


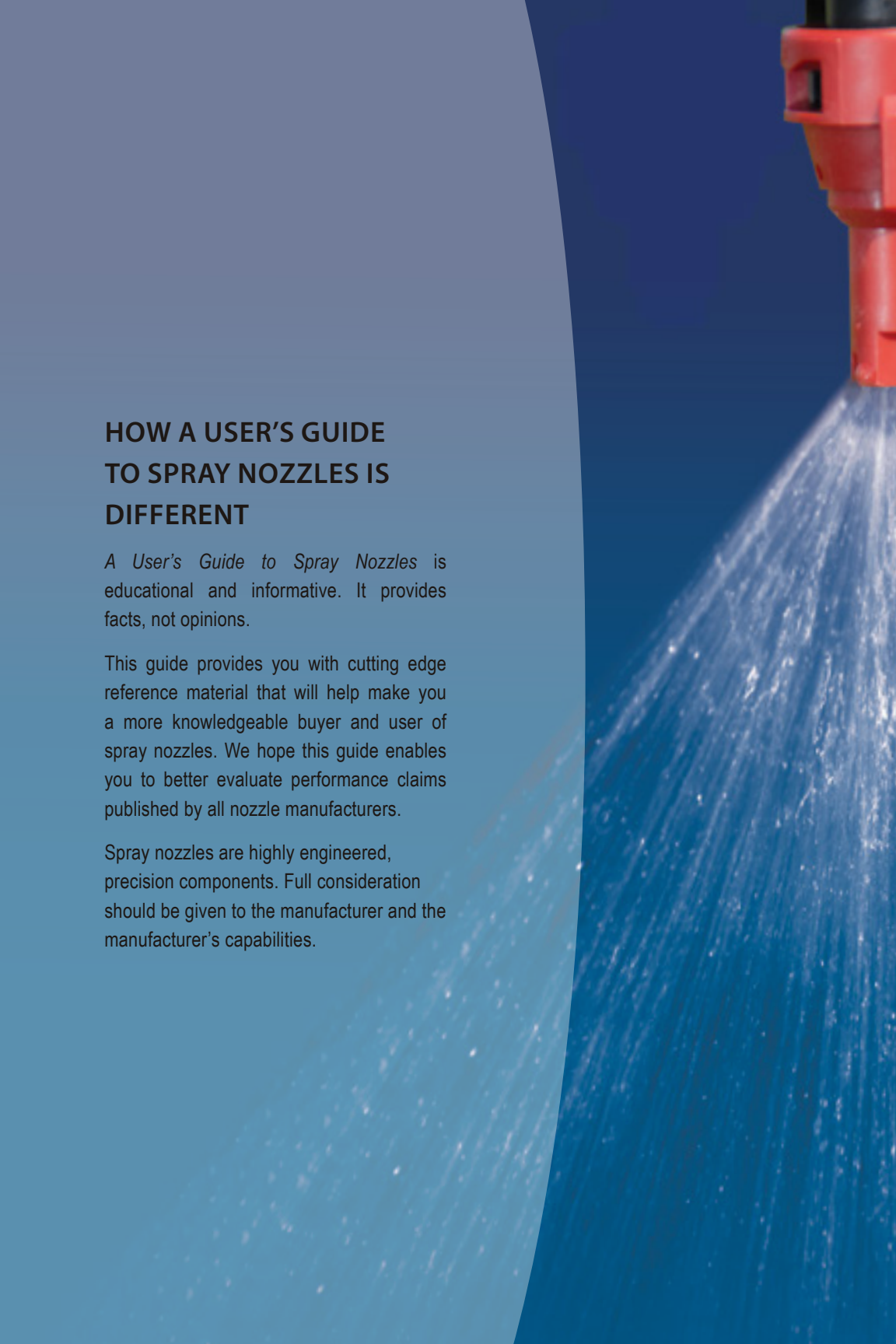


A USER'S GUIDE TO SPRAY NOZZLES



A Subsidiary of  *Spraying Systems Co.*[®]

TeeJet[®]
TECHNOLOGIES

A close-up photograph of a red spray nozzle, likely from a pressure washer or agricultural sprayer, positioned in the upper right corner. The nozzle is emitting a wide, fan-shaped spray of fine water droplets that fills the right half of the frame. The background is a gradient of blue, transitioning from a lighter shade on the left to a darker shade on the right. The overall composition is clean and professional, emphasizing the precision of the spray technology.

HOW A USER'S GUIDE TO SPRAY NOZZLES IS DIFFERENT

A User's Guide to Spray Nozzles is educational and informative. It provides facts, not opinions.

This guide provides you with cutting edge reference material that will help make you a more knowledgeable buyer and user of spray nozzles. We hope this guide enables you to better evaluate performance claims published by all nozzle manufacturers.

Spray nozzles are highly engineered, precision components. Full consideration should be given to the manufacturer and the manufacturer's capabilities.



A USER'S GUIDE TO SPRAY NOZZLES

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INTRODUCTION

A poor choice in spray nozzles,

or use of under-performing nozzles,
can lead to re-spraying and reduced
performance – two problems no user
should face.



Your success in any spraying season is dependent on many individual factors. Some of these factors, like the equipment you choose to use, are controlled by you; others, like the weather, are not. The purpose of this guide is to assist you in an area where you have total control: spray nozzle selection and use.

Even though spray nozzles are a physically small component in your overall operation, they are vitally important. Improper application of plant protection products can be extremely costly if re-spraying is required, performance is reduced or legal issues arise as a result of chemical drift. However, many users perceive spray nozzles as fairly simple components, when in fact it is quite the opposite. There are dozens of nozzle types from various manufacturers that offer very different performance.

This guide will help you:

- Learn more about the technical aspects of spray nozzles
- Select the spray nozzles best suited to your specific application requirements
- Maintain your spray nozzles for optimal performance

SECTION ONE

THE COSTLY CONSEQUENCES OF SPRAYING TOO MUCH OR TOO LITTLE


Making sure you have the proper spray nozzles for your application and that they are performing properly are two things that every user should practice to maximize performance and profitability. The spray nozzles you select will determine:

- The amount of chemical applied to an area
- The uniformity of the application
- The coverage of the chemical on the target surface
- The amount of potential drift

Using the wrong spray nozzle or a spray nozzle that isn't performing properly can result in over or under application. Over application can be wasteful and costly; under application can result in a reduction in performance or the need for re-application.

The use of a rate controller can certainly help ensure the proper amount is sprayed. You can also make minor adjustments to sprayer pressure or speed to apply the correct amount of chemical. However, the proper application volume doesn't necessarily mean maximum effectiveness.

**EVEN A SPRAY NOZZLE
WITH ONLY 10% WEAR
MAY NOT GIVE YOU THE COVERAGE
AND PERFORMANCE YOU EXPECT**



For example, if you are using the wrong nozzle or if the nozzle is worn by as little as 10%, the spray pattern may not be uniform across the boom and you will not get the spray coverage you expect. Coverage may be streaky and some areas may receive more or less chemical than intended, resulting in the need to re-apply the product.

No matter the root cause, over and under application both have high price tags – thousands of dollars, and in some cases, tens of thousands of dollars. The full cost of these losses will likewise depend on your operation and the plant protection products you use. See the example below.

Problems like this can be avoided by making sure you've selected the proper spray nozzles for your application and that they are in good working order. If you think there is a nozzle that may better meet your needs, or you suspect that your nozzles are worn, do not hesitate to replace them. The cost of replacing nozzles is minor compared to the effects of poor spraying. In fact, you'll recoup the cost of the nozzles almost immediately by applying the proper amount of chemical in just a few acres.

Cost calculator for under or over application:

Under application of chemical causing re-spray* (U.S. dollars):

\$27/acre x 100 acres	\$2,700
\$27/acre x 1000 acres	\$27,000
\$27/acre x 2000 acres	\$54,000

**Does not include time/labor, fuel or machinery expense.*

Over application of chemical by 10% (U.S. dollars):

(\$27/acre x 10%) x 100 acres	\$270
(\$27/acre x 10%) x 1000 acres	\$2,700
(\$27/acre x 10%) x 2000 acres	\$5,400

SECTION TWO

SPRAY NOZZLE FUNDAMENTALS

Spray Patterns

There are many types of nozzles and spray patterns available; your best choice will depend on the application. Three of the most common types are:

- Flat fan
- Cone spray
- Streaming nozzles

Flat Fan

The flat fan spray nozzle forms a narrow, elliptical, inverted “V” pattern commonly referred to as a tapered spray (FIGURE 1). Deposition is heaviest at the center of the pattern and dissipates toward the outer edge. A uniform distribution pattern across the boom is achieved when the boom height and nozzle spacing are optimized for proper spray pattern overlap of adjacent nozzles. Variations of the flat fan include:

- Extended range flat fan for broadcast spraying; designed to operate with a wider range of spray pressures (FIGURE 1).
- Symmetric or asymmetric twin flat fan for broadcast spraying; flow is divided between two orifices pointed forward and backward; can provide improved coverage and canopy penetration (FIGURE 2).
- Flooding for broadcast spraying; wide angle flat pattern using larger droplets (FIGURE 3).
- Even spray for band spraying; non-tapered spray patterns provide even coverage without overlapping (FIGURE 4).
- Additionally, all of the above nozzle types may be offered in a traditional single orifice design, pre-orifice design or air induction design. More to come on this in the next section.

