A Study of the Inhalation of Pentachlorophenol by Rats
Part II
A New Inhalation Exposure System for High Doses in Short Exposure Time

by HEINZ J. HOBEN, STEPHANIE A. CHING, and LOUIS J. CASARETT*
Department of Pharmacology
University of Hawaii
3675 Kilauea Avenue
Honolulu, Hawaii 96816

INTRODUCTION

In initial inhalation experiments with Pentachlorophenol, an ultrasonic atomizer and the Lauterbach nebulizer were used to generate an atomized solution. The first proved inadequate in reproducing consistent concentrations in subsequent trials. The second, though adequate in reproducibility, failed to generate high enough concentrations of atomized solution for the intended studies. Hence, a generator which exhibited consistent reproducibility and generated high concentrations of aerosol was developed. This paper describes the construction of an efficient exposure system and the results of subsequent trials to test its characteristics.

DESCRIPTION OF THE GENERATOR AND ITS RELATED PARTS

The major components of the aerosol generator (Fig. 1) consist of an air chamber, air jets, ascending liquid tubes, an air tube and two aerosol chambers (the lower and the upper chamber). The generator is held upright by a cast iron circular lamp base into which the lower end of the air tube is screwed.

The air chamber (a) is a 3.6 cm long brass cylinder which is closed with an inner diameter of 16 mm. Its walls are 6 mm thick. The top is closed; the lower end has a threaded opening. Six threaded holes with a diameter of 3 mm run around the cylinder at an equal distance from each other 1.0 cm below the top.

Six air jets (b) which are threaded at the ends screw into the six holes in the air chamber. The jet openings have a diameter of 300 microns. The six brass tubes for the ascending cylinder (c) are 63 mm long with an inner diameter of 2 mm. Their pointed tips have an opening the diameter of which is equal to that of the air jets. Tygon tubing (d) 36 mm in length is attached to the lower end of the tubes. Each ascending liquid tube is held perpendicular to a corresponding air jet which directs a flow of pressurized air over the tip of the tube. The ascending liquid tubes are held in place by a brass holder (e) which is welded to the lower end of the air chamber. The holder consists of a 8 mm thick brass ring with six

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holes into which the tubes fit loosely. The proper position of each tube is held by tightening a corresponding screw (f).

The air tube (g) is made of brass. It is 13 cm long and has an outer diameter of 16 mm. Its lower end is screwed into a 3 cm long brass mantle (h) which is sealed on its bottom and welded to the lamp base (i). A threaded hole on one side with a 1.0 cm Swagelok fitting (j) accepts pressurized air through a tygon tubing.

The upper end of the air tube is screwed into the air chamber. Six cm below this point it runs through the center of a brass disc (k). This disc is welded to the air tube. It is 24 mm thick and machined to the shape of a stopper the size of which corresponds to that of the larger ground glass joint of the lower aerosol chamber.

The liquid can be drained through a hole which has been drilled through the brass stopper. This drain (o) has a diameter of 10 mm and consists of a Swagelok elbow which is screwed into the hole, and a 5 cm piece of tygon tubing with a clamp to regulate the flow.

The smaller opening of the aerosol chamber consists of a ground glass joint with a 20 mm diameter (p) onto which a 1 liter round bottom flask is fitted invertedly. The upper flask (q) is a cyclone dropout chamber which removes the larger droplets by impact, thus allowing only the smallest particles to enter the exposure chamber. A glass tube, fused to its bottom, is used to drain the accumulating liquid (r). The outflow (s) of this flask stands at a right angle to the inflow and consists of a 30 mm long tube with a diameter of 10 mm which is connected to the exposure chamber by a ball and socket joint.

OPERATION OF THE GENERATOR

The operation of the generator is similar to that of the DeVilbiss nebulizer as described by T.T. MERCER, et al. (1968). Pressurized air from a tank is released through a flow meter to the inflow junction at the bottom of the air tube. The air flows through the air tube to the air chamber and to the air jets which direct a stream of air over the top of the ascending liquid tubes, thus creating pressure differentials. Within the lower pressured ascending liquid tubes, an upward draft is formed, creating a suction which draws the liquid solution. The drawn liquid moves up to the tips of the tubes where it is then atomized by the flow of pressurized air from the air jets. The resulting spray impacts against the walls of the aerosol chamber and the coarser droplets coalesce and fall back into the liquid. The aerosol moves into the upper chamber where by cyclonic action the larger droplets are trapped allowing only a fine mist to enter the exposure chamber.

