INTRODUCTION TO AERIAL APPLICATION

P.A. Boving, Agricultural Engineer
And
Robert G. Winterfield, Pilot
*Agricultural Engineering Research Division**
USDA – Yakima Agricultural Research Laboratory
Yakima, Washington

* Duplicated with permission from the authors

GENERAL

This chapter covers the desirable features of good aerial applicating equipment. The next chapter describes procedures for calibration and operation.

Agricultural chemicals require strict adherence to label instructions to do their job successfully. Haphazard applications are harmful to the crop, the farmer and the applicator.

Aerial applications are made with both fixed-wing and rotary-wing aircraft. With each machine, the greatest single factor in the success of application is the effective performance of the pilot.

Aerial dispersal equipment must be lightweight to provide for maximum payload strongly built and mounted to withstand the wear and the loads that they encounter. Operating controls must be simple. All components should be designed and installed to permit thorough cleaning between jobs, to avoid residual contamination from previous uses.

A clean aircraft is not only good advertising; it makes daily inspections quicker and easier. Well cared for equipment will inspire the customer's confidence in the operator.

UNIFORMITY OF DISTRIBUTION

Accurate applications and uniform distribution can only be obtained when equipment is equipment is calibrated. Spray from a single nozzle on the boom covers a wide swath, overlapping the output of several nozzles on either side of it. The wide swath pattern is made up of the output of all the nozzles, taking into account their overlapping. Many factors influence the spray pattern and rate of distribution. For this reason only generalizations will be made on the location of nozzles on the boom. Swath pattern tests should be used to check distribution patterns of individual aircraft. Changes made on the spraying system should be accompanied by a swath pattern check to be sure that spray distribution is adequate. Swath patterns can be checked by using techniques described in Chapter XI.

Granular materials are spread out laterally by the disseminator and by the air currents in the wake of the aircraft. Differences in the weight and shape of the particles (prilled fertilizers, granular pesticides or seeds) will affect the patterns. Calibration is necessary to make sure that the material and the disseminator together produce an adequate pattern. Swath patterns can be checked by methods described in Chapter XI. Dusts are difficult to calibrate, owing to their fineness.

AGRICULTURAL AIRCRAFT EQUIPMENT

With the marketing of agricultural aircraft and disseminating equipment, the conversion of general aircraft for agricultural use is disappearing. The following general points should be considered whether you operate a manufactured or converted aircraft. They apply to both fixed-wing aircraft.

1. Pilot's fresh air supply: Filtered air for the pilot is desired because it is impossible to avoid flying back through some of the swath of previous flight passes. If a filtered air-helmet is not available, he should wear an approved respirator.
2. Fuselage features: Enclosed fuselages should be fitted with out panels for the regular removal of corrosive sprays and dusts. Spray pumps, filters and control vales should be easy to get at for maintenance and repair.
3. Maintenance: The seasonal use of agricultural aircraft lends itself to inspections and repair during the idle periods, but the critical demands of agricultural flying call for all the regular maintenance checks to ensure that the aircraft is in first class order at all times.

GRANULAR DISPERSAL EQUIPMENT

Dusts, impregnated granulars, granular fertilizers, prilled fertilizers and seeds all fit into this category. For the finer materials (smaller than 60 mesh) some agitation may be needed in the hopper to prevent to prevent bridging. Since most commercial granulars contain fines, the seals between the components of the equipment (the tank, to the metering gate to the disseminator) require frequent inspection to make sure that no leaks occur. Seal strips that look mechanically tight on the ground will often leak under the influence of air pressures developed in flight.

The size, shape and weight of the particles, and the "flowability" of the material affect the swath width, the application rate and the pattern. Common effective swath widths are 35 to 40 feet when applied at 10 to 15 feet altitude. Some disseminators at low application rates achieve satisfactory swath widths of 50 feet.

Fixed-Wing Equipment

The usual disseminator for fixed wing aircraft is the ram-air or venturi type. The throat of the venturi is attached to the fuselage under the hopper outlet. If has a broad aft section to deliver up to 250 lbs. per acre. Overloading the disseminator tends to peak the application pattern at the center and to reduce the swath width. Overloading should be avoided because it can lead to uneven flow making the pattern erratic.

Rotary Wing Equipment

Two systems are being used. One system uses saddle tanks mounted next to the engine, each tank having its own disseminator system. The metering devices to be linked to prevent one tank being emptied faster than the other. The second system uses a single hopper and disseminator, hanging on a cable below the rotary-wing aircraft. A single tank and disseminator avoids the problem of balancing the output of two metering devices. Also, being on a cable, the equipment is more remote from the aircraft where corrosive granules create problems. The disseminators are either spinning plate "slingers" or some form of blower and ducting. The lower forward speed of the rotary aircraft prevents the use if the ram-air principle.

