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1. Introduction

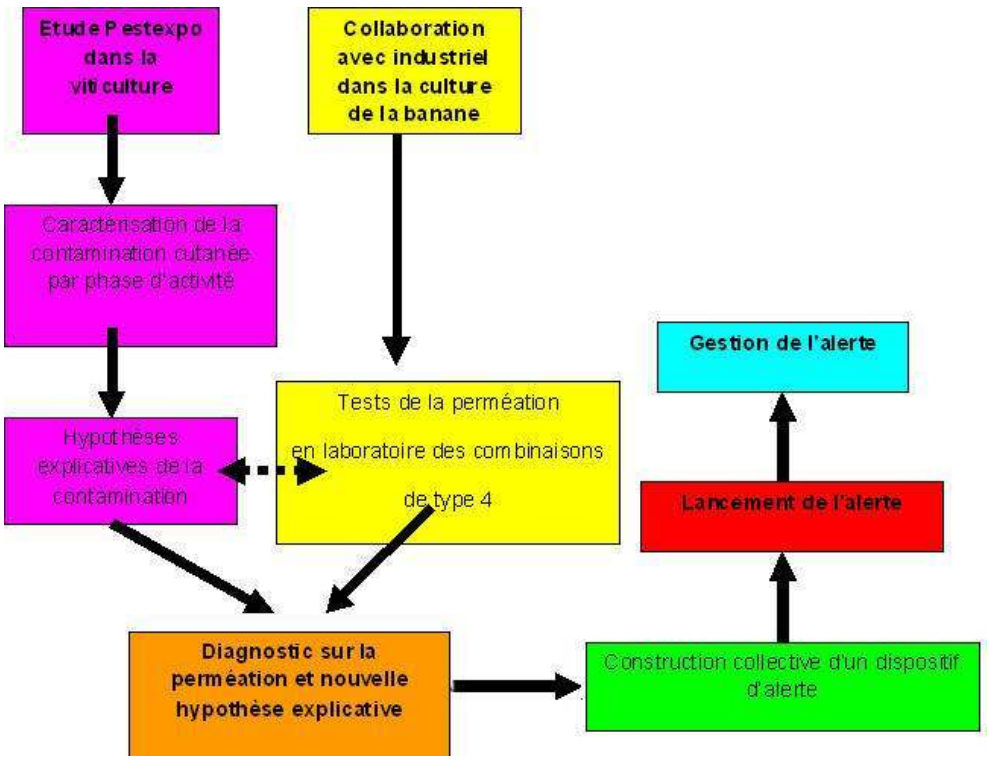
1 With respect to chemical risk and phytosanitary risk in particular, even though comprehensive prevention measures have been developed for years by prevention organizations, the prevention measures most often used are still personal protective equipment (PPE). Though from a regulatory standpoint priority must be given to collective protection, in reality, the latter is not commonly encountered in the field for a variety of reasons: substantial cost in relation to possible investments for farmers, technologies not always suited to farming, etc.

2 From a regulatory standpoint, the employer, farm manager, or company owner are responsible for safety. This means that the company owner or person in charge of a farming enterprise is responsible for the results: in the event of exposure or contamination by phytosanitary products with an impact on health, they could be held liable. A recent inquiry conducted by France's Department of Agriculture (2006) revealed that the recommended protection equipment was only rarely worn, which puts into question the actual effectiveness of prevention practices and measures. This inquiry confirmed the data gathered by *Réseau Phyt'attitude* set up by the *Mutualité Sociale Agricole* (MSA), where 64% of cases that reported an adverse effect associated with the handling of products showed, for instance, that no gloves had been worn (2004-05 review). Note that Jourdan (1989), Rouilleau and Sagory (1997), Bernon (2002) and Brunet et al. (2005) had already mentioned these problems in relation to PPE use and the resulting constraints.

3 The effectiveness, in actual conditions, of personal protective equipment thus entails major health-related challenges in terms of responsibility, as defined by the labour code.

4 This paper discusses the actual effectiveness of personal protective equipment and in particular that of coveralls from an ergotoxicological perspective. The study was conducted at two sites, i.e. the Pestexpo study on wine growing and a joint study with a manufacturer on banana growing. The results of these different studies allowed us to show permeation problems in coveralls as well as hypotheses on the causes of farmers' contamination by phytosanitary products. This led us to develop a strategy aimed at issuing warnings to those in charge of PPE matters. Figure 1 (below) shows the mechanism that was implemented along with the different parts that will be presented in the document.

Figure 1. Whistle-blowing process on farmers' contamination by phytosanitary products



2. An ergotoxicological approach to the phytosanitary risk in wine growing

5 The ergotoxicological approach has historically been developed by various authors (Sznelwar, 1992; Mohammed-Brahim, 1996; Garrigou et al., 1998; Mohammed-Brahim et al. 2003). Based on an analysis of the work involved, the ergotoxicological approach seeks to identify situations where workers are exposed to chemical-based hazards that will in fact constitute a risk. Second, the approach seeks to characterize the forms of *contamination*, i.e. the product's contact with the skin or penetration into the body, based on the physico-chemical and toxicological characteristics of the products and the type of work being done. It will then be possible to identify the determinants of these exposure situations, whether they are technical, human or organizational in nature, and then draw up preventive measures that will transform these determinants (Garrigou et al., 2004).

