Aerial Application of Agricultural Chemicals
Michigan State University Cooperative Extension Service
David C. Star, Pesticide Education Programs; Fred H. Tschirley, Botany and Plant Pathology; Robert Wilkinson, Agricultural Engineering; George Bird, Entomology
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Aerial Application of Agricultural Chemicals

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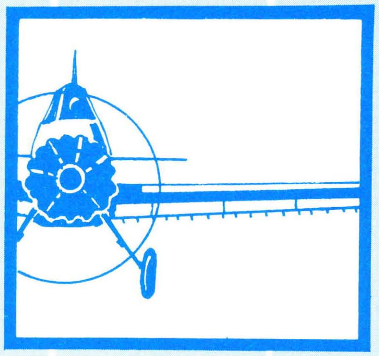
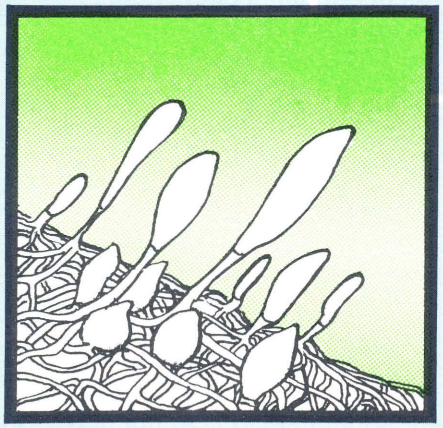
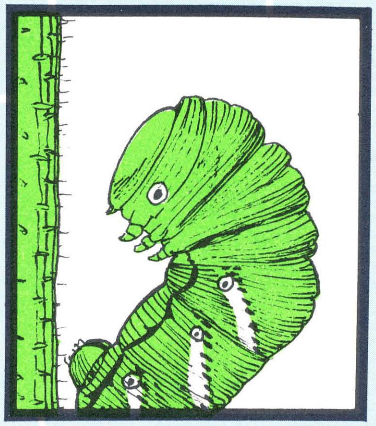

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Category 11 Instruction Manual

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a. *Amaranthus retroflexus* L. - Common amaranth
b. *Venturia inaequalis* Fries - Apple scab
c. *Manduca quinquemaculata* (Haworth) - Tobacco hornworm

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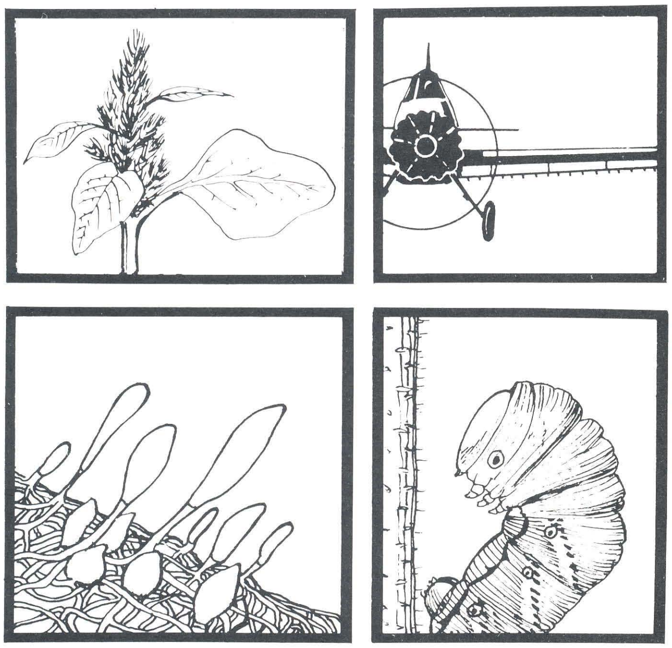

Aerial Application of Agricultural Chemicals

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TABLE OF CONTENTS

PREFACE

This manual is intended as a basic reference and education manual for individuals who conduct aerial application of pesticides in Michigan. The activities of the agricultural aviation industry are highly visible—the chemicals that are dispensed can be subject to drift away from the intended treatment area, and all pesticides have some level of toxicity and potential hazard if misapplied. As a result, this unique agricultural activity is subject to close public scrutiny. In light of these considerations, this manual is annually reviewed and revised so that aerial applicators will have an appreciation for public concerns and will have the most current, basic information available to apply pesticides in an effective, economical and environmentally sound manner.

The regulations referred to in this manual are current as of January 1, 1987. As with all regulations, they are subject to change. Aerial applicators should therefore obtain updates on current pesticide and aviation regulations at both the federal and state level. Federal rules and regulations can be obtained by contacting:

Assistant Public Printer
Superintendent of Documents
Government Printing Office
Washington, D.C. 20402-9325
(202) 783-3238

or

Government Printing Office
Bookstore
477 Michigan Avenue
Detroit, MI 48226
(313) 226-7816

Obtain current copies of state rules and regulations from the Michigan Department of Agriculture, or other state lead agencies responsible for the enforcement of specific laws.

FEDERAL AND STATE LAWS

Knowledge of the federal and state laws and associated regulations governing the purchase, handling, storage, application, and disposal of pesticides is essential for the aerial applicator to use pesticides legally and safely. The old adage "ignorance of the law is no excuse" applies very much to laws governing the use of pesticides.

Federal Aviation Act

The application of agricultural chemicals from aircraft is regulated by the Federal Aviation Administration (FAA) under the authority of the Federal Aviation Act of 1958 as amended in 1968. The associated regulations make it illegal for aerial applicators to dispense any pesticide for a use other than that for which it is registered (**labeled**). The regulations that govern agricultural aircraft operations are in the code of Federal Regulations, Title 14—Aeronautics and Space. Aerial applicators should be thoroughly familiar with the following sections of this title:

Part 61—Certification of Pilots and Flight Instructors

Part 91—General Operation and Flight Rules

Part 133—Rotocraft External Load Operations

Part 137—Agricultural Aircraft Operations

Complete familiarity with these four parts of Title 14 will place the aerial applicator in full compliance under the Federal Aviation Act. Part 137 has been printed below in its entirerty. It is important for the ag-aviator to obtain current copies of the other three parts from the Government Printing Office.

Changes in land-use-patterns have created uncomfortable urban sprawl adjacent to productive farmland. This problem has acted as a nucleus for the majority of complaints/problems investigated by the Michigan Department of Agriculture. A knowledge of Part 137 will assist the ag-pilot in dealing with and avoiding urban complaints about aerial application of agricultural chemicals.

TITLE 14 CFR PART 137 AGRICULTURAL AIRCRAFT OPERATIONS

General Information—Subpart A

Applicability (137.1)

[a] This part prescribes rules governing:

[1] Agricultural aircraft operations within the United States; and

[2] The issue of commercial and private agricultural aircraft operator certificates for those operations

[b] In a public emergency, a person conducting agricultural aircraft operations under this part may, to the extent necessary, deviate from the operating rules of this part for relief and welfare activities approved by an agency of the United States or of a state or local government.

[c] Each person who, under the authority of this section, deviates from a rule of this part shall, within 10 days after the deviation send to the nearest FAA District Office a complete report of the aircraft operation involved, including a description of the operation and the reasons for it.

Definition of Terms (137.3)

For the purpose of this part—"Agricultural aircraft operation" means the operation of an aircraft for the purpose of (1) dispensing any economic poison, (2) dispensing any other substance intended for plant nourishment, soil treatment, propagation of plant life, or pest control, or (3) engaging in dispensing activities directly affecting agriculture, horticulture, or forest preservation, but not including the dispensing of live insects.

"Economic poison" means (1) any substance or mixture of substances intended for preventing, destroying, repelling, mitigating any insects, rodents, nematodes, fungi, weeds, and other forms of plant or animal life or viruses, except viruses on or in living man or other animals, which the Secretary of Agriculture shall declare to be a pest, and (2) any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

Certification Rule—Subpart B

Certificate Required (137.11)

a Except as provided in paragraphs (c) and (d) of this section, no person may conduct agricultural aircraft operations without, or in violation of, an agricultural aircraft operator certificate issued under this part.

b Notwithstanding part 133 of this chapter, an operator may, if he complies with this part, conduct agricultural aircraft operations with a rotocraft with external dispensing equipment in place without a rotocraft external-load operator certificate.

c A Federal, State, or Local government conducting agricultural aircraft operations with public aircraft need not comply with this subpart.

d The holder of a rotocraft external-load operator certificate under part 133 of this chapter conducting an agricultural aircraft operation, involving only the dispensing of water on forest fires by rotocraft external-load means, need not comply with this subpart.

Application For Certificate (137.15)

An application for an agricultural aircraft operator certificate is made on a form and in a manner prescribed by the Administrator, and filed with the FAA District Office that has jurisdiction over the area in which the applicant's home base of operations is located.

Amendment of Certificate (137.17)

a An agricultural aircraft operator certificate may be amended

1 On the Administrator's own initiative, under section 609 of the Federal Aviation Act of 1958 (49 U.S.C. 1429) and part 13 of this chapter; or

2 Upon application by the holder of that certificate.

b An application to amend an agricultural aircraft operator certificate is submitted on a form and in a manner prescribed by the Administrator. The applicant must file the application with the FAA District Office having jurisdiction over the area in which the applicant's home base of operations is located at least 15 days before the date that it proposes the amendment become effective, unless a shorter filing period is approved by that office.

c The District Office grants a request to amend a certificate if it determines that safety in air commerce and the public interest so allow.

d Within 30 days after receiving a refusal to amend, the holder may petition the Director, Flight Standard Service, to reconsider the refusal.

Certification Requirements (137.19)

a General. An applicant for a private agricultural aircraft operator certificate is entitled to that certificate if he/she shows that he/she meets the requirements of paragraphs (b), (d), and (e) of this section. An applicant for a commercial agricultural aircraft operator certificate is entitled to that certificate if he/she shows that he/she meets the requirements of paragraphs (c), (d), and (e) of this section. However, if an applicant applies for an agricultural aircraft operator certificate containing a prohibition against the dispensing of economic poisons, that applicant is not required to demonstrate the knowledge required in paragraphs (e) (1) (ii) through (iv) of this section.

b Private operator-pilot. The applicant must hold a current U.S. private, commercial, or airline transport pilot certificate and be properly rated for the aircraft to be used.

c Commercial operator-pilots. The applicant must have available the services of at least one person who holds a current U.S. commercial or airline transport pilot certificate and who is properly rated for the aircraft to be used. The applicant himself may be the person available.

d Aircraft. The applicant must have at least one certified and airworthy aircraft, equipped for agricultural operation.

e Knowledge and skill tests. The applicant must show, or have the person who is designated as the chief supervisor of agricultural aircraft operations for him show, that he/she has satisfactory knowledge and skill regarding agricultural aircraft operations, as described in paragraphs (e) (1) and (2) of this section.

[1] The test of knowledge consists of the following:

[i] Steps to be taken before starting operations, including survey of the area to be worked.

[ii] Safe handling of economic poisons and the proper disposal of used containers for those poisons.

[iii] The general effects of economic poisons and agricultural chemicals on plants, animals, and persons, with emphasis on those normally used in the areas of intended operations: and the precautions to be observed in using poisons and chemicals.

[iv] Primary symptoms of poisoning of persons from economic poisons, the appropriate emergency measures to be taken, and the location of poison control centers.

[v] Performance capabilities and operating limitations of the aircraft to be used.

[vi] Safe flight and applications procedures.

[2] The test of skill consists of the following maneuvers that must be shown in any of the aircraft specified in paragraph (d) of this section, and at that aircraft's maximum certified takeoff weight, or the maximum weight established for the special purpose load, whichever is greater:

[i] Short-field and soft-field takeoffs (airplanes and gyroplanes only).

[ii] Approaches to the working area.

[iii] Flare-outs.

[iv] Swath runs.

[v] Pullups and turnarounds.

[vi] Rapid deceleration (quick stops) in helicopters only.

Duration of Certificate (137.29)

An agricultural aircraft operator certificate is effective until it is surrendered, suspended, or revoked. The holder of an agricultural aircraft operator certificate that is suspended or revoked shall return it to the Administrator.

Carriage of Narcotic Drugs, Marijuana, and Depressant or Stimulant Drugs or Substances (137.23)

If the holder of a certificate issued under this part permits any aircraft owned or leased by that holder to be engaged in any operation that the certificate holder knows to be in violation of S 91.12 (a) of this chapter, that operation is a basis for suspending or revoking the certificate.

Operating Rules—Subpart C

General Information—(137.29)

[a] Except as provided in paragraphs (d) and (e) of this section, this subpart prescribes rules that apply to persons and aircraft used in agricultural aircraft operations conducted under this part.

[b] (Reserved)

[c] The holder of an agricultural aircraft operators certificate may deviate from the provisions of Part 91 of this chapter without a certificate of waiver, as authorized in this subpart for dispensing operations related to agriculture, horticulture, or forest preservation in accordance with the operating rules of this subpart.

[d] Sections 137.31 through 137.35, 137.41, and 137.53 through 137.59 do not apply to persons and aircraft used in agricultural aircraft operations conducted with public aircraft.

[e] Sections 137.31 through 137.35, 137.39, 137.41, 137.51 through 137.59 and subpart D do not apply to persons and rotorcraft used in agricultural aircraft operations conducted by a person holding a certificate under Part 133 of this chapter and involving only the dispensing of water on forest fires by rotorcraft external-load means. However, the operation shall be conducted in accordance with—

[i] The rules of part 133 of this chapter governing rotorcraft external-load operations; and

[ii] The operating rules of this subpart contained in SS 137.29, 137.37, and 137.43 through 137.49.

Aircraft Requirements (137.31)

No person may operate an aircraft unless that aircraft—

[a] Meets the requirements of S 137.19 (d); and

[b] Is equipped with a suitable and properly installed shoulder harness for use by each pilot.

Carrying of Certificate (137.33)

[a] No person may operate an aircraft unless a facsimile of the agricultural aircraft operator certificate, under which the operation is conducted, is carried on that aircraft. The facsimile shall be presented for inspection upon the request of the Administrator or any Federal, State, or Local law enforcement officer.

[b] Notwithstanding Part 91 of this chapter, the registration and airworthiness certificates issued for the aircraft need not be carried in the aircraft. However, when those certificates are not carried in the aircraft they shall be kept available for inspection at the base from which the dispensing operation is conducted.

Limitations on Private Agricultural Aircraft Operator (137.35)

No person may conduct an agricultural aircraft operation under the authority of a private agricultural aircraft operator certificate—

a For compensation or hire;

b Over a congested area; or

c Over any property unless he is the owner or lessee of the property or has ownership or other property interest in the crop located on that property.

Manner of Dispensing (137.37)

No persons may dispense, or cause to be dispensed, from an aircraft, any material or substance in a manner that creates a hazard to persons or property on the surface.

Economic Poison Dispensing (137.39)

a Except as provided in paragraph (b) of this section, no person may dispense or cause to be dispensed from an aircraft, any economic poison that is registered with the U.S. Department of Agriculture under the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 135-135k)—

1 For a use other than that for which it is registered;

2 Contrary to any safety instruction or use limitations on its label; or

3 In violation of any law or regulation of the United States.

b This section does not apply to any person dispensing economic poisons for experimental purposes under—

1 The supervision of a Federal or State agency authorized by law to conduct research in the field of economic poisons; or

2 A permit from the U.S. Department of Agriculture issued pursuant to the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 135-137k).

Personnel (137.41)

a Information. The holder of an agricultural aircraft operator certificate shall insure that each person used in the holder's agricultural aircraft operation is informed of that person's duties and responsibilities for the operation.

b Supervisors. No person may supervise an agricultural aircraft operation unless he has met the knowledge and skill requirements of S 137.19 (e).

c Pilot in command. No person may act as pilot in command of an aircraft unless he holds a pilot certificate and rating prescribed by S 137.19 (b) or (c), as appropriate to the type of operation conducted. In addition, he/she must demonstrate to the holder of the Agricultural Aircraft Operator Certificate conducting the operation that he has met the knowledge and skill requirements of S 137.19 (e). If the holder of that certificate has designated a person under S 137.19 (e) to supervise his/her agricultural aircraft operations, the demonstration must be made to the person so designated. However, a demonstration of the knowledge and skill requirement is not necessary for any pilot in command who—

1 Is, at the time of the filing of an application by an agricultural aircraft operator, working as a pilot in command for that operator; and

2 Has a record of operation under that applicant that does not disclose any question regarding the safety of his flight operations or his/her flight operations or his competence in dispensing agricultural materials or chemicals.

