

## Analysis of Personal Protective Equipment Requirements on Labels of Pesticides for Agricultural Use

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### Abstract

Personal protective equipment (PPE) is one way to protect the health and safety of pesticide handlers. EPA's Worker Protection Standard mandates that PPE requirements for handlers be stated on labels of pesticide products intended for agricultural use. The requirements, based on potential risk, range from no requirements for certain categories to more stringent requirements that affect comfort and job performance. As labels are the primary means of communicating PPE requirements, the study was conducted to analyze label data to address stakeholders' concerns regarding PPE use, protection, availability, and comfort. Additionally, label language was examined for accuracy, consistency, and clarity. A performance-based approach to assign PPE based on risk assessment, as opposed to garment type, is proposed to simplify pesticide product labeling.

**Keywords:** personal protective equipment, risk assessment, pesticide label requirements, chemical-resistant garments, performance-based standards

### Introduction

In the United States, pesticide registration falls under the jurisdiction of the Office of Pesticide Programs, Environmental Protection Agency (EPA). This office is responsible for the registration (including reevaluation) of all pesticide products sold in the United States. As part of the registration review process, updated risk assessments are conducted to determine the mitigation required to protect the health of people engaged in mixing, loading, applying, or otherwise handling pesticides. Personal protective equipment (PPE) is a basic tool used for risk mitigation. PPE label requirements provide information on how to protect individuals from exposure to pesticide products. They also serve as the regulatory basis for determining PPE compliance requirements. Clear, easy-to-understand pesticide label language reduces the possibilities of misinterpretation by users and compliance officials.

The *Label Review Manual* (EPA, 2011) and PPE-related Pesticide Registration Notices (PRNs; EPA, 1993a, 1993b, 1998) are used as guidance documents to develop PPE statements for pesticide labels. Pesticide Registration Notices are published and disseminated to communicate label requirements and, in some cases, changes to the requirements. For example, PRN 98-9: Modification of Respirator Statements for Pesticide Product Labels (EPA, 1998) was published when the National Institute for Occupational Safety and Health (NIOSH) changed requirements of NIOSH-certified respirators. These publications also serve as guidance documents for pesticide safety educators, state agency personnel, researchers in risk assessment, and PPE manufacturers. In addition, materials such as web pages, presentations, and fliers are developed by educators for pesticide applicator training. These educational materials

often have images of individuals wearing coveralls, respirators, gloves, goggles, and boots. Such fully geared images create a perception that this PPE is commonly required for applicators, mixers and loaders, and other handlers.

In 2010, NIOSH's National Personal Protective Technology Laboratory organized conference calls with stakeholders to better understand the challenges concerning use of PPE. Some of these challenges related directly to identifying the correct PPE: i.e., which gloves, respirators, and chemical-resistant clothing to use. Coincidentally, a review of a document recommending PPE for DuPont products showed that most of its products require only a long-sleeved shirt and long pants for adequate protection. Follow-up calls and an Internet search indicated that aggregate data in this area were either not published or not easily available. Therefore, to assess the magnitude of stakeholder concerns and to generate baseline information, a database was developed at the University of Maryland Eastern Shore. This database includes information from specimen labels on pesticide products for agricultural crop use.

### **Methodology**

Permission was obtained from Crop Data Management Systems (CDMS) to use specimen label files in PDF format to gather the information. The CDMS website lists products by manufacturer. A page with the following information was printed for each product listed:

- EPA registration number and product name.
- Company name.
- Pesticide type and signal word.
- Glove requirements.
- Garment requirements.
- Apron and headwear requirements.
- Footwear requirements.
- Eyewear requirements.
- Respiratory protection device (respirator) requirements.

The printouts were then used for data entry.

Information from the labels was entered into a Microsoft Access® database. To the extent possible, dropdown menus were used to reduce data entry errors. After the initial data entry, the information was verified and corrected. Statistical analysis was conducted to summarize the data contained in 27 columns (1,868 rows: one per product). The analysis also helped standardize unique entries for which dropdowns were not feasible. In addition to the summary table, comparisons were made between the text on the labels and the guidelines provided in Chapter 10 of the EPA's *Label Review Manual* (EPA, 2011).