6 Some of the situations covered by ergotoxicology, i.e. the use and actual effectiveness of protective equipment, are a major source of concern for worker health. Prior studies such as those dealing with asbestos removal (Garrigou et al., 1998 and Héry et al., 1997) showed that the PPE used at the time did not provide a sufficient level of protection, and even created new risks (oil vapour in the oxygen provided by inappropriate compressors and depression caused in the airline masks resulting from the ventilatory flow created by physical effort, which accounted for asbestos fibres making their way inside the mask).

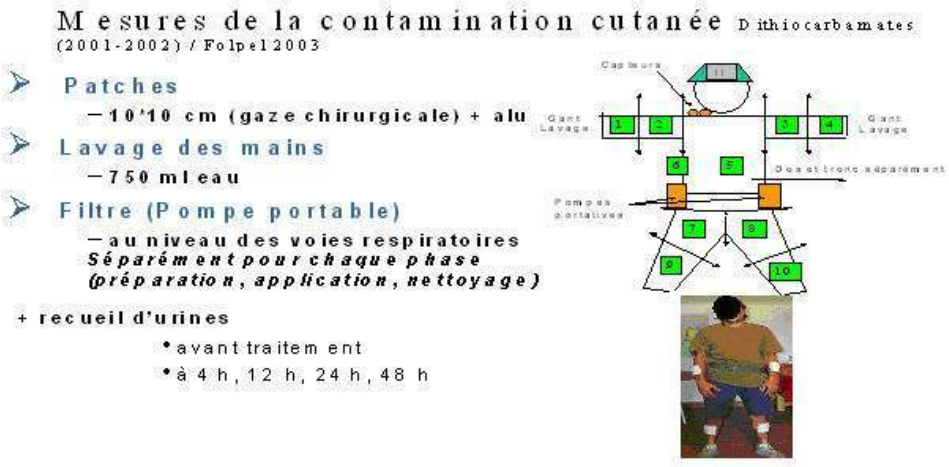
7 With respect to the phytosanitary risk regarding agricultural uses, researchers such as Packham (2006) discussed the actual efficiency of protective gloves. In the case of coveralls, prevention organizations recommend using type 4 coveralls, i.e. that provide full or partial protection of the user against liquid chemicals in aerosol form (see Appendix 1 and NF EN 14605). We will also discuss the actual effectiveness of coveralls based on the results dealing with outside contamination of vineyard workers, produced by the Pestexpo study, conducted in Gironde by Isabelle Baldi (Baldi et al. (2002) and Baldi et al. (2006)). This study, which used an ergotoxicological approach, attempted to characterize the exposure and actual contamination of vineyard workers via phytosanitary products (Dithiocarbamates, in 2001 and 2002) so as to define the determinants of such contamination.

8 The study, for instance, measured the vineyard workers' actual level of contamination from phytosanitary products. For the treatment operations in Gironde (since there were also observation days during grape harvesting), 72 observation days in actual conditions (67 of which involved work using a tractor and a sprayer and 5 with a backpack sprayer) allowed different types of data to be generated for each phase of the process (preparation of the spray mixture, treatment or application of the product and cleanup of equipment). Note that as part of the contamination studies, the expression *"actual contamination"* refers to the contamination on the operator's skin, compared to *"potential contamination,"* which designates what is deposited on the coveralls when these are worn.

9 The contamination was determined by analyzing the amount of phytosanitary product deposited on 10-cm^2 patches of surgical gauze. The patches were placed directly on the skin on different parts of the vineyard worker's body and were replaced at the end of each stage of work (see Figure 2). The protocol met the recommendations of the OECD

(1997) for this type of field study. The patches were placed directly on the skin, i.e. under the clothing and any protective coveralls.

Figure 2. Mesures de la contamination cutanée



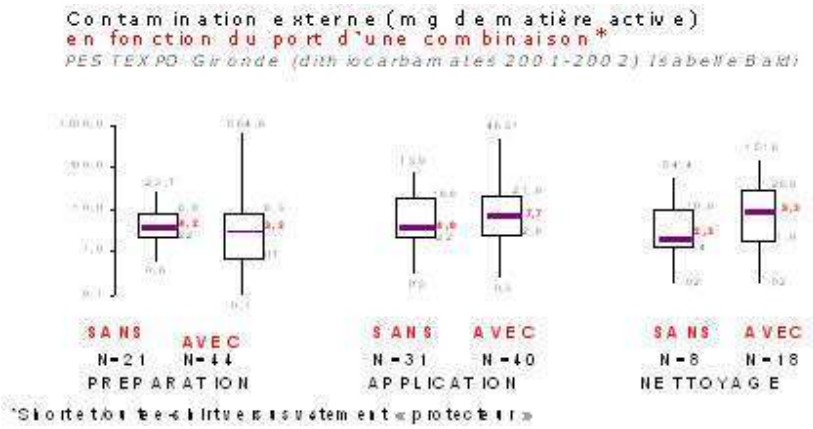
10 Note that during observations, vineyard workers carried out the different tasks in keeping with their usual routines. Some wore protection and others did not. For those who wore protection, some had appropriate equipment and others did not. During the preparation stages, close to two-thirds of the individuals were protected, slightly more than half for application and more than half for cleanup; however, it was not because the vineyard workers wore coveralls that they were fully protected, i.e. that protection prevented all contamination (this will discussed more further on). Based on an analysis of the data obtained from 67 observations of work done with a tractor and sprayer, the rate of PPE use can be broken down as follows:

- 50% of the vineyard workers did not wear any gloves, 40% wore gloves during one of the work stages (preparation or application (2% of the time)) and only 10% wore gloves during both stages;
- 58% never wore any coveralls[1], 24% wore coveralls during one of the stages (with only 4% wearing coveralls during the application) and 18% wore coveralls during both stages;
- 61% never wore a mask, 36% wore one during one of the two stages (4% during application) and only 3% for both stages.

