AERIAL APPLICATION PROCEDURES

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TESTING

Remarks on Spray and Granular Tests

Fixed-wing aircraft and helicopters exhibit similar flight characteristics (wingtip vortex and main rotor vortex). Since the airflow patterns around and in the wake of each aircraft are sufficiently different, each type and series of aircraft needs testing. Changing the horsepower of the engine, the type of propeller or wingtip shape will change the distribution pattern. Generalizations can be used to guide the operator on nozzle placement or granular disseminator adjustment. Pattern testing is needed to check the effect of each feature added to the aircraft.

Pattern tests should be made in calm air to avoid crosswind distortion. If wind is unavoidable, the tests should be made in a direction parallel to the wind. Testing should be carried out in winds less than 3 mph at all times. The best time for this is in the early morning before the sun heats up the ground, creating eddies and inversions. The tests must duplicate the use for which the application is required in terms of airspeed, the height of flight, nozzle pressure or gate setting for granulars, nozzle angle and placement or disseminator adjustment, etc. It is best to test with the same materials to be applied if at all possible.

Substitute materials do not always act in quite the same manner as the chemicals. This is evident with granulars, where minor changes in the surface characteristics of the granules (shape, surface finish, fineness or grind, etc.) alter the discharge rate.

SPRAY TESTING

The nozzle type and pressure should be selected for the material being used and the atomization required for the job. The application rate (gallons per acre) will be set by the chemical being applied and the crop being treated as listed in WSU's Handbooks or the manufacturer's label. Since each aircraft exhibits a normal and effective swath width, this value should be used with the following tables to determine the acres per minute being treated.

TABLE 1

Computation of Acreage and Materials

Formula:

$$\text{Acres covered} = \frac{\text{swath length (miles)} \times \text{swath width (ft.)}}{8.25}$$

The number of acres in a swath of a given width and length can be determined from the chart below.

Example: An aircraft with a 40-foot effective swath treats a strip 1 mile long. To find the number of acres follow the 40-foot vertical column until it intersects the 1-mile line. The answer to the nearest tenth is 4.8 acres. For swath widths other than those shown, interpolate or use combinations of the figures shown. To determine the amount of chemical required, multiply the acres by the desired rate of application.

ACREAGE CHART

Swath Length (miles)	**30'**	**35'**	**40'**	**45'**	**50'**	**75'**	**100'**	**200'**
¼	.9	1.1	1.2	1.4	1.5	2.3	3.0	6.1
½	1.8	2.1	2.4	2.7	3.0	4.5	6.1	12.1
¾	2.7	3.2	3.6	4.1	4.6	6.8	9.1	18.2
1	3.6	4.2	4.8	5.5	6.1	9.1	12.1	24.2
2	7.2	8.4	9.8	10.9	12.1	12.1	24.2	48.5
3	10.8	12.6	14.5	16.4	18.2	24.2	36.4	72.7
4	14.4	16.8	19.4	21.8	24.2	36.4	48.5	97.0
5	18.0	21.0	24.2	27.3	30.3	48.5	60.6	121.1

TABLE II

Aircraft Calibration

Formula:

Acres per = 2 **x** swath width **x** miles per hour
Minute: 1.000

The chart below shows the rate, in acres per minute, at which spray or dry material can be applied when swath width and the speed of the aircraft are known. For swath widths or aircraft speeds other than those shown, interpolate or use combinations of the figures shown. To find the rate of flow in gallons per minute or pounds per minute, multiply the acres per minute figure by the number of gallons or pounds per acre to be applied.

Example: A 100 mph aircraft has a 40-foot effective swath. Follow the vertical 40-foot column down until the figure opposite 100 miles per hour is intersected. The aircraft would cover 8.0 acres per minute. If 1 gallon of spray is to be applied per acre, the aircraft should be calibrated to disperse material at the rate of 1 x 8.0 or 8.0 gallons per minute. (If 10 pounds of dry material is to be applied per acre, the aircraft should be calibrated to disperse material at 10 x 8.0 or 80 pounds per minute.)