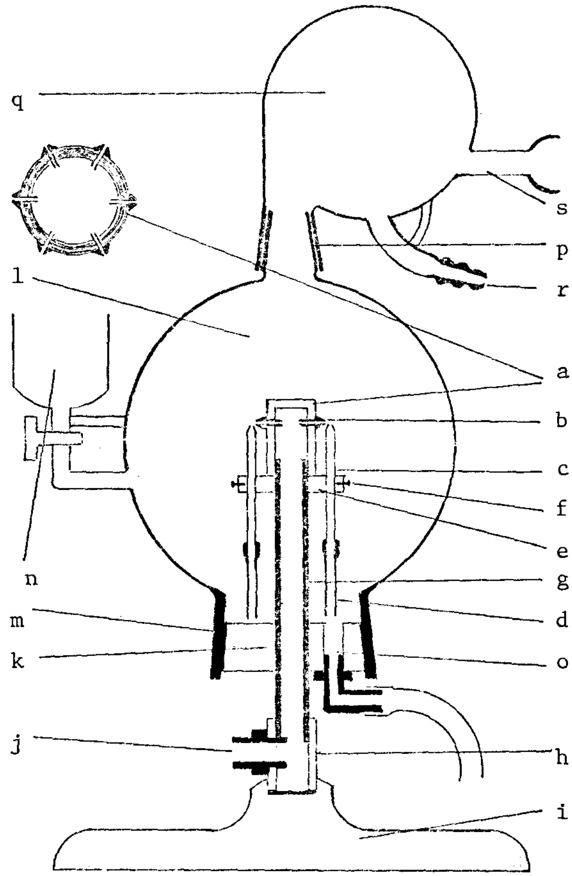


FIGURE 1 Aerosol Generator

DESCRIPTION OF THE EXPOSURE CHAMBER

The exposure chamber is supported horizontally by a wooden cradle. The chamber is built from a large glass funnel which is 24 cm long and has a diameter of 30 cm. Its pointed end is joined to the generator by a ball and socket joint. The larger end is sealed with a plexiglass plate onto which are attached four component systems: the actual inhalation site with the animal container; the outflow system with filters and pumps; an aerosol sampling device; and a manometer.

The animal containers consist of 12 plastic baby bottles with their bottoms removed and replaced by No. 11 stoppers to facilitate the entering and removal of the animals. The corresponding bottle tops with the nipples removed are glued into twelve holes which are cut into the plexiglass plate equidistant from one another. Slitted round rubber seals are fitted into these sockets and held in place by the bottles into which 200-230 gram rats fit snugly. The seals are made from car inner tubes in the shape of large washers with holes of a 12 mm diameter in their centers. A thinner softer rubber is then glued over the entire disc and slitted crosswise over the center hole to allow only the noses of the animals to stick through and be exposed to the aerosol.

The outflow component is connected to the chamber by three vacuum tubes with an inner diameter of 1/2 inch. They join into a large single tube which branches into two identical filtration systems each of which consists of a 1 liter impinger containing 250 ml of water, followed by another 1 liter impinger filled with glass wool. Each system is powered by a Little Giant suction pump.

The sampling system is connected to the chamber by an inverted L-shaped glass tube attached at the center of the plexiglass plate. A 50 ml impinger is attached to the glass tube by a ball and socket joint. A second 50 ml impinger is connected to the first. The two impingers each contain 20 ml 0.1 KOH and act as a sampling trap, catching the atomized PCP. The suction line continues to a Fischer trap which condenses any moisture, preventing it from entering the following flow meter, which in turn is connected to another Little Giant suction pump.