11 The results were presented in the form of milligram per active ingredient deposited on the farmer's skin (after extrapolation of the patch on the surface area involved). Figure 3 shows the average contamination (horizontal bar) distribution (from bottom to top: minimum, 25th percentile, mean, 75th percentile, maximum). The most striking observation is the wide coverage of the distribution of contamination values for individuals wearing protective clothing compared to those who were not. Thus, in some cases, individuals who wore protective clothing showed higher levels of contamination than those who did not. Hence, the resulting data bring up several points :

- Wearing protective clothing ***does not completely prevent*** contamination;
- During preparatory work, wearing coveralls ***provided partial protection against contamination*** but did not prevent it entirely;
- During treatment and cleanup, the individuals who wore coveralls ***were contaminated overall more*** than those who were not wearing any.

Figure 3. Contamination externe en fonction du port d'une combinaison



12 These results led to problems in the different prevention organizations since one of the main streams of the recommendations is the use of personal protective equipment, in particular type 4 coveralls providing protection against aerosols (see Appendix 1).

3. Hypotheses to explain the contamination

13 Following numerous discussions with various experts in the field (the Caisse centrale de la mutualité agricole, caisses départementales de la mutualité agricole, the Institut National de Recherche en Sécurité, the national labour union for manufacturers of phytosanitary products, the European labour union for manufacturers of phytosanitary products, the French labour directorate and ministry of agriculture), we proposed various hypotheses to explain the contamination:

- ***Individual and collective knowledge of precautionary measures*** developed and enhanced over time. During the observations, very distinct practices were characterized, for instance, with respect to the precautions taken while opening and emptying the bag of powdered phytosanitary product. The fact of limiting the cloud of powder and of emptying the bag while in direct contact with the hopper could run contrary to practices where the bag was opened and abruptly emptied. Knowledge of precautions may, in such instances, significantly limit direct contamination as well as the indirect contamination resulting from repeated contact of certain parts of the body with already contaminated materials. The conditions under which such know-how is developed and its transmission to groups then becomes a major prevention issue. This precaution knowledge also includes habits and hygiene practices (Bernon, 2002), such as scratching one's face with gloves or dirty hands and washing one's hands before meals or at breaks;
- ***Organization and preparation*** of work-related tasks. We noted that certain vineyard workers would prepare the treatment-related tasks and made sure to avoid interruptions, would anticipate unforeseen situations, etc. Conversely, other vineyard workers seemed to attach less importance to these preparatory and setup stages, which created problems for them, more time pressure, and could possibly account for certain types of contamination;
- ***Contamination*** related to instinctive gestures such as scratching one's head, wiping one's face with one's gloves or with hands that had been exposed to the products. Similarly, basic issues of hygiene can be brought up: we noted operators who would open a paper bag of

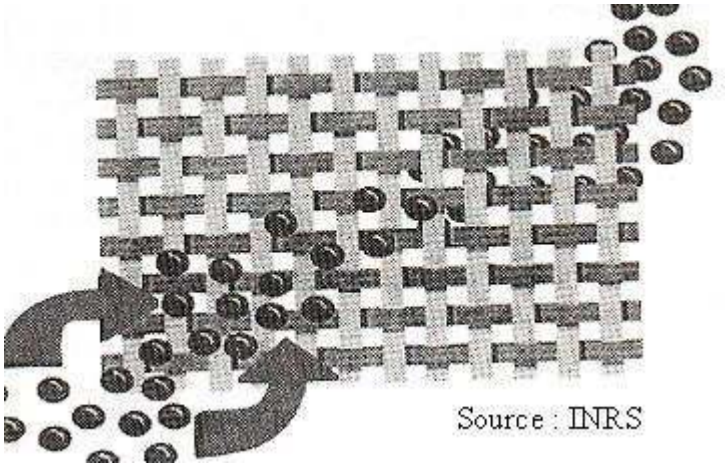
phytosanitary product in powdered form with a knife, which they would then use a few hours later to peel some fruit.

- ***Pre-contamination*** of personal protective equipment through re-use. When the equipment would be stored in an already contaminated area and not cleaned, either adequately or at all, cumulative contamination inside the coveralls is quite likely. The same point is brought up with the tractor cab filter;
- ***Statements made by vineyard workers*** focusing on the respiratory route of entry and significantly underestimating skin absorption;
- ***Believing that one is sufficiently protected:*** for some vineyard workers, the fact of wearing coveralls could reinforce the belief of **"feeling protected,"** which could lead to other precautionary measures not being taken;
- Insufficient ***recommendations on PPE use, maintenance and cleaning*** in order to minimize direct and indirect contamination. When workers use personal protective equipment, they have instructions that are not always complete and are often difficult to understand. However, they do not always find the procedure for putting on and taking off the protective equipment to avoid contamination;
- ***Spray equipment designers not fully taking into account*** vineyard workers' needs. On example is that to fill the hoppers of the tractor-hauled sprayers, the vineyard workers are required to climb on top of the sprayer wheel and press up against the side of the hopper to maintain their balance while emptying the bags. The outside surface of the hopper is usually covered with a film of phytosanitary product resulting from prior treatments or overfilling. Remaining against the soiled hopper repeatedly in such an extended fashion could account for some of the contamination. Another example pertains to the tractor cab filters: the fact that the machine's hydraulic commands are found outside the cab on the back part of the tractor forces workers to leave the back window open during spraying. Also, upon completion of several passes, the tractor's side windows will be covered with the phytosanitary product, which will limit visibility and hamper maneuvers when having to make turns. Under these conditions, workers will tend to leave the windows partially open, which could account for the contamination inside the cab. The last example pertains to the small-scale manufacture of the sprayers, which leads manufacturers to use the same pump on different models which may not be powerful enough, which will result in the nozzles becoming clogged.