Airport Traffic Areas and Control Zones (137.43)

a Except for flights to and from a dispensing area, no person may operate an aircraft within an airport traffic area, or within a control zone having an operative control tower, unless authorization for that operation has been obtained from the control tower concerned.

b No person may operate an aircraft in weather conditions below VFR minimums within a control zone not having an operative control tower unless authorization for that operation has been obtained from the appropriate ATC facility.

c Notwithstanding S 91.107 (e) of this chapter, an aircraft may be operated in a control zone under special VFR weather minimums without meeting the requirements prescribed therein.

Nonobservance of Airport Traffic Pattern (137.45)

Notwithstanding Part 91 of this chapter, the pilot in command of an aircraft may deviate from an airport traffic pattern when authorized by the control tower concerned. At an airport without a functioning control tower, the pilot in command may deviate from the traffic pattern if—

a Prior coordination is made with the airport management concerned;

b Deviations are limited to the agricultural aircraft operation;

c Except in an emergency, landing and takeoffs are not made on ramps, taxiways, or other areas of the airport not intended for such use; and

d The aircraft at all times remains clear of, and gives way to, aircraft conforming to the traffic pattern for the airport.

Operation Without Position Lights (137.47)

Notwithstanding Part 91 of this chapter, an aircraft may be operated without position lights if prominent unlighted objects are visible for at least 1 mile and takeoffs and landings at—

a Airports with a functioning control tower are made only as authorized by the control tower operator; and

b Other airports are made only with the permission of the airport management and no other aircraft operations requiring position lights are in progress at that airport.

Operations Over Other Than Congested Areas (137.49)

Notwithstanding Part 91 of this chapter, during the actual dispensing operation, including approaches, departures, and turnarounds reasonably necessary for the operation, an aircraft may be operated over other than congested areas below 500 feet above the surface and closer than 500 feet to persons, vessels, vehicles, and structures, if the operations are conducted without creating a hazard to persons or property on the surface.

Operation Over Congested Areas: General (137.51)

a Notwithstanding Part 91 of this chapter, an aircraft may be operated over a congested area at altitudes required for the proper accomplishment of the agricultural aircraft operation if the operation is conducted

1 With the maximum safety to persons and property on the surface, consistent with the operation; and

2 In accordance with the requirements of paragraph (b) of this section.

b No person may operate an aircraft over a congested area except in accordance with the requirements of this paragraph.

1 Prior written approval must be obtained from the appropriate official or governing body of the political subdivision over which the operations are conducted.

2 Notice of the intended operation must be given to the public by some effective means, such as daily newspapers, radio, television, or door-to-door notice.

3 A plan for each complete operation must be submitted to, and approved by appropriate personnel of the Federal Aviation Administration District Office having jurisdiction over the area where the operation is to be conducted. The plan must include consideration of obstructions to flight; the emergency landing capabilities of the aircraft to be used; and any necessary coordination with air traffic control.

4 Single engine aircraft must be operated as follows;

i Except for helicopters, no person may take off a loaded aircraft, or make a turnaround over a congested area.

ii No person may operate an aircraft over a congested area below the altitudes prescribed in Part 91 of this chapter except during the actual dispensing operation, including the approaches and departures necessary for that operation.

iii No person may operate an aircraft over a congested area during the actual dispensing operation, including the approaches and departures for that operation, unless it is operated in a pattern and at such an altitude that the aircraft can land, in an emergency, without endangering person or property on the surface.

5 Multi-engine aircraft must be operated as follows:

i No person may take off a multiengine airplane over a congested area except under conditions that will allow the airplane to be brought to a safe stop within the effective length of the runway from any point on takeoff up to the time of attaining, with all engines operating at normal takeoff power, 105 percent of the minimum control speed with the critical engine inoperative in the takeoff configuration or 115 percent of the power-off stall speed in the takeoff configuration, whichever is greater, as shown by the accelerate stop distance data. In applying this requirement, takeoff data is based upon still-air conditions and no correction is made for any uphill gradient of 1 percent or less when the percentage is measured as the difference between elevation at the end points of the runway divided by the total length. For uphill gradients greater than 1 percent, the effective takeoff length of the runway is reduced 20 percent for each 1 percent grade.

ii No person may operate a multiengine airplane at a weight greater than the weight that, with the critical engine inoperative, would permit a rate of climb of at least 50 feet per minute at an altitude of at least 1,000 feet above the elevation of the highest ground or obstruction within the area to be worked or at an altitude of 5,000 feet, whichever is higher. For the purposes of this subdivision it is assumed that the propeller of the inoperative engine is in the minimum drag position; that the wing flaps and landing gear are in the most favorable positions; and that the remaining engine or engines are operating at the maximum continuous power available.

iii No person may operate any multiengine aircraft over a congested area below the altitudes prescribed in Part 91 of this chapter except during the actual dispensing operation, including the approaches, departures, and turnarounds necessary for that operation.

Operations Over Congested Areas: Pilots and Aircraft (137.53)

[a] General. No person may operate an aircraft over a congested area except in accordance with the pilot and aircraft rules of this section.

[b] Pilots. Each pilot in command must have at least—

[1] 25 hours of pilot-in-command flight time in the make and basic model of the aircraft, at least 10 hours of which must have been acquired within the preceding 12 calendar months; and

[2] 100 hours of flight experience as pilot-in-command in dispensing agricultural materials or chemicals.

[c] Aircraft.

[1] Each aircraft must—

[i] If it is an aircraft not specified in paragraph (c) (1) (ii) of this section, have had within the preceeding 100 hours of time in service a 100-hour or annual inspection by a person authorized by Part 65 or 145 of this chapter, or have been inspected under a progressive inspection system; and

[ii] If it is a large or turbine-powered multiengine civil airplane of U.S. registry, have been inspected in accordance with the applicable inspection program requirements of S 91.217 of this chapter.

[2] If other than a helicopter, it must be equipped with a device capable of jettisoning at least one-half of the aircraft's maximum authorized load of agricultural material within 45 seconds. If the aircraft is equipped with a device for releasing the tank or hopper as a unit, there must be a means to prevent inadvertent release by the pilot or their crewmember.

Business Name: Commercial Agricultural Aircraft Operator (137.55)

No person may operate under a business name that is not shown on his/her commercial agricultural aircraft operator certificate.

Availability of Certificate (137.57)

Each holder of an agricultural aircraft operator certificate shall keep that certificate at his/her home base of operations and shall present it for inspection on the request of the Administrator or any Federal, State, or Local law enforcement officer.

Inspection Authority (137.59)

Each holder of an agricultural aircraft operator certificate shall allow the Administrator at any time and place to make inspections, including on-the-job inspections, to determine compliance with applicable regulations and his agricultural aircraft operator certificate.

Records and Reports—Subpart D

Records: Commercial Agricultural Aircraft Operator (137.71)

[a] Each holder of a commercial agricultural aircraft operator certificate shall maintain and keep current, at the home base of operations designated in his application, the following records:

[1] The name and address of each person for whom agricultural aircraft services were provided;

[2] The date of the service;

[3] The name and quantity of the material dispensed for each operation conducted; and

[4] The name, address, and certificate number of each pilot used in agricultural aircraft operations and the date that pilot met the knowledge and skill requirements of S 137.19 (e).

[b] The records required by this section must be kept at least 12 months and made available for inspection by the Administrator upon request.

Change of Address (137.75)

Each holder of an agricultural aircraft operator certificate shall notify the Federal Aviation Administration in writing in advance of any change in the address of his home base of operations.

Termination of Operations (137.77)

Whenever a person holding an agricultural aircraft operator certificate ceases operations under this part, he shall surrender that certificate to the Federal Aviation Administration District Office last having jurisdiction over his/her operation.

Note: The record keeping and reporting requirements contained herein have been approved by the Office of Management and Budget in accordance with the Federal Reports Act of 1942.

AUTHORITY: Secs. 313(a), 307(c), 601 and 607, 72 Stat. 752; 49 U.S.C. 1354(a), 1348(c), 1421, and 1427.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended by the Federal Environmental Pesticide Act of 1972, is the major federal law regulating the manufacturing, shipping, selling/purchasing, use, and disposal of pesticides. The Act is administered by the U.S. Environmental Protection Agency (EPA). In addition to the above FAA regulations, all aerial application operations should be knowledgeable concerning the FIFRA. The associated regulations for FIFRA are found in the Code of Federal Regulations, Title 40—*Protection of Environment,* Subchapter E—Pesticide Programs, Parts 162-172 and Part 180. The Act stipulates that state legislation enacted to implement the FIFRA may not be less restrictive, but may be more restrictive than the FIFRA. FIFRA and its implementing regulations in Title 40 CFR provide:

1. All pesticide products intended for use in the United States must be *registered* with the U.S. EPA and unclassified for general use or classified as restricted use;

2. The label of a pesticide product is the legal document on the proper use of that chemical and all instructions and limitations must be followed;

3. The requirements of certification of private and commercial agricultural chemical applicators;

4. Worker protection standards for individuals using agricultural pesticides;

5. The authority of the States to register and regulate the sale and use of any federally registered pesticide or device in the State to meet their local need(s);

6. The authority of the States to train and certify applicators and enforce the proper use/application of agricultural chemicals, in cooperation with the U.S. EPA;

7. The provisions for civil and criminal penalties. The civil penalty for a commercial applicator who unknowingly violates the Act may be a fine of not more than $5,000 for each offense. The criminal penalty for a commercial applicator who knowingly violates the Act may be a fine of not more than $25,000 or imprisonment for not more than one year, or both.

Unlawful acts of which aerial applicators should be well aware include:

a. detaching, altering, or destroying any part of a label,

b. not following the entire label instructions and limitations accompanying the pesticide product,

c. refusing to keep records, permit inspection, or permit sampling,

d. making a restricted use pesticide available to anyone who is not certified to use such classified pesticides,

e. applying a restricted use pesticide when not certified, or not under the direct supervision of someone who is certified.

Michigan Pesticide Control Act of 1976

Under the authority of the FIFRA, Sections 22, 23, 24, 25, and 26, the Michigan Pesticide Control Act (Act No. 171, Public Acts of 1976) and associated Regulations 633 (Restricted Use Pesticides) and 636 (Pesticide Applicators) are the key rules that enforce the standards of proper pesticide use in this State. This Act and its associated regulations have several specific requirements that are of importance to aerial applicators operating in Michigan.

Standards For Certification of Commercial Applicators—Reg. 636, Rule 4

Commercial applicators shall demonstrate a practical knowledge. . . of the principles and practices of pest control and the safe use of pesticides, to include the general standards applicable to all categories and the standards specifically identified for each category or subcategory designated by the applicant as set forth in 40 CFR Parts 171.4 and 171.6 and these rules. . . .

Additional Standards For Certification—Reg. 636, Rule 4 (b) (i)

Aerial applicators. . . shall demonstrate a practical knowledge of the techniques of aerial application and applicable Federal Aviation Administration Regulations. Practical knowledge is required concerning nontarget injury that may result from aerial application of pesticides.

Certificate of Competence Reg. 636, Rule 7 (1)

An applicant for certification who is found to be qualified under the act and these rules shall be issued a certificate of competence, which shall be valid, unless suspended or revoked for cause, for three years.

Certification In Additional Category Or Method— Reg. 636, Rule 7 (2)

A commercial applicator certificate shall show the categories and applicable methods of application in Regulation 636, Rule 4 (b) for which the person has demonstrated competence.

Application For License— Reg. 636, Rule 8 (1)

An application for license to engage in the business of applying pesticides shall be. . . The applicant shall be a certified applicator or shall employ a certified applicator to apply or supervise the application of pesticides. . .

Financial Responsibility— Reg. 636, Rule 10 (1)

A licensed commercial applicator shall maintain comprehensive general liability insurance for bodily injury and property damage during the licensing period or during the period of time necessary to span a seasonal operation,. . .

Minimum Insurance Coverage— Reg. 636, Rule 10 (2)

Minimum insurance coverage for persons engaged in aerial application,. . . shall be $100,000.00 for each occurrence for bodily injury and $100,000.00 for each occurrence for property damage, or a combined single limit of $300,000.00 for bodily injury and property damage.

Insurance Expiration or Cancellation— Reg. 636, Rule 10 (6)

If the required insurance coverage for a license expires or is canceled during the license period, the license shall be suspended and the licensee shall surrender the license to the director for the remainder of the licensing period or until such time as the financial responsibility requirements have been complied with.

Accepted Good Practices— Act 171, Section 12 (5)

A pesticide applicator shall follow recommended and accepted good practices in the use of pesticides including use of a pesticide in a manner consistent with its labeling.

Powers of the Director of the Michigan Department of Agriculture— Act 171, Section 18 (e)

The Director or designee may enter upon any public or private premises or other place, including vehicles of transport, where pesticides or devices are being used or held for distribution or sale, for the purposes of inspecting and obtaining samples of pesticides or devices or to inspect equipment or methods of application.

Director's Order to Cease Use of a Pesticide— Act 171, Section 21 (1)

When the Director believes that an applicator is using or intending to use a pesticide in an unsafe or inadequate manner, or *in a manner inconsistent with its labeling,* the Director shall order the applicator to cease the use of or refrain from the intended use of the pesticide. The order may be either oral or written, and shall inform the applicator of the reason therefor. **(2):** Upon receipt of the order, the applicator shall immediately comply therewith. Failure to comply constitutes cause for revocation of the license or certification and subjects the applicator to the penalty imposed under Section 26 of this Act. **(3):** The Director shall rescind the order immediately upon being satisfied after inspection that the order has been complied with. The inspection shall be conducted as soon as possible at the oral or written request of the applicator. The rescinding order of the director may be oral and the applicator may rely thereon. However, an oral order shall be followed by a written rescinding order. . . **(4):** . . .

Suspending a Certificate or License—Act 171, Section 13 (9)

The Director may at any time deny, revoke, or suspend a certificate or license for a violation of this act, or a violation of an order issued under this Act, or upon conviction under Section 14 of the FIFRA, or upon conviction under a State pesticide law of a reciprocating State in accordance with Section 16 of this Act.

Records of Commercial Application— Act 171, Section 12 (4)

A certified commercial applicator shall maintain records of restricted use pesticide applications for 2 years from the date of application and make those records available upon request to an authorized representative of the Director during normal business hours.

Commercial Applicator Record Keeping—Reg. 636, Rule 11

All commercial applicators shall maintain a record of restricted-use pesticide applications for a period of at least 2 years following the application. Such records shall show the name of the pesticide applied, amount used, purpose, date, place where applied, and the method and the rate of application. The applicator's records shall be made available upon request to an authorized representative of the Director during normal business hours.

RECORD KEEPING

Record keeping is a key requirement for every pilot on each aerial application operation, as outlined under Title 14 CFR 137.71 and Act 171, Section 12 (4). Such records must include:

1. The name and address of each person for whom services were provided;

2. The date of service;

3. The name and quantity of material dispensed for each operation; and

4. The name, address, and certificate number of each pilot used in the operations.

The records must be kept at least 12 months and made available for inspection upon request by the Administrator of the Federal Aviation Administration or his/her representative. The same records must be kept at least 2 years and made available for inspection upon request by the Director of the Michigan Department of Agriculture or his/her representative.

Maintaining accurate records on each agricultural chemical application is essential to protect the pilot and operation and the liability that goes along with releasing any potentially hazardous material into the environment. Figure 1 illustrates a simple yet complete work sheet for keeping records on each pesticide application.

Figure 1. Record-keeping format.

