AEN-170

University of Kentucky
College of Agriculture, Food and Environment
Cooperative Extension Service

When to Replace Sprayer Nozzle Tips

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Figure 1. Examples of nozzle tips made from different materials that are commonly used on agricultural sprayers.

Nozzle tips are critical sprayer components for achieving accurate and uniform application of chemicals (Figure 1). Furthermore, nozzle tips are not cheap, especially when considering how many are required on a sprayer. As with any component on a machine, they will not last forever. So when should nozzle tips be replaced? It would be nice if there were a maximum number of sprayed acres or a fixed period of time after which the nozzle tips should be changed for new ones. Unfortunately, there are too many complicating factors to give such a simple answer. This document explains the causes of nozzle tip wear and some simple ways to tell when they should be replaced.

Functions of Nozzle Tips

As with any machine component, a nozzle tip needs to be replaced when it is worn out and cannot perform its original functions. Therefore, it is critical to know exactly what functions the nozzle tip performs. The two main functions of a nozzle tip on the sprayer are to control flow rate and create a uniform spray pattern. When it cannot accurately perform either of these functions, the nozzle tip should be replaced.

Nozzle tips are manufactured with very precise sizes and shapes of openings. The size of the opening controls the flow rate of liquid through the nozzle tip, based on the pressure drop across it. As pressure increases, flow increases. The shape of the opening controls the pattern of spray that exits the nozzle tip. The spray pattern is critical to maintaining uniformity across the spray boom, from tip to tip. Furthermore, the shape of the nozzle tip opening, along with the size of the opening, contributes to the size of the droplets within the spray pattern. Droplet size has a critical influence on both spray coverage and physical drift.

Causes of Nozzle Tip Failure

Aside from physical damage to a nozzle tip, there are two primary processes that will cause a nozzle tip to wear out: erosion and corrosion.

Erosion

As liquid is pushed through the nozzle tip, the material will slowly erode, in much the same way water moving in a river will erode rock. This erosion will cause the opening in the nozzle tip to get larger. As the opening gets larger, the flow rate will be higher than expected for a certain pressure. Erosion of the nozzle tip can also alter the shape of the spray pattern, which will impact spray uniformity.

Corrosion

Sometimes corrosion can occur in the nozzle tip opening (Figure 2). Corrosion will often have a major effect on the shape of the spray pattern, because it can change the shape of the opening. Corrosion can also alter flow rate through the nozzle tip. If the corrosion causes a loss of material, the opening will be larger and the flow rate will increase. If the corrosion causes blistering of the material in the opening, that occlusion could decrease the flow rate.

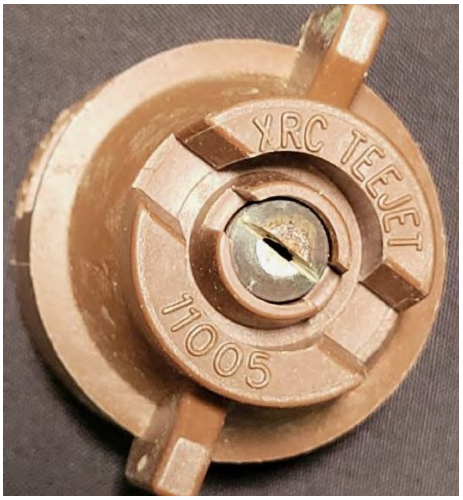

Figure 2. Corroded stainless-steel nozzle tip that should be replaced.

Factors Affecting Nozzle Tip Life

Several things can affect how quickly a nozzle tip will wear out, either through erosion or corrosion. Nozzle material, application rate, liquid properties, operating pressure, and time are five of the major contributing factors.

Nozzle Material

Nozzle tips are typically manufactured from one of four different materials (Figure 1):

- **Brass**. This is the least expensive material and will typically have the shortest life.
- **Plastics or polymers**. There are many different materials that could fall into this category. They will typically last two to four times longer than brass tips.
- **Stainless steel**. These tips will generally last about six times longer than brass tips.
- **Ceramic**. These are the longest lasting, with a lifespan as much as 20 times longer than brass tips.

Of course, the longest-lasting tips will also be the most expensive, so the purchaser must consider price versus longevity when choosing nozzle tip materials.

Application Rate

Nozzle tip wear is directly affected by the amount of liquid that passes through the tip. If the tip is used in higher-volume (gal/acre) applications, it will wear out with fewer acres covered than when used in lower-volume applications. But don't use lower carrier volumes than specified by the labels just to reduce nozzle tip wear. Stay on label to maximize chemical efficacy and to remain compliant with regulations.

