraft/*tensile strength* (ISO 13934-1, [13]) | X | X | X | X |
| | 5.5 | bestimmen der Reißfestigkeit/*tear resistance* (ISO 9073-4, [14]) | X | X | X | X |
| Nähte *Seam* | 6.2.1 | Widerstand gegen Penetration von versprühten Flüssigkeiten/*seam penetration resistance* (EN 14786, [13]) | X | | | |
| | 6.2.2 | Widerstand gegen Penetration von versprühten Flüssigkeiten/*seam penetration resistance* (ISO 22608, [17]) | | X | X | |
| | 6.3 | Widerstand gegen Penetration von Flüssigkeiten unter Druck/*seam resistance to penetration by liquid under pressure* (ISO 13994, Methode/*method* E, [18]) | | | | X |
| | 6.3.1 | Widerstand gegen die Permeation von Flüssigkeiten/*seam resistance to permeation* (ISO 6529, Methode A und Gase/*method A and gas*, [10]) | | | | X |
| | 6.4 | Bestimmung der Höchstzugkraft von Nähten/*seam tensile strength* (ISO 13935-2, [19]) | X | X | X | X |
| Ganzer Anzug *Whole garment* | 7.2 | praktischer Eignungstest/*practical performance test* | X | X | X | X |
| | 7.3.1 | reduzierter Spraytest/*low-level spray test* (ISO 17491-4, Methode/*method* A, [20]) | | | X | |
| | 7.3.2 | Spraytest/*high-level spray test* (ISO 17491-4, Methode/*method* B, [20]) | | | | X |

Unfortunately these definitions are based on different criteria missing logical allocation of exposure and degree of protection.

In **table 5** testing requirements according to **table 1** of ISO 27065:2011 [16] are given.

The limit values for penetration are given for garments of:

- Level 1a to 5 % atomizer test
- Level 1b to <=40 % pipette test A
- Level 2 to 5 % pipette test B
- Level 3 garments must pass a pressure test with > 14 kPa and shall have a normalized breakthrough time ≥ 30 min for the active ingredient (permeation test).

A comparison of **table 4** and **table 5** shows some differences between both standards:

- Definitions and numbers of classes (levels) of protection
- limit values of penetration depending on the test procedure concerned
- test methods itself.

For testing the penetration two methods are used, the atomizer test [11] and the pipette test [17], which is not introduced in Europe at the present time. Joint studies showed that their results are not really comparable [21, 22]. **Figure 2** shows both methods in principle. The main differences are the kind of application, the concentration of the pesticide and the test chemical itself.

The pipette test applies one single large droplet of 0.2 ml 5 % Prowl ® suspension to a test specimen with an underlying sorbent. The atomizer test uses 1 ml spray ready diluted pesticides to contaminate the test specimen after being dispersed by a two phase nozzle.

To calculate the penetration P the applied and penetrated mass of active ingredients must be known by extraction and chemical analysis. This is the procedure of atomizer and method B of the pipette test. ISO allows with method A a more simple way by balancing, but the result is more or less related to the whole suspension and not to the active ingredient which should be determined with concern of protection.

## Conclusions

To secure human nutrition cultivated plants must be protected. Means for this purpose are mechanical and chemical: plant protection products. The chemicals may include risks for individuals and the environment which should be diminished to a certain level. At the end for farmers´ protection during handling pesticides appropriate PPE is required. According to the European rules PPE must be tested and certified. For this purpose CEN standards should be used. For respirators and gloves existing standards cover the requirements of agri- and horticulture while for suits special solutions are preferable. At the present time the DIN 32781 [1] and ISO 27065 [2] are in force but no CEN standard. For closing this gap a CEN TC162WG3 task group is installed to work out either with an own proposal or to prepare a revision of the ISO under the Vienna Agreement (VA).

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## Literature

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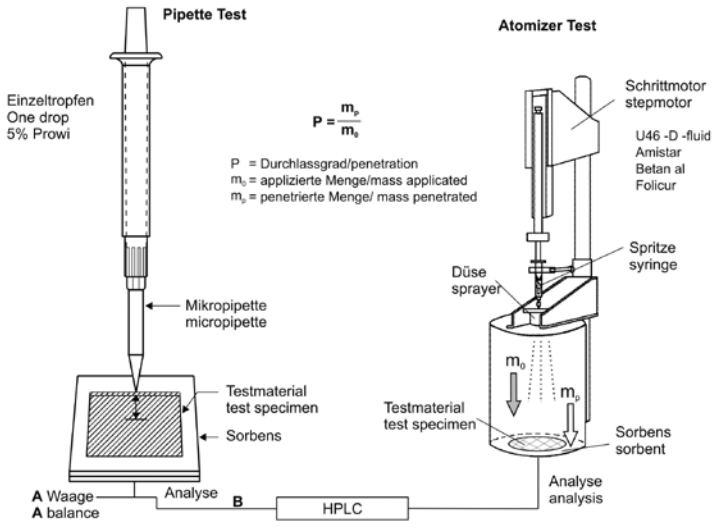
Fig. 2

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