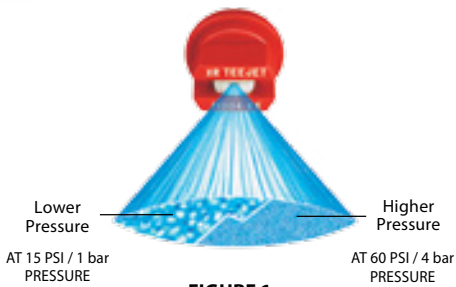


FIGURE 1:
Extended range flat fan spray pattern

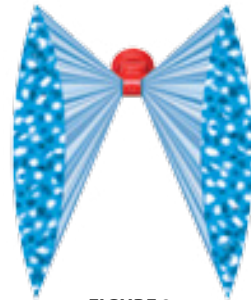


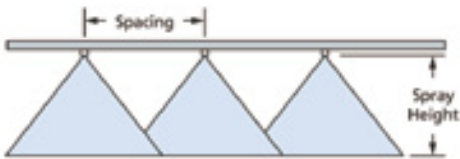
FIGURE 2:
Symmetric twin flat fan spray pattern



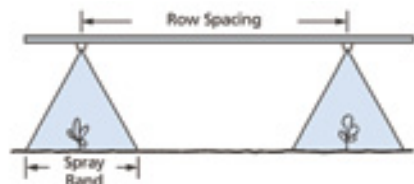
FIGURE 3:
Wide angle flat fan spray pattern



FIGURE 4:
Even spray pattern



Overlap broadcast pattern



Band spray application

Cone Sprays

Cone sprays come in two basic variations - hollow cone and full cone. The hollow cone spray nozzle forms a ring-shaped pattern, finely atomized spray and can be operated at high pressures. These unique characteristics make hollow cone nozzles well suited for air blast applications as well as specialty and directed spray applications. Hollow cone nozzles may be offered in a single-piece tip design or a two-piece disc and core design. Air induction hollow cone nozzles are a recent development that produces a spray pattern like a traditional cone spray, but with much coarser droplets to reduce drift. (FIGURE 5 & 6).

The full cone spray nozzle creates a full, circular spray pattern. Full cones typically produce coarser droplets and are offered in larger capacities than hollow cone nozzles. These nozzles are typically used for directed spraying and other specialty applications. Full cone nozzles may be offered in a single-piece tip design or a two-piece disc and core design (FIGURE 7).



FIGURE 5:
Hollow Cone Spray Pattern



FIGURE 6:
Air Induction Hollow Cone Spray Pattern



FIGURE 7:
Full Cone Spray Pattern

Streaming Nozzles

Solid stream or broadcast streaming nozzles are offered in a variety of configurations and are commonly used for liquid fertilizer application. The solid stream spray pattern reduces foliar coverage to minimize leaf burn while projecting the liquid more directly to the soil surface where it can be absorbed by the root system. More to come on these nozzles in the next section

Spray Tip Geometry

The charts to the right provide information on the theoretical spray coverage of the included spray angle at various spray heights. These values are based on the assumption that the spray angle remains the same throughout the entire spray distance. In actual practice, this does not happen due to the effects of gravity (FIGURE 8).

Always keep in mind that *spray coverage will vary based on operating pressure, spray height and nozzle spacing*. Follow the manufacturer’s recommendations to achieve uniform coverage.

Optimum spray heights can be found in the table on the next page (FIGURE 9). These heights are based on laboratory testing and provide the overlap required to obtain uniform distribution. In many cases, typical height adjustments are based on 1:1 nozzle spacing to height ratio. For example, 110° flat spray nozzles spaced 20"/50 cm apart are commonly set 20"/50 cm above the target.

Included Spray Angle	Theoretical Coverage at Various Spray Heights (in)							
	8"	10"	12"	15"	18"	24"	30"	36"
15°	2.1	2.6	3.2	3.9	4.7	6.3	7.9	9.5
20°	2.8	3.5	4.2	5.3	6.4	8.5	10.6	12.7
25°	3.5	4.4	5.3	6.6	8.0	10.6	13.3	15.9
30°	4.3	5.4	6.4	8.1	9.7	12.8	16.1	19.3
35°	5.0	6.3	7.6	9.5	11.3	15.5	18.9	22.7
40°	5.8	7.3	8.7	10.9	13.1	17.5	21.8	26.2
45°	6.6	8.3	9.9	12.4	14.9	19.9	24.8	29.8
50°	7.5	9.3	11.2	14.0	16.8	22.4	28.0	33.6
55°	8.3	10.3	12.5	15.6	18.7	25.0	31.2	37.5
60°	9.2	11.5	13.8	17.3	20.6	27.7	34.6	41.6
65°	10.2	12.7	15.3	19.2	22.9	30.5	38.2	45.8
73°	11.8	14.8	17.8	22.0	27.0	36.0	44.0	53.0
80°	13.4	16.8	20.2	25.2	30.3	40.3	50.4	60.4
85°	14.7	18.3	22.0	27.5	33.0	44.0	55.4	66.4
90°	16.0	20.0	24.0	30.0	36.0	48.0	60.0	72.0
95°	17.5	21.8	26.2	32.8	40.3	52.4	65.5	78.6
100°	19.1	23.8	28.6	35.8	43.0	57.2	71.6	85.9
110°	22.8	28.5	34.3	42.8	51.4	68.5	85.6	103
120°	27.7	34.6	41.6	52.0	62.4	83.2	104	
130°	34.3	42.9	51.5	64.4	77.3	103		
140°	43.8	54.8	65.7	82.2	98.6			
150°	59.6	74.5	89.5					



Disc Core

Included Spray Angle	Theoretical Coverage at Various Spray Heights (cm)								
	20 cm	30 cm	40 cm	50 cm	60 cm	70 cm	80 cm	90 cm	
15°	5.3	7.9	10.5	13.2	15.8	18.4	21.1	23.7	
20°	7.1	10.6	14.1	17.6	21.2	24.7	28.2	31.7	
25°	8.9	13.3	17.7	22.2	26.6	31.0	35.5	39.9	
30°	10.7	16.1	21.4	26.8	32.2	37.5	42.9	48.2	
35°	12.6	18.9	25.2	31.5	37.8	44.1	50.5	56.8	
40°	14.6	21.8	29.1	36.4	43.7	51.0	58.2	65.5	
45°	16.6	24.9	33.1	41.4	49.7	58.0	66.3	74.6	
50°	18.7	28.0	37.3	46.6	56.0	65.3	74.6	83.9	
55°	20.8	31.2	41.7	52.1	62.5	72.9	83.3	93.7	
60°	23.1	34.6	46.2	57.7	69.3	80.8	92.4	104	
65°	25.5	38.2	51.0	63.7	76.5	89.2	102	115	
73°	29.6	44.4	59.2	74.0	88.8	104	118	133	
80°	33.6	50.4	67.1	83.9	101	118	134	151	
85°	36.7	55.0	73.3	91.6	110	128	147	165	
90°	40.0	60.0	80.0	100	120	140	160	180	
95°	43.7	65.5	87.3	109	131	153	175	196	
100°	47.7	71.5	95.3	119	143	167	191	215	
110°	57.1	85.7	114	143	171	200	229	257	
120°	69.3	104.0	139	173	208	243			
130°	85.8	129	172	215	257				
140°	110	165	220	275					
150°	149	224	299						

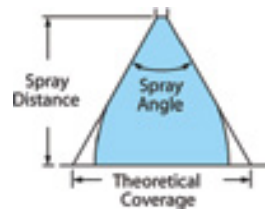


FIGURE 8:
Theoretical Coverage

The most commonly used spray angle for various nozzle types are listed below.

- Tapered flat fan nozzles are most often available with 80° or 110° spray angles
- Even flat fan nozzles are commonly available with 40°, 65°, 80°, or 95° spray angles
- Flooding (wide angle) nozzles typically produce a 120° spray angle
- Hollow cone nozzles are commonly available with 65° or 80° spray angles





The trend in broadcast flat fan spray tip design is toward wider spray angles. This is why you will see most new generation tips offered in 110° or wider spray angles only. The advantages of wider spray angles include increased overlap for better spray distribution and the ability to run booms closer to the target surface to reduce drift potential.

