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AERIAL APPLICATION

of Agricultural Chemicals

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AGRICULTURE HANDBOOK NO. 287

U.S. DEPARTMENT OF AGRICULTURE

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**This handbook contains some information formerly in Farmers' Bulletin
2062, "How To Spray The Aircraft Way."**

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Prepared by

Agricultural Research Service

AERIAL APPLICATION of Agricultural Chemicals

This handbook has two uses—a textbook in training agricultural aircraft pilots and a reference guide for aerial application operators.

Regulations and even methods in this relatively new industry vary widely in the different States, but the basic requirements for safe and effective work apply equally in all areas. Aerial applicators will better serve the interests of agriculture if they are well informed. Cer-

tainly, operators who know how to handle agricultural chemicals safely and usefully will be less likely to have trouble.

Broad recommendations that apply generally often need to be modified to meet local situations. Therefore, for the solution of your special problem, draw freely on the advice of your county agricultural agent and State experiment station.

EQUIPMENT

Aircraft

When you are planning to buy a new aircraft for aerial application, select the type best suited to perform the major part of the anticipated work. Do not consider only the price; do not buy another type originally designed for other purposes merely because it is readily available at nominal cost.

Incorporated into aircraft designed specifically for aerial application are many features to enhance the safety of the pilot, increase the versatility of the aircraft, and improve the efficiency of operations. Features you should look for are:

- Design that emphasizes pilot comfort to reduce fatigue.
- Special ventilation to avoid pilot exposure to agricultural chemicals.
- Good visibility in all directions.

- High performance with gross loads.
- Ease of control during slow flight.
- Partial aileron control during stalls.
- Load placed forward of the pilot.
- Special fuselage design that allows progressive collapse in an accident and includes a 40-G cockpit that will fall outward.
- Sturdy structure for protection in a turnover.
- Shoulder harness that hooks to an inertia reel to allow free movement.
- Landing gear equipped with wire cutters.
- Cable to deflect wires over the tail.
- Large removable panels to allow easy cleaning, inspection, maintenance, and repair.

- Corrosion-resistant hoppers and other components.
- Treated structures to resist chemical corrosion.
- Quick-change dispersal apparatus to apply either dry materials or liquids.
- Adjustable dispersal apparatus that can produce a wide range of droplet sizes, deposit patterns, and application rates.

Application Equipment

SPRAYS

Tanks

Size and location.—Use a tank that is large enough to hold a full load and have enough space remaining to allow for foaming. Locate it as close as possible to the center of gravity and anchor it securely to the main structure of the fuselage. Install baffles to reduce sloshing and to add strength to the tank.

Shape.—The shape of the tank should be such that it will drain completely in flight and on the ground. Materials that cannot be drained in flight remain as ballast that reduces aircraft performance unnecessarily.

Install a valve in the low point of the tank to help in calibration and to allow purging it when you change to another agricultural chemical. A tank that can be drained completely when the aircraft is parked greatly simplifies calibration of the spray system, especially when you use low-volume application rates.

Material.—The tank should be built of or lined with a material resistant to agricultural chemicals.

Materials that rust or corrode may cause leakage problems or plug screens or nozzles.

Filler.—Bottom-filling attachments are preferable. A large opening in the top of the tank also is desirable because it provides a convenient entry for cleaning the tank interior. It should be large enough to allow filling from a 5-gallon can or bucket without a funnel.

Include a large fine-mesh screen in the filler to catch sediment. The screen is especially desirable if water from ponds, reservoirs, or ditches is used for mixing. Set the screen down into the tank to prevent splashing or flooding.

Agitator.—When you spray wettable powders that require agitation, recirculation during ferry to the worksite and during turn-arounds usually will suffice. Design the recirculation system so that the return flow will wash the bottom of the tank.

Air vent.—A large air vent is required to assure uniform flow during spraying and to prevent tank collapse or reduced flow when jettisoning a load. A large spring-loaded flapper valve is satisfactory, but a preferred vent is a tube in the top of the tank, projecting upward a few inches, then curving downward and out through the bottom of the fuselage. This type of vent confines accidental overflow during loading, so chemicals fall free of the aircraft without contaminating the cockpit or loading crew. It also keeps the chemicals away from the pilot during application maneuvers.

Gage.—It is desirable to have a spray tank quantity gage in the aircraft. It should be accurate in flight and when the aircraft is parked. Some chemicals applied by aircraft cannot be metered; nor is it always possible to accurately measure the quantity loaded into the aircraft each time from large mixing facilities. You can use the gage in the aircraft for this measuring.

The pilot can use a gage that is accurate in flight to check on the calibration. For example, as the spraying progresses, he can check the quantity applied on one or more swaths, to each field, or several fields. If the quantity used is too little or too great, he can make an immediate adjustment before continuing with the application.

Pumps

A pump in the spray system is necessary to insure uniform and proper flow rates at all times, to assist in producing the desired atomization, and to keep wettable powders in suspension.