14 Since the fall of 2006, we drew up a new hypothesis that questions ***the actual effectiveness*** of the coveralls recommended for phytosanitary applications. As part of a joint project with a phytosanitary product manufacturer, the issue was brought up regarding the permeation of the fabric in certain coveralls. The manufacturer, which had a prevention department and was aware of the risk involved with the use of a pesticide in conditions of exposure (with a backpack sprayer), had an accredited laboratory carry out permeation tests. The tests involved a type of coverall recommended for use with the pesticide. A Type 4 coverall was tested (see Appendix 1) of a brand commonly found on the market and the test conformed to the permeation test procedures set out in EN 374-3 (2004).

15 **Permeation**[2] is defined as the process through which a chemical passes through a material on a molecular scale (see Figure 4).

Figure 4. Permeation process



16 Permeation therefore implies :

- The adsorption of molecules from the chemical in the outside contact surface of a given material;
- The spreading of the molecules adsorbed in the material;
- The desorption of the molecules from the opposite (inside) surface of the material.

17 A distinction must be made between permeation and *penetration*, which refers to a chemical passing through the seams, pores, joints or imperfections of the glove or coverall material on a non-molecular scale (see NF EN 14325).

18 The results are ***alarming*** since they reveal a permeation process that occurs very quickly for a wide range of pesticides currently used in farming: an undiluted product can migrate inside the coveralls in less than 1 minute and a diluted product in less than 10 minutes.

19 This type of test was not done with the substance used for the Pestexpo study. However, we are developing a hypothesis on possible permeation to explain that individuals who are *theoretically* protected are in fact exposed to contamination. In fact, after discussing the matter with coverall manufacturers, it was found that the coveralls recommended for farming were initially designed for industrial use. As farming was only a market niche, the effectiveness of the coveralls ***was not tested in relation to the active ingredients contained in the phytosanitary products used, including the most common ones.***

20 There is nothing in the current state-of-the-art to indicate that the permeation problem is not encountered in an industrial setting (for instance, in the pharmaceutical/health or chemical industry) for other products.

21 In addition, it is highly likely that the perspiration created by physical effort that cannot evaporate as a result of being trapped in the coveralls can favour the penetration of phytosanitary products inside the coveralls. With respect to the cleanup phase, one could say that the water pressure and runoff could promote the migration of the products accumulated on the outside of the coveralls.

22 An immediate response would be to recommend a prevention solution consisting of a Type 3 or 2 coverall (see Appendix 1), which in theory would provide greater protection. However, the permeation issue would not necessarily be solved. Furthermore, setting an overly high protection level decreases thermal comfort, which would make the coveralls

unsuited to farming applications. They could potentially generate new dangers related to working in hot weather by preventing body sweat from evaporating and thus causing the different physiological mechanisms that regulate core body temperature to fail. This is one of the explanations for why personal protective equipment is not worn since it would be impossible to work in such conditions.

4. PPE use in farming: Technology transfer?

23 We need to consider the issues of PPE design and use as a technology transfer problem (Wisner, 1997; Palis et al., 2006). PPE has been designed for applications that are far removed from the farmers' actual working conditions: in terms of managing unforeseen situations and incidents (e.g. frequent tears resulting from rugged field conditions and vegetation, sprayer hopper spills, clogged nozzles), laborious effort, handling, temperature and humidity conditions. For instance, during a project in Guadeloupe on banana growing, we were able to determine that for treatment operations in a semi-mountaineous environment that lasted 3 hours and 7 minutes, for 2 hours and 20 minutes, the heart rate corresponded to heavy exertion, during 42 minutes to moderate exertion, and for 5 minutes to slight exertion (Balagne, 2006). This laborious work is a reality experienced by farmers which could lead them to make compromises between ***minimizing the laboriousness***, especially in relation to thermal comfort, and ***not use any protection***. We surveyed some vineyard workers who mentioned "feeling too hot in full sun." It is also important to remember that the risks and effects related to the use of phytosanitary products are not always directly perceptible (for instance, a worker said "you can't feel anything on your skin, but you can feel it in your airways..."). This perception of risk can thus cause workers to favour respiratory protection to the detriment of skin contamination, whereas the latter is the more significant of the two.

24 It is also important to consider that the PPE issue cannot solely be considered from a technical perspective. This issue has ***overlapping*** subjective and social aspects. In fact, PPE is perceived as a symbol of prevention, which itself carries different perceptions, such as looking like an astronaut, giving the impression that the grapevines/wine have been contaminated by hazardous substances, giving the public the impression of farming that is a source of pollution, etc. Some of the workers reported that they no longer wore protection since they had been stopped by local residents: because they were wearing coveralls, they were being treated as ***polluters***!