Liquid Properties

Different chemical formulations and tank mixtures will have different effects on the nozzle tip material and service life. Some spray solution carriers, such as liquid nitrogen, can also have a greater impact on nozzle wear. Some will be more erosive than others. Some will cause more corrosion than others. Chemical labels will often prescribe appropriate nozzle tip materials and cleaning procedures. Users should pay attention to information in the chemical labels when selecting and using nozzles.

Operating Pressure

If the nozzle tips are generally operated at higher pressures, the liquid flow through the tip will be more turbulent and tend to erode the tip material away faster.

Time

Some tips that are used infrequently or intermittently will not last for as many acres as other tips. Even though they are not subject to as much erosive action with limited use, time can still take a toll on the material. Corrosion can still occur when the tip is not being used, especially if it was not properly cleaned. Also, some materials are more susceptible to deterioration over time, especially with prolonged exposure to sunlight. Proper cleaning and storage will increase the life of nozzles.

Methods to Gauge Nozzle Tip Wear

Since the nozzle tip is responsible for controlling flow rate and spray pattern, both functions should be regularly assessed.

Check Flow Rate from Each Tip

Most sources recommend replacing a nozzle tip when the flow rate deviates by more than 10 percent from its specified value. For example, a common 8006 nozzle tip should allow a flow rate of 0.6 gallons per minute (gpm) at a nozzle pressure of 40 psi. If the actual measured flow rate is above 0.66 gpm or below 0.54 gpm, (i.e., plus or minus 10 percent), it should be replaced.

Nozzle flow rate should be checked at least once per season for sprayers that receive relatively limited use; it should be checked more often for higher-use sprayers. Many modern sprayer controllers have calibration procedures that are very easy to follow and are often guided by the in-cab display. In general, it is a relatively simple process of setting the sprayer pressure (or flow on machines equipped with flow controllers) to a given value and then measuring the amount of liquid that comes out of the nozzle in a given amount of time. The selected pressure can be anything in the operating range of the nozzle, but 40 psi is often used, since it is a common calibration point for many nozzle tips used by manufacturers.

Flow can be measured with any kind of measuring device that has fluid-volume markings and that will not allow liquid to splash out. (Be careful not to use containers that are marked for dry ounces, such as those calibrated for weight of specific dry formulation materials.) Many nozzle manufacturers provide calibration containers designed specifically for this purpose (Figure 3). Time can be measured with a stopwatch; almost all phones now have stopwatch functions or apps. Depending on the measuring device used, some simple calculations may be necessary to determine flow rate in gallons per minute or liters per minute, so the results can be compared to the specifications for the nozzle tip.

A quicker way to measure actual flow rate is to use a dedicated nozzle calibrator, like the one shown in Figure 4. These

Figure 3. Examples of different graduated containers that can be used to measure the flow rate from nozzles.

Figure 4. Electronic calibrator used to measure the flow rate from a nozzle tip.

Figure 5. Kinked hose on a spray boom could cause lower pressure and flow in one section of a boom.

relatively inexpensive devices can be used to check the flow rate from a nozzle tip in a few seconds, which makes it reasonable to check all nozzles, even on larger booms. The device will give a flow indication in gallons per minute that can be compared directly to nozzle specification sheets.

The first thing to look for when assessing flow rate is any nozzles that have a significantly different flow than the others. An unusually high flow from a tip is a good indication that the nozzle tip is worn out or has been damaged. It should be replaced. A low flow could indicate that something is restricting the flow. The problem could be corrosion that is occluding the opening. Corroded tips should be replaced. The problem could also be plugging, either in the nozzle tip itself, in the filter screen, or in some other nozzle body component. Plugging may be rectified with some careful cleaning of the nozzle tip, screen, or other components, or it may require replacing a component. If the sprayer is equipped with solenoid valves on the nozzle bodies for individual nozzle control, a low flow could also indicate a problem with the control valve, which may itself need to be cleaned or replaced.

When cleaning nozzle tips, remember to use water, air, or a small plastic brush. Never use something hard like a screwdriver, pocketknife, or metal wire, as hard objects will likely damage the nozzle tip and alter the spray pattern.

Once problem nozzle tips are identified and rectified, look for any boom sections that have a different flow rate than others. A problem with an entire boom section could be caused by a malfunction in the plumbing to that or other sections on the boom. Look for pinched hoses, plugged filters, residue buildup, sticky valves, excessive plumbing adapters, etc. (Figure 5).

Once uniformity is established across the boom, the next step is to compare the average flow rate from all nozzles to the expected flow rate. Again, the specification sheet for the nozzle will indicate what flow the nozzles should allow at the given pressure. During assessment, keep in mind the threshold of plus or minus 10 percent for determining when action should be taken. If the average flow rate through all nozzle tips is higher than expected, that could indicate that all the nozzle tips are worn, but it could also indicate a problem with the pressure gauge or flow meter on the sprayer. A good way to tell the difference is to replace one tip with a new or unused tip. If the flow rate from the new tip is significantly different (by more than 10 percent) from the rest of the tips on the boom, that provides some assurance that the tips are worn and should be replaced. If the flow from the new tip is similar to the used tips, then there could be a problem with a pressure gauge or flow meter, or it could be caused by a systematic pressure drop in the plumbing between the pressure gauge and the nozzle tips.