Job No. ____________ Date Rec'd ____________

Name ____________ Phone ____________

Address ____________ City ____________

State ____________ Zip Code ____________

Bill To ____________

Crop ____________ Total Acres ____________

Location
County ____________ Twp. ____________ Sect. ____________

TacTime In ____________ Wind Direction ____________
Out ____________ Time Done ____________ M
T.T. ____________

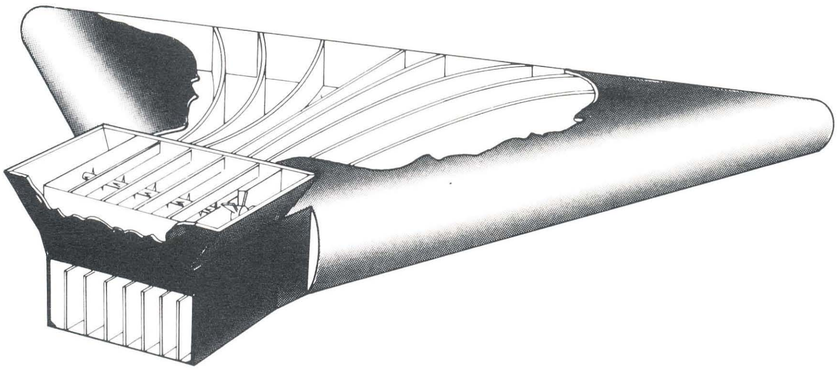
Pilot ____________ Date ____________

Chemical Ours ____________ Cust. ____________

1. ____________	@ ____/acres		
2. ____________	@ ____/acres		
3. ____________	@ ____/acres		
4. ____________	@ ____/acres		
5. ____________	@ ____/acres		
6. ____________	@ ____/acres		
	TOTAL CHEMICAL		
Application Charge			
______ Acres @ $ ______ /Acres			
	TOTAL		

Figure 2. Aerial application equipment for dry materials (a) design of a spreader with agitator; (b) illustration of spreader mounted below fuselage of a Thrush ag-plane.

(A)



(B)

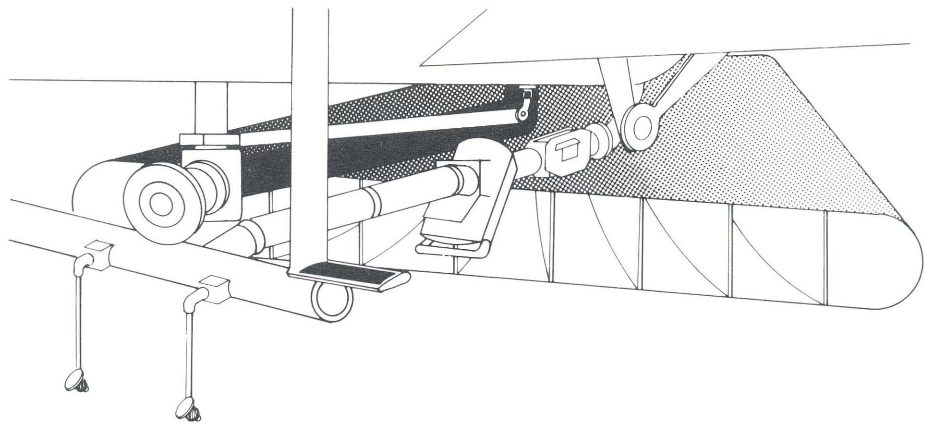
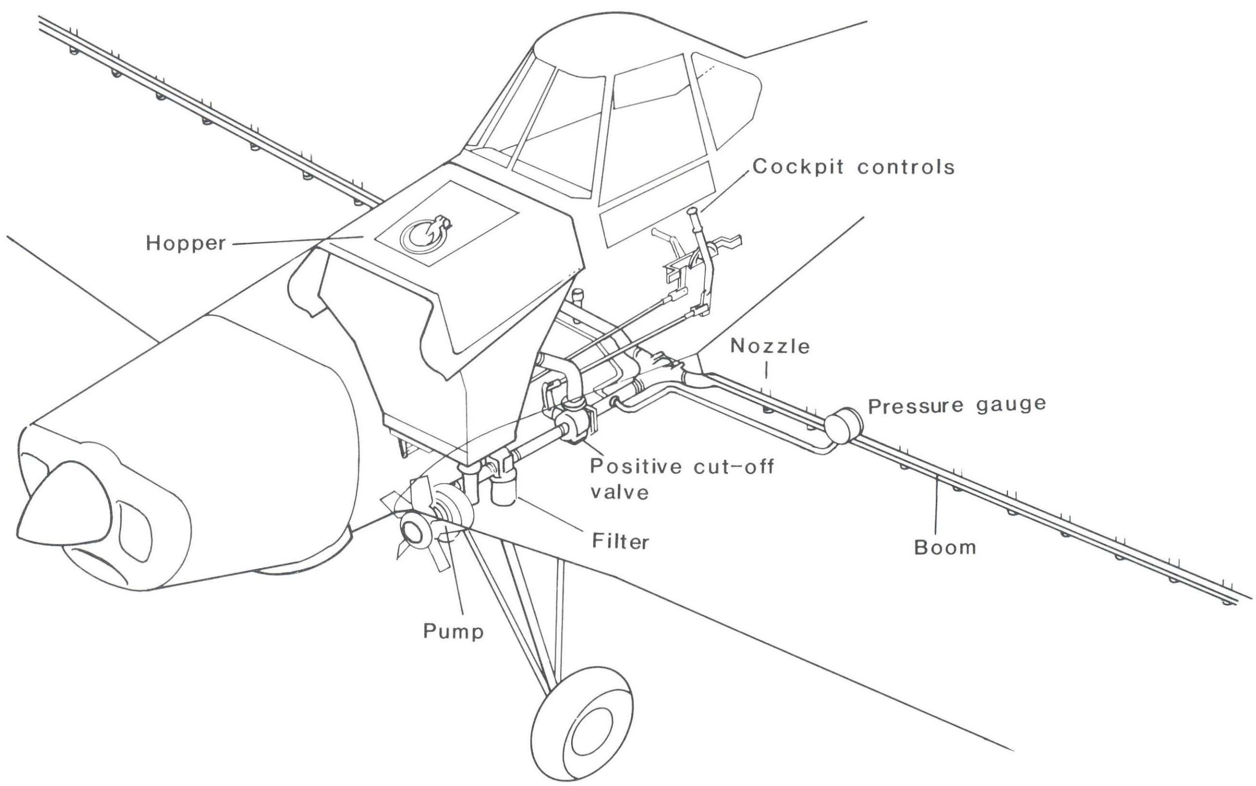


Figure 3. The various components of a liquid dispersal system on a Piper Brave ag-plane



APPLICATION EQUIPMENT

Equipment for aerial application of pesticides must be capable of lifting, transporting, and dispersing pesticides safely and accurately to the target area. Equipment can be either fixed- or rotary-wing aircraft. In either case, metering and delivery equipment must be capable of delivering relatively large quantities of liquids or solids because of the large area covered by the aircraft per unit of time. Fixed-wing aircraft have the advantages of speed, adequate maneuverability, and large payload capacity per dollar invested. Rotary-wing aircraft offer the advantages of excellent maneuverability, speed variation, and may be operated in almost any area because a landing strip is not needed. Minimum time loss in turns, hovering, and loading are required because rotary-wing aircraft are more expensive to operate than fixed-wing aircraft. Rotary-wing aircraft put special demands on a pilot's skill.

Metering of spray material is a key function of all agricultural aircraft dispersal systems. 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 and the spray material applied within the guidelines of the label for that material.

Equipment for Dry Materials

Dry materials are dispensed from a *hopper* through a *spreader* mounted below the fuselage. The hopper walls should slope enough to ensure uniform flow of material to the spreader. The hopper should be *vented* properly to assure a more uniform flow, especially when the hopper and loading door have air-tight seals. The *gate* that controls the flow of material from hopper to spreader should move freely, provide a tight seal to prevent leakage when closed, and provide a uniform flow to all portions of the spreader.

The hopper should be equipped with an *agitator* when sticky or lumpy materials are to be dispersed. A properly designed and functioning agitator promotes uniform flow of the hopper contents (Figure 2).

Equipment for Liquids

Liquid dispersal systems consist of a hydraulic circuit including a tank, pump, hose, boom, filters, regulators, and nozzles. These systems on aircraft may be wind-driven or powered directly from the aircraft engine. In all cases there must be a proper blend of the various components of the dispersal system in order for the system to operate properly (Figure 3).

The Tank

The tank should be leakproof 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 that will prevent a vacuum from developing that would alter or stop the normal flow of the liquid. Most pesticide formulations require some form of agitation during application. Recirculation of the spray mixture during ferrying to the worksite and during turn-arounds is usually enough. The return flow should wash the bottom of the tank.

The Pump

The pump in the spray system is necessary to ensure uniform and proper flow rates at all times, to

Figure 4. The internal mechanism of a centrifugal pump.

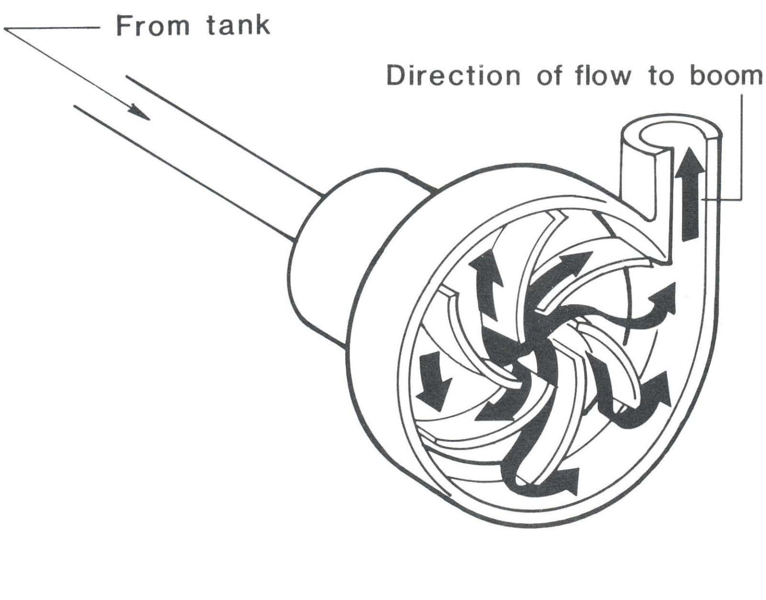
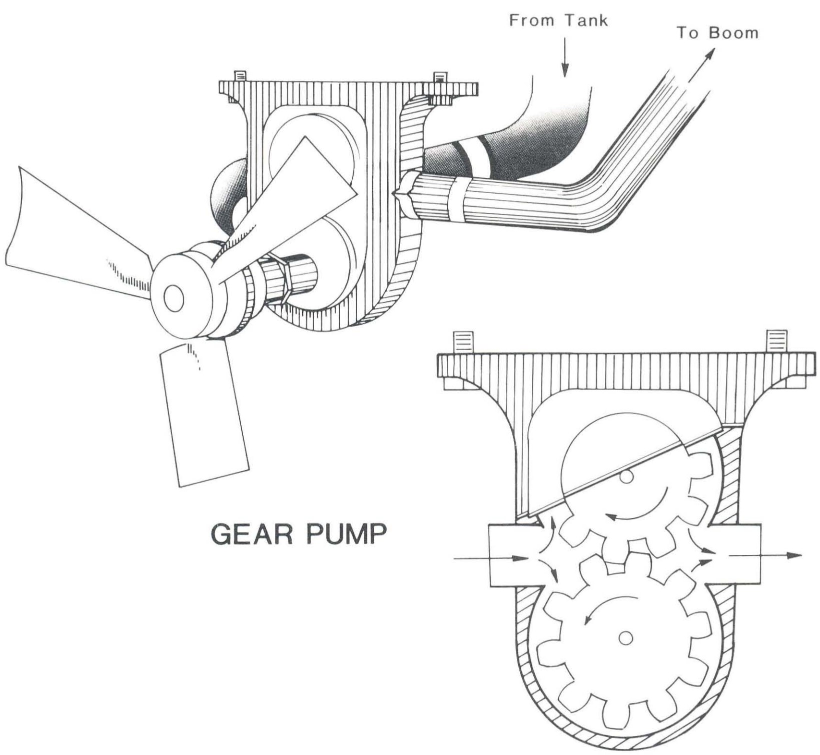


Figure 5. The internal and external construction of a rotary-gear pump.



produce the desired atomization from nozzles, and to keep wettable powders in suspension. Select pumps carefully. Inadequate capacity will limit the range of applications possible; too large a pump (especially a centrifugal pump) may lead to cavitation of the impeller. Pumps should be mounted below the tank to provide self-priming.

Carefully consider the size of the pump when equipping an aircraft. A pump with too little capacity will require reducing the swath spacing to assure adequate deposit on the crop. Use of a centrifugal pump with a pumping capacity considerably greater than required often results in trouble because the impeller cavitates. When this occurs, air gets into the system and calibration becomes erratic.

Most operators prefer a centrifugal pump because it is available in many sizes, handles all kinds of spray chemicals with minimum wear, produces pressures up to 70 pounds per square inch (psi), and can be operated without a relief valve (Figure 4). Mount a centrifugal pump lower than the bottom of the spray tank so that it will be self-priming and will not lose its prime during spraying.

A rotary-gear pump is positive displacing, self-priming, and capable of producing pressures up to 200 psi. A pressure-relief valve or bypass must be incorporated into the spray system to relieve the pressure or bypass the chemical when the spray valve is turned off (Figure 5). Do not use a rotary-gear pump to apply wettable powder suspensions because such suspensions usually cause excessive wear of the teeth and side walls and may cause a new pump to seize.

Ultralow volume (ULV) applications need only a minimum capacity pump. ULV spraying is done at 0.05 to 0.5 gallon per acre. If your aircraft will be used only for ULV spraying, use a small centrifugal, gear, or other rotary pump that can provide the required flow rate at 40 psi to assure uniform flow and optimum nozzle performance.

If your aircraft is equipped for high volume spraying and you wish to do ULV spraying too, a minor modification will be required. Many high volume pumps are capable of pumping 75 gallons per minute. ULV applications may require only 2 gallons per minute. Bypassing 73 gallons back into the spray tank will aerate the spray solution or cause excessive foaming of some materials. In either case, accurate calibration of the spraying system is impossible. Installing a modification will make it possible to use the same spraying system for high volume and ULV applications.

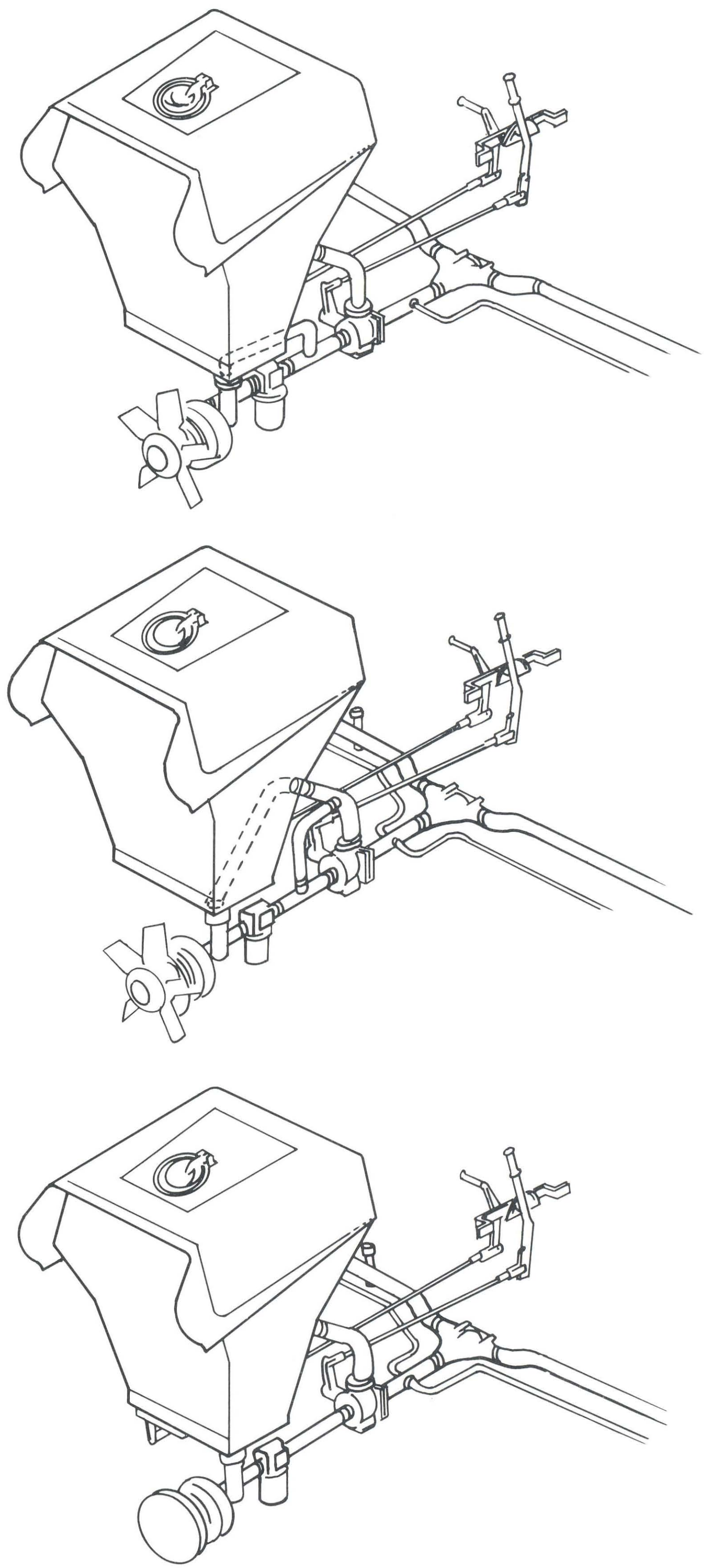
Figure 6 illustrates one of three equally effective bypass modifications that can be used. Choose the one easiest to install in your aircraft.