### **Results and Discussion**

This section includes summarized data for 1,868 product labels. PPE information is divided into the following subsections: protective clothing, gloves, respiratory protection devices (respirators), chemical-resistant apron, protective headwear, and protective eyewear. Bar graphs were used to display the data.

Signal words “Caution,” “Warning,” “Danger,” and “Danger – Poison” stated on product labels were recoded for each product. The signal word is determined by comparing the adverse effects of the five triggers for acute toxicity: oral toxicity, dermal toxicity, inhalation toxicity, skin irritation potential, and eye irritation potential. The trigger with the highest acute toxicity determines the signal word on the label. “Danger” is always used for products classified as Category I for any of the five triggers. “Danger – Poison” is used only for products classified as Category I for acute oral, dermal, or inhalation toxicity. Signal words on product labels are not used as a basis for determining PPE. PPE requirements stated on product labels are based on risk assessment. Table 1 from EPA’s *Label Review Manual* (Chapter 10, Table 7; EPA, 2011) serves as the basis for labeling language for different types of PPE.

**Table 1.** Guide to selecting the most protective handler PPE

Type of PPE	Minimum required	Next highest level of protection	Next highest level of protection	Highest level of protection
Protective clothing	Long-sleeved shirt and long pants	Coveralls over short-sleeved shirt and short pants	Coveralls over long-sleeved shirt and long pants	Chemical-resistant suit
Protective footwear	Socks and shoes	Chemical-resistant footwear	Chemical-resistant boots	NA
Gloves	None	Chemical-resistant gloves	NA	NA
Protective headwear	None	Chemical-resistant headgear	NA	NA
Chemical-resistant apron	None	Chemical-resistant apron worn over long-sleeved shirt and long pants	Chemical-resistant apron worn over coveralls over long-sleeved shirt and long pants	NA
Respiratory protection device	None	Filtering facepiece respirator (N95, R95, or P95) <sup>1</sup>	Elastomeric half-mask respirator with appropriate cartridges and/or filters <sup>2</sup>	Air-supplying respirator

<sup>1</sup> Can be used only for dusts/mists where a protection factor of 5 is needed.

<sup>2</sup> Can be used for dusts/mists and/or vapors/gases with appropriate cartridges and/or filters.

On most pesticide product labels, there is a general statement at the beginning of the section on PPE that refers to the chemical-resistance category selection chart. However, since this chart is based on studies related to gloves, the materials listed are mostly for gloves and not for other chemical-resistant PPE (such as headwear and aprons). For example, elastomers (materials with elastic properties) such as nitrile, natural rubber, and butyl are typically not used for garments. Multicomponent fabrics (such as coated nonwoven fabrics), however, are often used for garments, aprons, and headgear.

### Protective Clothing

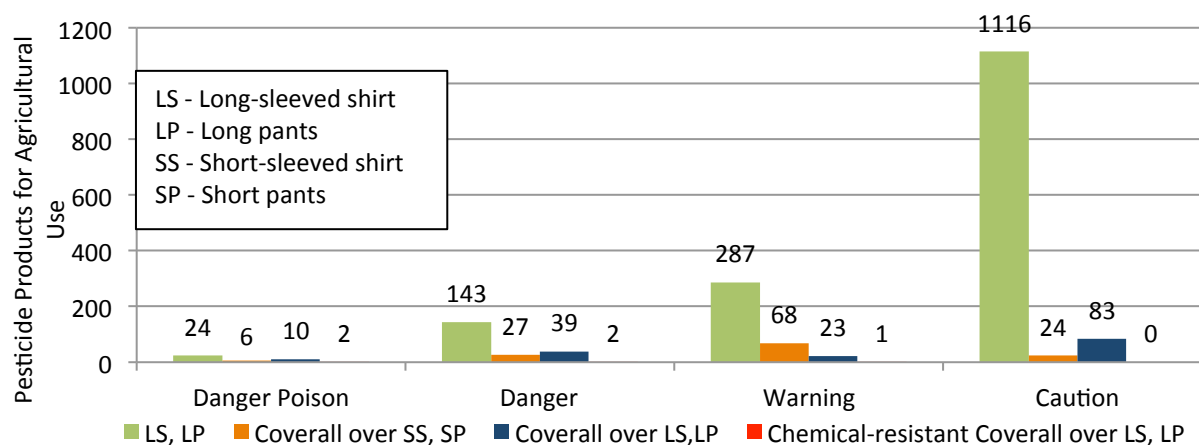
The general terminology used for protective clothing includes long-sleeved shirt and long pants, coverall with short-sleeved shirt and shorts, coverall with long-sleeved shirt