25 Moreover, insofar as we now know that some coveralls provide partial or complete protection against permeation, that there are doubts as to other PPE, is it reasonable for prevention organizations to continue making such recommendations? What should they be telling farmers: wear protection or not? This is a particularly difficult contradiction that prevention organizations will have to deal with, while they were relying on the recommendations made by phytosanitary-product and PPE manufacturers.

26 The limitations of PPE effectiveness that we have just shown are to be correlated with the results of studies conducted in relation to asbestos removal (Héry, et al., 1997; Garrigou et al., 1998). The studies revealed that asbestos fibres could pass through air line breathing apparatus. The depression, created inside the mask by the ventilatory flow associated with strenous effort, would account for the fibres passing through. This also brings up the

problem of the decreased efficiency of breathing apparatus that uses an electrostatic process to filter out dust that had been brought up by the INRS.

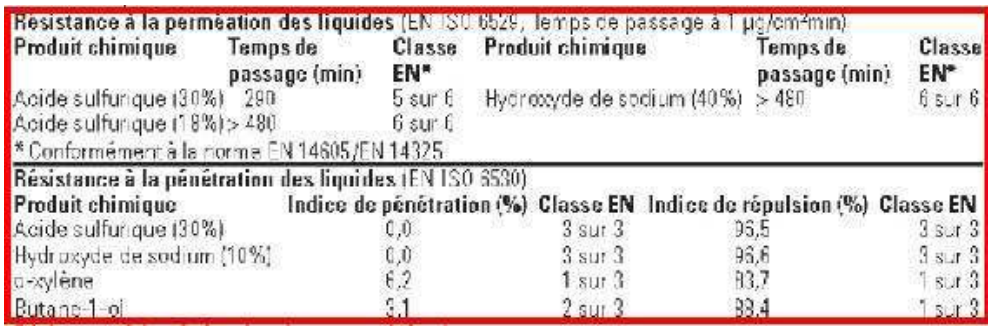
27 Based on this determination of the lack of effectiveness on the part of certain PPE, alternate prevention strategies could then deal with the cautionary measures that were implemented (Sznelwar, 1992; Mohammed-Brahim, 1996; Garrigou et al., 1998) by vineyard workers individually and collectively, as well as organizational and preparation-related issues.

28 As part of our research in ergotoxicology, we found major discrepancies between ***appealing prevention arguments*** (e.g. group protection must be a priority, require that products considered hazardous be replaced or even forbidden) and more pragmatic realities, whether technical, economic, agronomic, geographic, climatic or sociocultural in nature. In relation to the workplace environment, in many cases the use of phytosanitary products cannot be avoided, nor the need for personal protective equipment. When certain products are forbidden by law or replaced with other products, it would seem important to anticipate changes in practices so as to not replace one risk with another.

5. Technical and organizational flaws in PPE design and certification

29 This review of the situation reveals problems that can be qualified as technical and organizational flaws (Reason, 2004) dealing with the assessment of the actual effectiveness of the coveralls and therefore in terms of compliance with the requirements of the European PPE standard (design, certification and marketing); this issue was already brought up by Mayer and Bahami (2006) but was not resolved. If, like Dubuc (2007), the issue of the usage instructions for the coveralls (which are mandatory) is looked at in depth, it would seem that the information provided in terms of performance and serviceability limit are so technically complex that users will tend not to read them. This can be seen from the label for the most widely available coveralls (Figure 5).

Figure 5. Resistance to *permeation* and *penetretion* of liquids



Résistance à la permeation des liquides (EN ISO 6529, temps de passage à 1 µg/cm²min)

Produit chimique	Temps de passage (min)	Classe EN*	Produit chimique	Temps de passage (min)	Classe EN*
Acide sulfurique (30%)	280	5 sur 6	Hydroxyde de sodium (40%)	> 480	6 sur 6
Acide sulfurique (78%)	> 480	6 sur 6			

* Conformément à la norme EN 14605/EN 14325

Résistance à la pénétration des liquides (EN ISO 8530)

Produit chimique	Indice de pénétration (%)	Classe EN	Indice de répulsion (%)	Classe EN
Acide sulfurique (30%)	0,0	3 sur 3	96,5	3 sur 3
Hydroxyde de sodium (10%)	0,0	3 sur 3	96,6	3 sur 3
o-xylène	6,2	1 sur 3	83,7	1 sur 3
Butane-1-ol	3,1	2 sur 3	88,4	1 sur 3

30 First, the user needs to become familiar with the related but very different concepts of *penetration* and *permeation*, which is rarely the case. In addition, though this type of coverall is recommended by prevention organizations (Agriculture Ministry and Caisse Centrale de la Mutualité Agricole – CCMSA, 2007), it clearly appears that tests for resistance to liquid permeation for this type of coveralls are not conducted with the

active ingredients used in phytosanitary products but with different solutions of sulphuric acid and sodium hydroxide.