Spray Pressure

Nozzle flow rate varies with spraying pressure. In general, the relationship between flow rate in gallons per minute (GPM) or liters per minute (l/min) and pressure in PSI or bar is shown at the right (FIGURE 10).

Key facts about pressure:

- Increasing the pressure by four times doubles the flow rate
- Higher pressure decreases droplet size and increases drift potential
- Higher pressure increases orifice wear
- Pressure impacts the spray angle and coverage; operate your spray nozzles within the proper pressure range
- Performance data is typically provided in spray nozzle catalogs for spraying water. Liquids more dense, or heavier, than water, like 28% liquid nitrogen, form smaller spray angles. Liquids less dense, or lighter, than water form wider spray angles.

(in)			
	 20°	 30°	 40°
80°	30"	NR*	NR*
110°	20"	30"	NR*
120°	24"	30"	39"


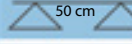
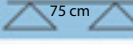
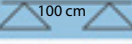
(cm)			
	 50 cm	 75 cm	 100 cm
80°	75cm	NR*	NR*
110°	50cm	75cm	NR*
120°	60cm	75cm	100cm

FIGURE 9:
Optimum spray heights
**Not recommended*

$$\frac{GPM_1}{GPM_2} = \frac{\sqrt{PSI_1}}{\sqrt{PSI_2}}$$

$$\frac{l/min_1}{l/min_2} = \frac{\sqrt{bar_1}}{\sqrt{bar_2}}$$

FIGURE 10:
Relationship between flow rate (GPM or l/min) and pressure (PSI or bar)

Droplet Size Basics

A nozzle's spray pattern is made up of many droplets of varying sizes. Droplet size is the diameter of an individual spray droplet and measured in microns (micrometers) often notated with the symbol μ . One micron equals 0.001 mm (0.0000394"); there are 25,400 microns in one inch. For example, the diameter of a human hair is about 100 microns.

Most nozzles have a wide array of droplet sizes. These droplet sizes are commonly summarized by statistical analysis based on testing from sophisticated droplet size measuring equipment such as laser and imaging systems. Droplets are then classified as shown to the right (Figure 11). These classification categories enable comparisons to be made between nozzles. The most reliable droplet size data will conform to the British Crop Protection Council (BCPC) standard in accordance with the American Society of Agricultural and Biological Engineers (ASABE) standard S572.1. This standard provides strict conditions for spray droplet measurement and is preferred because it uses reference nozzle sets to normalize data. This eliminates interpretation differences when comparing statistical data among different types of laser measuring equipment (Figure 12). Generally speaking, without these classification categories, you can never accurately compare droplet size numbers between nozzles or nozzle types.

Droplet size is a key factor in nozzle selection:

- When coverage is critical, such as in post-emergence contact applications, nozzles with finer droplets are used because of the excellent coverage on leaf surfaces.
- Nozzles producing mid-range droplets are most commonly used for application of contact and systemic herbicides, insecticides and fungicides.
- Nozzles producing coarser droplets are typically used for systemic herbicides and pre-emergence soil applied herbicides while minimizing drift.

Remember, droplet size can vary based on pressure. The same nozzle can produce medium droplets at low pressures and fine droplets at higher pressures.



FIGURE 11:
Droplet Size Classification



Laser Analyzer

Defining Spray Drift

Spray drift is defined as the movement and deposition of spray particles through the air to non-target locations. The two forms of spray drift are: particle drift which results from droplets physically moving to non-target locations via air currents; and vapor drift which results from the evaporation of and later re-deposition of spray particles in non-target areas. Droplets most prone to drift are those less than 150 microns in diameter.

Factors that determine drift:

- Wind velocity and direction has the greatest impact on spray drift.
- The greater the distance between the spray tip and the target area, the greater impact wind velocity can have on drift.
- A temperature inversion layer, a situation where the air temperature is cooler near the earth's surface than in the air immediately above it, can lead to increased lateral movement of spray particles leading to spray drift.
- Increased operating speeds can cause the wind to be diverted back into upward wind currents and vortices behind the sprayer that trap small droplets and can contribute to drift.
- When temperatures are over 77°F (25°C) with low relative humidity, small droplets are more prone to drift because of the effects of evaporation.
- Low application rates usually requires the use of small nozzle sizes, increasing the risk of drift.
- The smaller the nozzle size and the greater the spray pressure, the smaller the droplet size and the greater proportion of driftable droplets.

Various agencies conduct rigorous distribution and drift testing. When evaluating drift data, always inquire about the source of the data. The best data will come from independent testing agencies, such as Food and Environment Research Agency (FERA) in the United Kingdom, the Julius Kühn Institute (JKI) in Germany and the Centre for Pesticide Application and Safety (CPAS) in Australia.

Certain agencies also conduct assessment testing on spray application systems. Some of these agencies have rating systems and accreditation programs. Ask to see these such ratings when evaluating drift potential. The most popular rating system is the Local Environment Risk Assessment for Pesticides (LERAP).

For more information, please contact:

ASABE (<http://www.asabe.org>)

FERA (<http://www.fera.defra.gov.uk>)

JKI (<http://www.jki.bund.de/en>)

Pesticides Safety Directorate (PSD) (<http://www.pesticides.gov.uk>)

CPAS (<http://www.uq.edu.au/agriculture>)

LERAP (<http://www.pesticides.gov.uk/guidance/industries/pesticides/topics/usingpesticides/spray-drift/leraps>)

Helpful Drift Control Tips:

- Reduce operating pressure to increase droplet size. Flow rate will be reduced so it may be necessary to go to a larger nozzle size to stay within the labeled application rate.
- Use nozzles that produce larger droplets such as drift reducing nozzles or nozzles of larger capacity.
- Lower boom height to reduce drift but maintain proper overlap for spray coverage.
- Pay close attention to weather conditions throughout the day and adjust your application methods accordingly.

SECTION THREE

KNOW YOUR NOZZLE TYPES

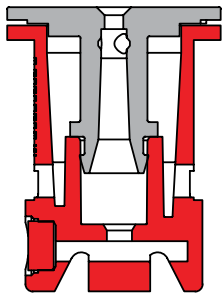
Venturi Air Induction Nozzles

Air induction (AI) nozzles feature two orifices. The first orifice, known as the pre-orifice, meters the liquid flow. The second orifice, known as the exit orifice, is larger than the pre-orifice and forms the spray pattern. A venturi or air aspirator sits between the two orifices. This air venturi draws air into the body of the nozzle where it is mixed with water. This mixing creates an air-entrained spray pattern at a lower pressure. The spray pattern is comprised of large, air-filled, coarse droplets with very few drift-susceptible droplets.

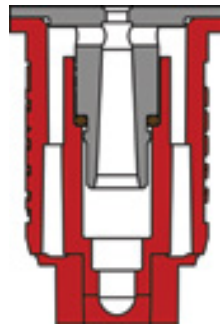
Using AI nozzles:

- Ideal for drift reduction while maintaining good coverage; when used with the proper chemicals/additives, air bubbles are formed in the droplet causing the droplets to shatter on impact, providing improved coverage.
- Be sure to use the proper operating pressures to achieve the proper droplet size. Some AI nozzles require an operating pressure of 30 to 100 PSI (2 to 7 bar) to maximize performance. Many newer AI nozzles have been designed to operate effectively at pressures as low as 15 PSI (1 bar).
- Most AI nozzles produce a wide angle flat fan or twin flat fan pattern.
- AI nozzles are typically used for broadcast spraying of post-emergence systemic herbicides, fungicides and insecticides. In banded and directed spraying, AI nozzles provide excellent performance in application of pre-emergence herbicides, post-emergence systemic herbicides, fungicides and insecticides.
- Asymmetric twin spray nozzles are a more recent development that features one spray pattern projected downward for canopy penetration and one pattern projected horizontally for coverage at the top of the crop canopy/seed head. These nozzles have proven to be particularly effective for fungicide application and disease control in small grains.

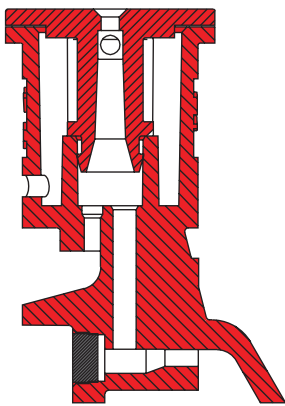
- Carry a few spares. Even though cleaning these nozzles shouldn't require tools, in-field cleaning isn't recommended because of the number of small pieces. If in-field cleaning is necessary, keep a small can of compressed air on board the sprayer.