and long pants, and chemically resistant garments (Table 1). This terminology was used consistently in labels. Of the 1,868 labels analyzed:

- 1,583 require the minimum protection of long-sleeved shirt and long pants.
- 128 require coveralls over short-sleeved shirt and short pants.
- 152 require coveralls over long-sleeved shirt and long pants.
- 5 (including two that are required for particular situations) require a chemical-resistant suit.

Figure 1 shows the relevant numbers of different protective clothing requirements by signal words found on pesticide labels. The breakdown by signal word demonstrates that hazard category alone is not used to determine PPE requirement. If hazard category were the only criterion, product labels with the signal word “Caution” would require only long-sleeved shirt and long pants, as the acute toxicity of these products is no more than Category III.

**Figure 1.** Protective clothing requirement



**NOTE:** Signal words were not available for 13 products.

It is important to note that the protective clothing requirements based on garment type and layers were implemented when there were no standards or performance requirements available for protective clothing. As work-wear clothing was commonly used, the minimum requirement was long-sleeved shirt and long pants. For additional protection, another layer (coverall) was added. For a few products, a chemical-resistant coverall is required. To reduce the chance of heat stress, air-impermeable, chemical-resistant clothing is used only when other risk-mitigation options are not sufficient.

Performance-based standards (ASTM, 2012; ISO, 2011) based on laboratory and exposure study data are now available. The lowest level of protection (Level 1) is similar to that provided by work-wear clothing that consists of long-sleeved shirt and long pants or coverall made with similar material. Level 2 is designed to provide an intermediary level that currently does not have an equivalent in the United States: two layers (coverall over pants and shirt) are used in this country. Level 3 is equivalent to the current chemical protective clothing requirement.

It is recommended that these performance-based standards be considered in place of garment type. There are three main reasons. First, fabric performance varies considerably. Protection largely depends on factors such as fiber content, fabric thickness, and finish or coating applied to the fabric. Data show that a pants/shirt combination can offer much better protection than some coveralls. Second, the difference between a two-piece coverall, a jacket and pants set, and even an overshirt and pants set is not clear. A jacket and pants or pants and shirt may provide the balance between comfort and protection when a higher level of protection is required. A one-piece coverall, in contrast, typically allows heat to build up. Last, language on the pesticide product label that matches the information on the protective clothing label would help the user choose the right garment. For example, if a pesticide product label specified a Level 1 garment, the user could select protective clothing also specified as Level 1 on the garment label.

## Gloves

The *Label Review Manual* states that no gloves are required for the lowest level of protection. Chemical-resistant gloves are required for the next higher level. The decision on the type of chemical-resistant glove required is based on the solvent in the product. Table 2 is from EPA's *Label Review Manual* (Chapter 10, Table 3; EPA, 2011). This table, based on permeation of the solvent in the product, is used to determine what gloves are required for products in toxicity Category I, II, or III. "Toxicity category" refers to acute dermal toxicity or primary skin irritation.

Category A gloves are required for no solvent or aqueous solvent; B, for ketones; C, for alcohols; D, for acetates; E, for aliphatic petroleum distillates; F, for aromatic petroleum distillates < 40%; G, for aromatic petroleum distillates > 40%; and H, for halogenated hydrocarbons. Only gloves rated "high" are selected for a given label.

