Aerial Pesticide Application

February 2009

FOR PERSONS SEEKING CERTIFICATION BY
THE STATE OF HAWAII DEPARTMENT OF AGRICULTURE
TO BUY, USE, OR SUPERVISE THE USE OF
RESTRICTED USE PESTICIDES APPLIED BY AIRCRAFT

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ACKNOWLEDGMENT

This booklet is a revision of the booklet APPLY PESTICIDES CORRECTLY, A GUIDE FOR COMMERCIAL APPLICATORS, AERIAL APPLICATION (1976) published by the U.S. Environmental Protection Agency, Office of Pesticide Programs. Revisions include additional text and a table that appeared in another version in the magazine, “The World of Agricultural Aviation” vol.3(3), pp.21–28, March 1976. We gratefully acknowledge the efforts of all authors, editors, and publishers.

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in the source booklet
APPLY PESTICIDES CORRECTLY
A GUIDE FOR COMMERCIAL APPLICATORS
AERIAL APPLICATION

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PURPOSE OF THIS STUDY GUIDE

This study guide was developed for persons preparing for the State of Hawaii’s restricted use pesticide certification examination for Commercial 4 aerial pest control, for persons using or supervising the use of restricted use pesticides applied by aircraft.

Other Study Items
This study guide is just one item of a complete set of study items. A list of the items in a complete set may be viewed at this webpage:
<http://pestworld.stjohn.hawaii.edu/studypackets/spcatgor.html>

DISCLAIMER

Where trade names are used, no endorsement is intended nor is criticism implied of similar suitable products not named.
INTRODUCTION

Effective aerial application requires:
• close cooperation between applicator and grower when planning a job,
• consideration of the effects of the application on the environment,
• concern for the safety of people, animals, and non-target crops,
• correct and well-maintained equipment,
• accurate and uniform application,
• a competent pilot, and
• adherence to the planned procedure.

Limitations of aerial application are:
• need for excellent weather conditions,
• difficulty in treating areas containing obstructions,
• difficulty in treating small or irregularly shaped areas,
• long ferrying distances between base of operation and job site.

DISPERSAL EQUIPMENT

Both fixed and rotary wing aircraft are used for aerial application. Metering and dispersal equipment on the aircraft must meter correct quantities of pesticide formulations and deliver them uniformly. The equipment must be accurate so it can be calibrated correctly.

Liquid Systems

Liquid dispersal systems consist of a tank, agitation system, pump, piping and fittings, filters (screens), boom, and nozzles. These systems may be wind-driven or they may be hydraulic or mechanical, powered by the aircraft engine.

Tank—The tank should be leak-proof and corrosion-resistant. It should have a mechanism for emptying the contents quickly in case of emergency. The aircraft must have a gauge that measures tank contents. The tank should be fitted with an air vent—either a tube-type or a spring-loaded flapper valve.

Pump—The pump system must be able to deliver large quantities of liquid material per unit of time. Wind-driven pumps must have a workable brake.

Agitation System—Most pesticide formulations require some form of agitation during application.

Piping and Fittings—Main piping and fittings should have a large diameter (approximately 2 inches) in order to apply high volumes of liquids, and a smaller diameter (approximately 1 inch) for low-volume application. On helicopters, smaller piping is adequate due to slow application speed.

Filters—Properly sized line filters and nozzle filters (screens) will prevent nozzle clogging. Screen sizes range from 20 to 100 mesh, according to the size of the nozzle opening (larger mesh (20) for larger nozzles). Screens should be located between the tank and pump or between the pump and the boom.

Boom—The boom supports and supplies the nozzles. When the boom is located near the trailing edge of the wing, clearance between control surfaces of the wing and the boom is essential. End caps on the boom make it easier to flush the boom and nozzles. The boom should have a positive shut-off valve.

Nozzles—Special nozzles are available for use in aircraft systems. They must be equipped with an anti-siphon or non-drip check valve. Manufacturer's specifications will guide you in your choice. A uniform spray pattern depends on correct nozzle placement on the boom.

ULV Systems

Ultra-low-volume (ULV) spraying requires a special liquid dispersal system. Manufacturers can supply specifications for ULV systems. Few pesticides are labeled for ultra low volume aerial application.

Front View of Variable Distance Nozzle Placement

Nozzle placement on a helicopter boom may be uniform except where the spray may hit parts of the aircraft such as the skids. A rear section boom is sometimes used to help keep spray off the helicopter.