31 For these coveralls, Dubuc (2007) analyzed the tests that were conducted in accordance with **NF EN ISO 6529:2001-12-01**[3]; Appendix A in this standard provides a list of chemicals recommended for determining the resistance of protective clothing materials to permeation. The list of recommended liquid chemicals includes a dozen substances commonly used in the chemical industry but not representative of phytosanitary products. At this stage, it is at the very least surprising that PPE manufacturers or the notified bodies did not respond when the guide was produced by the agriculture ministry and the CCMSA (2007) to specify the serviceability limits (that they are aware of) of the coveralls recommended for the use of phytosanitary products.

6. A legal approach for potentially incurred responsibilities

32 Dubuc (2007) proposes a legal approach for the responsibilities incurred by the issues that have been brought up. He reaches an initial conclusion regarding the workers' contamination despite the use of protective coveralls. The author explains it as the *wrong type of equipment* being chosen, the result of inadequate understanding of the manufacturers' instructions.

33 His legal analysis of French law is presented here (p. 6 and 7):

> "Given the potentially serious consequences to worker health, the legal aspects of this issue cannot overshadow the penal aspects, as the offence of endangering another person is blatant. In this context, the provisions of Article 121-3 of the penal code are applicable": [translation]
> ...persons who did not directly cause the damage but who created or helped created the situation resulting in the damage or who did not take measures to avoid it, are criminally responsible if it is determined that they have either violated in an obviously deliberate manner a particular safety measure or precaution required by law, or committed a blatant fault that exposed others to a particularly serious risk that could not be ignored."[translation]

34 In this case, different parties are likely to be questioned in attempting to find those indirectly responsible for the offence:

> **"The manufacturer,** with respect to the Labour Code regarding the drafting of the instructions of use (R. 233-151 of the French Labour Code – Schedule II 1.4) and regarding:
> - b) The performances obtained during technical inspections aimed at ensuring the levels or categories of protection of individual protective equipment;
> - d) The categories of protection suitable to different levels of risk and the corresponding serviceability limits;
> And the application of specific rules for exposure to hazardous substances or preparations which only received partial application that was not clear to the user.
> **The notified body** with respect to the instructions for use, which is part of the technical specifications given by the manufacturer as part of the initial conformance inspection: Did these instructions meet precision and clarity requirements?
> **The parties responsible for the proper application of supplementary certification procedures:** did the instructions of use change and do potential revisions put the initial certification into question? The manufacturer can choose between the two complementary production quality certification procedures: CE

quality assurance system and CE quality assurance system for production control. In both cases, are the instructions for use checked on a regular basis?
Lastly, the **standard,** and more broadly the standardization process, in terms of the ambiguity in what certain experts say." [translation]

7. Contribution of ergotoxicology: from an assessment of activities and contamination to the development of a whistle-blowing process

35 At this stage of the assessment, it is important to reiterate the different aspects of the general context that could account for the technical or organizational flaws mentioned above.

36 First, remember that according to PPE manufacturers, the agricultural market only represents a 4% market niche, for which it would not be profitable to invest in R&D.

37 Second, we deal with major barriers between the different players involved. Manufacturers of phytosanitary products are focused on the development of new active ingredients that must be efficient, cost-effective and the least environmentally polluting. A second concern of phytosanitary-product manufacturers is the certification of the new active ingredients by regulatory bodies, without which their new products could not be put on the market.

38 PPE manufacturers, for their part, focus on the transfer of generic PPE initially developed for the chemical industry or for industry-wide use. In their thinking, provided that their PPE model is certified impervious to aerosols – in the case of a type 4 coverall – the requirements are met even if permeation tests, for instance, were not conducted with phytosanitary products, but with a few acids or solvents, as is usually the case, as per the corresponding standard.

39 Certification bodies, which are private organizations, are accredited by the labour ministry. Provided that they apply highly technical and difficult to apply standards, they believe they are fulfilling their role.

40 The applicator's safety design is impliedly attributed to prevention organizations. From this standpoint, one can see that traditionally, PPE use has played a crucial role in their prevention messages (e.g. labels, awareness), whereas in practice, their agents may use a more comprehensive approach, in particular with respect to organization (Bernon, 2002; Brunet et al., 2005).

41 Overall, there is little communication (usually informal) between these different players. This situation shows that each player remains in its respective field of expertise and very rarely are experiences shared. Subsequent to the release of the results of the Pestexpo study, for the past two years, some of the "boundaries" have shifted. One specific example is the role of the phytosanitary-product manufacturer, who, in addition to its traditional development and marketing role, has decided to tackle the issue of applicator safety. This strategic choice must be correlated with pressure from authorities and the media risk.

42 In this global context, we decided to assume the role of "whistle-blower" (Vaughan, 1996). Our strategic approach therefore consisted in defining a process for preparing and disseminating a warning in order to mobilize as many stakeholders as possible. This approach then became part of a socially based process that was backed by the results obtained through the ergotoxicological approach. Note that the permeation data were