**Table 2.** EPA chemical-resistance category selection chart.

Solvent category	Barrier laminate	Butyl rubber ≥ 14 mils	Nitrile rubber ≥ 14 mils	Neoprene ≥ 14 mils	Natural rubber ≥ 14 mils*	Poly-ethylene	Polyvinyl chloride (PVC) ≥ 14 mils	Viton ≥ 14 mils
A (dry & water based)	high	high	high	high	high	high	high	high
B	high	high	slight	slight	none	slight	slight	slight
C	high	high	high	high	moderate	moderate	high	high
D	high	high	moderate	moderate	none	none	none	slight
E	high	slight	high	high	slight	none	moderate	high
F	high	high	high	moderate	slight	none	slight	high
G	high	slight	slight	slight	none	none	none	high
H	high	slight	slight	slight	none	none	none	high

\* Includes natural rubber blends and laminates.

**HIGH:** Highly chemical resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticides at rest breaks.

**MODERATE:** Moderately chemical resistant.

**SLIGHT:** Slightly chemical resistant.

**NONE:** No chemical resistance.

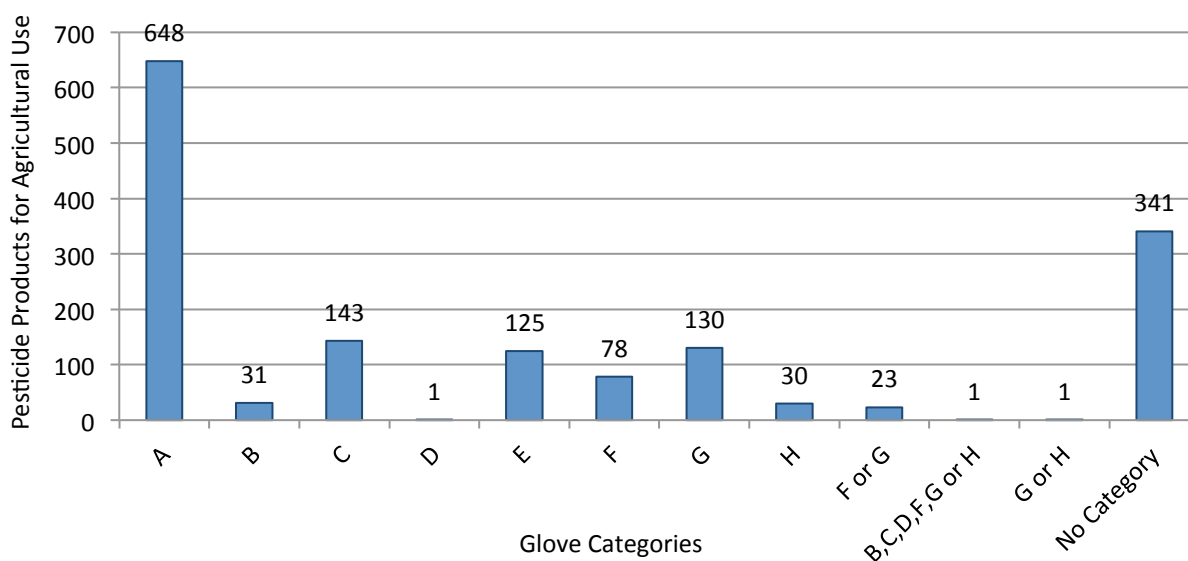
Of the 1,868 pesticide labels:

- 1,552 call for chemical-resistant gloves.
- 174 call for waterproof gloves.
- 2 require just gloves.
- 140 require no gloves.

Of the 1,552 labels calling for chemical-resistant gloves, 648 fall into Category A. No category is identified for 341 labels. Categories C, E, and G were indicated on 143, 125, and 130 labels, respectively. See Figure 2 for other glove categories.

It is quite possible that the term “waterproof” is used for products for which Category A gloves are sufficient. In general, the terms “waterproof” and “chemical resistant” are used interchangeably. While a chemical-resistant glove is waterproof, a waterproof glove may not be chemical resistant. There is considerable variation in the descriptions within each category of A through G. The terminology overlaps on labels, even within the same description. For example, the words “Chemical-resistant glove made of any waterproof material such as ...” appear on many labels.