The first method is to use a bypass to connect the spray pump outlet with the spray pump inlet. Install a tee near the pump outlet and another tee in the pump inlet. Connect the two tees with a line that has a diameter equal to that of the pump outlet. Install a valve in this bypass line to adjust spray pressure. During ULV applications, the standard bypass normally must be closed.

The second method is to install a bypass line inside of the spray tank. This line should be equal in diameter to the standard bypass and attached so that the liquid from the standard bypass will be directed at the spray pump intake. If the application rates do not exceed 5 gallons per acre, this modification can be left in the tank for all spraying operations; however, for higher application rates, it may be necessary to remove it.

A third modification option also available is the use of a simple

Figure 6. Modifications to allow ULV aerial application with a standard high volume spray system. (a) Modification to connect the spray pump outlet with the spray pump inlet. (b) Modification with a bypass line installed within the tank and directed toward the spray pump intake. (c) Modification of the fixed-pitched pump fang by reducing the wind force that drives the pump.



[A]

[B]

[C]

wind-reducing plate in front of a fixed pitch fan to reduce pump speed.

The Plumbing

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. Smaller piping is adequate on helicopters because of their slower application speed. Aluminum, stainless steel, brass, or some type of synthetic tubing is preferred for most installations. The piping must be able to handle pump pressure. Common steel tubing usually rusts or corrodes, especially when the aircraft stands idle for several months. Flakes of rust or corrosion deposits then break loose and plug nozzles and nozzle screens.

Hoses should be large enough to carry the desired flow and should be corrosion-resistant. A positive-cutoff valve in the line and a check valve in each nozzle will prevent dribbling when the system is shut off. Figure 7 illustrates the operation of a positive-cutoff valve and Figure 8 illustrates a standard nozzle anti-drip device.

Correctly sized line filters and nozzle screens will alleviate nozzle clogging. Select screen sizes, ranging from 20 to 100 mesh, according to the size of the nozzle opening. Line filters should be located between the tank and pump and/or between the pump and the boom. Locating the line filter between the tank and pump will protect the pump from damage.

Figure 7. The internal mechanisms of a positive-cutoff spray valve.

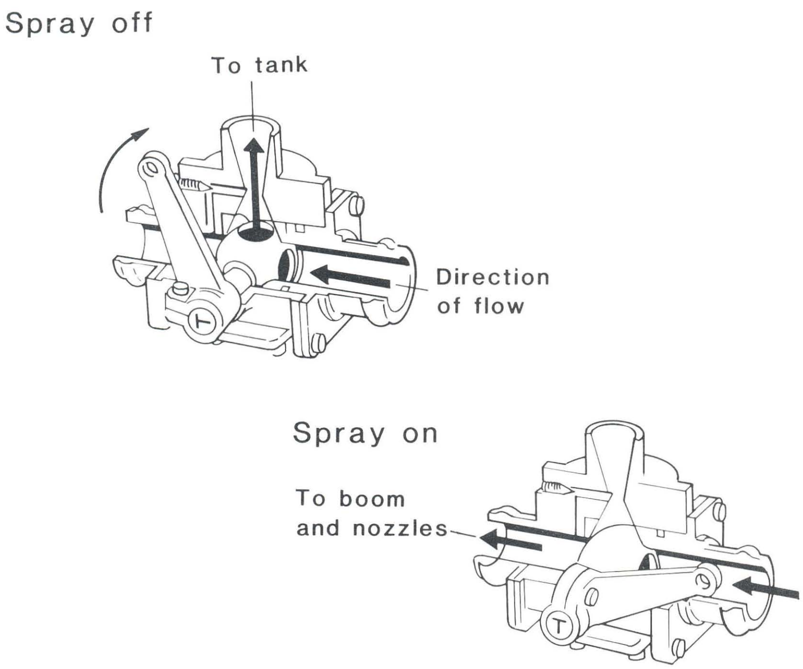
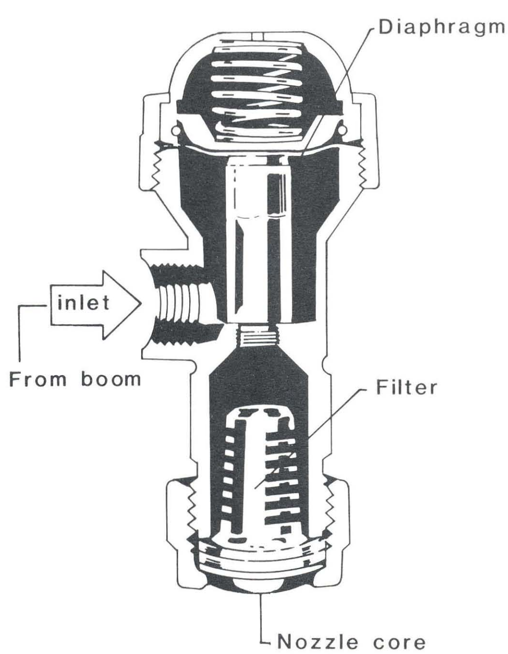


Figure 8. The internal mechanisms of an anti-drip nozzle system.



The Boom and Nozzles

The boom and nozzle is the most common dispersal system used for agricultural chemical applications. A large variety of deposition patterns can be produced by shifting the location of the nozzles on the boom. Different droplet sizes can be produced by changing the size and type of orifice in each nozzle, the core in each nozzle, the direction of the nozzle in relation to the airstream, and the pump pressure. Nozzle selection, placement, and orientation are thus extremely important for efficient deposition, desired droplet size, and reduced drift.

When spraying 6 to 10 feet above the crop canopy, use a boom approximately three-fourths as long as the wingspan or no longer than the rotor length. When using a longer boom, spray may get into the wingtip or rotor vortices, and spoil the swath pattern by increased deposition at swath edges, and increased drift.

Figure 9. General nozzle configuration on the boom of a fixed-wing aircraft.

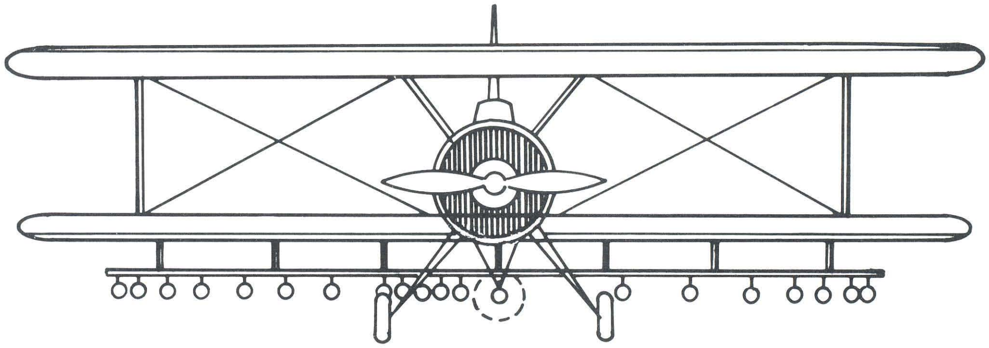
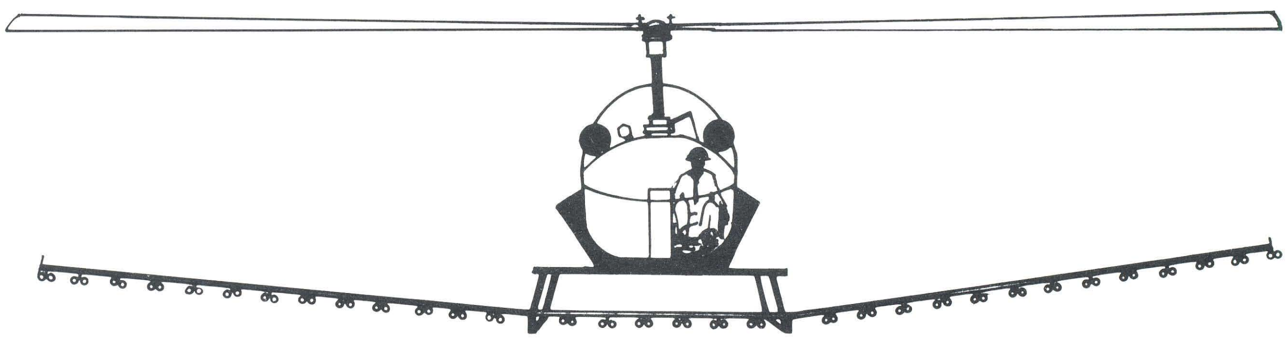


Figure 10. General nozzle configuration on the boom of a rotary aircraft.



To space the nozzles for spraying from this height with a fixed winged aircraft, group a few nozzles close together, on the boom, 2 to 4 feet to the right side of the aircraft centerline, and leave the boom free of nozzles 2 to 4 feet to the left side of the centerline. This practice will compensate for propwash. Reverse this procedure for aircraft with PZL engines. From these points outward, space nozzles progressively closer together as the boom tips are approached (Figure 9).

For helicopters, use an even nozzle spacing between the skids. Outboard of the skids use a close spacing of nozzles; increase the spacing as distance from the rotor root increases; and then use a closer nozzle spacing as the rotor tips are approached (Figure 10). Applicators must realize that the spray pattern must be evaluated for each aircraft and each nozzle configuration. *There is no standard configuration that will provide a uniform pattern.*

When spray drift must be kept to an absolute minimum, limit the nozzle span to not more than two-thirds of the wingspan nor four-fifths of the rotor length. This will reduce the amount of spray trapped in the vortices.

Position booms and nozzles so that spray will not strike any part of the aircraft or the boom attachments. If the spray strikes any structural member of the aircraft it will: collect and fall off in large drops; distort the spray pattern; waste material; and cause corrosion of aircraft parts. Ideally, the nozzle span will be equal to the boom length. However, when the nozzle span is less than the boom length, make provisions to purge the air trapped in the outer ends of the boom. Trapped air will cause the spray to continue flowing after the spray valve is closed. Eliminate it by using a tee to attach each outboard nozzle to the boom and connecting a small bleed line from the tee to the end of the boom (Figure 11). This measure will ensure rapid filling of the boom, immediate flow from each nozzle, and quick and positive cutoff when the spray valve is closed.

Some operators prefer rotary nozzles, which allow the applicator more control over the size of the droplets released (Figure 12). Spray droplets are formed by toothed, grooved, spinning discs or cups. Centrifugal force generated by the spinning action causes the release of spray droplets. The speed at which the nozzle turns and the liquid flow rate control the size of the droplets. Rotary nozzles reduce the range of droplet sizes, so very small droplets and very large droplets are eliminated. Control of droplet size with rotary spray nozzles is particularly significant when oil carriers are used. It may be necessary to fly up to 25 feet above the target surface to obtain a uniform deposit pattern. Uniformity also depends on how fine the spray is and the spacing of the nozzles on the aircraft. For low-level work, six or more nozzles are required to provide swath uniformity.

Figure 11. Modification of the end of a boom to eliminate trapped air in the spray system beyond the spray valve.

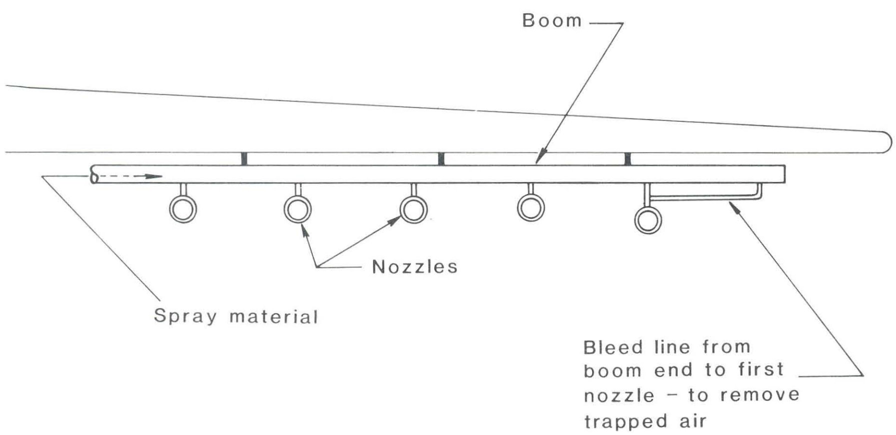
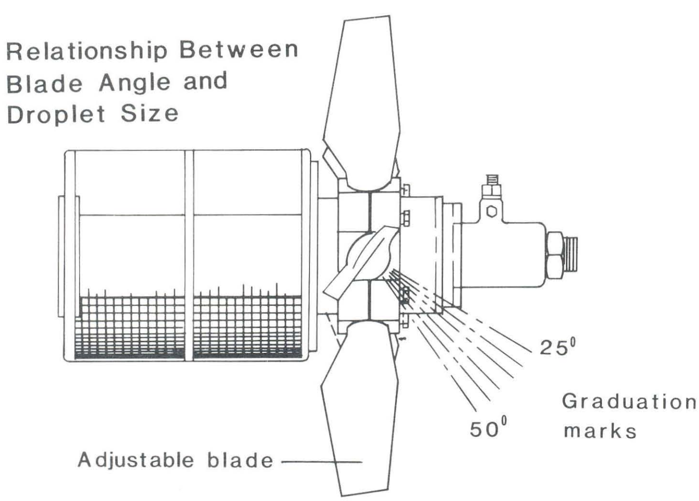


Figure 12. A micronair Atomiser AV3000 rotary nozzle.



A microfoil boom can be used on helicopters to control droplet size. This boom consists of a series of 6-inch long, airfoil-shaped nozzles. Sixty needle-like tubes project from the trailing edge of each nozzle (Figure 13). Spray pressure and orifice diameter control droplet size. Droplets are formed on the needle-like tubes and pulled off by the airstream, then enter the non-turbulent air behind the nozzle. The microfoil boom is specifically designed for helicopters because droplet size cannot be maintained at high rates of speed. It cannot be used for high viscosity sprays or wettable powders due to the tendency of the orifices to clog.

The TVB-45 boom system, a modification of the microfoil boom, was recently developed for the purpose of controlling drift by controlling droplet size (Figure 14). The new boom system is said to be effective at higher release altitudes and faster flying speeds. However, insufficient information is available at this time to be certain whether the TVB-45 boom will control droplet size successfully.

Figure 13. Standard microfoil boom used on rotary aircraft for aerial application of chemicals on forest sites.