produced as part of a study conducted by a phytosanitary-product manufacturer in which we took part. The correlation of the above data with the Pestexpo data revealed the importance of the issue that was brought up. However, the data belonged to the manufacturer and could not be used publicly. There was an initial stage during which there were discussions with the manufacturer so that the results could be used without naming the company in question or the one that manufactured the coveralls. The second step consisted in testing the resulting diagnosis with the different stakeholders involved. Given the cautious or even nervous attitude on the part of some of the stakeholders, it was decided that a warning would be issued in the form of a scientific paper. Considerable thought was given to type of warning along with the target audience to ensure it was effective (Chateauraynaud and Tourny, 1999). The warning was sent out and systematically discussed with all of the stakeholders involved, especially those with a PPE project management role in the various organizations. There were six successive versions of the warning; the changes that were made were intended to make the wording clearer, clarify arguments that may have been presented too technically, add complementary elements, ensure the anonymity of the various stakeholders and, lastly, determine the transformative perspectives. Note that this verification work and progressive development of the warning was done informally and took close to four months to complete. Another aim was to prepare the stakeholders to manage the warning and anticipate their organization's reaction before the warning is officially transmitted to their representatives. Subsequent to these steps, the "permeation warning" was sent by registered mail to the representatives of the organizations involved (six in all). At the end of one month, the warning was widely broadcast to various prevention networks. At this point, only two prevention organizations have officially responded. The last stage in the warning process consisted in working with a journalist from an occupational health and safety publication (Santé Travail de la Mutualité Française). We helped write a four-page report (Mahiou, 2007) dealing in-depth and in detail with the issue of farmers' exposure to phytosanitary products. It was important for us to reach a wider prevention-based audience, especially farmers or labour unions representing farm workers. Note that the issue was covered in a non-controlled manner by the mainstream print and radio media; though their coverage was fairly superficial, it succeeded in increasing media pressure especially with respect to the organizations involved.

43 A final stage consisted in sending the warning to the different professional labour unions and to the unions representing farmers and food industry workers (five in all). Note that only two labour organizations responded.

44 Following this long process, the labour directorate (labour ministry) submitted the case to court (AFFSET – *Agence française de sécurité sanitaire de l'environnement et du travail*) on this matter. In 2008, AFSSET must coordinate a broader study on coverall permeation by testing them using the main active ingredients found in phytosanitary products. AFSSET will also handle the coordination of the actions of the various prevention organizations in this respect.

45 There appears to be a risk of competition among the organizations involved. The second risk that was identified is that of the search for a party at fault among all the stakeholders mentioned above, especially the manufacturers of phytosanitary products. In the current situation, given the problems encountered, it would seem important to create conditions so that each stakeholder can mobilize its expertise and share it beyond traditional boundaries.

8. Conclusion

46 Beyond the agricultural sector, this alarming observation could be correlated with the growing number of cases of occupational cancer. In fact, in most work-related situations, the only means of protection implemented is individual protective equipment; the Pestexpo study, however, shows its lack of effectiveness in field conditions. This issue involves French and European prevention and certification organizations. It also shows the need to review European standards on protection equipment using in farming. This choice is in the process of being discussed in Germany (DIN 32781 standard), Holland (Gerritsen-Ebben et al., 2007), Spain, Portugal, and Greece. This could be an approach for dealing with the technical and organizational flaws presented above provided that methods used to assess PPE effectiveness under field conditions are developed.

47 From a methodological standpoint, we consider it important to use farming activities as a basis for drawing up a risk assessment specific to each exposure situation:

- Type of hazard (product; physical state: liquid, powder, aerosol, etc.);
- Body areas exposed based on the technique being used;
- Weather conditions ;
- Workers' reports of the risks and routes of entry, etc.;
- Most common unforeseeable events and incidents;
- Specifics of work structure ;
- Differences between the conditions and expertise required for using phytosanitary products and the safety measures provided by manufacturers and the conditions and expertise ***actually*** encountered in a farming environment;
- The role played by the inadequate design of equipment and technical devices (e.g. tractors, sprayers) in contamination;
- Etc.

48 In this line of thinking, the concept of "generic" coveralls that can be used in all kinds of situations is unsuitable, in addition to coveralls that can be reused in farming, without any control as to their duration of use. On the contrary, hybrid coveralls could be considered, such as when using a pesticide combined with a backpack sprayer: type 3 or 4 pant bottom and type 6 top of pant, etc. Such solutions would include compromises between thermal comfort and protection, based on an assessment of the incurred risks on the basis of the specific work of the farmers that could differ based on the crops or environment.

49 However, this perspective is only valid if the PPE that will meet the requirements of this agriculture standard is not prohibitively expensive for vineyard workers. The issue of disposable or reusable protection must be explained in detail; in fact, one could say that a coverall used only once and throw out is not consistent with the "culture" of farmers, who tend to reuse the different objects they have.

50 Multiple approaches must be used to deal with the multi-causality of contamination incidents as well as the responsibilities of all the stakeholders. These prevention approaches must be comprehensive, they must take into account the elimination of hazards at source, the design of equipment as well as individual and collective protection issues. At the same time, it would be wrong to neglect individual protection by arguing that collective protection must be favoured. Multidisciplinary or transprofessional

actions (Garrigou, 2006) must be undertaken in both areas. It also appears necessary to go beyond the divisions between or philosophies of companies that manufacture phytosanitary products, those that design protection equipment, the organizations that draw up prevention-related regulations and recommendations, institutional or corporate preventionists (occupational health physicians and those involved in occupational safety), representatives of professionals, and workers and occupational safety researchers.

51 As the situation now stands, it is completely unrealistic to think that it is up to phytosanitary product users to ensure that the protection at their disposal is effective and compatible with the phytosanitary products being used. In addition, because they decide to use protective equipment, by accepting the associated thermal discomfort and inconvenience, vineyard workers believe that they are protected. The worst-case scenario in prevention and protection is to be exposed to known hazards and to use protection, or ***believe to be protected***, whereas this is not at all the case.