**Figure 2.** Requirement for chemical-resistant gloves by category



The chemical-resistance chart for gloves provides eight categories (A through H). It includes eight types of materials with four levels for each category: none, slight, moderate, and high). While the chart provides extensive information, such complexity may not be needed for glove selection. For example, is it necessary to list all the options

for 648 Category A labels (and possibly many of the 174 waterproof gloves) when a thin polyethylene or nitrile glove would suffice? (Disposable nitrile gloves are not currently an option as they do not meet the thickness requirements.)

It is recommended that levels cited in Table 1 (minimum required, next highest level of protection, and highest level of protection) be considered for gloves. Current glove requirements are based on permeation tests using solvents as the test chemical. Testing with solvents was used as the basis because the findings of a 1980s study concluded that breakthrough for solvent typically occurs before breakthrough of active ingredients (Ehnholt et al., 1990). Note that handlers applying liquid pesticides are often exposed to products that are highly diluted with water. Handlers doing mixing and loading may be briefly exposed to concentrates.

Testing a glove that is in contact with a 100 percent solvent may significantly overestimate the protection requirement. This overestimation and the resulting protection requirement may necessitate use of more expensive and thicker gloves that limit dexterity. The testing was done on thicker gloves (except polyethylene and barrier laminates), so disposable nitrile gloves typically used in labs and hospitals do not meet the criteria. If thin polyethylene is acceptable for Category A, a thinner elastomeric glove could also be an option. (Currently, elastomeric gloves are not acceptable, as the minimum requirement for most glove categories is 14 mil.)

University of Maryland Eastern Shore is working on a collaborative project to determine how a performance-based approach can be used for gloves. The goal is to have three performance levels:

1. Lowest for protection against dry and water-based formulations.
2. Middle for protection against liquid formulations with solvents.
3. Highest for products with high permeation.

This project seeks to determine whether thinner and (presumably) less expensive gloves can provide protection, especially for pesticide applicators. Existing data and information on solvent permeation used to develop the current categories, exposure study data, and new laboratory studies in progress will be used to develop performance guidelines. Gloves available in the United States bear statements such as “Comply with USDA and FDA regulations, 21 CFR, for use in food processing” and European symbols. In the future, compliance with an approved standard for use when handling pesticide could be added for gloves that meet the requirements.

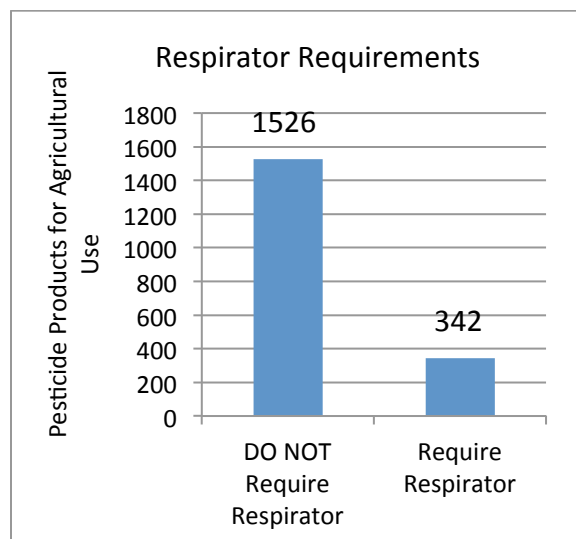
### **Respiratory Protection Devices (Respirators)**

EPA considers inhalation toxicity and vapor pressure to determine respirator type when a respirator is required. As shown in Figure 3, NIOSH-approved respirators are required for 342 of the 1,868 labels analyzed. PRN 98-9, *Modification of Respirator Statements for Pesticide Product Labels*, was published when the requirements of NIOSH-certified respirators were changed in 2004. Today, some labels have old respiratory language, some have both old and new, and some have only new language based on PRN 98-9. However, this information concerning respiratory protection is not reflected in Chapter 10 of the *Label Review Manual* (EPA, 2011).