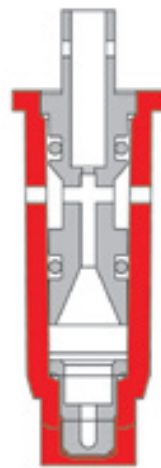
Twin Spray Venturi Air Induction Nozzle



Venturi Air Induction Nozzle



Asymmetric Twin Spray Venturi Air Induction Nozzle



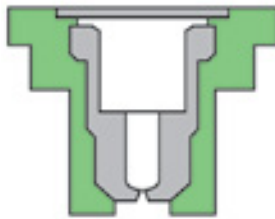
Venturi Air Induction Nozzle

Extended Range Flat Fan Nozzles

Extended range flat fan nozzles provide excellent spray distribution over a range of pressures. When operated at lower pressures drift can be reduced while at higher pressures coverage can be improved.

Using extended range flat fan nozzles:

- Commonly used for contact products (herbicides, insecticides & fungicides) where thorough leaf coverage is needed for effective control.
- Lower pressures and higher flow rates will produce droplets more resistant to drift. Pressures above 30 to 40 PSI (2 to 3 bar) produce finer droplets more prone to drift.
- Nozzles should be placed so patterns overlap a minimum of 30% on each spray pattern edge.



Extended Range Flat Fan Nozzle

Pre-Orifice Flat Fan Nozzles

Pre-orifice flat fan nozzles reduce the operating pressure internally and produce a larger droplet than conventional flat fan nozzles. The nozzle's pre-orifice restricts the amount of liquid entering the nozzle and creates a pressure drop through the tip. Fewer droplets prone to drift are produced creating excellent spray pattern uniformity. Pre-orifice nozzles are available in flat fan and plug-resistant flooding versions.

Using pre-orifice nozzles:

- Flat fan versions operate at pressures from 15 to 90 PSI (1 to 6 bar), require a minimum of 30% overlap on the edge of each spray pattern and should be mounted so the preset spray angle is directed away from the direction of travel.
- Flat fan versions are widely used for the application of post-emergence products.
- Compared to extended range flat fan nozzles, drift can be reduced by as much as 50%.
- Carry a few spares. The pre-orifice is more difficult to clean than conventional nozzles and not practical for in-field cleaning. If in-field cleaning is necessary, keep a small can of compressed air on board the sprayer.



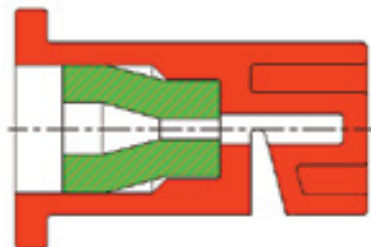
Pre-Orifice Flat Fan Nozzle

Flooding Type Nozzles

Flooding type nozzles produce a wide angle flat fan pattern. Pressure changes affect the width of the spray pattern more than with extended range flat fan nozzles.

Using flooding type nozzles:

- Best distribution is achieved with nozzles mounted for 100% (or double) overlap, meaning the edge of one spray pattern extends to the center of the adjacent nozzle, at the lowest possible operating pressure.
- Nozzles can be mounted to spray in any direction but the mounting position will impact the distribution. If spraying downward, rotating the nozzles 30° to 45° up from horizontal will help uniformity at operating pressures in the 10 to 30 PSI (0.7 to 2 bar) range.
- At low pressures, flooding type nozzles produce large droplets; at high pressures, smaller droplets are produced – even smaller than flat fan nozzles with an equivalent flow rate.
- Compared to extended range flat fan nozzles, drift can be reduced by as much as 50%.
- Pre-orifice style flooding versions operate at pressures from 10 to 40 PSI (0.7 to 2.8 bar), require a minimum of 30% overlap on the edge of each spray pattern and can be mounted in a variety of positions for spraying in any direction.
- Flooding versions are well-suited for soil applications especially when applying a mix of fertilizers and herbicides.

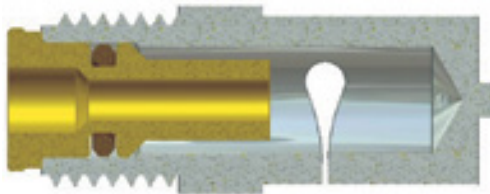


Flooding Type Nozzle

Nozzles for Specialty Applications

There are many variations to the basic nozzle types and many other specialty nozzles available as well. Your choice will, of course, depend on your application requirements.

- Variation of standard nozzles includes, wide angle and extra wide angle sprays, double-outlet flat spray and even flat spray.
- Boomless nozzles are designed for spraying areas not easily accessed with a boom sprayer. Flat spray and extra wide flat spray patterns are typically used to provide a wide swath.
- Hollow cone nozzles are available in disc and core types for spraying pesticides at higher pressures and flow rates. Standard hollow cone nozzles produce a finely atomized spray and are commonly used for spraying post-emergence contact herbicides, fungicides and insecticides. Wide angle versions are also available.
- Full cone nozzles provide a coarse spray pattern and are available in standard and wide angle spray patterns. These nozzles can be used in broadcast spraying and in some banded applications.



Boomless Type Nozzle

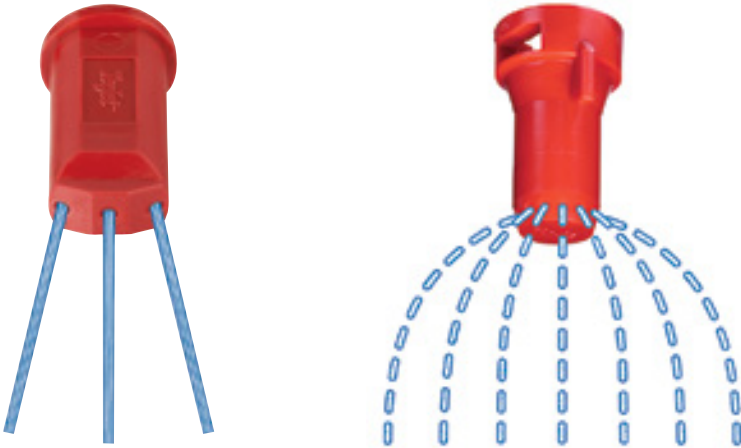
Fertilizer Nozzles

Solid stream nozzles are offered in a variety of sizes offering anywhere from 1 to 7 or more individual streams. By utilizing individual liquid streams instead of a fan spray, liquid fertilizer can be applied more directly to the soil surface where it is needed. This minimizes foliar coverage in standing crop reducing the chances of leaf burn and makes the likelihood spray drift extremely low. Fertilizer streaming tips are not recommended for pesticide application.

Using fertilizer nozzles:

- Streaming nozzles typically utilize a removable pre-orifice to meter the flow. The ability to remove this pre-orifice for cleaning is a good feature.
- When selecting a liquid fertilizer tip, always remember to apply the liquid density correction factor when calculating your application rate and selecting the tip size/operating pressure (see Section Four for more details).
- Single stream tips are often used in conjunction with a coulter or knife which creates a trench in the soil surface and allows the liquid fertilizer to penetrate into the root zone where it is most accessible to the plant.
- 3-stream (or similar) tips produce a narrower coverage area and project liquid more directly to the soil surface. These are more commonly used in directed spray applications. The fewer streams and narrower spray pattern generally require a lower, more consistent boom height and may be more suitable for lower-speed applications common with pull-type machines.
- 7-stream (or similar) tips produce a wider coverage area making them ideal for broadcast application in both standing crop and bare soil. Due to the greater number of streams and wider spray pattern these tips are most ideal for higher boom heights as well as higher ground speeds commonly encountered with self-propelled machines.

- Due to the more 3-dimensional nature of some streaming nozzles, be sure to verify that the spray pattern formed by the tip is compatible with your spray boom. Some manufacturers offer simple adapters that can be utilized to adjust the orientation/position of the tip for optimum performance.



Fertilizer Nozzle Spray Patterns




SECTION FOUR

SELECTING THE RIGHT SPRAY NOZZLE

To find the right spray nozzle, ask yourself these questions:

1. What are you spraying?
2. How are you spraying?
3. What is your tolerance to drift?
4. What is the weight of the spray solution?
5. What is the pressure range of the sprayer?
6. What is the nozzle spacing on the boom?
7. What is the boom height?
8. Which nozzle material is best?
9. Who is the nozzle manufacturer and why does it matter?



There is a reason why there are dozens of different nozzle types available in hundreds of different sizes, capacities and materials. Each nozzle is designed to yield very specific performance based on what you're spraying, when you're spraying and how you're spraying.

It may be tempting to overlook the role spray nozzles can have in the overall success of your spraying season simply because they are a small, relatively low-cost component. However, a poor choice in spray nozzles or the use of under-performing nozzles, can lead to re-spraying or reduced performance – two problems no user should face.