ACRES-PER-MINUTE CHART

Speed (mph)	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

To determine gallons (or pounds) per acre discharged from the aircraft, divide the gallons (or pounds per minute) discharged by the acres per minute that the aircraft covers in a swath.

Knowing the gallons per minute required, the number of nozzles can be calculated based on the manufacturer's data for that type and pressure. The pressure and airspeed are now fixed for the tests and the application.

Discharge Calibration

Having installed the desired type, size and number of nozzles, the output of the system should be checked to see that the correct discharge in gallons per minute is taking place. If the pump can be run at operating speed with the aircraft stationary, nozzle discharge can be checked with a measuring container and a stopwatch. Boom pressure must remain constant. If this stationary test cannot be done, the aircraft should be parked and the tank(s) filled with water to a suitable mark. The aircraft is flown and the spray system in run for a time period (30, 60, 90, or 120 seconds). The aircraft is brought back to the same point used previously and the water used is determined by reading the tank(s) scales or refilling to the first mark using measuring devices.

Swath Pattern Tests

With the application rate now established, the swath pattern should be checked to see that the distribution across the swath is as uniform as possible. The methods mentioned in the previous chapter as follows:

The best method of spray pattern testing consists of adding a tracer (dye, fluorescent material, etc.) to water in the tank(s) of the aircraft. The aircraft is then flown at the chosen airspeed and height and the spraying system is operated at the chosen pressure. One pass is made over a row of target plates or cards laid out at right angles to the direction of flight. The aircraft flies over the center of the target line 100 to 150 feet wide. The targets are collected and the spray deposit on each target is measured by the quantity of tracer. From the results, the distribution curve of the pattern can be determined. Corrections to the nozzle location can be made and the results checked by further testing.

A less satisfactory method is to lay out a roll of paper tape (adding machine tape) and visually inspect the resultant pattern. Interpretation of the spray pattern using this method is at best, only a rough estimate of the uniformity of the deposit pattern.

GRANULAR MATERIALS TESTING

Disseminators are sensitive to adjust and the differences between granular materials have a profound effect on the rate of delivery and the pattern. Some disseminators are restricted as to quantity or type of materials being handled. These limitations should be checked before testing.

Discharge Calibration

Several runs should be made with the disseminating equipment installed to determine the quantity of material metered out for a given rate setting. If the disseminating equipment can be run with the aircraft on the ground, the material can be caught in large linen or paper bags and weighed. Ram-air disseminators require actual flight tests to get true discharge rates since the air currents and engine vibration in flight affect the metering gate discharge rate. After running the disseminator for a given time (30, 60, 90, 120 seconds) collected material is weighed. If flight tests are used, the quantity needed to refill the hopper is weighed. Where flight is needed to calibrate the system, use blank granulars (the granular carrier without the pesticide of the same type used to carry the chemical). Test for three gate settings to determine the gate setting that will give the required discharge in pounds per minute of granular material. Use the figures in Tables I and II to convert pounds per minute discharge to pounds per acre applied.

Swath Pattern Tests

These tests are similar to the spray pattern tests except that the targets are replaced with containers (large buckets or 5-gallon grease pails). Use containers that have the same area of opening. The quantity caught in each container is measured with a sensitive balance or the volume determined in a narrow graduated tube. From these readings and the spacing of the containers the swath pattern can be drawn. Adjustments to rate and pattern are made and the tests are repeated to check the adjustments.

OPERATIONS

General

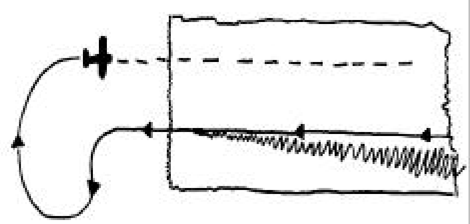
When an aircraft has been calibrated, the airspeed, spraying pressure or gate setting for granulars, height of flight and the effective swath width are fixed. Applications must be made at the same settings.

Ferrying height between the airstrip and the field should be done at a minimum of 500 feet height, loaded or empty. Avoid flying over farm buildings, feedlots or residential areas both for noise and possible leakage. Courtesy to you neighbor costs so little and pays real dividends.