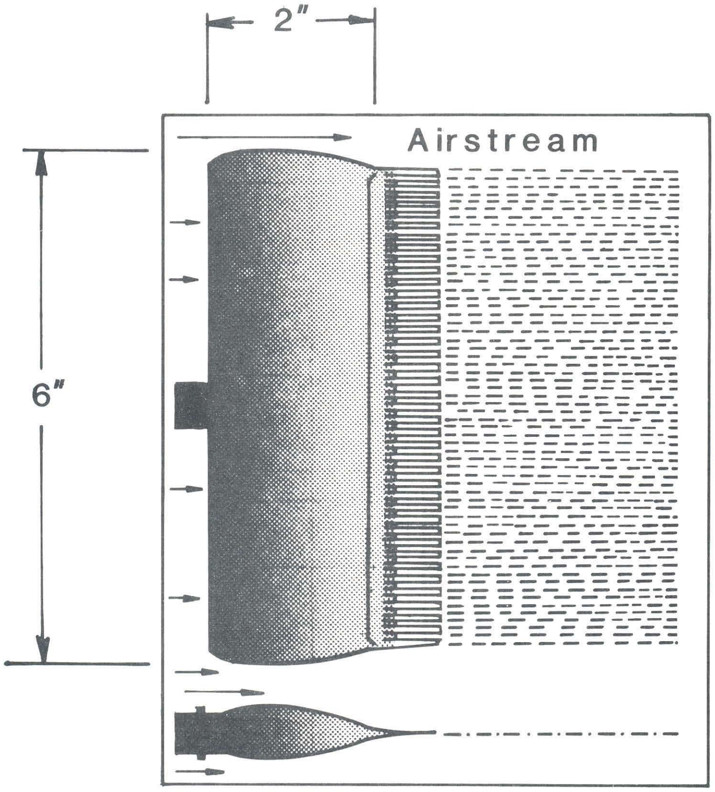
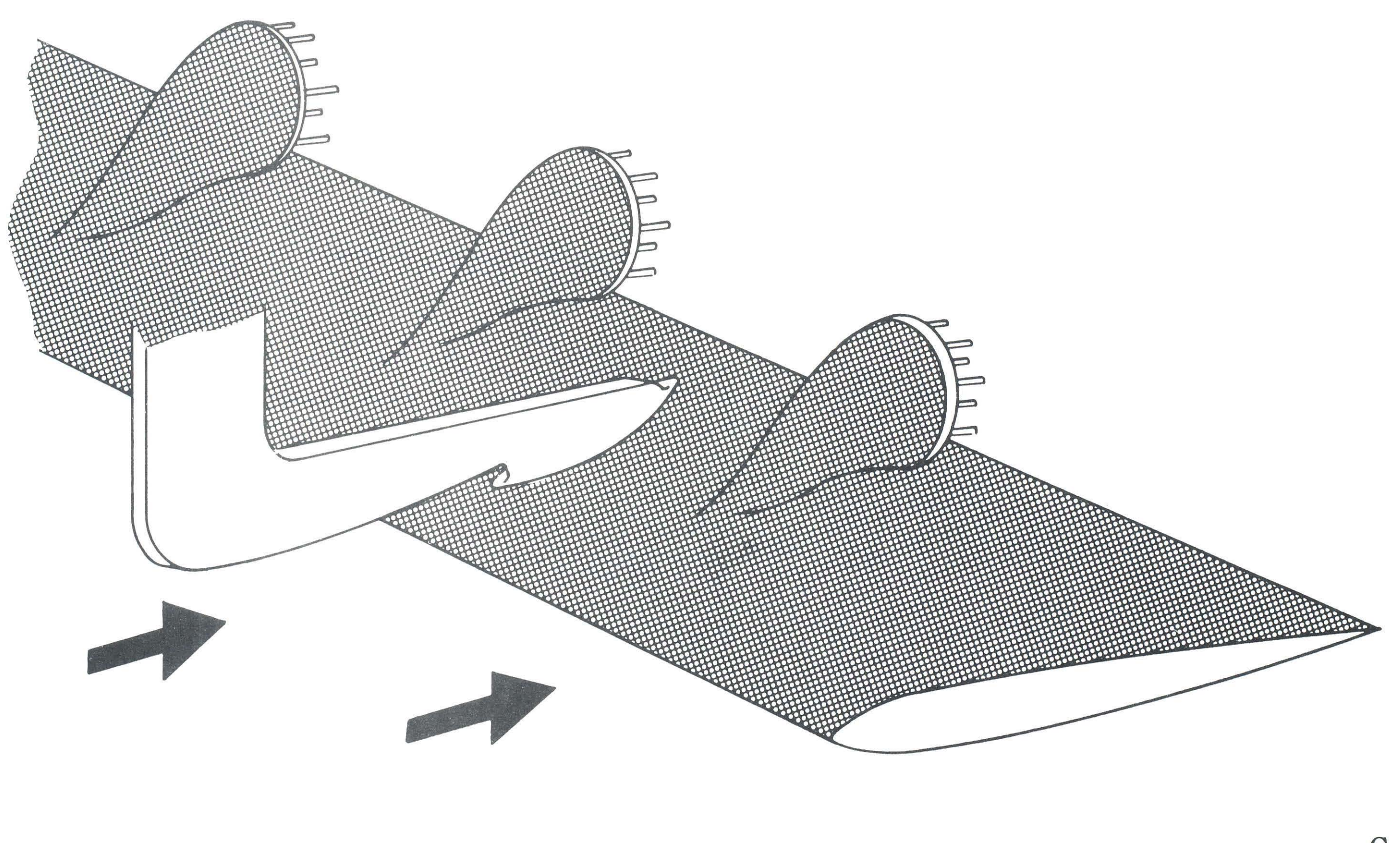


Figure 14. Representation of the TVB-45 Boom System.



Effects of Equipment Design and Configuration

A number of factors will influence swath width, application uniformity, and the amount of drift that may occur. All of these variables are important in terms of effective pest control and reducing the concerns of adjacent homeowners about drift onto their properties. Applicators must always be aware that they must conduct their operations in a way that will provide effective pest control, while alleviating the concerns of the public in the application area.

Wingtip Vortex

One major problem still affecting agricultural aviation is wingtip vortex. This phenomenon is often misunderstood and misused. Many, if not most, people think of vortex as being all bad. Actually, vortex can be used to obtain a swath width wider than the wingspan for liquid applications and a wide spread pattern for granular operations. Proper use of the vortex allows a reduction of chemical drift out the target area and a wide, uniform swath.

Extensive research has been done on vortex wakes. The investigations show that a pair of oppositely rotating vortices exhibit a very slow rate of decay when descending in a quiescent atmosphere undisturbed by ground effects. These "ideal" conditions are not often met in aerial application situations. More commonly, vortex pairs encounter background turbulence, wind gradients, or the ground in an atmosphere that is not stable, resulting in a reduced lifetime of a vortex pair.

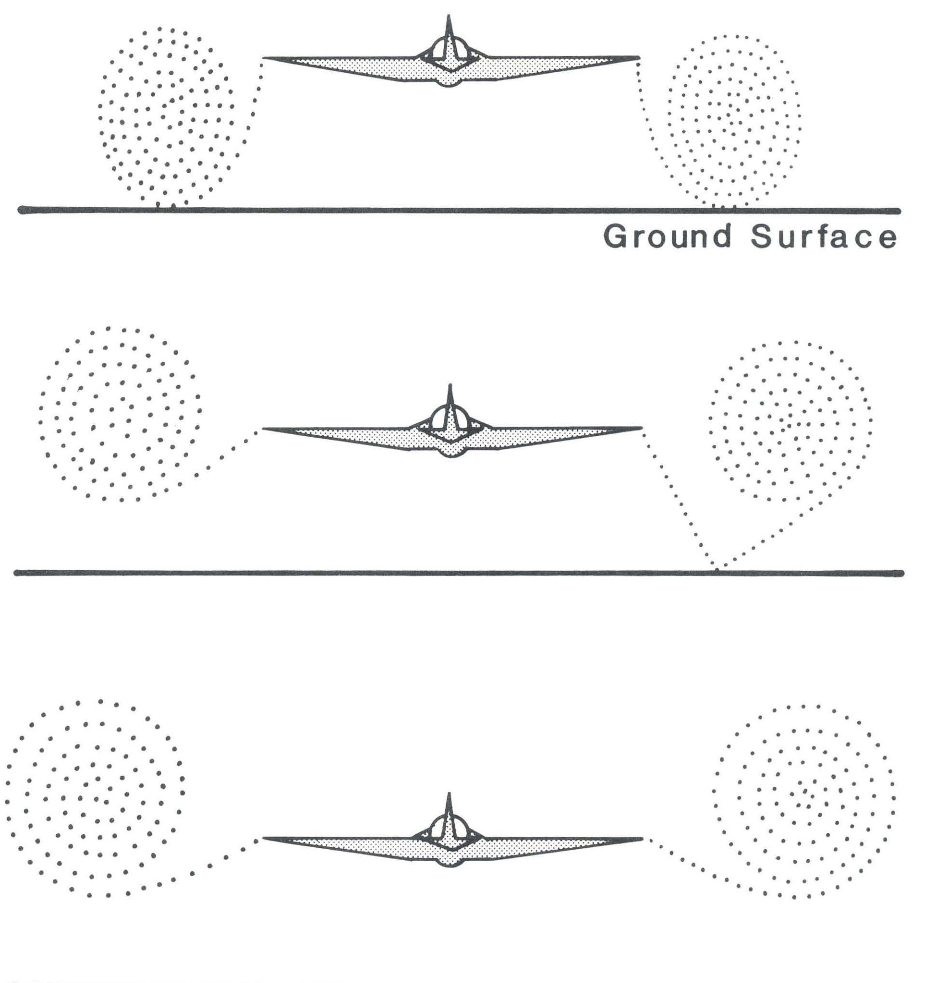
During aerial application of a pesticide on a calm day on bare ground, for example, one would be able to observe (from a position outboard of the wingtip) "vortex bounce," which is the upward movement of the vortex as it moves laterally across the field. As the rotating vortex approaches the ground, the boundary layer of air next to the ground reacts by inducing an upward and outward motion on the descending vortex, which results in its "bounce" away from the ground surface (Figure 15).

When a cross-wind is present close to the ground surface, the symmetries of movement are destroyed. The vortex from the upwind wingtip interacts with the crosswind so that the vortex moves very little. On the downwind wingtip; however, the vortex moves downward and laterally downwind with very little upward motion (Figure 16).

A crop canopy will affect a vortex descending into it. Lateral motion of vortex will be decreased as the height of the vegetation increases. A tall canopy of dense vegetation will decrease the lateral motion of vortices to an insignificant amount.

Wingtip vortex can be useful when used properly. However, for liquid applications especially, the vortex must be controlled. A suppressed vortex is characterized by a low lift coefficient obtained by highpower settings, low angle of attack, or a low wing loading. The vortex can

Figure 15. Vortex bounce when aerial application is made on a calm day.



also be diffused by a tapered wing design or devices such as winglets.

Swath width determination is the key to vortex control. Spray droplets caught in the vortex will not increase swath width. The key is to determine the location where the droplets will travel downward and outward, but do not yet start the upward travel. This can be determined experimentally by running swath checks with water and dye. Turn off one nozzle inboard from the wingtip, spray onto paper or cards, determine swath width, and repeat. Continue turning off one nozzle at a time until the swath width starts to decrease. At that point, you have determined the outermost nozzle that should be used for liquid applications. The nozzles outboard of this location emit spray into the vortices that has little or no pesticidal effectiveness and is subject to drift. As a rule of thumb, the outermost nozzle will be located inboard from the wingtip ¼ to ⅓ of the wing length.

For granular materials, the vortex can be amplified by flying at high speeds. This will increase the angle of attack, increase the vortex strength, and result in the widest spread pattern.

Rotor Vortex

The operator must have a reasonable working knowledge of the rotor wake characteristics of the helicopter. Note that the wording "rotor wake" is used rather than the more popular but misleading "rotor downwash." Rotor wake includes the total amount of air moved by the helicopter as opposed to rotor downwash, which by implication, considers only the downward motion imparted to the air mass. Only when the helicopter is hovering is the rotor wake considered synonymous with rotor downwash.

As an air machine, the helicopter must force its way through the air. The rotor blades must accelerate a large volume of air to achieve force. The only means available to counteract gravitational force is with a lift force equal in magnitude and opposite in direction. This lift is generated by a turning wing moving huge volumes of air downward. In forward flight the helicopter must overcome the force of gravity and drag resistance. Consequently, two large volumes of air displacements are involved: downward displacement to overcome gravitational force, and horizontal displacement to overcome drag force.

For speeds below 20 mph, the primary air movement is downward. Within this range, the helicopter rotor wake acquires its maximum downward velocity with maximum downward wake angle.

The rotor on the helicopter operating at a constant rpm imparts downward velocity to the air unevenly, increasing in magnitude from the center of the rotor to the end of the blade. Consequently, most of the total air movement in the rotor wake is confined to the outer portion of the rotating blade. The resulting air flow takes the shape of an annular ring or doughnut with a large dead area in the center. This phenomenon is similar to the air movement of a hurricane in that the central portion is calm while violent high velocity air

Figure 16. Vortex bounce when aerial application is made in a cross-wind occurring close to the ground surface.

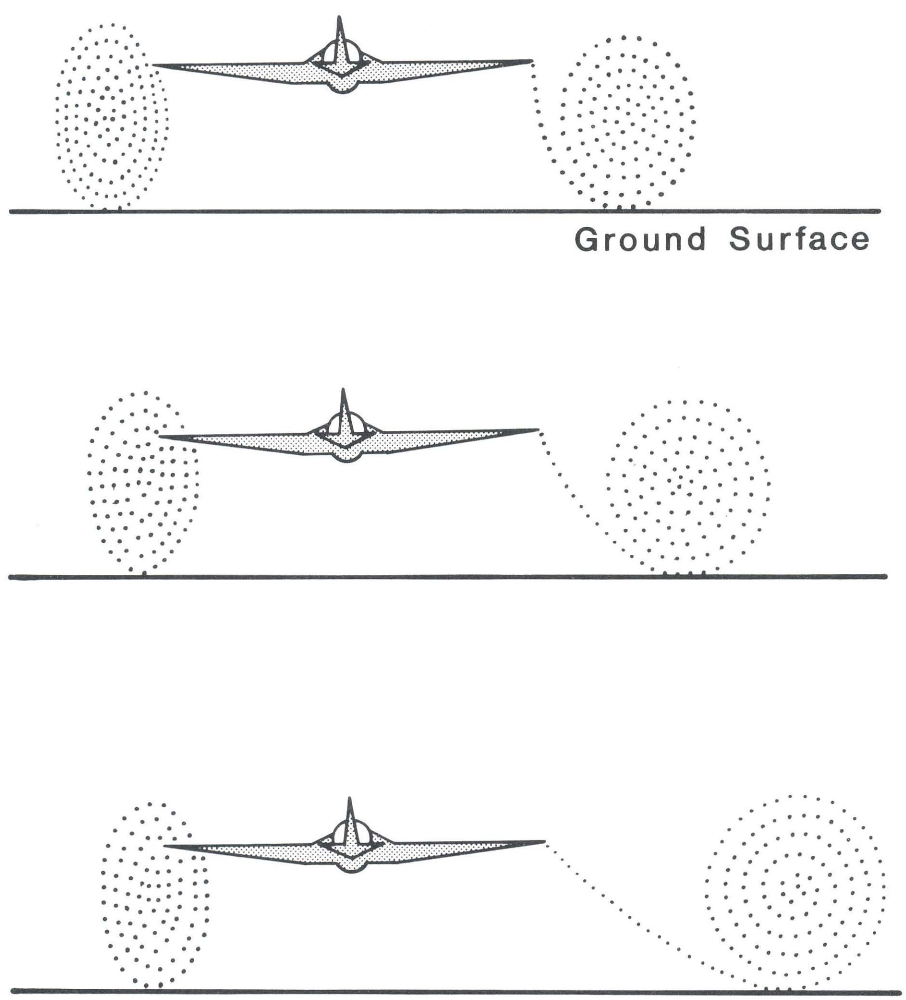
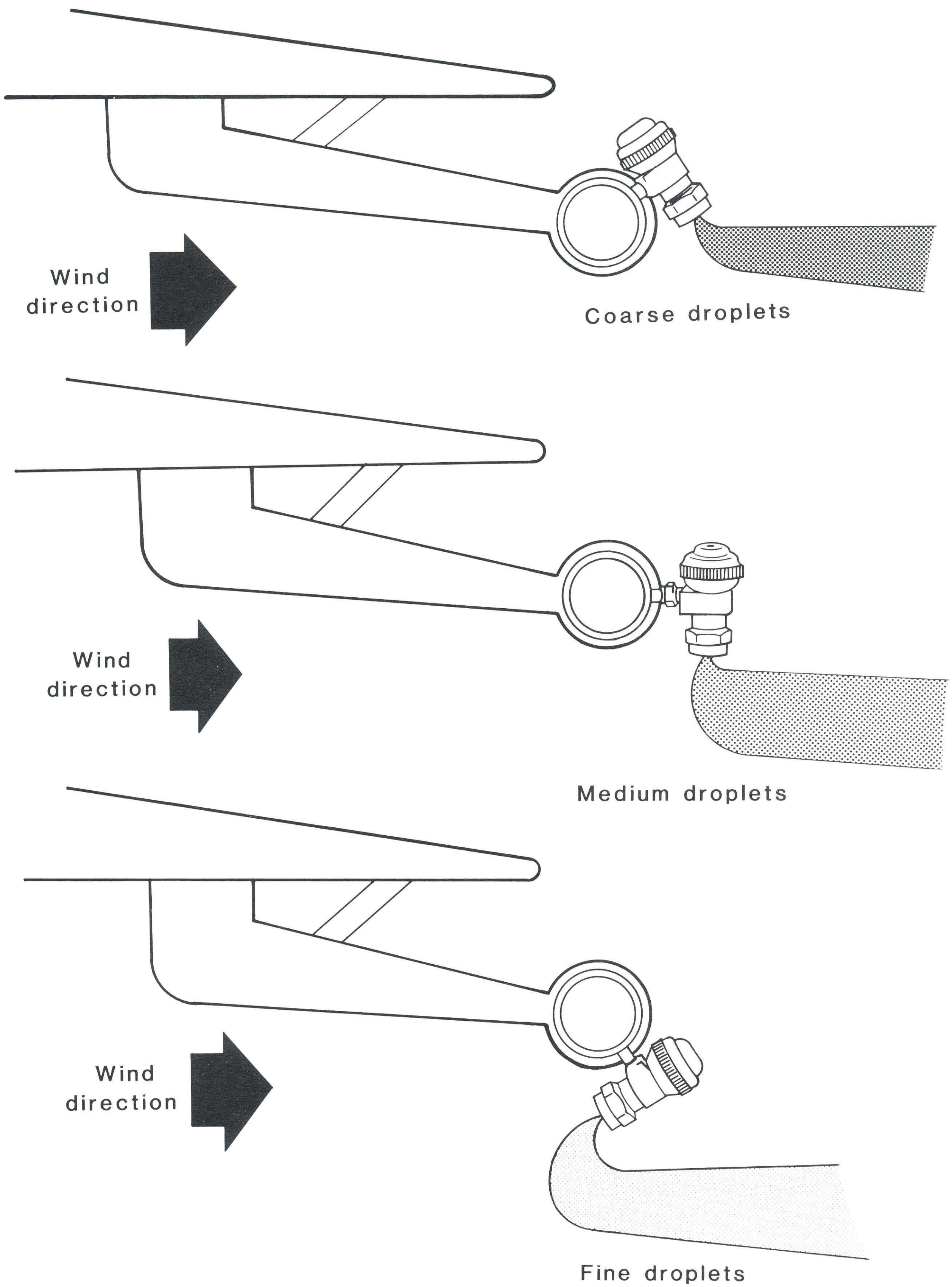