Giving serious consideration to your spraying objectives and studying your options shouldn't be shortchanged. It's a small time investment that will help maximize your success. Start by reviewing your spraying requirements and be prepared to have multiple nozzle sets on hand to meet your varying needs.

1. What are you spraying?

Herbicides, fungicides or insecticides — for soil incorporated, pre-emergence or post-emergence? If post-emergence, contact or systemic? Is it a wettable powder, emulsifiable concentrate or flowable? Will two or more chemicals be used in combination?



2. How are you spraying?

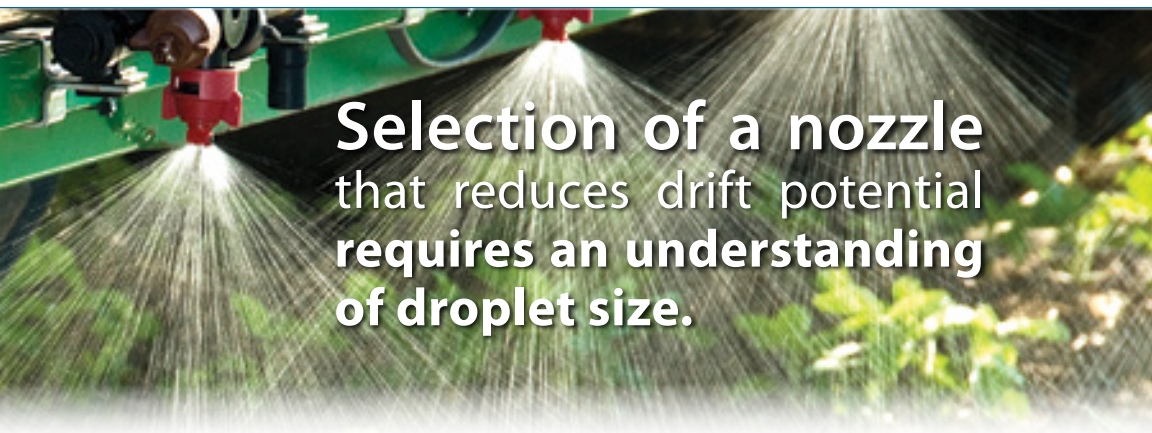
- Broadcast?
- Banded?
- Directed?
- Mechanical air assisted?

The answers to these basic questions will get you started. Consult the charts at the end of Section Four for recommended nozzle types. Another good source of information on nozzle type is the pesticide label. In addition to information on recommended nozzle types, many chemical labels include information on gallons per acre (GPA) or liters per hectare (l/ha), nozzle spacing and droplet size recommendations.

3. What is your tolerance to drift?

If you answer yes to any of the following questions, you may want to consider low drift nozzles.

- Will you be applying near any residential areas?
- Do you spray in an area with different, adjacent crops or ornamentals?
- Do the adjacent crops have different herbicide tolerant genetics and/or will spray drift result in crop damage?
- Are you concerned about the impact your spraying may have on the environment?
- Have you had a drift complaint in the past?
- Do time constraints require you to spray under less than ideal conditions?



Selection of a nozzle that reduces drift potential requires an understanding of droplet size.

The correlation between droplet size and drift

All nozzles produce a range of droplet sizes within the given spray pattern. To measure the range of droplets produced by a nozzle, three measurements are generally used.

- $D_{v0.1}$ is a value where 10% of the total volume of liquid sprayed is made up of droplets with diameters smaller or equal to this value. For example, if the $D_{v0.1}$ is listed as 100 microns, this means that only 10% of the volume of the spray is contained in droplets smaller than 100 μ (microns). The other 90% of the volume of the spray is contained in droplets larger than 100 μ .
- $D_{v0.5}$ also known as VMD, is a value where 50% of the total volume of liquid sprayed is made up of droplets with diameters larger than the median value and 50% smaller than the median value. For example, if the VMD is listed as 250 μ , this means that 50% of the volume of the spray is in droplets both larger and smaller than 250 μ .
- $D_{v0.9}$ is a value where 90% of the total volume of liquid sprayed is made up of droplets with diameters smaller or equal to this value. For example, if the $D_{v0.9}$ is listed as 500 μ , this means that 90% of the volume of the spray is contained in droplets 500 μ or smaller. Only 10% of the volume is contained in droplets larger than 500 μ .

Be sure to verify which standards are being used when reviewing droplet size classification data. BCPC (formerly known as British Crop Protection Council) specifications and ASABE standard S572.1 are the leading standards for compliance.

Droplet size classification information is provided by nozzle manufacturers for products at varying pressures. Chemical labels also use this classification system to indicate proper product usage and ensure efficacy.

Drift studies

Drift has become a topic of great interest in recent years and many studies have been conducted to document drift potential of different types of nozzles at varying operating pressures. However, drift studies can be difficult and costly to conduct and there are several different methodologies in use. The methodology influences the results so it is very important to understand these differences if you are comparing drift data from different manufacturers or studies from different research groups. Direct comparisons should not be made between:

- **Field studies** – They are costly and difficult to conduct, but the data from these studies is considered the most reliable since actual spraying conditions are tested.
- **Lab studies** – They use various collection devices and dye concentrations. This technique uses various sophisticated collection devices in a lab setting that replicates field spraying as precisely as possible.
- **Wind tunnel testing** – Uses water sensitive paper to collect and observe drift. The use of wind tunnels and water sensitive paper is the least accurate and clear guidelines for accuracy and repeatability do not exist.

When evaluating drift data, it is important to read the entire test report. Some companies can selectively extract information to make their spray nozzles look better and/or make invalid comparisons across various nozzle types.



**Wind Tunnel
for Drift Studies**

Key drift concepts

If you've determined that drift is a concern, keep these concepts in mind:

- Weather conditions, sprayer set-up and nozzle choice are the most important influences on drift.
- Reduce the proportion of small droplets in the spray. This can be achieved by using spray nozzles that produce coarse droplets at the intended operating pressure.
- Protect the spray from wind by adjusting boom height and shrouding. Lower boom heights are usually recommended to reduce drift. Shrouds, cones and other protective shields can also reduce drift but can be costly and may not fit all sprayers.
- Dilute the spray solution if the chemical label allows it. Use of higher carrier volumes reduces drift by necessitating the use of larger nozzles to apply the higher volumes, which results in a less drift-prone spray. Plus, the spray solution is more dilute at the higher volume so the drift will contain less active ingredient and have less potential for damage.
- Select the appropriate nozzle for your travel speed. Higher travel speeds typically require the use of larger flow rate nozzles that generate coarser sprays and reduce drift potential.
- Consider the active ingredients in your herbicides and insecticides and adjust accordingly to minimize vapor and spray drift.
- Larger droplets do reduce drift potential. However, larger droplets can negatively impact product effectiveness. Insecticides, fungicides and contact herbicides with little or no systemic activity usually require small droplets to ensure thorough coverage. Systemic materials that move within plants can use larger droplets.

General guidelines:

- **Fine, Medium & Coarse Droplets** – Use for post-emergence contact applications that require excellent coverage on leaf surfaces including herbicides, fungicides and insecticides.
- **Coarse & Very Coarse Droplets** – Use for contact and systemic herbicides, insecticides, and fungicides.
- **Very Coarse, Extremely Coarse & Ultra Coarse Droplets** – Use for systemic herbicides, pre-emergence surface applied herbicides and when working in highly sensitive areas.
- Droplet size will vary based on pressure. In general, the smaller the nozzle size and the greater the spray pressure, the smaller the droplets and the greater proportion of driftable droplets.
- A larger capacity nozzle will produce more coarse droplets.
- Spray for the situation at hand. Crop conditions, pest conditions, and weather conditions can dramatically impact the performance of the applied product.
- ALWAYS consult the chemical label for the manufacturers application and droplet size recommendations before applying.

4. What is the weight of the spray solution?

Tabulations in spray nozzle catalogs are based on spraying water that weighs 8.34 pounds per U.S. gallon or 1 kilogram per liter. Use conversion factors (FIGURE 12) when using solutions heavier or lighter than water. Multiply the desired GPM or GPA (l/min or l/ha) of solution by the water rate conversion factor. (FIGURE 13) Then use the converted GPM or GPA (l/min or l/ha) to select the proper size nozzle.

$$\begin{array}{l} \times \quad \frac{\text{GPA (solution)}}{\text{Conversion Factor}} \\ \hline \text{GPA (water)} \\ \\ \times \quad \frac{\text{l/ha (solution)}}{\text{Conversion Factor}} \\ \hline \text{l/ha (water)} \end{array}$$

FIGURE 12:
Density conversion formulas

Pounds per Gallon	Kilograms per Liter	Conversion Factor
7.0 lb/gal	0.84 kg/l	0.92
8.0 lb/gal	0.96 kg/l	0.98
8.34 lb/gal	1.00 kg/l (water)	1.00
9.0 lb/gal	1.08 kg/l	1.04
10.0 lb/gal	1.20 kg/l	1.10
10.65 lb/gal	1.28 kg/l (28% Nitrogen)	1.13
11.0 lb/gal	1.32 kg/l	1.15
12.0 lb/gal	1.44 kg/l	1.20
14.0 lb/gal	1.68 kg/l	1.30

FIGURE 13:
Density conversion tables



5. What is the pressure range of the sprayer?

Always operate any nozzle in the middle of its recommended operating range for best performance. Sizing nozzles in the middle of the sprayer pressure range offers more flexibility for adjustments in speed or changes in the terrain, especially when using an automatic rate controller. Reducing spray pressures below the rated minimum will result in poor spray patterns.