SPRAY DISPERSAL EQUIPMENT

Spray dispersal equipment consists of the following items: tank(s), pump, pressure regulator, line filter, flow control valve, boom and nozzles. On fixed wing aircraft the tank is built into the fuselage. The pump, pressure regulator, line filter and control valve are mounted under and outside the fuselage. The boom and nozzles are usually attached to the trailing edge of the wing.

On rotary-wing aircraft, the tanks are mounted on the sides of the frame to keep the load in line with the main rotor shaft. The tanks are coupled at their bases with a crossover pipe that feeds the pump. The pump is driven by the engine. The filter, regulator and valve are attached to the lower frame of the fuselage. The spray boom and nozzles are mounted to the toe of the landing skids, or to the frame under the main rotor. The toe mounting puts the boom and nozzles where the pilot can see them. Mounting the boom under the main rotor gives a slightly wider swath.

Spray equipment provides effective swath widths of 40 to 60 feet in the range of one to 10 gallons per acre, when flown at heights of 5 to 8 feet above the ground or crop. Special applications such as ULV can give much wider swaths, but they are flown at 15 to 25 feet altitude.

TANKS

Top loading tank openings should be wide enough to permit pouring materials into them. All tanks should be fitted with emergency dump valves and the valve action should be checked each time the equipment is flushed. They should be fitted with vents to permit free flow of the materials at emergency dump rates. Bottom-loading systems should have capacity enough to match the loading pump. Spray tanks need agitation that reaches the bottom to maintain suspensions and mixtures of materials. If hydraulic agitation (pumping the material back into the tank) is used, a rule-of-thumb flow rate is a 10 gpm agitation flow for every 100 gallons capacity of the tank. The pump outlet and the emergency dump should connect to the bottom of the tank to permit complete emptying.

PUMPS

All water-based sprays can be handled with centrifugal pumps. Centrifugal pumps are mechanically simple, lightweight, flexible in their output and have a maximum pressure determined by design. Normal power sources for these pumps are:

- Wind-driven fan, using the forward motion of the aircraft.
- Direct coupling to the aircraft engine, with or without a clutch.
- Hydraulic or electric drive from the aircraft engine to a hydraulic or electric motor coupled to the pump.

The size of the centrifugal pumps is selected to provide adequate flow (gpm) to handle the maximum nozzle capacity (and agitation, if included) and the maximum pressure (psi) to give the needed boom pressure and to take care of the pressure loss (about 5 psi) in the pipes, vales and filter. Specialized applications (ULV, bi-fluid, microbial sprays, etc.) call for special pumps.

CONTROLS

Controls should include a shut-off valve and a pressure regulator between the pump and the boom. The valve should be a quick-acting gate or ball valve. The pressure regulator should be a bypass type that returns the relief liquid to the tank(s). If the pump is powered by a wind-driven fan, a brake should be installed to stop the spray pump when not in use.

FILTERS

Filter screens at the nozzles prevent the spray tips plugging with sediment that normally collects in a spray system. It is wise to have a line filter installed behind the pump so that sediment is not forced into the parts of the valve and the regulator, creating unnecessary wear. Screen size should be 50 or 100 mesh, depending on the size of the nozzle tips. A pressure gauge, couple to the line beyond the filter will indicate (by low pressure) when the line filter is starting to get clogged. Clean the line filter daily during spray operations.

PLUMBING

To prevent excessive pressure losses:

- For application rates over 2 gallons per acre, all main piping and fittings should be at least 1½ inches inside diameter.
- For application rates of ½ to 2 gallons per acre, all main piping and fittings should be at least 1 inch inside diameter.
- For ULV applications, hoses to individual nozzles should be 1/8 inch ID. Main line hoses and fittings should be at least 3/8 inch ID.

Tees should be the size of the incoming pipe and fitted with reducers to couple the branch pipes. All joints should be made with the minimum of pockets that can trap materials. The number of bends should be kept to a minimum and all bends made with as large a radius as possible.

All spray plumbing connections using hoses should be double clamped or clamped and safety wired to secure the connections.

BOOMS

Booms need strong support. Placing the boom at the trailing edge of the wing reduces the drag resistance of the boom. They should be far enough back to avoid airstream interference with the control surfaces. Booms should be fitted with caps having openings the full size of the pipe to permit flushing and cleaning with a "bottle" brush when needed. Twin-boom or return line systems are used to eliminate air pockets at the boom tips and also to provide agitation in the boom for chemicals that settle out rapidly. Nozzle orientation to the direction of flight is important for droplet size control. If the boom cannot be rotated, use 45° elbows or swivel connectors to provide for nozzle adjustment.

NOZZLES

Nozzle Location

The location of the outboard nozzle on each end of the boom is critical. Since wingtip vortexes or main rotor vortexes are used to develop the width of the pattern, the end nozzles must be inboard enough to prevent the vortex trapping the fine droplets. This entrapment creates peaking in the pattern and drift. On fixed-wing aircraft, the propeller disturbance shifts the spray from the right to the left (as the pilot sees it). Nozzles need shifting to the right within the area of this disturbance to compensate for the uneven pattern. The choice of nozzles and the amount of shift cannot be determined without testing.