Based on PRN 98-9, the lowest level of protection requires no respiratory protection device. A filtering facepiece respirator (N95, R95, or P95) is the next level, noting that only R95 and P95 can be used if the formulation has oil. An elastomeric half-mask respirator with appropriate cartridges and/or filters is required for the next higher level of protection. Finally, an air-supplying respirator is required for the highest level of protection (EPA, 1998, 2011). The document provides revised language with a provision for the transition.

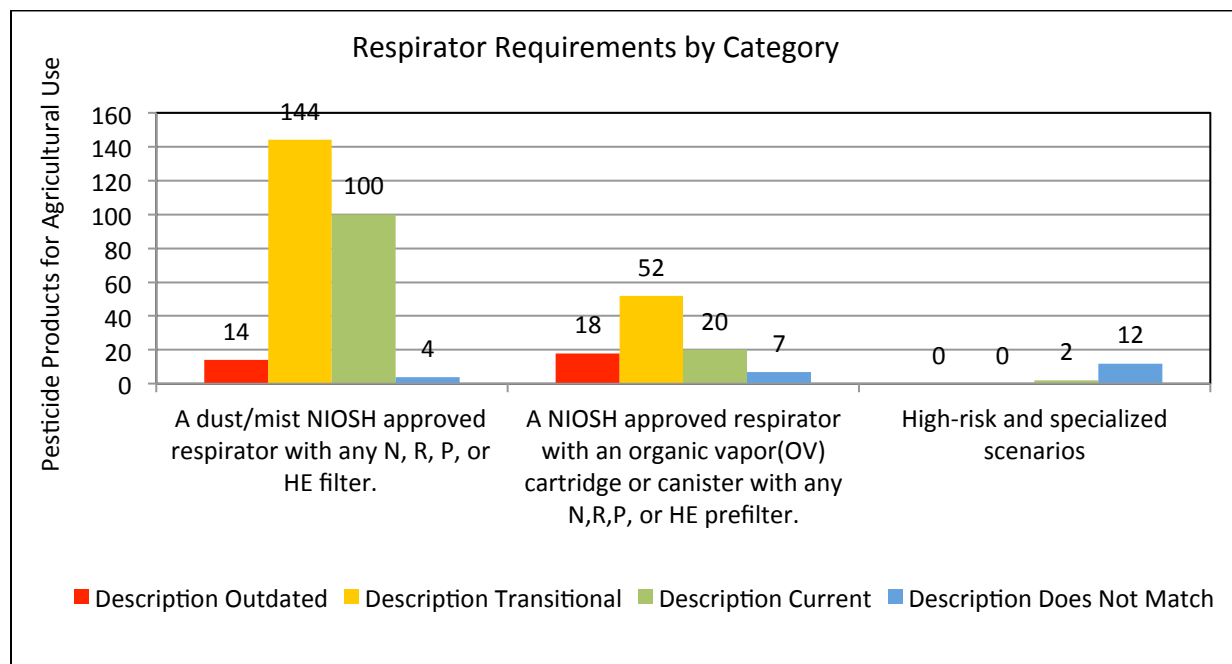
According to PRN 98-9, all labels were to have reflected the wording changes by 2004. As seen in Figure 4, however, many labels continue to use the transitional wording. Some retain the old terminology. The continued use of transitional wording may be because although the change date is stated in PRN 98-9, it is not mentioned in the *Label Review Manual* (EPA, 2011). Additionally, when NIOSH made changes to respirator certification, they no longer co-certified respirators with the Mine Safety and Health Administration (MSHA). Thus, respirators in the marketplace today suitable for pesticides would have only the NIOSH coding system and would not mention MSHA.

**Figure 3.** Respirator requirements





**Figure 4.** Respirator requirements by category



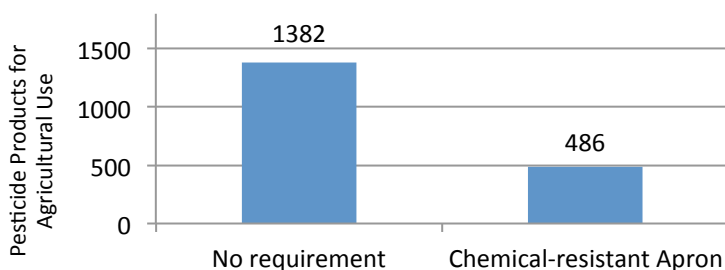
**NOTES:**

1. Twenty-eight pesticide products for agricultural applications had labels with requirements for two scenarios: exposure in enclosed areas and exposure outdoors. These products were counted for each scenario.
2. Twelve product labels are specific to scenarios; therefore, their descriptions do not match a category.