Field Flight Patterns

With rectangular fields, the normal procedure is to fly back and forth across the field in parallel lines. Flight directions should be parallel to the long axis of the field (reducing the number of turns). Where crosswinds occur, treatment should start on the downwind side of the field to save the pilot flying through the previous swath (See Fig.1).

FIG. 1
FIGURE 1.



Where this fits in with crop rows or orchard rows the pilot can line up the aircraft with a crop row.

If the area is too rugges or steep for these patterns, flight lines should follow along the contours of the slopes. Where spot areas are too steep for contour work (mountainous terrain) make all treatments downslope.

Swath Marking

Swaths can be marked with flags set above the height of the crop to guide the pilot. This method is useful if the field is going to be treated several times in a season.

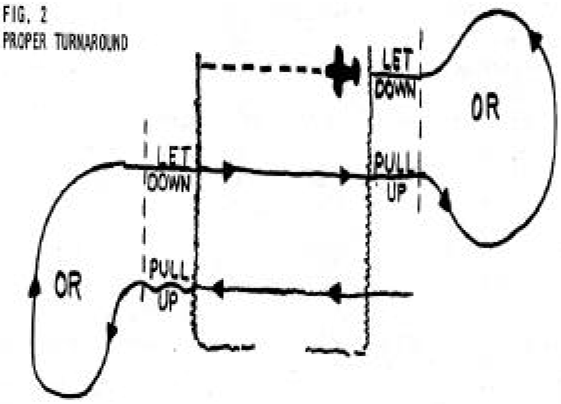
Two flagmen can be used to aid the pilot to line up across the field. When the pilot has lined up on his swath, the nearer flagmen starts pacing off (or counting crop rows) to the next swath. Flagmen should avoid being directly sprayed on and they should NEVER turn their backs on an oncoming aircraft. Federal orders forbid using youths under 16 years of age as flagmen. Where the aircraft is flown parallel to a crop row, one flagman can be used to identify the swath row to the pilot.

Automatic flagmen (a swath marking device) are in common use now. These devices, attached to the aircraft and controlled by the pilot, release weighted streamers. These streamers give the pilot a visible mark to help him judge the next swath.

Turnaround

At the end of each swath the pilot should stop the disseminator and pull out of the field before beginning his turn. The turn should be completed before dropping into the field again. He should fly far enough beyond the field going out to turn to permit slight course corrections before dropping into the field again for the next swath. (See Fig.2 and Fig.3)

FIG. 2
PROPER TURNAROUND



Obstructions

Where obstructions occur, (trees, power and telephone lines or buildings) at the beginning or end of the swath, it is preferable to turn the equipment on late or shut off early. Then when the field is completed, fly one or two swaths crossways (parallel to the obstruction) to finish out the field. Do not run the disseminator when dropping in or pulling out of the field – the pattern will be distorted. Obstructions inside the field should be treated in the same way. Skip the treatment as you avoid the obstruction, then at the finish, come back and spot treat the skipped part flying at right angles to the rest of the job.

Areas adjacent to buildings, residences and livestock should be treated with extra care. Try to fly parallel to the property line, leaving a border of untreated crop, to avoid possible drift onto unwanted houses. Adjust pullout and drop in paths and avoid making turns over houses. Use caution when fields include or are adjacent to waterways, canals, or reservoirs. Treat fields with care if they have beehives near the field to be treated and you are applying chemicals that are harmful to the bees.

Suggested Hand Signals for Flagmen

The following figure shows a series of suggested hand signals for flagmen to guide the pilot. Each operator has his own system of signals. The figure is printed as a separate page so that copies can be made. The pilot and the flagman should agree on what signals to use before the work begins. Many operators use portable radios to overcome the problem of communication. Using their assigned frequency, the base, the aircraft and the nurse trucks as well as the flagmen or spotters can communicate with each other easily.

SUGGESTED HAND SIGNALS

1. FLY SWATHS FARTHER APART – arms extended down, thumbs pointed out, arms in an outward movement. This signal is used to show the pilot he is getting an overlap on the spray swaths.