Figure 17. The relationship between the direction of the nozzle orifice to the airstream and the droplet size that results during application.



movements surround the relatively calm eye. It is obvious that any spray material introduced into the central dead area would achieve no benefit from the rotor wash. However, the concentration of force in the annular ring causes violent agitation of crop foliage. When the air is saturated with spray droplets, the air turbulence contributes to good chemical coverage.

As the helicopter moves forward from a hover, the ring of violently agitated air becomes foreshortened, taking on the shape of an ellipse. As the helicopter increases its speed beyond 20 to 25 mph, the annular ring is dissipated and a large mass of ill-defined air flow is generated; that is to say, the "eye" of the hurricane has been closed in a multitude of small incremental air flows enjoined or opposed to each other in direction and in force. In this area, the air flow for practical purposes cannot make up its mind whether to go downward or aft. It is fairly homogenous in that it is all agitated and the predominant air flow is downward.

When the helicopter reaches a forward speed of approximately 35 to 40 mph, the disturbed, ill-defined air flow assumes an entirely new pattern that is well-defined and consistent, although quite complicated. It is this airflow from which the aerial applicator should derive maximum benefit. At this speed or greater, the nature of the air flow generated by the helicopter assumes continuity. The vortices created will behave in a manner similar to those described for fixed-wing aircraft.

Droplet Size

One can vary droplet size by:

- Changing the size and type of orifice in each nozzle. For example, with an operating pressure of 50 psi, changing from a D4-45 to a D6-46 nozzle will increase the volume mean diameter of the droplets from about 150 microns to about 280 microns.
- Increasing pump pressure, which reduces droplet size; or reducing the pressure, which increases droplet size, and
- Changing the direction of the nozzle orifice in relation to the airstream (Figure 17). Droplet size decreases as the nozzle is oriented forward 90 degrees to the line of flight. Smallest droplets are formed when nozzles are oriented forward at 45 degrees. (This latter practice is *not* recommended because it faces into the airstream causing some spray to collect on the nozzle or attachments and fall in large drops, wasting the spray material.)

Adjuvants in the form of thickening agents and particulating agents help maintain a more uniform droplet size by modifying spray consistency. Thickening agents are natural or synthetic polymers that, when added to the spray solution, increase the viscosity of the solution. The size of the droplets released is increased, thus reducing the potential for drift. Some thickening agents may function as stickers, increasing adhesion of spray to leaves and stems. The increased viscosity of the solution may also slow the rate of evaporation of the solution. Thickening agents are available that are water-soluble, and soluble in the water phase of oil-in-water emulsions. However, they are not compatible with all pesticides. Some thickening agents require the use of special equipment because of mixing difficulties. For such materials, instructions for the proper equipment are given on the product label.

Particulating agents absorb water rather than increase viscosity. They are composed of a water-swellable polymer that swells to a fixed size. Particulating agents are designed to be used only with water soluble pesticides. Special types of equipment are often required for use with particulating agents to ensure good mixing.

CALIBRATION OF DISPERSAL EQUIPMENT

Accurate calibration of dispersal equipment is essential for any operation performed by an aerial applicator. The best pilot flying the best aircraft is worthless if the equipment dispenses the incorrect amount of material in a variable pattern. Inaccurate treatment will result not only in dissatisfied customers, but will also entail a legal violation of the pesticide label and Federal and State regulations governing pesticide use.

Calibration for Liquids

Gallons per minute (gpm) and acres per minute (apm) are the two most important variables. They must be coordinated with vehicle speed and an appropriate swath width in order to achieve accurate calibration. The following procedures will help reduce the time required and will improve the accuracy of calibration:

1. Select the size and number of nozzle tips that will deliver the desired gpm at a selected operating pressure. Use the specifications provided by the nozzle manufacturer as your guide.

2. Make a trial run with water and dye to determine an effective swath width and uniform deposition. (This will be discussed later in the subsection entitled "Distribution Patterns.")

3. Calculate the acres treated per minute at the speed and swath width you intend to use.

4. Calculate the gallons sprayed per minute in order to apply the recommended volume on each acre.

5. Make a trial run to check the calculated delivery. There are only a few simple formulas needed to determine calibration.

$$\text{apm} = \frac{2 \times \text{swath width (ft)} \times \text{ground speed (mph)}}{1{,}000}$$

$$\text{gpa} = \frac{\text{gpm}}{\text{apm}}$$

Other useful formulas may be found in the Appendix.

For example, assume a tank with a 300-gallon capacity has an effective swath width of 50 feet when flying 8 to 10 feet above the ground, a ground speed of 100 mph, an application rate of 3 gpa, and an operating pressure of 40 psi.

1. Calculate acres per minute from the assumed values.

$$\text{apm} = \frac{2 \times \text{swath width (ft)} \times \text{ground speed (mph)}}{1000}$$

$$\text{apm} = \frac{2 \times 50 \times 100 = 10 \text{ acres per minute}}{1000}$$

Table I is convenient for determin-

Table I. Acres Per Minute (APM) applied at specific air speeds and swath widths.

ACRES PER MINUTE

Speed mph	Swath width, ft. 30	35	40	45	50	75	100	200
40	2.4	2.8	3.2	3.6	4.0	6.0	8.0	16.0
50	3.0	3.5	4.0	4.5	5.0	7.5	10.0	20.0
60	3.6	4.2	4.8	5.4	6.0	9.0	12.0	24.0
70	4.2	4.9	5.6	6.3	7.0	10.5	14.0	28.0
80	4.8	5.6	6.4	7.2	8.0	12.0	16.0	32.0
90	5.4	6.3	7.2	8.1	9.0	13.5	18.0	36.0
100	6.0	7.0	8.0	9.0	10.0	15.0	20.0	40.0
110	6.6	7.7	8.8	9.9	11.0	16.5	22.0	44.0
120	7.2	8.4	9.6	10.8	12.0	18.0	24.0	48.0

ing apm when swath width and speed are known.

2. Calculate the gpm required. In the example, gpm = gpa × apm, or gpm = 3 × 10 = 30.

3. Select nozzles based on the gpm per nozzle specified by the manufacturer. The number of nozzles on the boom can be variable, but assume 30 nozzles for this example:

$$\text{gpm per nozzle} = \frac{\text{gpm desired (30)}}{\text{number of nozzles (30)}} = 1.0$$

Use the manufacturer's catalog to select a nozzle that is rated closest to 1.0 gpm at a pressure of 40 psi. Minor differences in output can be accommodated by slight pressure adjustments.

4. Make a trial run to check the system. Fill the tank to a known level. Fly the aircraft at 100 mph for 60 seconds, land, and measure the amount of water needed to fill the tank to the previous level. Then,

$$\frac{\text{gallons used}}{\text{acres treated}} = \text{gpa sprayed}$$

The amount actually sprayed should be close to the calculated value. Make adjustments by varying pressure or air speed as needed.

5. Calculate the amount of chemical needed per tank. At 1 lb/A as a recommended rate, 100 acres x 1 = 100 lb of chemical. If the recommendation is given in pints, simply multiply 100 acres x the pint per acre recommendation to give the amount of chemical needed per tank.

Calibration for Solids

Give as much attention to calibrating equipment for dispensing solids as for liquids. The type of spreader, type of granular or other solid material, the rate per acre, and the amount of swath overlap will all affect the calibration accuracy. If one condition changes, the calibration procedure will have to be repeated to ensure accuracy.

Use the following procedure to determine and check equipment calibration:

1. Screen granules before putting them into the hopper.

2. Check the distribution pattern over the entire width of the application.

3. Determine the effective swath based on the distribution pattern, recognizing that overlap will be required to give uniform distribution — 50 percent overlap is common.

The distribution pattern can be determined only by setting out pans across a line of flight. The pans should be at least 4 inches deep with an inside area of about 1 square foot. Place them at 2-foot intervals for 20 feet on each side of the swath centerline and at 5-foot intervals for an additional 30 feet on each side (Figure 18). This procedure should be done on flat ground for a total distance that exceeds the expected swath width.

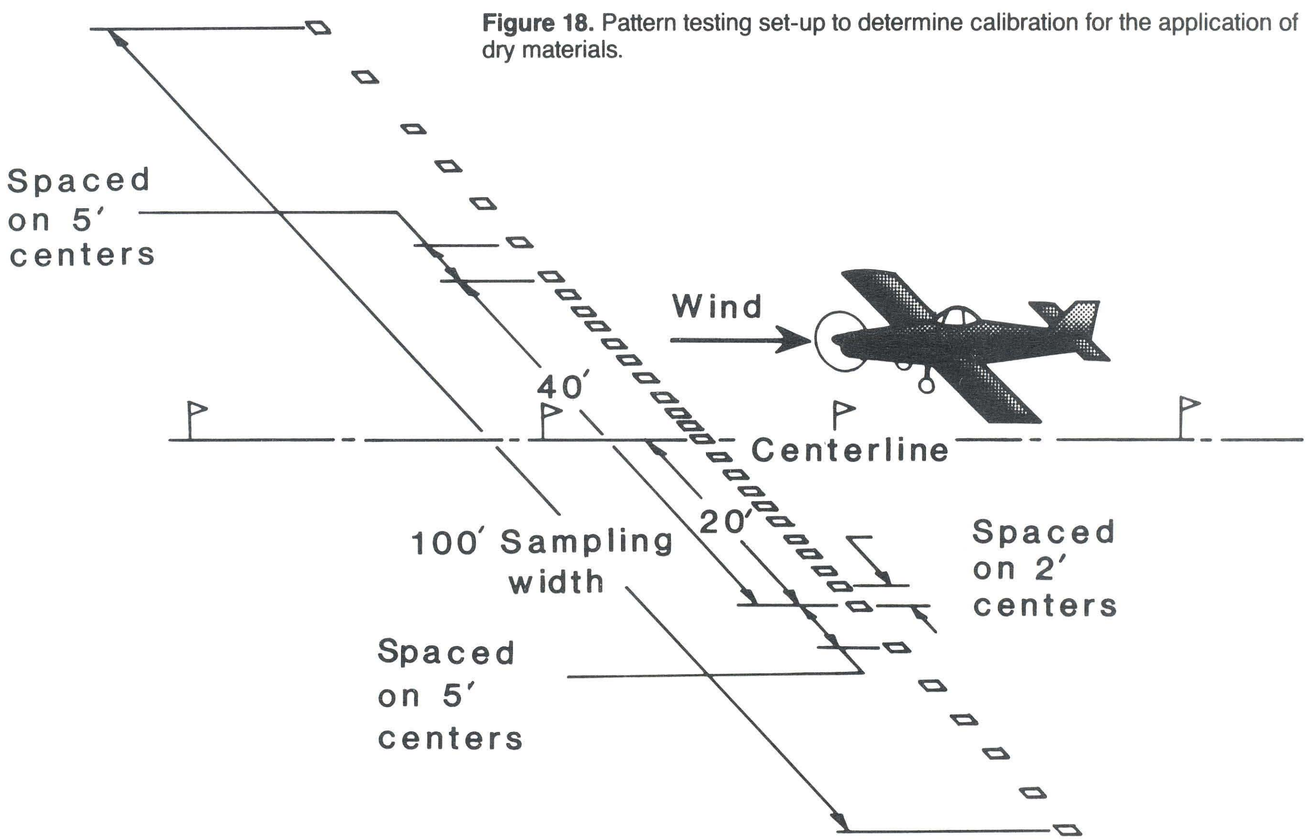


Figure 18. Pattern testing set-up to determine calibration for the application of dry materials.

If the gate setting is not known, some preliminary work can be done on the ground. Time the flow of 100 pounds of granules through the gate opening. The flow rate will be approximately twice as fast during flight as it was on the ground, so gate adjustments must be estimated for the desired rate per acre. Assume a swath width based on previous experience with similar equipment. Once you know the flying speed, you can calculate the rate per minute:

$$\frac{\text{min/hr} \times \text{seconds/min}}{\text{mph}} = \frac{60 \times 60}{90}$$

$$= 40 \text{ seconds to fly 1 mile.}$$

If the swath width is estimated to be 50 feet, then:

$$\text{acres covered} = \frac{50 \times 5280}{43{,}560}$$

$$= 6.06 \text{ acres in 40 seconds.}$$

and

$$\frac{6.06 \times 60 \text{ sec}}{40 \text{ sec}} = 9.09 \text{ acres per minute.}$$

If the desired rate is 10 lb/A, then a flow rate of $10 \times 9.09 = 90.9$ lb/minute is required.

Check the distribution by flying over the center of the line of pans. Perform the test during minimum wind conditions and fly into the wind.

Flight altitude should be 30 to 50 feet above the ground surface, which is normal for granular applications. After the run is completed, collect the granules from each pan, starting at one end, and transfer them to a small-diameter glass tube (test tubes do nicely). Place the tubes in sequence for a visual display of distribution. From that display you will be able to determine the shape of the distribution curve, and from that, closely estimate the overlap needed to provide an even coverage. Your estimation of required overlap will be more accurate if you chart the height of the granules in each glass tube on a piece of graph paper. The graph can then be cut out, a duplicate made, and the two graphs then manipulated to give the most uniform distribution. The effective swath width will be the total width minus the distance of overlap.

Deposition Patterns

Having accurately calibrated a dispensing system to deliver a specified amount of material in a specified time interval at an expected flying speed does not mean that the aircraft is ready to uniformly control the late blight in your client's potato field. For a spraying system, the nozzles have to be placed on the boom in such a way that uniform deposition is achieved when multiple passes are made over a field. The distribution pattern will be different for each airplane (even though the same aircraft model is used) and for each spraying system. The proper nozzle arrangement needs to be worked out for each plane and its spraying system.