The angle of the nozzle in relation to the direction and speed of travel affects droplet size. (See illustration of four nozzle positions on next page.) Flight speed also has an effect on the size of droplets.
Dry Systems

These systems are used for applying dry formulations such as dusts, granules, and baits. The application equipment and the size, shape, density, and flowability of the materials affect swath width and pattern. The hopper must have walls steep enough to ensure uninterrupted flow and a lid that will close tightly. An agitator will keep fine materials from bridging. The air vent should be either a spring-loaded flapper valve or a tube-type. An adjustable gate, which must have a tight seal when closed, is frequently used to regulate flow rate. Check the gate often to be sure it is set correctly and is not leaking.

CALIBRATION

Calibration is adjusting your equipment to apply the desired rate of pesticide spray volume. Calibration is especially important in aerial application since large areas are covered in a short time. Calibrate often to be sure that the equipment is adjusted correctly.

Liquid Systems

Here are the basic steps in sprayer calibration:

1. Determine the acres your aircraft’s system treats per minute at the speed and height you plan to fly.
2. Figure the gallons you must spray per minute to apply the recommended spray volume.
3. Select the size and number of nozzle tips which will deliver the correct number of gallons per minute at the operating pressure of your system. Use the nozzle manufacturer’s specifications as a guide.
4. Make a trial run.
5. Determine the amount of chemical to add to the tank.

The following example will explain these basic steps. Your aircraft has a 300 gallon tank. The effective swath width is 50 feet. You plan to spray at 100 mph at a height of 8-10 feet. The chemical is to be applied at the rate of one pint per three gallons of spray per acre. The operating pressure will be 40 psi.

1. Determine acres per minute covered.

\[
\text{Acres per minute} = \frac{2 \times \text{swath width (ft.)} \times \text{speed (mph)}}{1,000}
\]

In our example, \[
\frac{2 \times 50 \times 100}{1,000} = 10 \text{ acres per minute}
\]

The table below will tell you the acres covered per minute when swath width and aircraft speed are known.

<table>
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<th>Acres per Minute for Various Speeds and Swath Widths</th>
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<td>Speed (MPH)</td>
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2. Determine gallons per minute (gpm) required. In our example, \(3 \times 10 = 30\) gallons per minute. Be sure your pump can deliver this volume.
3. Select the nozzles.

First determine the gpm per nozzle that would deliver the required 30 gpm flow. Most agricultural aircraft booms can accommodate about 40 nozzles, but most applicators prefer to use the smallest number that will provide a uniform pattern. Let’s assume you choose to use 26 nozzles. The gpm per nozzle is determined this way:

\[
gpm \text{ per nozzle} = \frac{gpm \text{ required}}{\text{number of nozzles}}
\]

In our example, \[
\frac{30}{26} = 1.16 \text{ gpm per nozzle}
\]

You chose a pressure of 40 psi. Using the manufacturer’s catalog, select a nozzle delivering 1.16 gpm at 40 psi. You may find that the nozzle closest to your needs delivers only...
1.1 gpm. This small difference can be adjusted by increasing the pressure.

4. Make a trial run to check the system.

After installing 26 of the selected nozzles, make a trial calibration test flight to be sure you are spraying at the correct rate.

Fill the tanks with water to a known level on a level apron or strip. Fly the aircraft at the selected 100 mph air speed and at the selected pressure for a timed period (60 seconds in this example). Bring the aircraft back to the same point and measure the amount of water needed to refill the tank to the original mark. Divide the number of gallons used by the number of acres (10 in this example) treated to determine the gallons you are spraying per acre.

5. Determine the amount of chemical to add to the tank.

\[
\text{Chemical per tank} = \text{acres per tank} \times \frac{\text{chemical recommended per acre}}{\text{gallons per acre}}
\]

\[
\text{Acres per tank} = \frac{\text{gallons per tank}}{\text{gallons per acre}}
\]

In our example, \( \frac{300 \text{ gallons per tank}}{3 \text{ gallons per acre}} = 100 \text{ acres per tank} \)

\[
100 \text{ acres per tank} \times 1 \text{ pint per acre} = 100 \text{ pints per tank} = 12.5 \text{ gallons per}
\]

**Dry Systems**

Make several test flights with the spreader installed to determine the quantity of material metered out for a given gate setting. Helicopters may use electric or hydraulic air blowers and the material can be caught and measured while on the ground. You should use inert (blank) granules of the same size and density as those in the formulation to be applied. Operate the spreader for a measured period of time (at least 30 seconds). Weigh the quantity needed to fill the hopper. It may take three or more trial gate settings to determine the one that will give the required discharge in pounds per minute of granular material. To find the pounds per acre being applied divide the pounds per minute by the acres per minute.