A centrifugal pump is preferred by most operators 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, and can be operated without a relief valve. 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.

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. This increases the amount of flying needed to complete a job and reduces efficiency. A centrifugal pump with a pumping capacity considerably greater than required often has trouble because the impeller cavitates. When this occurs, air gets into the system and calibration becomes erratic. You should install an air bleed line in the high point of the impeller section to insure full and positive flow at all times. This line should return to the top of the spray tank.

A rotary-gear pump is positive displacing, self-priming, and capable of producing pressures up to 200 pounds per square inch. 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. Do not use a rotary-gear pump for applying wettable-powder suspensions, because such suspensions usually wear the teeth and sidewalls and may cause the pump to seize.

Pump Power Sources

Power sources used to drive spray pumps include windmills, hydraulic motors, electric motors, belt or gear drive off the aircraft engine accessory section, and, on large aircraft, gasoline engines.

Windmills are by far the most common power source, and many kinds are available. They may be made of wood, metal, or plastic. The number of blades ranges from two to six. Some have adjustable blades to allow variation in pump

Fly Safe Campaign



MAINTAIN ACCIDENT AWARENESS

Don't become a statistic!

NTSB has reported 5 ag accidents including 1 fatal accident so far this year.

A FIRE-RESISTANT FLIGHT SUIT CAN SAVE YOUR LIFE – START WEARING ONE TODAY

As professional agricultural aviators, you should use any and all available safety equipment to protect yourself and have the greatest chance of surviving an accident. While the majority of agricultural aviators now wear helmets and securely fasten their aircraft's seat belt and harness, one piece of safety equipment that is not as commonplace is a fire-resistant flight suit. Nomex®, the material that flight suits are made of, can provide protection against a fire, which could mean the difference between surviving an accident or succumbing to injuries.

From 2010 to 2019, 11% of agricultural aviation accidents involved a fire. Of those accidents where a fire occurred, 41% resulted in a fatality. The one fatal accident in 2020 so far involved a post impact fire that consumed a majority of the fuselage. There is no guarantee that a fire-resistant flight suit would have prevented those deaths. But if having a flight suit gives you an increased chance of surviving an accident, why not wear one?

Nomex® is fire resistant, which means that it will burn when a flame is held to it, but as soon as that flame is removed, Nomex® will stop burning. It is also a poor conductor of heat and will not melt or drip. A [video](#) demonstrating the difference between Nomex® IIIA, cotton, and polycotton blend reveal just how well it works to protect the wearer from flames. PAASS urges you to purchase and wear a fire-resistant flight suit to increase your chances of surviving an accident.

Check Temporary Flight Restrictions (TFRs)

Always check TFR NOTAMs before flying! Make sure you have proof of a preflight TFR briefing from sources such as FSS or <https://www.1800wxbrief.com>.

Make a “Fly Safe” Resolution Now!

Watch your fax or e-mail every other Monday in April, May, June and August and every Monday in July for scheduled issues. Supplemental messages may be sent when increased flight activity warrants additional safety awareness. To be removed from the “Fly Safe” fax list, please call 202-546-5722 or e-mail information@agaviation.org. Let us know if you wish to be removed only from these Fly Safe messages or all faxes or e-mails from the NAAA.

Fly Safe Campaign



MAINTAIN ACCIDENT AWARENESS

Don't become a statistic!

NTSB has reported 31 ag accidents including 7 fatal accidents so far this year. There has been 1 fatal accident not yet reported by NTSB.

BEWARE OF MIXTURES IN YOUR HOPPER – UNKNOWN COMBINATIONS CAN BE DEADLY

A recent fatal accident highlights the dangers that certain product combinations can create. An ag pilot had a problem with solution foaming out of the hopper and covering his windshield. He had returned once to the airport to add more defoamer in an attempt to correct the issue. Unfortunately, he was unsuccessful and subsequently crashed after taking off again. The [preliminary NTSB report](#) provides more details including the contents of the spray mixture. The pilot survived the accident only to later succumb to his injuries, which may have been linked to the contents of the spray mixture.

Many crop consultants like to recommend complex tank mixtures of various pesticides, fertilizers, and adjuvants. You may have sprayed some of the individual products before, but not the exact combination being requested. If you're unsure of how the mixture will react, do a jar test to verify compatibility. Foaming, toxic fumes, exothermic reactions, physical and other chemical incompatibilities may result. Tank cleaning agents that have not been thoroughly rinsed from the hopper may also contribute to dangerous chemical reactions.

Labels should provide warnings for any known issues when using the product. Manufacturers, however, may not be aware of every combination in which their product might be used. Read the labels, and if you have any questions, reach out to your local company representatives to get those questions answered before you fly. A pilot overloaded an aircraft last week but was stopped by his operator before takeoff because of concerns about excessive foaming. Don't let spray mixtures lead to an accident.

Check Temporary Flight Restrictions (TFRs)

Always check TFR NOTAMs before flying! Make sure you have proof of a preflight TFR briefing from sources such as FSS or <https://www.1800wxbrief.com>.