2. FLY SWATHS CLOSER TOGETHER – arms extended out from shoulders, thumbs pointed in, arms in an inward movement toward hips. This signal is to show the pilot to fly his swaths closer together, that there is an area between swaths that is not receiving coverage by the spray.

3. DENOTING BOUNDARY OF FIELD - Signal may be given either in the position demonstrated showing the corner boundary with arms extended straight out from the shoulders, one forward and one sideward, or with both arms extended sideward denoting the end of the field to be sprayed.

4. DIRECTION OF SPRAY PATHS – arms above head, then moved to forward extended position This signal is used to direct the pilot to the best heading on which to fly his spray patterns as determined by the ground man after taking into consideration such factors as wind direction, length of spray run and obstructions in the line of flight.

5. REPEAT SPRAY – One arm extended above head then moved to forward extended position. This signal is used to direct the pilot to repeat spray over the swath just completed or in some cases over the entire field or area just completed, in case of heavy infestation where positive kill is to be assured.

6. BRING SPRAY CLOSER TO GROUND – Arms extended at waist level, palms down, short up and down movement of arms from the elbow. This signal directs the pilot to fly the airplane lower to the ground in the event that the temperature or winds have risen; and by lowering the spray, drift of the spray is decreased.

7. DANGER! OBSTRUCTION IN LINE OF FLIGHT – One arm pointed to danger point, other arm in short circular movement from the elbow – otherwise self-explanatory

8. DANGER! DON'T SPRAY – Cut across throat, palm down.

* See illustrations on next page. Numbers correspond to descriptions above.