6. What is the nozzle spacing on the boom?

The nozzle size you need depends on many factors including the desired application rate, ground speed and nozzle spacing. For each nozzle type and spray angle, the manufacturer recommends proper spray heights and nozzle spacing. Nozzle spacing of 20" (50 cm) and 30" (75 cm) are most common. This information may also be available on the chemical label.

7. What is the boom height?

Lower boom heights are usually better as long as proper overlap of spray nozzles is achieved. In general, nozzles with 110° fan angles can be used at lower boom heights than 80° fan angles. Lower boom heights reduce drift and improve coverage. Higher boom heights increase nozzle overlap and can help maintain good pattern uniformity for low drift nozzles.

8. Which nozzle material is best?

To determine the best material for your application, you need to know what chemicals you will be spraying and what you perceive to be an acceptable wear life (spray hours) for your nozzles. It may be advantageous to choose nozzles in wear-resistant materials. The initial cost may be higher, but the longer life will offset the cost in the long run. Also, depending on your application requirements, you may need different types of spray nozzles in different materials.

Note: Do not mix nozzle types or materials on a boom. Always equip a boom with identical nozzles.



Material selection guidelines:

- Wear-resistant materials such as ceramic maintain a constant flow rate over a longer period of use.
- Brass materials wear quickly. A brass nozzle may have an increase in flow of 10-15% after 50 hours of use, depending on what product is being sprayed.
- Plastic material with stainless steel or ceramic inserts cost less than solid stainless steel and will last longer than brass.
- Plastic can, in some cases, be more fragile than other materials and can be damaged more easily. However, with advancements in manufacturing technique and with proper care, the life expectancy of plastic nozzles can be quite good. In fact, with some nozzle designs, plastic nozzles can wear as long as, if not longer than, stainless steel.
- Stainless steel will last longer than brass.
- Ceramic will last the longest.

Comparing wear life of nozzle materials:

- **Plastic** – two to three times longer than brass, four to six times longer than brass with some plastic nozzle designs.
- **Stainless steel** – four to six times longer than brass.
- **Ceramic** – 20 to 50 times longer than brass.

9. Who is the nozzle manufacturer and why does it matter?

Once again, because spray nozzles are so small, it may be easy to think of them as simple components. However, spray nozzles are highly engineered, precision components and consideration should be given to the manufacturer and the manufacturer's capabilities. Here's a list of credentials to look for:

Focus on agricultural and turf spray technology – Is the manufacturer focused on spray nozzles and related equipment? Is spray nozzle manufacturing a core competency or just a “supplemental” offering? Manufacturers committed to the industry will invest more in research and development, quality control and support than those producing spray nozzles as an auxiliary or secondary item.

Experience, expertise and a willingness to share – The manufacturer should have a proven track record in the industry – preferably spanning decades. The company should also demonstrate its understanding of the technology and changing trends by introducing new products on a regular basis.

Does the company share its knowledge and invest in making you a savvy customer? Catalogs, technical publications, and company web sites should do more than sell you products – they should help you improve quality and efficiency in application of your crop protection products.





Size – How many spray nozzles does the manufacturer produce annually? How much manufacturing space is dedicated to spray nozzle production? These are often good indicators of quality. Manufacturers producing low quality nozzles won't have the same level of demand as those producing superior products.

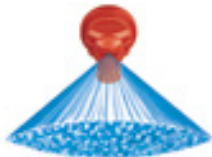
Commitment – Is the manufacturer actively involved in the international spray community? Does it participate in conferences and technical committees? Does it conduct research and share the findings with the industry to advance spray technology? All of these items indicate a long-term commitment to the industry and the environment – both of which provide value to you.

Selecting The Right Spray Nozzle

	Herbicides			
	Soil Incorporated	Pre-Emergence	Post-Emergence	
			Contact	Systemic
Extended Range Flat Spray			Excellent	Good
Wide Angle Pre-orifice Flat Spray	Good	Good	Very Good	Very Good
Air Induction Flat Spray	Very Good	Very Good	Good	Excellent
Low Pressure Air Induction Flat Spray	Excellent	Excellent		Excellent
Twin Flat Spray			Excellent	
Pre-orifice Twin Flat Spray	Good	Good	Excellent	Excellent
Air Induction Twin Flat Spray	Very Good	Very Good	Good	Excellent
Wide Angle Pre-orifice Flood Spray	Excellent	Excellent		Very Good



Extended Range Flat Spray



Wide Angle Pre-orifice Flat Spray



Air Induction Flat Spray



Low Pressure Air Induction Flat Spray

Selecting The Right Spray Nozzle

Fungicides		Insecticides		Drift Management
Contact	Systemic	Contact	Systemic	
Excellent	Good	Excellent	Good	Good
Very Good	Very Good	Very Good	Very Good	Very Good
Good	Excellent	Good	Excellent	Excellent
	Excellent		Excellent	Excellent
Excellent		Excellent		
Excellent	Excellent	Excellent	Excellent	Very Good
Good	Excellent	Good	Excellent	Excellent
	Very Good		Very Good	Very Good



Twin Flat Spray



Pre-orifice Twin Flat Spray



Air Induction Twin Flat Spray



Wide Angle Pre-orifice Flood Spray

Selecting The Right Spray Nozzle

		Herbicides		
		Pre-Emergence	Post-Emergence	
			Contact	Systemic
Banding	Even Air Induction Flat Spray	Excellent	Good	Excellent
	Even Flat Spray	Good	Very Good	Good
	Twin Even Flat Spray		Excellent	
Directed Spraying	Even Air Induction Flat Spray		Good	Excellent
	Even Flat Spray		Good	Good
	Twin Flat Spray		Very Good	
	Air Induction Flat Spray		Good	Excellent
	Hollow Cone Spray		Excellent	
	Air Induction Hollow Cone		Good	Excellent
Mechanical Air Assisted	Hollow Cone Spray		Excellent	Good

Fungicides		Insecticides	
Contact	Systemic	Contact	Systemic
Good	Excellent	Good	Excellent
Very Good	Good	Very Good	Good
Excellent		Excellent	
Good	Excellent	Good	Excellent
Good	Good	Good	Good
Very Good		Very Good	
Good	Excellent	Good	Excellent
Excellent		Excellent	
Good	Excellent	Good	Excellent
Excellent	Good	Excellent	Good



Even Flat Spray



Even Air Induction Flat Spray



Twin Even Flat Spray



Hollow Cone Spray



Air Induction Hollow Cone Spray

SECTION FIVE

CONSULT THE EXPERTS

This booklet is filled with a tremendous amount of actionable information. Its goal is to educate you and guide you through the spray nozzle selection process so you make the best decision possible. However, the process is complex because there are so many variables. It is recommended you consult with spray nozzle experts for assistance during the selection process to validate your decision.

Local resources

University and county extensions are always willing to help. Tap into their personnel and request recent publications on spraying equipment. These agencies have no manufacturer bias.

Third-party research

Broaden the scope of your knowledge. There are several respected researchers in the field that publish technical data on a regular basis. Ask your local university extension for additional information or consider researching on the Internet. <http://www.asabe.org> has a variety of helpful articles available.



Government sources

State agricultural departments as well national and international departments shouldn't be overlooked. Below is a list of a few of the many additional institutions who all have information to share.

The Spray Drift Task Force (<http://www.agdrift.com/>)

The Environmental Protection Agency (<http://www.epa.gov/>)

The United States Department of Agriculture (<http://www.usda.gov/>)

Chemical and spray nozzle manufacturers

These companies can be a good source of information. However, it is important to remember their goal is to have you purchase their products, so watch for bias. Several companies do invest in customer education for the betterment of the industry, but carefully scrutinize manufacturer-sponsored research. Manufacturers typically don't publish research unless it presents their products in a positive fashion.



SECTION SIX

MAKING MAINTENANCE A PRIORITY

Crop protection products can only be effective if applied properly. That means selecting the proper spray nozzle and then ensuring optimal performance. Sounds simple enough, right? But in reality, ensuring proper spray nozzle performance can be challenging. Here's why.