Determining the best nozzle arrangement involves intercepting the spray that is dispensed and evaluating the amount of deposition across the spray swath. The usual method is to spread a paper tape on the ground or place moisture sensitive cards at short intervals to intercept the spray from a plane flown at a right angle to the line of paper tape or cards. A dye is used when paper tape serves as the interceptor.

Equipment has been developed during the last few years that greatly simplifies the analysis of spray deposit. Although details of the various systems vary, the basic design is similar. The deposited spray is fed to a sensing unit, which reads the amount of deposit and enters the values into a computer. After the deposits across the entire width of spray deposit have been read, the computer will print a graph of the deposit, with the center of the graph representing the line of aircraft flight.

Computer software has also been developed that permits a composite graph of three passes in either a racetrack pattern (same flight direction for each pass) or a standard back-and-forth pattern. Swath width is determined most accurately from the back-and-forth pattern. There must be sufficient overlap to preclude gaps between swaths. The speed with which distribution patterns can be analyzed with the modern technology available has greatly simplified the procedures for designing a nozzle configuration that gives uniform distribution. Even with the use of such technology, multiple passes may be needed before the most effective nozzle configuration is achieved.

The Michigan Agricultural Aviation Association conducts annual fly-ins for the purpose of checking aircraft spray patterns. Fly-ins have been conducted since 1983 under the auspices of the National Agricultural Aviation Association's OPERATION SAFE program, which is designed to improve agricultural aviation operations. Effective spray pattern is a dominant element in effective application. Pilots and aircraft that have successfully completed the training provided through OPERATION SAFE are certified to that effect. One expected benefit from the program will be lower insurance rates for those who have successfully completed the program. Although OPERATION SAFE has been in existence for only a short time, the response to the program has been enthusiastic.

Fly-ins will be continued in Michigan. Pilots are strongly encouraged to participate in this program because the training they receive will enhance their professional skills. OPERATION SAFE fly-ins may also become an alternative to recertification examinations in the near future.

APPLICATION PROCEDURES

The pilot is the key to successful aerial application because the pilot must decide when and when not to spray, what and what not to spray, and how to spray. Knowledge of all aspects of aerial application is essential to making proper judgements. Equipment should be in good working order and accurately calibrated with a nozzle configuration that provides uniform coverage. Use only the amount of pesticide recommended on the product label and avoid unnecessary exposure to the chemical. Avoid sensitive areas enroute to the spray site. Apply chemicals uniformly and take care to minimize drift. Avoid obstructions while spraying and always consider the location of nearby homes so that lives and property are not threatened nor needlessly antagonized. Spray only when climatic conditions are appropriate. Remember, all of these factors must be evaluated for each job to prevent serious or fatal accidents.

Airstrip Operation Prior to Application

A well organized airstrip will ensure that the aircraft spends the minimum amount of time on the ground and the maximum time spraying (Figure 19). The layout of the airstrip will vary but it must ensure that fuel and pesticide are kept well apart and that both of these potentially hazardous materials are protected from sunlight and other environmental extremes. All ground work should be done on a seamless cement pad constructed so that any accidental spills can be contained, properly recovered and discarded.

Loading the aircraft should be carried out via a closed system from a mixing tank. All ground crews, as well as pilots, should wear appropriate protective clothing to prevent exposure to any chemical(s) being handled. All personnel involved should be trained to carry out emergency procedures in case of an accident.

The aircraft payload may need to be reduced from the manufacturer's maximum specification to compensate for airstrip conditions or the effect of atmospheric conditions on engine performance. Only a mechanically sound aircraft should take-off from an airstrip, and the pilot should be wearing the correct and functional safety equipment for in-flight protection.

Field Operations—Application Methods

The normal procedure is to fly back and forth across the area being treated in straight, parallel lines. In areas too rugged or steep for the pilot to hold a uniform altitude and speed in both directions, the flight lines should follow the contours of the slopes. In mountainous terrain, it may be necessary to make all treatments downslope. Upslope treatments are extremely dangerous—attempt them with extreme caution only. Whenever possible, make the flight lines or swaths crosswind—to assist in overlap and coverage uniformity, and lengthwise to the area—to reduce the number of turnarounds. Begin treatments on the downwind side of the areas so that you can make each successive swath without flying through chemicals suspended in the air from previous swaths. To ensure uniform coverage and to avoid excessive overlap or stripping of the area, mark each swath to guide the pilot.

A race track pattern may be more energy efficient for small fields or more appropriate in situations where it allows the aircraft to avoid sensitive areas.

THE TURNAROUND

This maneuver is performed more often than any other during aerial applications and, when poorly executed, causes many accidents. The pullup and downwind turn puts the aircraft in a low-speed, high-drag attitude and must be executed carefully. The pilot should never look back—orientation for the next swath should be accomplished before the pullup.

Whenever possible, do not start the turnaround at the end of each swath until after pulling up over obstructions and leveling off. Complete the turnaround before dropping in over the obstructions on the next swath. Start the turnaround by turning 45 degrees downwind, leveling off for several seconds, then making a smooth coordinated reversal of 225 degrees (Figure 20). The number of seconds you spend in level flight is determined by the swath spacing or distance the aircraft must move over. Maneuverability of the aircraft, power, load remaining, wind, temperature, and elevation affect safe airspeed and rate of turn. As you continue the last of the turn, orient yourself in time to line up for the next swath. It is during this part of the turn that pilots often encounter difficulty, so time yourself to avoid fast or intricate maneuvering to get into position.

Avoid snapping reversal, lowball, or wingover turns at all times. When you must make a turn by going upwind first, you need more space and time to complete the turn.

Whenever possible, avoid turnarounds over residences, farm buildings, penned poultry or livestock, watering places, ponds, and reservoirs. Be particularly alert to the dispersal apparatus shutoff, always making sure it is closed.

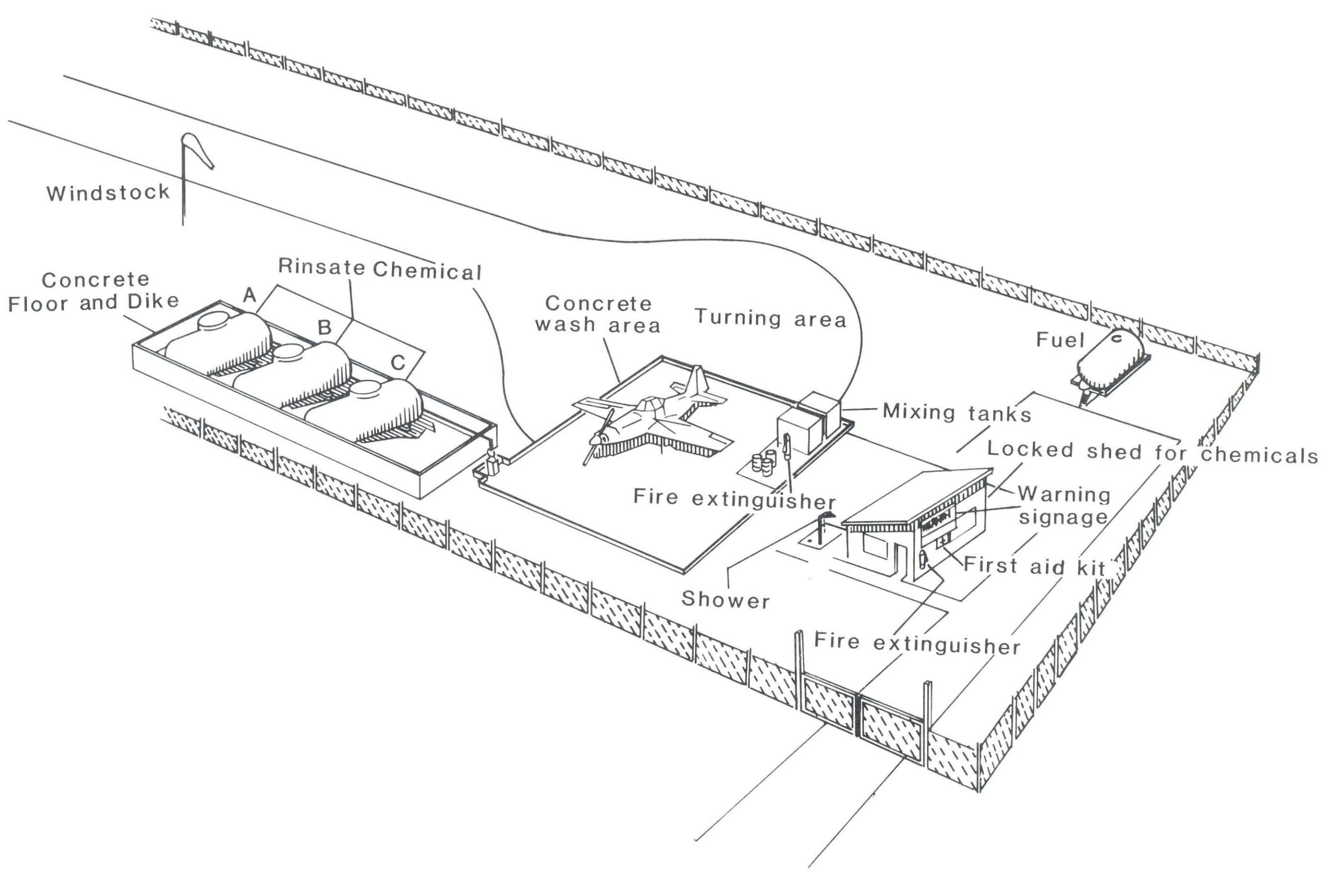
FERRYING

Fly at least 500 feet of altitude during ferry flights between the airstrip and worksite, whether loaded or empty. Avoid flight over farm buildings, scattered residential areas, and penned poultry or livestock. Too often, because of the noise they make or their mere presence, agricultural aircraft are accused of damaging or contaminating property. When making many trips back to the same area, avoid taking the same route each time. A deviation of ⅛ to ¼ mile off direct course will avoid flying close to the same areas each time.

SPEED

Control of speed during aerial application is important. Calibration of dispersal apparatus depends on flow rate and flight speed. No device is available that changes flow rate automatically and proportionately as the flight speed

Figure 19. Important features that should be included at an airstrip.



changes. Once the dispersal apparatus has been properly calibrated, keep the speed constant during each swath to ensure uniform coverage of the area. Table 2 shows the amount of application error caused by headwind and tailwind components while maintaining various application speeds.

ALTITUDE

Altitude is usually determined by the form of material being applied. For example, herbicides must be applied from a low height to reduce drift, which may damage nearby vegetation. Insecticides may be applied at heights up to ½ the wingspan depending on conditions. Seeds and granular materials are usually applied from wingspan height.

Arrange nozzles and adjust granular distributors to produce the desired deposit pattern with the material being applied from the flight height you select. Keep this height constant during each swath run to obtain uniform coverage of the treated area. As a rule of thumb, the best deposition patterns are obtained at flying heights of 8 to 10 feet above the target site for liquid materials and 25 feet above the target site for granular materials.

DRIFT

Spray drift is an extremely sensitive issue. Its importance cannot be overstated. Pilots who ignore the reality of drift do so at their own risk and to the detriment of the entire industry.

Drift is the airborne movement of pesticidal spray to areas outside the target area. There are many factors that may cause drift to occur during spraying. Weather factors, such as wind velocity, air temperature, and the presence of temperature inversions, and mechanical factors, such as spraying height, flying speed, type of equipment used, droplet size, and the pressure at which the droplets are released

Figure 20. Routine turnaround flight patterns for any aerial application job: (a) back and forth pattern; (b) race track pattern.

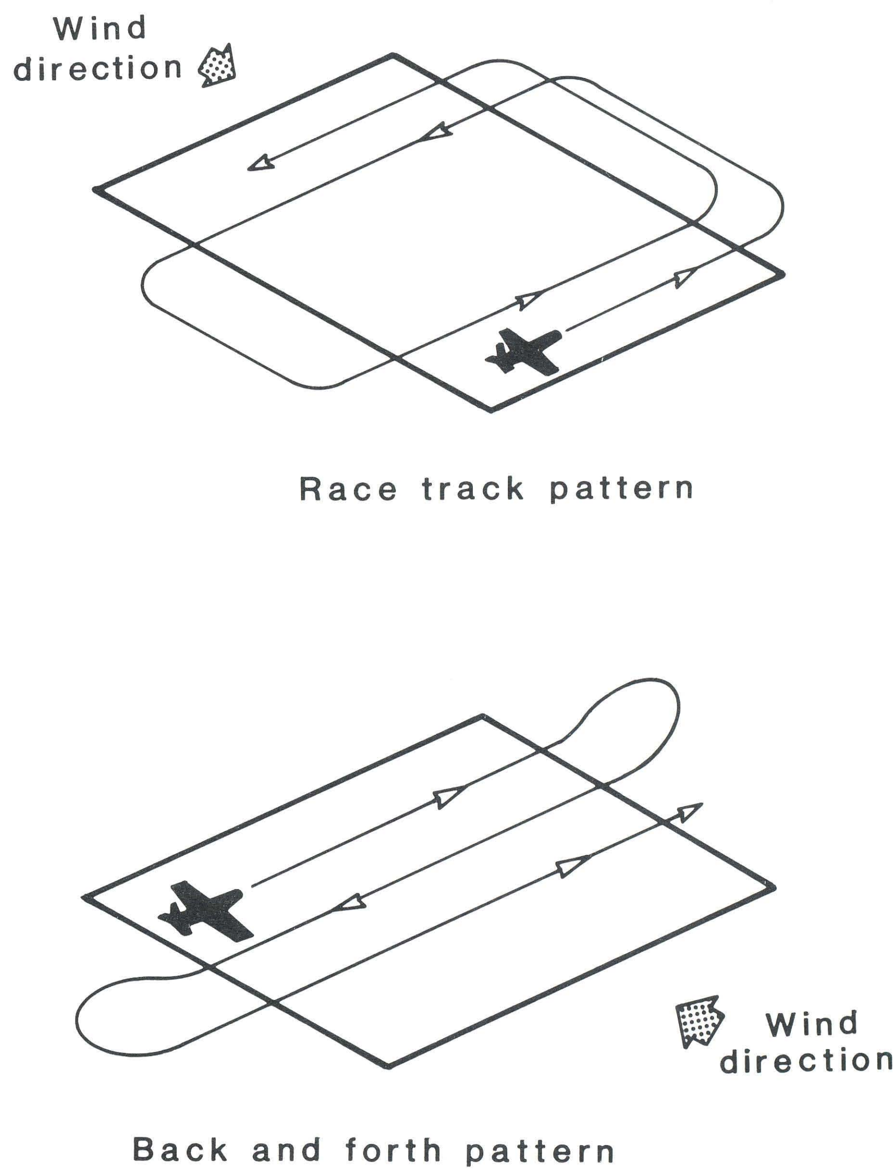


Table II. Percentage of application error at various flight speeds—headwinds represent overapplication; tailwinds represent underapplication.

Flying speed, mph	Headwind, mph					Tailwind, mph				
	2	4	6	8	10	2	4	6	8	10
60	4.0	7.8	11.8	15.7	19.8	2.9	5.8	8.7	11.8	14.4
70	3.2	6.6	9.9	13.2	16.4	2.4	5.1	7.7	10.1	12.6
80	2.7	5.6	8.5	11.2	14.1	2.1	4.6	6.8	9.1	11.2
90	2.3	4.9	7.4	9.9	12.2	2.0	4.2	6.3	8.2	10.1
100	2.0	4.3	6.7	8.8	10.8	1.7	3.8	5.6	7.5	9.2
110	1.8	3.7	5.9	6.5	9.9	1.7	3.4	5.1	6.8	8.4
120	1.7	3.3	5.3	7.2	9.1	1.6	3.2	4.6	6.2	7.7

affect drift. Drift cannot be completely eliminated, but it can be greatly reduced if each of the above factors is considered before application.

Drift is guaranteed to occur under inversion conditions. Under normal conditions, temperature decreases 1 degree C for each 100 meters of altitude. A temperature inversion exists when temperature increases with altitude. Temperature inversions are usually caused by rapid cooling of the soil surface coupled with evaporative cooling of crops. The lost heat radiates upwards causing the air above the ground surface to be warmer than near the ground. The cooler air, because it is more dense and heavy than warmer air, remains as a layer near the ground. Maximum temperature inversions occur when high day temperatures are followed by cool night temperatures. The inversion builds during the night, reaching its peak in the early morning. When the sun begins to warm the land again, convection from the soil surface warms the cool inversion air and reestablishes the normal temperature gradient.