**Chemical-Resistant Apron and Protective Headwear**

A chemical-resistant apron and protective headwear are additional PPE required when specified criteria are met for certain products with dermal toxicity Category I or II and/or skin irritation. A chemical-resistant apron is required during mixing and loading and while cleaning equipment. Based on the analysis, 486 product labels require chemical-resistant aprons (see Figure 5). Information was not recorded for the garment worn under the apron or as to whether the requirement is for mixing and loading or for cleaning.

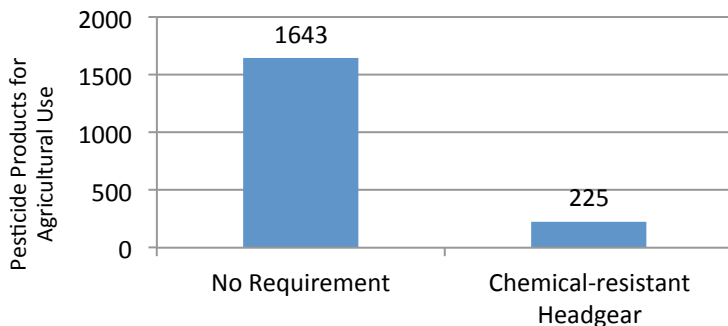
**Figure 5.** Apron requirements



Chemical-resistant headgear is required for products classified as Category I or II for acute dermal toxicity or skin irritation potential that might involve overhead exposure. As

shown in Figure 6, only 225 of the 1,868 product labels require chemical-resistant headgear.