Spray nozzles don't last forever. Yet it is extremely difficult to detect wear because it may not be visible. Spray nozzle wear of 10, 20 or even 30% won't be visible. Special optical equipment would be required to actually see changes in the orifice size. So rather than relying on visual inspection, you should compare the flow rate from a used nozzle with the flow rate from a new nozzle of the same size and type.

- Check the flow rate by using a graduated collection container, a timing device and a pressure gauge mounted at the nozzle.
- Compare flow rates. If the flow from the used nozzle is 10% greater or more, replace it.
- A 10% over application of chemical on a twice-sprayed 1000 acre (247 ha) farm could represent a loss of \$2,000 to \$10,000 (USD) based on current chemical costs. This number doesn't take into account fuel, machinery wear and tear, time/labor or crop damage.

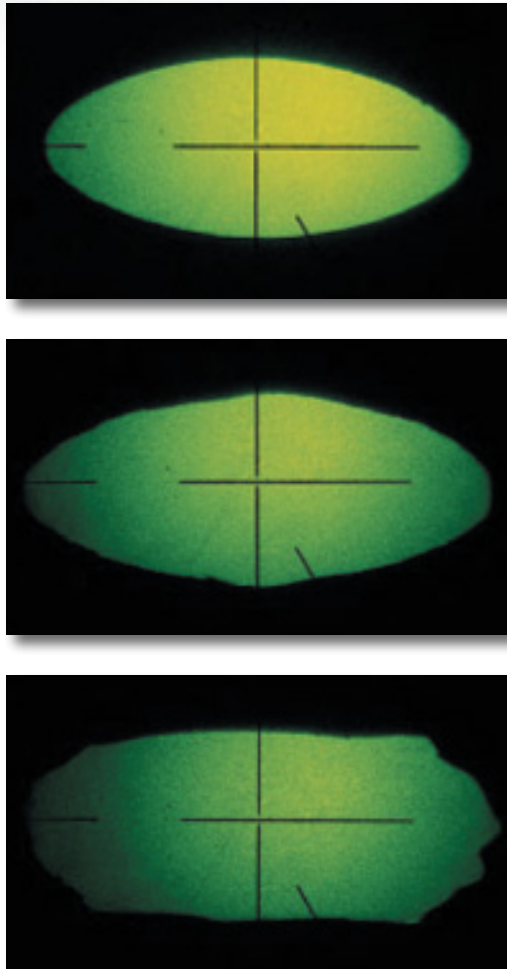
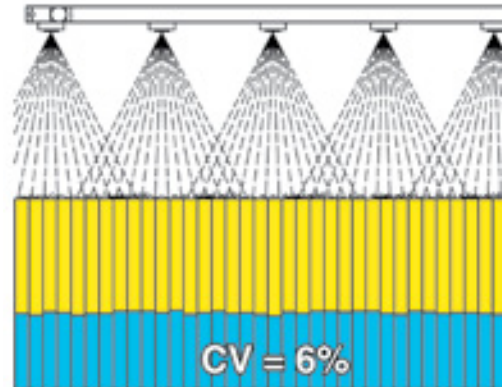


FIGURE 14:
An inside look at nozzle orifice wear and damage.
New nozzle (top), worn nozzle (middle) and damaged nozzle (bottom).

- If you feel your spray nozzles are wearing quickly, consider upgrading to longer wearing materials.
- Prior to replacing spray nozzles due to wear, it is critical to keep them in good working order. Variations in spray distribution, droplet size or flow rate can reduce the effectiveness of the application.
- It is important to clean clogged spray nozzles properly. Use a soft-bristled brush or compressed air for cleaning. Do not use metal objects under any circumstances.
- Use extreme care with softer tip materials such as plastic.
- Be sure to use adequate filtration and properly sized strainers to minimize clogging.

The coefficient of variation

is a statistical method used throughout the world for determining spray uniformity of nozzles across a spray boom.



NEW SPRAY TIPS

Produce a uniform distribution when properly overlapped.

What is Cv? Coefficient of Variation is what it stands for. The Cv is a statistical method used throughout the world for determining spray uniformity of nozzles across a spray boom. The lower the Cv value, the better the distribution quality. For extremely uniform distributions the Cv can be less than or equal to 7%. In some countries, nozzles must conform to very strict Cv specifications, while other countries require annual sprayer distribution testing. These stipulations emphasize the importance of distribution quality and its impact on chemical effectiveness. See the chart below for more information.

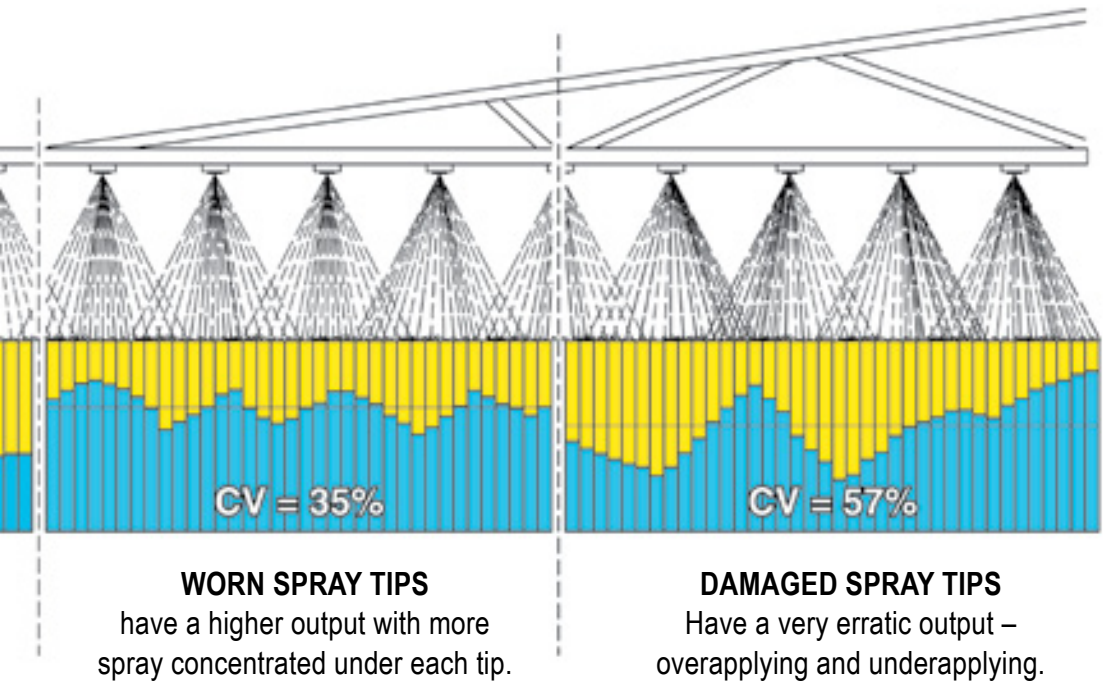


FIGURE 15:
The Coefficient of Variation

SECTION SEVEN

SPRAYER CALIBRATION ENSURES OPTIMAL PERFORMANCE

You may think you're ready to spray, but you need to calibrate your sprayer. The time investment is well worth it as it can help you avoid a re-spray.

Start by measuring your travel speed

While GPS speed sensors have become increasingly popular and are very reliable, many machines are still equipped with traditional speed sensors that may need calibration. To check your tractor/sprayer speed see how long it takes you to travel down a 100 ft (30.5 m) or 200 ft (61 m) strip, FIGURE 16 gives some commonly used speeds.

- Do your test in the area to be sprayed or an area with a similar surface and select the engine throttle setting and gear that will be used when spraying.
- Fence posts or other permanent devices can be used as markers.
- The starting point should be far enough away to permit your tractor or sprayer to reach the desired spraying speed.
- Hold that travel speed between markers.
- Most accurate results will be achieved with the spray tank half full.
- Calculate your real speed (FIGURE 17).

Speed MPH	Time Required in SECONDS to Travel a Distance of:			Speed km/h	Time Required in SECONDS to Travel a Distance of:			
	100 ft	200 ft	300 ft		30 m	60 m	90 m	120 m
1.0	68	136	205	5	22	43	65	86
1.5	45	91	136	6	18	36	54	72
2.0	34	68	102	7	15	31	46	62
2.5	27	55	82	8	14	27	41	54
3.0	23	45	68	9	—	24	36	48
3.5	19	39	58	10	—	22	32	43
4.0	17	34	51	11	—	20	29	39
4.5	15	30	45	12	—	18	27	36
5.0	14	27	41	13	—	17	25	33
5.5	—	25	37	14	—	15	23	31
6.0	—	23	34	16	—	14	20	27
6.5	—	21	31	18	—	—	18	24
7.0	—	19	29	20	—	—	16	22
7.5	—	18	27	25	—	—	13	17
8.0	—	17	26	30	—	—	—	14
8.5	—	16	24	35	—	—	—	12
9.0	—	15	23	40	—	—	—	11

FIGURE 16:
Speeds

$$\text{Speed (MPH)} = \frac{\text{Distance (ft)} \times 60}{\text{Time (s)} \times 88}$$

$$\text{Speed (km/h)} = \frac{\text{Distance (m)} \times 3.6}{\text{Time (s)}}$$

FIGURE 17:
Calculate Speeds

Travel speed tips

In general, slower speeds are better and produce more consistent results. Faster speeds reduce canopy penetration, increase dust and may cause drift problems. In addition, faster speeds may require larger nozzles that produce a coarser droplet which may reduce target coverage. Furthermore, they may result in vertical and horizontal boom movement which can negatively impact overall coverage.