**PATTERN TESTING**

Check the swath pattern to make sure the distribution across the swath is as uniform as possible. Both helicopters and fixed-wing aircraft create wind currents (vortices) that affect the swath pattern. The tests must duplicate the airspeed, height of flight, spray pressure, and nozzle angle and placement or gate settings that will be used for the actual application. Make pattern tests in calm air (winds less than 3 mph) to avoid distortion caused by crosswinds. The best way to test a liquid pattern is to add a tracer (dye or fluorescent material) to the water in the tank(s) of the aircraft. For dry pattern testing, use a blank (non-toxic) material (with properties similar to the formulation to be applied if possible). Collect the test material on paper (for liquids) or in buckets (for dry materials) placed across the flight path on the ground. Observation of the collected materials will show the actual swath pattern.

A rectangular pattern gives perfect distribution if flight swaths are spaced perfectly. The trapezoidal and triangular patterns are better, however, because they allow for some error in spacing swaths. They give uniform distribution across the field except for the first and last swaths.

**Ideal Swath Patterns**

- **Rectangular pattern** gives perfect distribution with perfect spacing but is poor with imperfect spacing.
- **Trapezoidal pattern** also gives perfect distribution with perfect spacing and less variation with imperfect spacing.
- **Triangular pattern** also gives perfect distribution with perfect spacing and less variation with imperfect spacing.

**OPERATIONS**

**General**

When an aircraft has been calibrated, the airspeed, spraying pressure (or gate setting for dry materials), height of dispersal system, and effective swath width are fixed. Applications must be made at the same settings.

**Pressure**

Pressure should be around 40-50 pounds per square inch (psi). Choose the pressure near this range that will combine with your selected swath width, airspeed, and nozzle type to give the correct rate of application and desired droplet size. With most nozzle types, droplet size decreases as pump
pressure increases. Use pressure gauges to indicate boom or pump pressure.

Field Flight Patterns

For rectangular fields, fly back and forth across the field in parallel lines. Flying parallel to the long axis of the field will reduce the number of turns. For pilot safety, start treatment on the downwind side of the field. If there are low-speed crosswinds, this prevents flying through the previous swath. (See diagram below). To prevent skips and drift, stop flying if wind speed increases excessively.

Obstructions

If there are obstructions (trees, power and telephone lines, or buildings) outside the field at the beginning or end of the swath, turn the equipment on late or shut it off early. When the field is completed, fly one or two swaths crosswise (parallel to the obstruction) to complete the job. (See three-panel illustration on next page.)

Obstructions inside the field should be treated in the same way. Skip the area around the obstruction and spot treat it later.

Areas next to buildings, residences, livestock, non-target crops, or waterways should be treated with considerable caution:

- Fly parallel to the sensitive area.
- Leave a border of untreated crop to avoid possible drift onto the area.
- Avoid making turns over dwellings where possible.
- Remind your customer to warn beekeepers if bee hives are located near the field to be treated.

PROTECTING THE ENVIRONMENT

Controlling Drift

Drift is the airborne movement of spray, granule, or dust particles to places other than the target area. Properly controlled drift may help the pesticide reach the target. Drift is harmful when it causes damage in non-target areas.

The main factors that must be considered in controlling drift are discussed below.

Droplet Size

Droplet size is one of the most important factors affecting drift. Small droplets are a much greater drift hazard than large droplets. They stay in the air longer because they fall more slowly, and they are more easily carried by...
wind currents. (See table about drift distance on next page.)

Pesticide spray systems cannot produce a completely uniform droplet size. Rather, they produce a range of droplet sizes.

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<th>Strong downwash and vortices area</th>
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<th>Strong downwash and vortices area</th>
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<th>Strong downwash and vortices area</th>
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<th>Adjust distance to compensate for drift</th>
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Weather

An aerial applicator is concerned mainly with the weather in the immediate area of application and less than 1,000 feet from the ground. The weather in this small area has a major effect on the pesticide application, including the chances for drift problems.

