An Air Filter-Pressurization Unit to Protect the Tractor Operator Applying Pesticides

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The hazards associated with the handling and use of moderate to extremely toxic pesticides makes essential the use of effective safety equipment by those likely to become exposed. The design of the equipment depends on the toxicity of the pesticide, the formulation, the method of application and the location of the application. The apparatus evaluated here is designed to protect the tractor operator while applying sprays or dusts in the field. During such an operation the critical hazards are dermal contamination, particularly at higher ambient temperatures, absorption through the eyes, and inhalation. The latter is generally considered of minor importance in relation to dermal absorption, however, it must be recognized that at times the operator is exposed to rather high levels of spray and dust drifts of the more volatile pesticides.

Protection against the above hazards is usually provided by covering the nose and mouth with a chemical-absorbing cartridge respirator, the eyes with snug-fitting goggles, and wearing rubber or neoprene jacket, pants, hat and gloves. From the standpoint of performance there appears to be no basis for doubting the efficiency of this gear. However, it becomes extremely uncomfortable after an extended period of use, particularly at higher temperatures. In addition, proper attention to the fit of the respirator and goggle straps is often lacking which results in a reduction in the efficiency of such protective equipment. There is a need for an improved system for protecting spray operators from pesticide exposure.

Since the introduction of insecticides such as parathion and other hazardous pesticides, there has been no marked improvement in the protective gear worn by spray operators. With the advent and general acceptance of the tractor cab there was an opportunity to undertake a new approach to the problem of safety for the applicators applying pesticides on a commercial scale. Recently, considerable progress has been made in the development of an air filtering device to protect the tractor operator.

One such unit[1], designed and manufactured by Engineered Air

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Division, Thermal Components, Inc., was the subject of the testing described in this report. It is shown in some detail in the diagramatic sketch in Fig. 1.

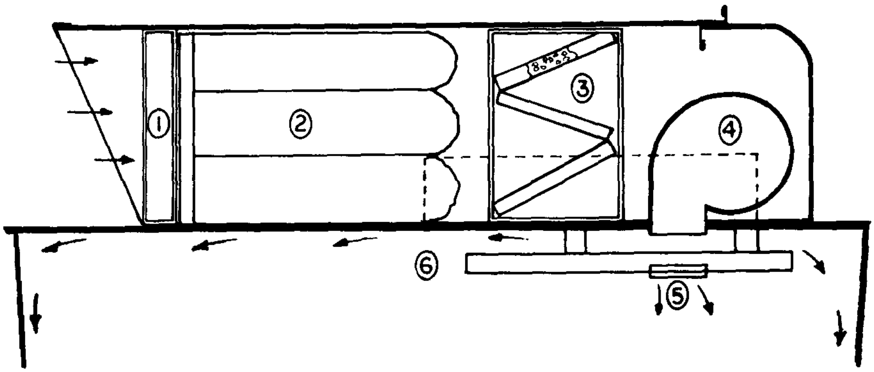

Fig. 1.-A longitudinal sketch showing essential parts of the air filter-pressurization unit (1) prefilter, (2) high-efficiency bag filters, (3) activated charcoal, (4) fan, (5) aid distribution nozzle, and (6) air deflector plate.

EQUIPMENT AND METHODS

The essential parts of the unit (filters and fan) are enclosed in a rectangular-shaped sheet metal casing. The forward facing air inlet in the casing is protected by a 2.5 x 2.5 cm mesh screen. The top or cover is a panel section held in place by either bolts or latches and air leakage around this access cover is prevented by a rubber seal. When the cover is removed there is sufficient access to all internal parts. The unit is mounted on the roof of the tractor cab.

Air purification is accomplished by three filters mounted in series. The first or pre-filter is a heavy duty coarse mat constructed of fiberglass. The second is an air bag filter designed to remove fine solid particles and spray mist. The final or chemical-absorbing filter contains 40 pounds of activated charcoal having an activity range of 60 to 65. Its purpose is to absorb pesticide vapors which pass through the first two filters.

After air from outside the cab is filtered it is forced from the discharge ducts of the fan downward through outlet openings in the bottom of the filtering unit casing and through inlet openings in the roof of the tractor cab. Inside the cab the filtered air, under pressure, is brought in contact with a sheet metal air distribution plate suspended below the cab roof. Between these two surfaces a clean air plenum chamber is formed and from here the air is directed around the perimeter of the cab. This creates positive air pressure which prevents outside, unfiltered, air from entering the cab even if there are small openings. Two air distribution nozzles in the air deflecting plate to maintain a steady flow of filtered air without producing a draft over the operator.