With proper management, the sprayer can still be operated accurately with an errant gauge. It will require careful calibration and noting of the difference between the actual gauge indication and the expected indication. For example, if a flow rate of 0.6 gpm is achieved from a set of new 8006 nozzle tips at 45 psi on a particular gauge instead of the expected 40 psi, then an accurate application should be achievable by consistently running the indicated pressure at 5 psi higher than expected.

Evaluate Spray Pattern

The spray pattern from each nozzle tip is important to achieve nozzle-to-nozzle uniformity and avoid streaking in the field. The only way to precisely evaluate spray pattern is to use a tool called a patternator (examples shown in Figure 6) that divides and measures the spray distribution across the width of the nozzle spray pattern. Utilizing these to evaluate every nozzle tip on large booms would obviously be very impractical. Alternatively, many spray pattern problems can be identified with a careful visual inspection of the nozzle discharge. Most

Figure 6. Examples of laboratory/shop and portable patternator tables, used to measure spray pattern distribution of individual or multiple nozzles.

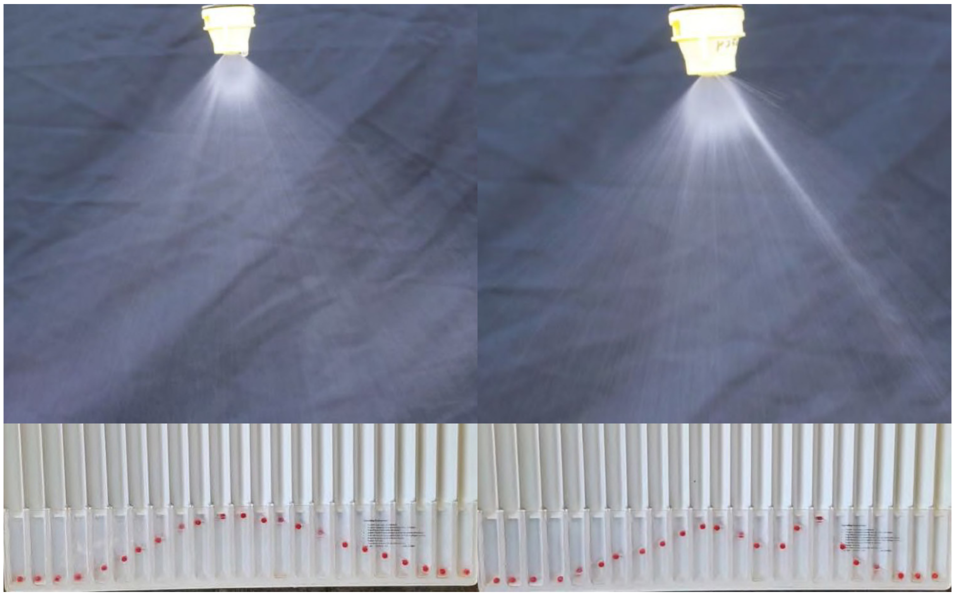

Figure 7. Spray patterns from an 8003 flat-fan, stainless-steel nozzle tip that is in good condition (left) and one that has been damaged by cleaning with metal wire (right). The damage is visible as a heavy stream in the pattern, and it causes a misshapen distribution.

nozzle patterns should look very uniform across their width. If heavier streaks or voids are noticed in the spray pattern, this probably indicates a problem with a tip that will result in streaky application (Figure 7).

The other way to detect possible spray pattern problems is through flow rate evaluation. The flow error replacement rule of thumb of plus or minus 10 percent is partially driven by an expected compromise of spray pattern. If the nozzle tip is worn enough to cause a flow rate error of more than 10 percent from original specification, the pattern is likely altered to the point that uniformity across the boom has also been compromised.

Yet another way to assess application uniformity is with the use of a pattern indicator dye. This is a temporary, non-toxic dye that is added to the tank to leave a visible indication of where the spray was deposited on the field. Visual assessment of the deposited spray pattern can indicate nozzle tip problems.

Summary

Proper management of the nozzle tips on a sprayer is critical to accurate placement of chemicals. Nozzle tips should be replaced when they are no longer able to adequately control the desired flow rate or pattern of the spray. Flow accuracy should be regularly checked to determine if some or all nozzle tips are more than 10 percent out of specification and should be replaced. Visual inspections of spray patterns should also be used to identify improperly functioning nozzle tips.

Issued 12-2022