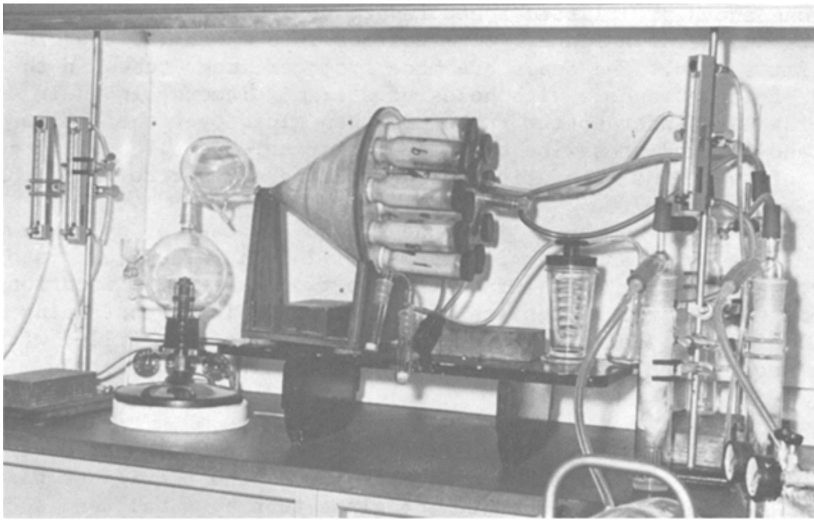
The manometer is connected to the chamber by a single tube attached to the plastic plate. It consists of a U-shaped glass tube filled with water which indicates differences between internal chamber and outer atmospheric pressure.

OPERATION OF THE EXPOSURE SYSTEM (Fig. 2)

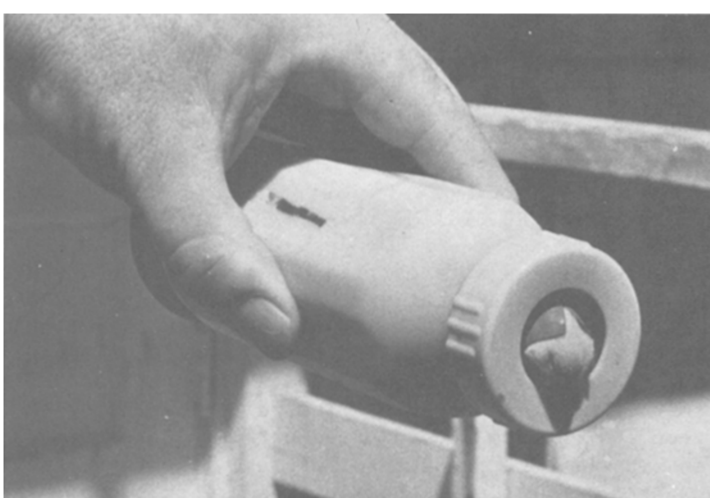
All exposure studies were carried out in a hood. The system was adjusted for each experiment in the following manner. All components were connected, and the regulator of the air tank was turned to about 60 psi. The air line which supplied the generator ran through a flow meter which maintained a flow rate of 9 liters of air per minute at this pressure. The pumps regulating the air flow were then switched on and adjusted until the attached manometer showed the same pressure within as without the chamber, indicating a steady air flow without a pressure build up. The sampling pump was set in action, and the flow meter of the sampling system was adjusted to an air flow of 0.5 l/min. With the exposure system now adjusted to the conditions of the experiment, the air supply was closed and all the pumps were switched off again.

The animals were loaded into the holders and then attached to the exposure chamber. The generator was filled with the solution

Fig. 2   The Exposure System



(a) The generator, exposure chamber, and filtration system



(b) Loaded animal container

to be atomized. The stop cock of the filling funnel was left open to act as an air vent as described by T.T. MERCER, et al. (1968) concerning the DeVilbiss Generator. The system was again set into operation as described above marking the initiation of the exposure. Readjustments were made during the exposure time, if found necessary. At the end of the exposure period, the system was switched off in the previously described manner. The animals were quickly removed from their containers and treated according to the plans of the experiment.

OUTPUT CHARACTERISTICS AND DISCUSSION

The described exposure system fulfilled all the requirements for the intended studies.

