

Use of Ambient Aerosol for Testing Agricultural Cabs for Protection Against Pesticide Aerosol

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INTRODUCTION

Pesticide application can create aerosols that pose a health risk to the workers. During air blast spraying in orchards, dilute emulsions, solutions, and suspensions of pesticides are sprayed into an air flow of about 44 to 67 m/s (100 to 150 mph). This results in a mist with a primary droplet size in excess of 100 μm and some smaller droplets. Thus, pesticide spray application can cause detectable pesticide exposure via respiratory and skin exposure routes [Carman et al., 1982; Wojeck et al., 1980]. The U.S. EPA Worker Protection Standard (WPS) requires that applicators and workers must wear the personal protective equipment specified by label [Title 40 Code of Federal Regulations, 1992]. To comply with the WPS, a governmental agency or manufacturer must declare in writing that the enclosed cab (Fig. 1) provides protection which is equivalent to the protection provided by a respirator. For agricultural cabs to be an acceptable substitute for respirators, cab manufacturers must demonstrate a 50 to 1 reduction in pesticide exposure during pesticide application [Department of Pesticide Regulation, 1995, and California Department of Food and Agriculture, 1991].

Frequently, however, pesticide concentrations outside a cab are not large enough to determine whether the cab offers a protection factor of 50. Therefore, a study was undertaken

to evaluate test procedures for tractor cab protection factors which use optical particle counters and ambient aerosol to measure aerosol concentrations inside and outside of tractor cabs while operating the cab under realistic field conditions. This approach has been used in the American Society of Agricultural Engineers (ASAE) Standard S525 which specifies that the enclosure will provide a 50:1 reduction in exposure for particles with an aerodynamic diameter of larger than 3 μm [ASAE, 1997], a protection which is equivalent to a full-facepiece respirator. In this report, the use of optical particle counters (OPCs) to evaluate the exposure reduction obtained by these cabs is presented.

METHODS

The test procedures were developed during field evaluations conducted on a tractor manufacturer's cab (John Deere 7000 series tractor cab) and a retrofit cab (Nelson Spray Cab[®] designed to fit on a Massy-Ferguson 396 tractor). Two OPCs, the Grimm Portable Dust Monitors (PDMs) (Model 1106, Grimm Labortechnik GmbH & CoKg, Ainring, Germany), were used to measure the number concentration of particles inside and outside of the cabs being evaluated. After mounting the OPCs on the inside and the outside of the enclosures, the tractors were driven over unpaved surfaces such as dirt, gravel, and a tilled field at speeds between 3 and 5 kph. The OPC measured size-dependent particle concentrations for a period of 30 min. The test was stopped and the location of the OPCs was switched. This process was repeated until there were four sets of OPC measurements.

ASAE S525 specifies the use of an impactor preselector to eliminate particles larger than 4 μm . In an OPC, light scattered by the passage of individual particles through a

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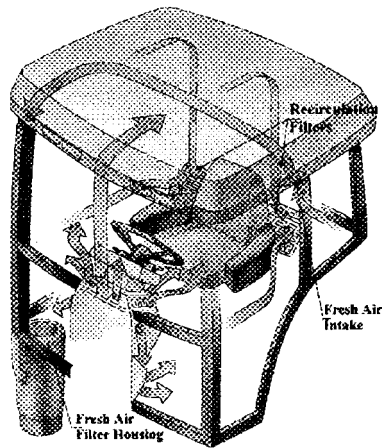


FIGURE 1. Diagram of air flow inside a tractor cab. This particular design used two blowers. One blower was used to pressurize the cab and move air through the filtration system. A second blower is used to recirculate conditioned air through recirculation filters and a heat exchanger used to temper the air.

beam of light is used to detect and size particles. The amount of scattered light is a complex function of particle size, as well as the shape and optical properties of the particle [Fenn, 1976]. Thus, the calibration of an OPC may vary with the test aerosol. To overcome this problem, an impactor is used as a preselector to eliminate particles larger than $4\ \mu\text{m}$ and the instrument's detection threshold determines the smallest particles to be detected. This will result in the use of particles smaller than $4\ \mu\text{m}$ for testing the enclosures. The impactors were not used during the NIOSH evaluation which predated the development of the standard.

The penetration into the cab was computed as a function of particle size, and upper 95% confidence limits were placed on the penetration into the cab. (Penetration is the ratio of the aerosol concentration in the cab to the aerosol concentration outside of the cab.) In Fig. 2, the mean penetration, an upper 95% confidence limit on this mean,

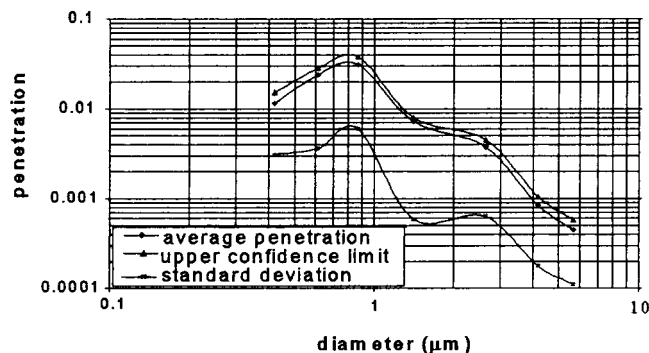


FIGURE 2. Aerosol particulate penetration into a tractor cab. The standard deviation is based upon replicate measurements and the upper confidence limit is a 95% confidence limit.

and the standard deviation of penetration are plotted as a function of particle size. S525-1.1 requires computing upper confidence limit on penetration based upon counting statistics and total experimental error. For the data presented in Fig. 2, the variability attributed to the number of particles counted was negligible. At $3\ \mu\text{m}$, the results indicate that the two cabs were acceptable in terms of S525-1.1 because the upper confidence limit was below 0.02. S525-1.1 also requires the evaluation of coincidence losses by the optical particle counter and this is done by using formulas presented in aerosol science textbooks.

DISCUSSION AND CONCLUSIONS

The standard and test procedure provides a relatively convenient means of testing cabs for their ability to protect workers from pesticide and other aerosols. S525 was developed by collaboration between committee members from industry and government based upon the available information. The standard assumes that all of the pesticide aerosol is larger than $3\ \mu\text{m}$. Subsequent field evaluations by NIOSH researchers indicates that noticeable amounts of pesticide aerosol can be smaller than $3\ \mu\text{m}$. Presently, this issue is being addressed by the ASAE committee.

In practice, this standard is applied by driving the tractor over an open field and using ambient sampling to test the enclosure. If the ambient aerosol concentration is too low, aerosol generation by the cab's ventilation system becomes a noticeable source of bias in this testing. Although this test procedure appears to be relatively straightforward, the actual use of this standard requires some experience in the conduct of experimental work.

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