Wind is an important weather factor affecting drift. Stop at once if wind increases excessively during application.

Other important factors are “inversion” and “lapse.” These terms refer to the temperature change from the ground upward.

An inversion layer exists in still air that:
• is coolest at the ground level,
• gets warmer up to a certain height, and
• gets cooler from that point up.

Particles released into the cool air layer at ground level during an inversion have a minimum upward movement. Particles released above this cool air layer are suspended in the air. Unable to penetrate the cool air, this mass of particles tends to drift off target with the slightest air movement.

A lapse exists when the air:
• is warmest at ground level, and
• gets continuously cooler at higher elevations.

During a strong lapse, the warm air near the ground rises, carrying very small pesticide particles with it. An applicator should at least be aware of these two conditions, because sometimes they can be severe enough to cause serious drift problems.

Vaporization

Another type of pesticide movement is called vaporization (vapor drift)—the volatilization of an active ingredient during or after application. You must know which pesticides are highly volatile (evaporate easily). High temperatures or other climatic conditions may cause vaporization of some active ingredients. Apply them during periods of relatively low temperature and high humidity. Use active ingredients with low-volatility where vaporization might cause problems.

Protecting Bees

Honeybees and other beneficial insects can be harmed by some pesticide applications. Beekeepers, aerial applicators, and their customers must cooperate closely to protect honeybees. You can reduce bee losses significantly by careful planning and good communications. Bees travel for long distances, so any hives near the area treated with a pesticide toxic to bees may be affected. When using materials hazardous to bees, remind your customer to notify the beekeeper so that he may protect his bees. With few exceptions, dusts may be more hazardous to bees than sprays. Time of
application is important and depends on blooming period and attractiveness of the crop. Treatment during the night and early morning before bees are foraging is less apt to harm the bees.

**PERSONAL SAFETY**

**Pilot**

If possible, a pilot should not mix or load highly toxic pesticides. Exposure to toxic pesticides could cause illness that would make it unsafe for him to operate the aircraft.

The signs and symptoms of illness commonly include dizziness and constriction of the pupils of the eyes (myosis). Myosis impairs visual sharpness and can lead to fatal accidents. Direct eye contamination by organophosphate or carbamate pesticides may cause constriction of the pupils for up to 7 to 10 days without any other symptoms. A pilot who has experienced any symptoms of pesticide poisoning should not fly until he has had medical clearance. In addition to a crash helmet, the pilot should wear a respirator appropriate for the chemical being applied.

**Flagmen**

Flagmen should wear adequate protective clothing appropriate for the chemical being applied. Pilots should not spray or dust over flagmen. Use of permanent markers and automatic flagmen eliminates the possibility of harm to flagmen.

**Loading Crew**

The loading crew must wear the correct protective clothing and equipment. The label on each pesticide specifies the protection required.

**GENERAL SAFETY PRECAUTIONS FOR AERIAL APPLICATION**

- Wear protective clothing and equipment appropriate for the pesticide. (The label for each pesticide specifies the protection required.)
- Know the pesticide being applied and how to get emergency help if needed.
- Avoid all unnecessary contact with spray or dust.
- Change clothing and bathe after each day’s work.

**Pilot**

- Do not load or handle highly hazardous pesticides if possible.
- Make preflight aircraft check.
- Check operation and calibration of dispersal equipment periodically.
- Check target area and surroundings for safety or drift hazards before application.
- Avoid flying through drift if possible.
- Do not apply pesticides over flagmen or other persons.
- Pilots should see that the ground crew is properly checked out on its responsibilities and acquainted with label precautions.
- Do not fly in a manner or at a time which may create a hazard, even if customer insists.
- Warn all people in the treatment area about the application.

**Ground Crew**

- Close tanks and hoppers tightly after filling.
- Remove any spilled chemical.
- Clean aircraft, especially the cockpit, frequently.
- Where possible, clean equipment on a hard surfaced apron so that run-off can be collected and disposed of safely.
- Avoid splashing or standing in run-off water.

**Flagmen**

- Warn all people in the treatment area about the application.
- When the aircraft is lined up for a pass, move over to the next position.

This study guide was developed for the Pesticide Risk Reduction Education program, a Cooperative Extension Service program of the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. Please direct any question or comment about this guide to:

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