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NAAA eNewsletter

Fatal Accident's Suspected Cause Serves as a Wake-up Call about Unknown Tank Mixtures

By Sam Rogge, owner/operator, Jet Stream Aviation, Fowler, Colorado

In just about every aspect, 2020 has been a rough year and our application industry has been no exception with eight fatal accidents so far. We hope and pray there won't be any more. One of these accidents occurred July 10 in Springfield, Colorado, and as always, the word quickly spread.

There is always speculation about what happened, but the circumstances we were hearing about this accident were quite perplexing. Everyone was telling us that foam from the hopper coated the windshield of the aircraft because of a nitrogen product mixed with a glyphosate product, thereby causing the accident.

To us, this didn't seem to be quite right, so we set up our own "jar test" experiment. The results were unexpected and very surprising. We took a guess at the mix ratio and combined 2 ounces of glyphosate with 8 ounces of a low-salt nitrogen fertilizer. The initial response was a thin white layer that formed over the top of the solution. No big deal there, but after thinking about the conditions in the airplane's tank, we decided to agitate the mix. The result now was a little more spectacular, with foam forming immediately and filling our container to about the 30-ounce level within a few seconds. This did surprise us, and we thought this information should be made available industrywide. Watch the "jar test" video below to see for yourself.

[Jar-Test-Video](#) from [NAAREF](#) on [Vimeo](#).

If you are reading this on an iPhone and see a blank space where the video should be, you can view the video by A) clicking on the "aA" letters in the left corner of your Safari browser and then selecting "Show Reader View," or B) clicking the Jar-Test-Video link above to watch the video on Vimeo.

It turns out other operators have experienced significant foaming problems with mixtures as well and not with the same products we used either. We all agreed this information needed to be widely shared with ag pilots and operators, and, as a result, Dr. Scott Bretthauer wrote a [NAAREF Fly Safe Message](#) that was released Aug. 10. NAAREF emails these safety briefs as a public service to NAAA member and non-member operators and pilots alike. Dr. Bretthauer, as always, produced an excellent and informative safety brief warning us all about tank mixes. However, there are now a few more important safety-related details to the story I think we should also be aware of. We have a lot of connections to folks at the Springfield operation where the accident occurred, so I called the gentleman who is the mixer/loader for this operator. He and the family were more than willing to provide more information in the hope it will help others to stay safe.

First, they had already taken out a load that morning with a somewhat different mixture. This load had foamed a little but was nothing out of the ordinary and not a cause for concern. They did discuss using a defoaming agent in the next load. The loader then left on other business, and the pilot loaded his plane for his next run. The load sheet indicated two types of nitrogen fertilizer products totaling about 141 gallons and a glyphosate product at about 48 gallons for a total load of 189 gallons. They were sure defoamer would solve any foaming issues, and the loader is pretty sure the pilot added the defoaming agent. But it is unknown how much or if any was added. In any case, it was apparently not enough to solve the foaming issue.

The table was now set for a departure with at least 189 gallons on board. A Grumman G-164B Ag-Cat comes equipped with a 285-gallon hopper, although it is possible to upgrade to a 335-gallon tank. Now, remember what happened during our experiment. This mix probably did not cause the pilot any alarm during loading. We'll never know for sure, but the pilot may have had the spray pump fan on during the takeoff roll, thereby introducing agitation (i.e., mixing) to the loaded products. Whatever the reason, there was sufficient agitation to trigger a reaction. Our experiment showed there was enough foam now being produced to rapidly fill a 600-gallon tank to near capacity.

Witnesses at the airport thought the airplane had caught fire and described white smoke coming from around the cockpit. They were confused, however, by "white chunks" that seemed to be coming out of the aircraft, and the pilot told his wife foam was coming out of the top of the hopper and he just couldn't see. Impact occurred about a half-mile from the end of the departing runway. The pilot survived the crash but succumbed to significant burn injuries from the post-impact fire a few days later.

I don't know if any of us in this industry would have suspected the cause of this accident to be a problem. However, it does illustrate that sometimes it is the smallest things that can bite you. We all need to pay much more attention to the mixes going into our tanks. Don't just pour stuff together in a jar, though. You will need to mix it together to get a true picture of what is going on. But do use proper protection. Chemical reactions can sometimes be very vigorous. It also illustrates we should pay more attention to our personal gear.

For many years before I joined this profession, I flew with a fire-resistant Nomex flight suit and gloves. They are a bit warm to wear, somewhat costly and difficult to find in my size, and I really haven't worn one since I started in this business. However, I believe there are

two fatalities just this year related to post-crash burn injuries, and our NAAA leadership has been emphasizing what they have encouraged for many years now: Wear fire-resistant Nomex flight suits and gloves. I'm thinking I should put aside all my excuses and take their recommendations more seriously.

Sam Rogge chairs NAAA's Communications Committee and serves on the NAAA Board of Directors as the Colorado Agricultural Aviation Association's state director.