Nozzle Selection

A great deal of information is available from nozzle manufacturers for use by operators. Only general guides will be given here. Nozzles perform satisfactorily if they are operated at the manufacturer's recommendation of pressure and flow is not restricted. Departures from these values must be made with care since output and droplet size both vary with pressure. Nozzle types and operating pressures should be selected that can handle the material being applied and break it up into droplets of desired size.

Water solutions of pesticides should be pumped with nozzle pressures of 35 to 45 psi to get manufacturer's recommended breakup. Suspensions, heavy emulsions and slurries should be handled with nozzles having large openings to prevent clogging. Bi-fluid systems use special mixing chambers and tips. Foaming nozzles are marketed that have special passages for air incorporation with the spray to create foams.

Positive shut-off is achieved by the use of:

- Diaphragm check valves
- Ball check valves
- "Suck back" connection on pump, working on boom or return line.

These items will need regular attention if they are to perform properly. Aged or worn diaphragms or scarred ball seats need replacement. Any springs used to maintain pressure will require checking to see that they move freely. Seating faces should be smooth and free from cracks. Return lines need flushing to be sure that they are not clogged.

As a guide, the following suggestions are given to select the nozzle type for a treatment:

1. The atomizing or hollow cone type spray gives the finest breakup.
2. The flat spray nozzles have intermediate breakup.
3. The solid cone nozzles have the coarsest breakup.
4. Spinning nozzles tend to have a narrower range of droplet sizes than the hydraulic nozzles (1,2, and 3 above).

Calibration and Nozzle Testing

Brass nozzle tips and whirl plates wear. The nozzle tips should be checked at least once a year to insure uniformity of output. Any tip discharging 10% in excess of the manufacturer's ratings should be replaced with fresh stock and the old tips thrown away. If a lot of suspension sprays are being applied, use hardened steel or carbide tips in place of the brass tips.

ULTRA LOW VOLUME SYSTEMS

ULV spraying is a recent development in aircraft spray work, using concentrate materials (no water added) in a spray made up of fine droplets some pesticides exhibit better action in their concentrated form. Less evaporation takes place since water is absent from the spray. The density of the droplets is slightly greater than the same sized droplets of water-based sprays increasing the rate of fall. Application rates are reduced so more acres can be treated before reloading is needed. At present, however, the only material licensed for this use is Malathion.

Plans are available for the modification of aircraft dilute spray systems to handle ULV. If the aircraft is used for different spray jobs during the season, the operator can install a small ULV system, entirely separate from the dilute system. This system can be removed when the ULV applications are done, making cleanup much easier.

One system already marketed consists of a 5-gallon stainless steel pressure tank to hold the chemical. Pressure is obtained from a liquid carbon dioxide fire extinguisher hooked up to the tank with an air pressure regulator. An electric valve controls the flow from the tank, using a ½ inch or ¾ inch solenoid valve with a 12-volt DC coil. A half-inch hose leads from the valve to a tee that center-feeds the ULV boom. This boom is made up of nozzles and tees feeding the nozzles. The ULV nozzles and booms are clamped to the regular boom for support. The solenoid valve can be wired to the aircraft electrical system or a dry cell battery in the cockpit and to a push-button switch taped to the control stick. The 5-gallonn tank and fire extinguisher can be set in the regular spray tank, where it should stand in an upright position.

The following points should be observed: ULV spraying must create fine droplets to be effective. Flat fan nozzles discharging 0.1 gpm or less are recommended operating at 40 to 55 psi. Spinning nozzles can also be used. Do not use less than four flat fan nozzles to avoid gaps in the distribution pattern. On a helicopter, a single spinning nozzle may provide sufficient output if very low rates are needed (e.g. mosquito control). Since this system produces fine droplets, the extreme outboard nozzles must be located away from the wingtips on fixed-wing aircraft. This avoids spray entrainment in the wingtip vortices. Use 2/3 wingspan as a guide for the limit. Shift the central nozzles to the right to compensate for propeller wash. ULV applications should be made a little higher than usual, 20 to 25 feet above the ground, to provide for a wider swath and greater uniformity.

When full strength chemicals are used, the solvent carrier for the chemical gas has to be considered. The carrier for Malathion will attack rubber and neoprene. The seals in the solenoid valve should be of Teflon or Viton. Hoses may have to be replaced at the end of the season if they are not resistant to the solvent. Diaphragms in the nozzle bodies should be checked frequently and replaced each season. Nozzle screens are important since plugging is easier with the smaller tips. Use 100-mesh screens.

In calculating conversions from gallons per acre to ounces per acre (liquid), use the factor: 1 gallon – 128 ounces.

11/1/71
11/7/72