Temperature inversions provide the greatest opportunity for drift. Small spray droplets can become trapped in the cool air beneath the inversion ceiling. These droplets can travel laterally for considerable distances in sufficient amounts to cause damage to other crops. Early morning, the most common time for spraying, is also the time when there is the greatest chance for inversions. Inversions can be detected by using thermometers to measure the air temperature at 3 feet above ground and at 32 feet. An inversion is present if the temperature at 3 feet is lower than the temperature at 32 feet. Because temperature inversions can be very localized, this method is effective only if temperatures are compared at the spraying site.

Table III. Terminal velocity and drift assuming a 5 mph crosswind and release height of 10 feet.

Drop size, um	Vertical drop, ft/sec	Lateral Drift, ft
5	0.0026	29,800
10	0.01	7,450
20	0.04	1,863
50	0.27	298
100	1.09	75
150	2.12	33
200	2.83	17
250	3.54	12
300	4.25	8
400	5.66	5
500	7.08	3

To prevent vaporization, use low volatility sprays whenever possible. Apply sprays at low temperatures and high relative humidity, particularly when using a highly volatile spray. Oil-based sprays also reduce the rate of vaporization. The size of the droplets is another factor to consider in vaporization. Smaller droplets have a higher surface-to-volume ratio and will evaporate more quickly than larger droplets.

The potential for drift to occur is determined by the weather factors that affect drift and the quantity of droplets that are small enough to pose a drift hazard. Table 3 shows the potential drift distance and the time to extinction for given droplet diameters under specified conditions. The presence of a temperature inversion increases the drift distance.

Vaporization can be a problem when water-based sprays are used under certain weather conditions. At high temperatures and low relative humidity, the rate of vaporization increases. Highly volatile sprays will vaporize more quickly than those of low volatility. Vaporized spray will move with air currents and may cause damage to other crops.

A more practical method to detect inversions is to the use smoke. Oil squirted onto the hot exhaust manifold while flying at a low altitude will release a cloud of smoke. An inversion is present if the smoke levels off and travels laterally instead of rising.

It is the pilot's responsibility to be aware of an inversion by using one of the various detection methods. Never apply spray when there is a temperature inversion.

SAFE USE AND HANDLING RECOMMENDATIONS

Pesticides are toxic chemicals. Any pesticide, regardless of its degree of toxicity, can cause serious health problems if an organism receives a sufficient dose. Because of this fact, handle and use all pesticides with respect to prevent exposure. Aside from human toxicity, environmental hazards also must be considered because some pesticides are much more toxic to birds, fish, or other forms of wildlife than they are to mammals.

General Precautions

Prevent unintentional escape of agricultural chemicals from the spray system. Leakage of a pesticide inside the fuselage may cause corrosion of the airplane structure and/or may expose the pilot to the pesticide. If the chemicals used are highly toxic to man or give off poisonous fumes, the chemical leak will be extremely dangerous. Leakage outside the aircraft may contaminate pastures, crops, water, and other environmentally sensitive areas.

Inspect the entire spray system frequently and replace bad hoses, repair cracked or loose fittings, find and correct chafing points, clean screens and nozzles, check pump seals and stop mechanisms, and keep the entire system clean.

After you use material in which a solid is suspended in a liquid, flush and thoroughly clean the spray system to make certain all settlings are removed.

After you use weedkillers, neutralize the system with commercially available tank cleaners, or add 1 pint of household ammonia per 25 gallons of water, let it circulate and stand overnight, and clean and rinse thoroughly before applying insecticides or fungicides. Be especially careful in rinsing if the crop to be treated is one that is sensitive to weedkillers. Whenever you clean or flush an aircraft and its dispersal apparatus, be careful that drainage or runoff does not contaminate reservoirs, ponds, streams, grazing areas, or other sensitive areas.

Remember, there are three routes of exposure: ingestion (through the mouth) dermal (absorption through the skin), and inhalation (breathing the fumes). Pesticide residues are absorbed through the skin at different rates on different parts of the body. The values in Table 4, obtained from a study of volunteers exposed to parathion, show that you should take special care to protect the scalp, ear canal, forehead, and scrotum. Overexposure by any route can be dangerous. Eating a sandwich without washing one's hands will ensure some exposure by ingestion. Smoking a cigarette when fingers and hands are contaminated will assure exposure by inhalation. Wearing contaminated clothing will assure exposure by skin absorption. Good personal hygiene is the best safeguard against undue exposure. Practice it rigorously.

Table IV. Rate of pesticide absorbed on various human body sites.

Anatomy	% Absorption
Scalp	32.1
Ear Canal	46.5
Forehead	36.3
Forearm	8.6
Palm of Hand	11.8
Abdomen	18.4
Scrotum	100.0
Balls of feet	13.5

Pilot Responsibility

It is the pilot's responsibility to make a preflight check of all equipment before each flight. Give special attention to the operation and calibration of dispersal equipment. Equipment should be in good working order before any spraying is done. Leakage of chemicals can pose a threat to the aircraft and equipment, the pilot, and the environment. Make frequent checks of all equipment and replace any parts that are worn or broken.

Wear a respirator that is approved by the Mine Safety and Health Administration (MSHA) and the National Institute for Occupational Safety and Health (NIOSH) if the chemical product label being used recommends it. Use a filter or canister of a type appropriate for the chemical being used.

Selecting the respirator carefully will pay dividends in its efficiency, usefulness, and wearing comfort. If you must use a respirator for extended periods during hot weather, you may wish to use a respirator and crash helmet combination that is ventilated with forced air. If the equipment is uncomfortable, you may be tempted to work without it, which can be extremely dangerous. After use, clean the equipment and store it away from pesticides where it will not be damaged.

When using rubber or rubberized gloves, keep the insides clean at all times. Do not remove the gloves to adjust or clean a nozzle or do some other close work, then put them back on. This will contaminate the gloves. This can be extremely dangerous, because gloves may cause the hands to sweat, which opens the pores. With pores opened, the chemical is more readily absorbed through the skin.

Wear clean clothing at all times. A heavy denim coverall has been shown to provide good protection against dermal exposure. Many materials are highly toxic to man and can be absorbed through the skin. Stress personal cleanliness at all times.

When you use organophosphates or carbamates, have blood cholinesterase tests at regular intervals during the growing season. To determine your normal cholinesterase level, have the initial test before the spraying season begins. Reference to these tests would be helpful to your doctor if you become ill from possible exposure to an organophosphate or carbamate.

The pilot is also responsible for the safety of people on the ground. Before spraying, make a check for possible drift conditions and safety hazards. Avoid flying through drift, and never apply spray over flagperson or other people. When flagpersons are used, they should remain at the spray site until the job is completed in case an emergency arises.

Workers

Workers involved in the spraying operation should be well informed of their responsibilities and aware of the precautions on the pesticide label. All workers should be alert to possible pesticide poisoning to themselves and other workers. Before mixing chemicals, all workers should be advised of the measures to take if an accident should occur. Emergency phone numbers and the locations of nearby medical help should be readily available. If anyone requires medical treatment an exact copy of the pesticide product label (specimen label) to which the person was exposed should be taken along so that the doctor will know what chemical has caused the poisoning.

Note that in the precautionary section of many pesticide labels a telephone number is given that a physician can call to talk to an emergency expert at the pesticide manufacturer's headquarters.

All workers should wear the appropriate MSHA and NIOSHA approved respirator for the chemicals being used. If rubberized gloves are needed, take care to keep the insides clean. Pesticides trapped inside a rubber glove can be easily absorbed through the skin as the worker's hands perspire. All workers should wear protective clothing. Personal cleanliness is important. Clothing worn while working with pesticides should be changed after operations for the day have stopped, and should be laundered before being worn again. Clothing exposed to pesticides should be washed separately from other clothing. Workers should shower and change after handling all pesticides. Clothing should be changed immediately if any concentrated chemicals are spilled on them. Protective equipment should be comfortable so that workers won't be tempted to work without it.

If an Airplane Crashes

A ground crew should always be educated in the proper procedures in the event of a crash. Important things to remember are:

1. Do not panic. Stay calm and try to help the pilot as much as possible.
2. Get the fire extinguisher from your truck and go immediately to the plane.
3. If the plane is on fire, stay out of the smoke. Try to get the pilot out and move him to a safe distance.
4. If not too dangerous, try to put the fire out with your extinguisher.

5. Check the pilot and his clothing. If he has been splashed with pesticide, but is not seriously injured, help him to the nearest water and wash several times with soap, if possible.

6. If the pilot is not seriously injured, take the pilot to a hospital or doctor, or call a rescue squad, whichever is appropriate. Tell them what pesticide was being used.

7. If the plane is not on fire, and the pilot is not seriously injured, take him to the hospital or a doctor.

8. If the pilot is seriously injured or unconscious, DO NOT MOVE THE INDIVIDUAL from the plane. Check to see if he is strangling, choking, or bleeding. If an artery is cut in an arm or leg, use direct pressure at a pressure point. Use a tourniquet only as a last resort.

a. Phone for an ambulance and doctor, give your precise location, then phone your company to inform other personnel of the situation.

b. If you can't get an ambulance or rescue squad, phone your company.

c. Accompany the ambulance to the hospital or doctor's office to advise on the pesticide to which the pilot was exposed. Incorrect treatment could result in death.

Environmental Safety

All aerial applicators should be aware of potential environmental hazards resulting from the application of pesticides. Pesticide labels provide information on toxicity to fish, birds, and other forms of wildlife. Always follow these precautions against environmental damage.

All pesticide labels have a statement cautioning applicators to avoid contaminating water. While some pesticides are not particularly toxic to aquatic fauna and flora, always avoid contaminating water because it may be a source of drinking water. Give particular attention to mixing and loading sites because of the possibility of spills.

A high concentration of pesticide is more likely to cause environmental damage and human health problems than the much lower concentrations resulting from intended treatments. The most important environmental concern in a highly contaminated site is the possibility of groundwater contamination.

Many areas in Michigan have a high water table, which increases the likelihood of groundwater contamination, a possibility that must be guarded against most strenuously. Groundwater is the principal source of drinking water in many areas and the presence of pesticides, even in trace amounts, is cause for concern. Groundwater is also used for irrigation and water contaminated with herbicides could endanger irrigated crops.

Certain pesticides have been found in groundwater in some locations. The extent of groundwater contamination in the nation is not known, but monitoring efforts are underway to define the issue. Exercise the most vigorous precautions to prevent groundwater contamination.

In the event of any gross environmental contamination, contact the Pesticides and Plant Pest Management Division, Michigan Department of Agriculture at 517/373-1087, and/or the Pollution Emergency Alerting System, Michigan Department of Natural Resources at 800/292-4706

Pesticides and Bees

Some pesticides are especially toxic to bees. Bees are important not only as a source of honey, but also as pollinators of agricultural crops. Many crops cannot grow without bees as pollinators. Because of their importance, take extra care when using a pesticide that is highly toxic to bees. Keep in touch with local beekeepers and advise them of when and where applications will be made with specific pesticides.

Bees travel for long distances, so using pesticides toxic to bees may affect hives outside the immediate vicinity of the treatment area. With few exceptions, dusts are more hazardous to bees than sprays. Time of application is important and depends on blooming period and attractiveness of the crop. Treatment during the evening and early morning before bees are foraging is the safest time of day to prevent bee kills.

The Michigan Department of Agriculture maintains a current file on all registered apiaries and the addresses of the bee keepers. Obtain this list and use it in the notification program for sensitive areas to be sprayed!

APPENDIX

CALIBRATION FORMULAS/ EQUATIONS

1. $\text{Acres/Swath Run} = \dfrac{\text{Field Length (ft)} \times \text{Swath Width (ft)}}{43{,}560}$

   or

   $\text{Acres/Swath Run} = \text{MPH} \times \text{Swath Width} \times \text{Seconds Traveled} \times 3.37 \times 105$

   or

   $\text{Acres/Swath Run} = \dfrac{\text{MPH} \times \text{Swath Width (ft)} \times \text{Seconds Traveled} \times 1.466}{43{,}560}$

2. $\text{Acres/Minute} = \text{MPH} \times \text{Swath Width (ft)} \times 0.0020203$

3. $\text{Gallons/Acre} = \dfrac{\text{GPM} \times 495}{\text{MPH} \times \text{Swath Width (ft)}}$

4. $\text{Gallons/Minute} = \dfrac{\text{GPA} \times \text{MPH} \times \text{Swath Width (ft)}}{495}$

5. $\text{GPM/Nozzle} = \dfrac{\text{GPA} \times \text{MPH} \times \text{Swath Width (ft)}}{\text{\# of Nozzles} \times 495}$

6. $\text{Length of Swath Run} = \text{MPH} \times \text{Seconds Traveled} \times 1.466$

7. $\text{Minutes/Acre} = \dfrac{495}{\text{MPH} \times \text{Swath Width (ft)}}$

8. $\text{MPH} = \dfrac{\text{GPM} \times 495}{\text{GPA} \times \text{Swath Width (ft)}}$

   or

   $\text{MPH} = \dfrac{0.682 \times \text{Distance Traveled (ft)}}{\text{Seconds}}$

9. $\text{Swath Runs/Load} = \dfrac{\text{Acre Load In Hopper}}{\text{Acres/Swath Run}}$

   or

   $\text{Swath Runs/Load} = \dfrac{\text{\# of Gallons In Hopper}}{\text{GPA} \times \text{Acre/Swath Run}}$

10. $\text{Time (in minutes)/Load} = \dfrac{495 \times \text{\# of Gallons per Load}}{\text{GPA} \times \text{Swath Width (ft)} \times \text{MPH}}$

11. $\text{Time (in minutes)/Swath} = \dfrac{60 \times \text{Length of Run (ft)}}{\text{MPH} \times 5280}$

    or

    $\text{Time (in minutes)/Swath} = \dfrac{\text{Length of Run (ft)} \times 0.01136}{\text{MPH}}$

12. $\text{Time (in seconds)/Swath} = \dfrac{60 \times 60 \times \text{Length of Run (ft)}}{\text{MPH} \times 5280}$

    or

    $\text{Time (in seconds)/Swath} = \dfrac{\text{Length of Run (ft)} \times 0.68182}{\text{MPH}}$

PESTICIDE EMERGENCY INFORMATION

(Please post in an appropriate place)

For any type of emergency involving a pesticide, the following Emergency Information Centers should be contacted immediately for assistance. This Cooperative Extension Service Bulletin is the latest information available as of July 1986, and replaces all previous listings of similar information.

HUMAN PESTICIDE POISONING

Eastern Half of Michigan

within the Detroit City proper

***(313) 745-5711**

within the 313 area code

***(800) 462-6642**

statewide

***(800) 572-1655**

Poison Control Center
Children's Hospital of Michigan
3901 Beaubien
Detroit, MI 48201

Western Half of Michigan

within the Grand Rapids City proper

***(616) 774-7854**

within the 616 area code

***(800) 442-4571**

statewide

***(800) 632-2727**

Blodgett Regional Poison Center
Blodgett Memorial Medical Center
1840 Wealthy, S.E.
Grand Rapids, MI 46506

Upper Peninsula of Michigan

within the Marquette City proper

***(906) 225-3497**

Upper Peninsula only

***(800) 562-9781**

U.P. Poison Control Center
Marquette General Hospital
420 West Magnetic Street
Marquette, MI 48955

SPECIAL PESTICIDE EMERGENCIES

Animal Poisoning

Your Personal Veterinarian

(________)_________ - _____________

and/or

Animal Health Diagnostic Laboratory
Michigan State University

(517) 353-1683

Pesticide Fire

Local Fire Department

(________)_________ - _____________

and

Fire Marshal Division, Michigan State Police
(Local authorities will assist in contacting the State Fire Marshal)

Traffic Accident

Local Police Department or Sheriff's Department

(________)_________ - _____________

and

Motor Carrier Division, Michigan State Police

(________)_________ - _____________

Environmental Pollution

Pollution Emergency Alerting System (PEAS)
Michigan Department of Natural Resources

***(800) 292-4706**

Pesticide Use Incident

Pesticides & Plant Pest Management Division
Michigan Department of Agriculture

(517) 373-1087

*** Telephone Number Operated 24 Hours**