52 Though the results at our disposal originated from research on the contamination of farmers by phytosanitary products, we believe that industrial activity may at least in part be accountable for the issues presented here. To limit the problem to farming would be wrong.

53 Lastly, occupational studies and transdisciplinary approaches used to assess the efficiency, in field conditions, of the use of collective or individual protective equipment represent issues for worker health and the effectiveness of measures undertaken by prevention organizations. Putting existing scientific and technical models into question in the area of chemical hazards using a transdisciplinary analysis of ergotoxicological activities has been an innovative contribution to prevention.

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APPENDIXES

Appendix 1

Type 6		Limited protection against liquid chemicals. Equipment that provides full or partial protection against liquid chemicals in the form of a light spray (mist).
Type 5		Protection against solid chemicals in the form of an aerosol of solid particles. Equipment that provides full protection against chemicals in the form of low-concentration solid aerosols.

Type 4		Protection against liquid chemicals. Equipment that provides full or partial protection against liquid chemicals in the form of a spray.
Type 3		Protection against liquid chemicals. Equipment that provides full or partial protection against liquid chemicals in the form of a high-pressure stream (high-pressure release of liquid chemicals).
Type 2		Protection limited to gas. Equipment providing full or partial protection against gas.
Type 1		Gas-tight suit. Equipment providing full protection against gas.

NOTES

1. Here the terminology refers to coveralls that cover the entire body but do not necessarily have all of the characteristics of the protective coveralls recommended by prevention organizations to protect users from the risks related to the use of phytosanitary products such as type 4 coveralls that provide aerosol protection (see Appendix 1).
2. Protective clothing – Terminology from FD CEN ISO/TR 11610.
3. Protective clothing – Protection against chemicals – Determination of resistance of protective clothing materials to permeation by liquids and gases.

ABSTRACTS

This paper presents the results of an ergotoxicologic study on the effectiveness, in real-life conditions, of the protective suits recommended by preventionists. The arguments presented in the paper are based on the Pestexpo study conducted by Isabelle Baldi (Baldi et al. (2002) and Baldi et al. (2006)), which involved analyzing the exposure of vineyard workers to plant protection products by using an ergo-toxicologic approach. The point is to identify different types of exposure by taking into account the characteristics of the actual work (as opposed to what the operators are supposed to be doing) as an outcome of personal, technical and organizational determinants. We were able to point at the permeation of the fabric used for some of the suits. Indeed, after further discussion with PPE manufacturers, it would appear that the suits recommended for agricultural activities were initially developed for industrial purposes and that since farming is just a market niche, these suits may not have been tested for plant protection products, not even for the most common ones. We will explore this topic in terms of organizational and technical failure (Reason, 2004) in the personal protective equipment (PPE)

design, testing and standardization process. We will also present the collective whistle-blowing process that was initiated.

L'objectif de cet article est de présenter des résultats récents d'une recherche/action en ergotoxicologie concernant les risques liés à l'usage des produits phytosanitaires. Cette recherche propose une double articulation : la première entre des résultats issus d'analyses en situations de travail portant sur la contamination externe des viticulteurs et des résultats issus de tests en laboratoire portant sur la perméation des combinaisons. La seconde articulation concerne le lien entre l'ensemble des résultats cités ci-dessus et une analyse des failles techniques et organisationnelles de la conception et des processus de certification des EPI (équipements de protection individuelle). Sur ces bases, la question des EPI sera alors abordée sous l'angle d'un transfert de technologie entre des milieux industriels et les réalités des situations agricoles. Ceci conduit à un diagnostic très préoccupant en matière d'efficacité réelle des combinaisons. Nous aborderons aussi les questions des responsabilités juridiques soulevées par de tels manquements. Enfin, nous détaillerons le rôle de whistler blower (Vaugan, 1996) que nous avons décidé de jouer ainsi que le processus d'alerte que nous avons construit afin de poser autrement le problème des EPI et intéresser l'ensemble des acteurs.

El objetivo de este artículo es presentar los resultados recientes de una investigación/acción en ergotoxicología sobre los riesgos relacionados con el uso de productos fitosanitarios. Esta investigación propone una doble articulación : la primera, entre resultados que emergen de análisis realizados en situaciones de trabajo sobre la contaminación externa de los viticultores y resultados provenientes de tests de laboratorio sobre la permeabilidad de la vestimenta de protección. La segunda articulación trata de la relación entre el conjunto de resultados ya citados y un análisis de los fallos técnicos y organizacionales del diseño y de los procesos de certificación de los EPI (equipos de protección individual). La problemática de los EPI será abordada desde el ángulo de una transferencia de tecnología entre los medios industriales y las realidades de las situaciones agrícolas. Esto conduce a un diagnóstico muy preocupante sobre la eficacia real de las vestimentas de protección. Abordaremos también las preguntas sobre la responsabilidad jurídica que emergen de estas carencias. Finalmente, explicaremos el rol de whistler blower (Vaugan, 1996) que decidimos jugar y el proceso de alerta que construimos para plantear de otra manera el problema de los EPI y hacer emerger el interés del conjunto de los actores sobre esta cuestión.

INDEX

Keywords: ergotoxicology, phytosanitary risks, agriculture, PPE, technology transfer, ergonomics, prevention
Mots-clés: ergotoxicologie, risques phytosanitaires, agriculture, ÉPI, transfert de technologie, ergonomie, prévention, pluridisciplinarité
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