A group of rats could be exposed to a dose of aerosol with a PCP content high enough to make it comparable to single and multiple dose exposures by alternate routes (DEICHMANN, et al., 1942). Since only the nose areas were exposed, dermal and gastric exposures were almost totally excluded, and the exposure times could be kept short enough as to cause no undue stress to the animals. Rats which were exposed for one hour to water mist showed no discomfort due to the extreme confinements of their containers. All experiments - even LD 50 studies - lasted less than 45 minutes.

The aerosol droplets which reached the chamber were small enough as to leave no liquid residue on the bottom of the chamber. Their size was not measured. The particular aerosol to be generated would be absorbed through the respiratory system due to its solubility in liquid.

Small differences in the concentration of air born solute were recorded between exposure sites, but the pesticide levels found in animals exposed at the various ports indicated that these differences were not significant in terms of dose received.

To test the reproducibility of the aerosol output a PCP solution containg 10 g PCP, 6 ml glycerol and 1.7 g NaOH in 100 ml water was atomized four times for periods of 20 minutes. The aerosol was collected at a flow rate of 0.5 l/min. The results lay between 761 and 802 mg PCP with a standard error of 1.7%.

To achieve reproducible aerosol outputs, the generator had to be cold before the start of each run. Different exposure levels were achieved by varying the exposure times. However, exposure times were not proportional to aerosol output. The evaporation of water caused a continuous increase in the PCP concentration of the liquid remaining in the nebulizer. This in turn increased the concentration of air born solute. The PCP output stood in a linear relation to the exposure time for the time periods tested (Fig. 3).

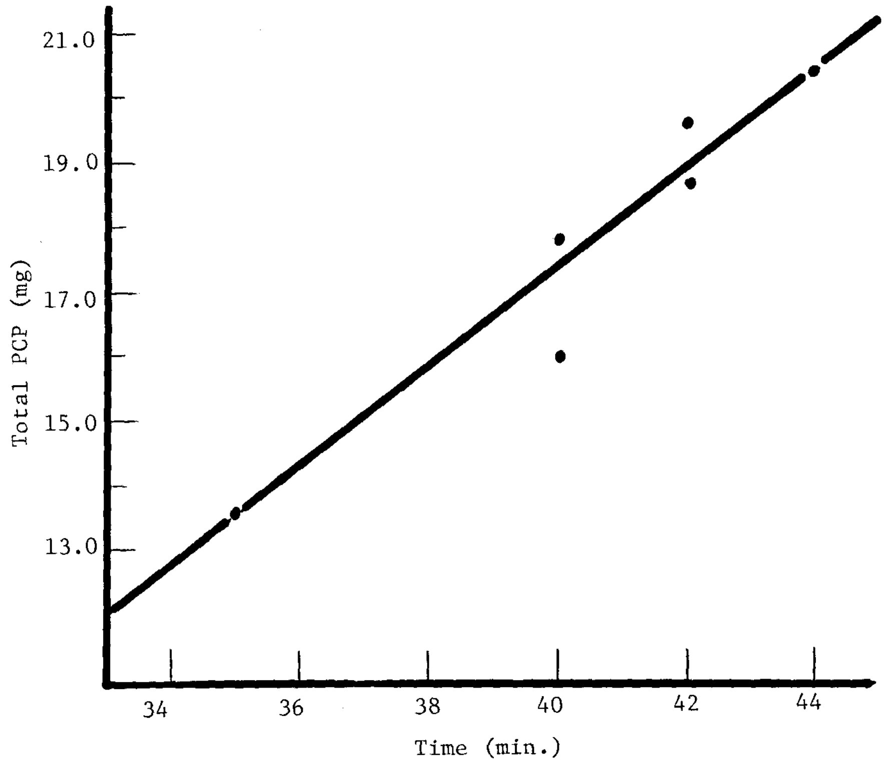


FIG. 3 PCP Output as a Function of Time

SUMMARY

An exposure system has been designed which is applicable for short time, acute exposures of rats to the aerosol of pesticides. The aerosol is generated by compressed air aspiration. Larger droplets are removed by a cyclone separation. The exposure chamber has 12 inhalation sites separated from the animal containers by rubber seals which insure inhalation as the only route of exposure.

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