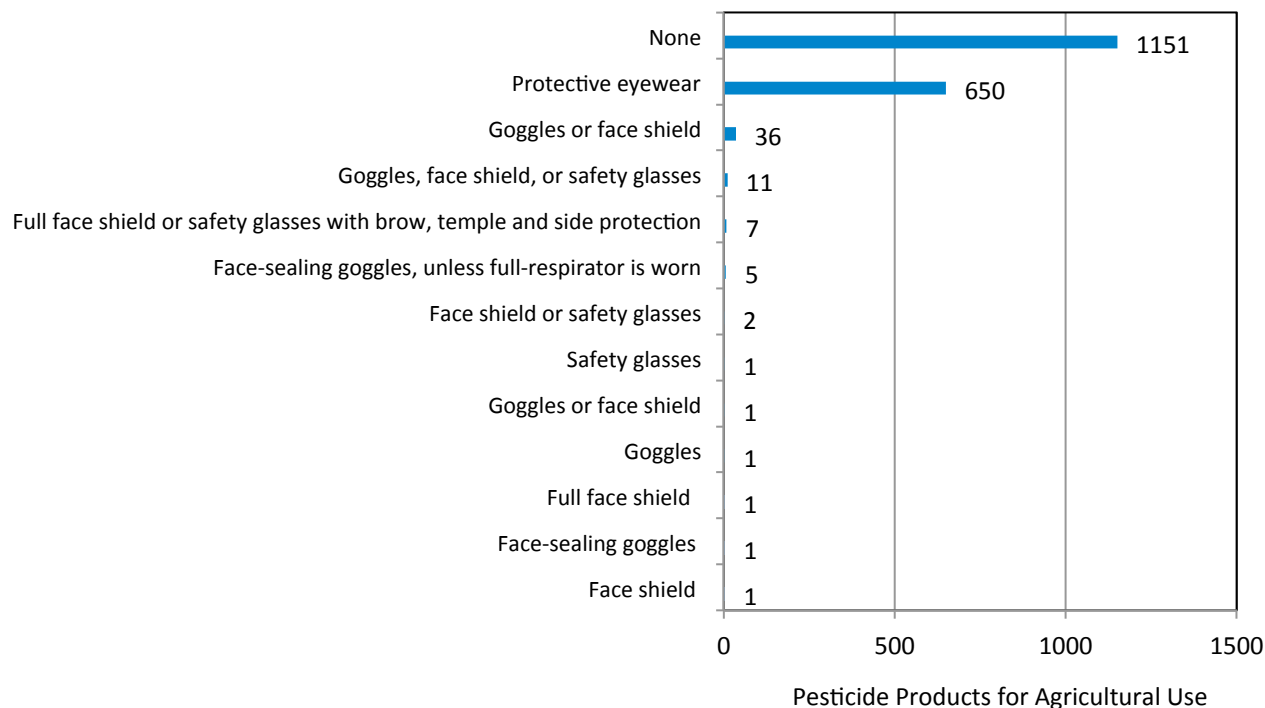
Figure 6. Headwear requirements



### Protective Eyewear

According to the *Label Review Manual* (Chapter 10, Table 1; EPA, 2011), protective eyewear is required for products classified as toxicity Category II for eye irritation potential. Eyewear may be required on a product-specific basis for other categories. Note 5 of the table states: “Protective eyewear’ is to be used as the label language instead of ‘goggles’ and/or ‘face shield’ and/or ‘shielded safety glasses’ and similar terms to describe eye protection, unless the assessment requires a specific type of eyewear for adequate protection.”

As shown in Figure 7, 1,151 product labels do not require protective eyewear. Of those that do, 650 labels state “protective eyewear,” indicating compliance with the required *Label Review Manual*. Eleven product labels state “goggles, face shield, or safety glasses,” and 56 specify a particular type of protective eyewear. Some of these were very specific, such as “safety glasses with brow, temple, and side protection.” One product label stated, “Face shield or safety glasses with brow temple shields when handling liquid product (Do NOT wear goggles).”

**Figure 7. Protective eyewear requirements**

### Conclusion

Most PPE requirements have not changed over the last two decades. However, available information, ongoing research, and the standards-development process have advanced considerably. A performance-based approach to assign PPE based on risk assessment is being proposed to simplify pesticide product labeling. A dialogue among the various stakeholders could serve as the basis for changes to produce easy-to-understand labels.

### Recommendations

Specific recommendations are outlined below. The rationale for these recommendations can be found in “Results and Discussion.”

#### Protective Clothing

The three performance-based protection levels used in ASTM F2669 (ASTM, 2012) should be considered in place of garment type and layers. A label that clearly designates a protection level based on risk assessment that matches the protective clothing’s own label would help the user choose the right garment.

## Gloves

Consideration should be given to replacing the existing chemical-resistance category selection chart with three levels (minimum level of protection required, middle level of protection, and highest level of protection). One option is to use the following:

1. Lowest for protection against dry and water-based formulations.
2. Middle for protection against liquid formulations with solvents.
3. Highest for products with solvents that have high permeation.

## Chemical-Resistant Apron and Protective Headwear

The terminology for these two categories is relatively consistent. However, there are no criteria to measure performance. The ASTM and International Organization for Standardization (ISO) standards (ASTM, 2012; ISO, 2011) could be revised to include protective clothing and accessories such as apron and headwear used for application as well as mixing and loading. Compliance with Level 3 (highest level of protection) requirements would be necessary for chemical-resistant clothing.

## Protective Eyewear

Most labels use the term “protective eyewear.” In general, protective eyewear provides physical protection. Therefore, the part of the face covered and fogging issues are more important than chemical protection. Input from stakeholders may be required to determine whether further action is necessary for this category.

## Proposed Format for PPE Information

Table 3 shows a proposed format that could automatically generate labels for final approval. This format would allow PPE statements to be more consistent among manufacturers unless there is a unique risk to be mitigated. It could also simplify the process of assigning label requirements.

**Table 3.** Proposed format for PPE requirements on product labels

Handler category	Protective clothing	Gloves	Respiratory protection device	Protective footwear	Chemical-resistant apron	Protective headwear
Applicator						
Mixer/loader						
Applicator in enclosed tractor cab						

**Additional requirements:** Other information not stated in the table.

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