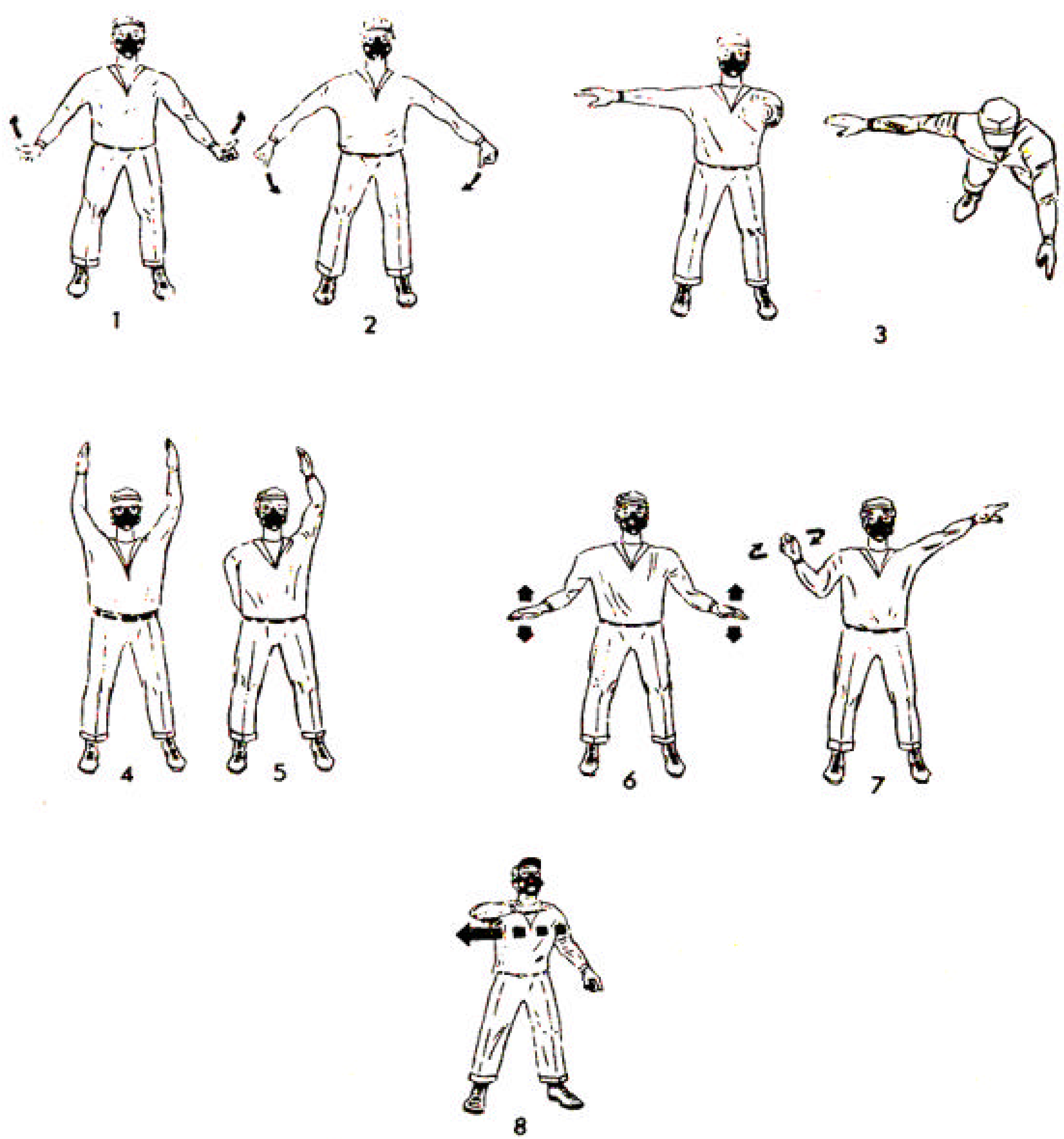
DROPLET SIZE

Controlling droplet size is the key to success in applying liquid chemicals from aircraft. Droplet size is affected by the following factors:

- Shape of the nozzle cone, flat fan whirljet, flood, etc.
- Size of the tip.
- Spraying pressure (20, 40 or 80 psi).
- Liquid or mixture of liquids being used (water, emulsion, chemical wetting agent, etc.).
- Angle of the nozzle with respect to direction of flight (down, forward, back).
- Airspeed of the aircraft.
- Density, viscosity, and surface tension of the liquid.

- Evaporative conditions in the air, between the point of release from aircraft and the point of impingement on ground.

All commercial spraying nozzles tend to produce a range of droplet sizes. The hydraulic nozzles (flat fan, hollow cone, solid cone, floodjet, etc.) produce a broad range of sizes. The choice of these nozzles shifts the range as a whole as well as the width of the range of these sizes. The spinning nozzles, using rotating discs, screens or brushes, produce a narrower range than the hydraulic nozzles. Overloading the spinning element will produce larger droplets and wider range of droplets.



Pesticide work normally requires fine droplets to be effective, depending on the mode of operation of the chemical. This provides a large number of droplets. Herbicides (and systemic insecticides) require coarse droplets so that the plant will absorb the chemical Fertilizer slurries can use very coarse droplets where they are normal NPK mixtures to be absorbed by the roots. Foliar fertilizers, however, should be applied like herbicides.

The control of drift is making the use of spray thickeners popular, reducing the number of fine droplets that create problems. These agents are often used with herbicides where sensitive crops are growing in the adjacent fields. Some sprays and spray mixtures demand fine droplets because they are phytotoxic to the crop when they are applied to the crop in coarse droplets (e.g. cover sprays in orchards).

To increase droplet size:

- Lower spray pressure (not below 20 psi) and add nozzles to keep application rates up OR
- Rotate the spray boom so that the nozzles discharge down and back with respect to the direction of flight OR
- Change to larger tips of the same type, adjusting to the number of nozzles being used OR
- Use thickening agents in the spray OR
- Stop spraying until cooler or calmer weather exists.

To reduce droplet sizes:

- Increase spray pressure (not above 60 psi) OR
- Rotate spray boom so that nozzles discharge down and forward with respect to the direction of flight OR
- Change to smaller tips of the same type, adjusting the number of nozzles being used to keep the gallonage constant OR
- Use thinning agents (wetting agents) in the spray.

It should be realized that all these changes affect the pattern and the rate of application with the exception of spray boom rotation. Rotation affects only the droplet size with little or no effect on the pattern. The other changes will interact to affect the application unless you compensate for them.