A study was undertaken to determine the extent to which the air filter pressurization unit removed an insecticide from air entering the tractor cab. In this investigation an attempt was made to simulate conditions that normally exist when treating crops with pesticides. The main difference between the usual spray operation and the procedure followed was that the tractor and spraying equipment were stationary thus resulted in the spray drift or spray clouds not being subjected to the buffeting effect of foliage as normally occurs when treating vineyards and orchards. The position of the air sprayer with respect to wind direction was such that the outlets discharged the spray upwards and into the wind. Under such conditions the spray drifted forward intermittently over the tractor cab and air filtering unit (Fig. 2). Cab and air filter exposure was judged to be equal to

Fig. 2.-Equipment used to evaluate the air filtering-pressurization unit. Note: Spray clouds drifting forward over tractor cab and air filtering unit.

that for normal operations. The ambient air temperature ranged from about 2 °C at the start of the experiment to 23°C at its termination. Meta-Systox R^R, S-[-(Ethylsulfinyl)ethyl] 0,0-dimethyl phosphorothioate, in a formulation containing 2 lbs of active ingredient per gallon was selected for this study. It has a volatility of 0.09 and 0.3 mg (m^3 at 20° and 30°C, respectively). The rates of insecticide used per 100 gallons of water are shown in Table 1. For the first test three duplicate 14.2 liter samples of air were taken during each of the 1-hour collecting periods. During each hour of operation 300 gallons of water containing 1.5 lbs of actual insecticide was sprayed out with a Hardie air sprayer (Table 1). In test 2 duplicate air samples were taken only for the first and second one-hour sampling period. For the third 1-hour of sampling one air sampler was located inside the cab and the other was positioned outside the cab so the intake opening was about 38 cm ahead of the air inlet of the filtering unit. A Windmill air sprayer calibrated to deliver 175 gallons of water and 1.4 lb of actual toxicant per hour (Table 1) was used in the second test.

TABLE I

Spray mixture and amount of actual insecticide sprayed in 1 hour

		Amount of Meta-Systox R^R AI (lb)		
Test no.	Applicator	Spray mixture lb/100 gal.	Sprayed in 1 hr.	Spray mixture delivered in 1 hr. (gals.)
1	Hardie Air Sprayer	0.5	1.5	300
2	Windmill Air Sprayer	0.8	1.4	175

The air sampling equipment consisted of a standard glass gas washing bottle containing 40 ml of acetone and a fine mesh sintered glass gas dispenser. Air was drawn through the sampler by a rotary air-vacuum pump and regulated by a controllable flow meter at 14.2 liters per hour. The position of the air scrubbers were positioned in the tractor cab in such a location that the inlets were in approximately the same position as the head of an average sized operator. The quantity of Meta-Systox R in each sample was determined by the total phosphorous colorimetric method (BRODERICK et al., 1967).

RESULTS AND DISCUSSION

The results from analyses to determine the efficiency of the filtering unit in removing Meta-Systox R from air are presented in Table II. In general there is rather good agreement between amounts recorded in duplicate samples each test. Concentrations of Meta-Systox R in 1 liter samples of filtered air ranged from 0.03

TABLE II

Amount of Meta-Systox R^R in air samples collected inside tractor cab equipped with the air filter pressurization unit

Test no.	No. replications	µg in 14.2 liters of filtered air (time, hr)		
		0-1	1-2	2-3
1[1/]	1	0.0	3.0	5.0
	2	1.0	0.0	0.0
	Avg	0.5	1.5	2.5
2[2/,3/]	1	2.0	1.0	2.0
	2	3.0	0.0	-
	Avg	2.5	0.5	2.0

[1/] Apparent Meta-Systox R^R in check 3.0 µg deducted.

[2/] In the 2-3 h sampling period, 1 sample inside cab and 1 outside.

[3/] Outside cab sample with 400 µg of insecticide in 14.2 liters air in 1 h.

to 0.18 µg as compared with 28 µg per liter of air outside the tractor cab. According to the data, the performance of the filtering unit in removal of pesticide is above 99%. Because of the location at which the outside unfiltered air sample was collected, the amount of 400 µg of insecticide collected in one hour is indicative of only that present in air entering the filtering unit (Table II, see Footnote 2). It seems reasonable to assume that larger amounts of pesticide would be present in samples if taken in more exposed areas, for example along the side or at the rear of the tractor cab.

When 2.5 µg of Meta-Systox R was scrubbed from air inside the tractor cab in one hour there was 0.18 µg of the insecticide in one liter of air. Thus, an operator inspiring 20 liters of air per minute (16 liters inhaled per minute when seated and 24 liters when walking) (KAHN, 1960), would inhale about 0.22 µg of the insecticide per hour. This amount is well below the inhalation LC_{50} value of 1.5 mg per liter in one hour (ANON. 1965). Sub-acute toxicity tests with Meta-Systox R indicate no deaths or cumulative effects to rats exposed to a concentration of 0.18 mg per liter for one hour daily over a period of 30 days (ANON. 1965). A comparison of the amounts reported (0.18 µg per liter an average) to the no-effect level (0.18 mg per liter) would suggest at least a 1000 to 1 safety factor is afforded by the air filter pressurization unit described. Dermal absorption is unimportant due to the physical protection afforded by the cab.

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