Record the following information

- Nozzle type on your sprayer – all nozzles must be identical
- Recommended application volume
- Measured sprayer speed
- Nozzle spacing

Calculate the required nozzle output

See the chemical label to ensure you apply the right volume. Then, use the travel speed of your sprayer to calculate nozzle flow rate (FIGURE 18).

Set the correct pressure

- Turn your sprayer on and check for leaks.
- Clean nozzles and strainers as needed.
- Replace one nozzle and strainer with an identical new nozzle and strainer.
- Use conversion factors (Section Four) to determine the target flow rate if the weight of the spraying solution is different than the weight of water.
- Determine the pressure required to deliver the nozzle flow rate calculated earlier.
- Turn sprayer on; adjust pressure.
- Collect and measure the volume of the spray from the new nozzle into a collection container. Fine-tune pressure until you collect your desired flow rate in GPM (l/min).

$$\text{GPM} = \frac{\text{GPA} \times \text{MPH} \times W}{5,940}$$

GPM = the nozzle flow rate in gallons per minute

GPA = application rate in gallons per acre

MPH = the ground speed in miles per hour

W = the nozzle spacing in inches for broadcast spraying

$$\text{l/min} = \frac{\text{l/ha} \times \text{km/h} \times W}{60,000}$$

l/min = the nozzle flow rate in liters per minute

l/ha = application rate in liters per hectare

km/h = the ground speed in kilometers per hour

W = the nozzle spacing in centimeters for broadcast spraying

FIGURE 18:
Nozzle output formulas

Check your system

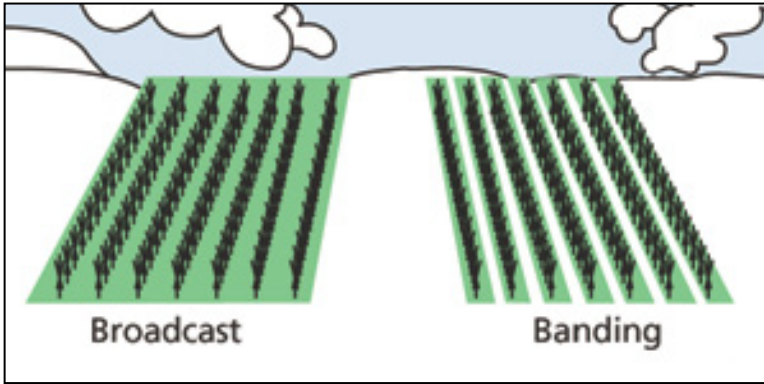
- Check the flow rate of a few nozzles on each boom section.
- If the flow rate of any nozzle is 10% greater or less than the new nozzle, recheck the output.
- If only one nozzle is faulty, replace with a new nozzle (and strainer, if necessary).
- If a second nozzle is faulty, replace all nozzles on the entire boom. Replacing only a couple of worn nozzles could cause distribution problems.

Broadcast versus banding and directed applications

The instructions just presented are for calibrating a sprayer for a broadcast application. For banding or directed applications, change the value of “W” in the formula.

- For single nozzle banding or boomless applications:
W = sprayed band width or swath width in inches or centimeters.
- For multiple nozzle directed applications: W = row spacing in inches or cm divided by the number of nozzles per row.

Use care when calculating for banding or directed applications. Make sure to read the chemical label carefully and understand the rate that is specified. Rates can be specified as Field Acres (Field Hectares) or Treated Acres (Treated Hectares), see FIGURE 19.



Field Acres or Hectares =

Total Acres (Hectares)
of area to be sprayed

Treated Acres or Hectares =

$$\text{Field Acres (Hectares)} \times \frac{\text{Band Width (in or cm)}}{\text{Row Spacing (in or cm)}}$$

FIGURE 19:
Formulas for Broadcast or Banding

SECTION EIGHT

FUTURE TRENDS IN SPRAYING AND NOZZLE TECHNOLOGY

New challenges lie ahead in the world of spraying. Thankfully, new advancements in spray technology are coming online to make those challenges more manageable. We'd like to use this final chapter to discuss these opportunities.

Herbicide Resistance and Next Generation Cropping Systems

The extensive use of a fixed set of herbicides (such as glyphosate) and herbicide tolerant cropping systems has led to the emergence of numerous herbicide resistant weeds. These weed escapes can have costly consequences for your operation if not managed properly and aggressively. According to www.weedscience.org there are now 220 weed species that have developed herbicide resistance. This problem is not limited to a single weed, a single herbicide, single crop or a single geographic region. While it may be true that your particular operation has not yet been a victim of this growing problem you should still be prepared to address this challenge. The global seed and chemical industry is developing and launching the next generation of herbicides and cropping systems to address this problem. With this broader range of chemicals and herbicide resistant genetics comes the need for improved spraying management and smarter spray nozzle selection. Products such as 2,4-D, glyphosate, glufosinate, dicamba and others have different modes of action and different potential for drift. This means that proper droplet size management and proper tip selection will be more important in upcoming years, perhaps more important than it has been in a generation. As a producer or applicator you must make the best application decisions possible.

As a nozzle manufacturer we must provide you the tools and information to make informed, effective decisions. Read on to learn more about these exciting, new technologies.

Droplet Size Monitoring

Nozzle manufacturers, chemical manufacturers and third party research institutes continue to invest heavily in the analysis of spray tip performance and droplet size measurement. Up to now, print and web-based sources have provided growers access to this critical droplet size information, while chemical labels continue to provide more complete application recommendations. However the burden is still on the applicator to ensure that their sprayer is delivering the proper droplet size during the actual spray application. New generation sprayer controls and GPS guidance systems are now incorporating real-time, in-cab droplet size reporting and recording capabilities. As you investigate new technologies for your operation consider selecting products with this valuable feature.

Category	Symbol	Color Code
Extremely Fine	XF	Blue
Very Fine	VF	Red
Fine	F	Orange
Medium	M	Yellow
Coarse	C	Light Blue
Very Coarse	VC	Green
Extremely Coarse	XC	White
Ultra Coarse	UC	Black

FIGURE 20:
Droplet Size Categories



FIGURE 21:
Droplet Size Monitor

Tip Flow Monitoring

A spray nozzle is only as good as the product coming out of it, provided something is indeed coming out of it at all. A familiar trend continues in the world of sprayers—machines are getting larger, are being operated at higher speeds, and run for more hours per day. These factors can make it more difficult to detect problems with your spray tips during operation. It also means a problematic spray tip can cause more problems across more acres faster than ever. The technology is available today to precisely measure the flow rate through every tip mounted on the spray boom and provide instant feedback to the operator of a malfunction caused by a plugged, damaged or missing spray tip. Monitoring systems like this can greatly reduce the likelihood of localized under- or over-application which, in addition to environmental concerns, can lead to yield loss, chemical waste and reduced profitability. Consider what individual tip flow monitoring technology may mean for your operation and for your peace of mind.



FIGURE 22:
Individual Tip Flow Meter

Pulse Width Modulation Control Systems

When spraying, your goal is to eliminate pests, increase crop yields and maximize your profits. The agronomic efficacy of your crop protection application and the field efficiency of your sprayer/labor are critical for success. New generation sprayer control systems are being offered today that incorporate pulse width modulation (PWM) technology. This technology uses individual tip solenoid shutoffs which oscillate between open and closed several times per second. By varying the amount of time the nozzle is “on” versus “off”, known as duty-cycle, the operator is able to vary flow rate through the nozzle independent of boom pressure. In other words, droplet size and flow rate through a single tip can be controlled independently of each other. PWM technology offers two key benefits depending on how you choose to use it. First it allows the operator to adjust the “size” of your spray tip from the seat of the cab allowing you to maintain your target application rate across a wider range of ground speeds. Secondly, it allows you to select the most appropriate droplet size for your application and maintain this droplet size across a wider range of ground speeds. As a sprayer operator this means you can potentially cover more acres per day while maintaining a more consistent application rate and droplet size, resulting in improved pest control and crop yields.

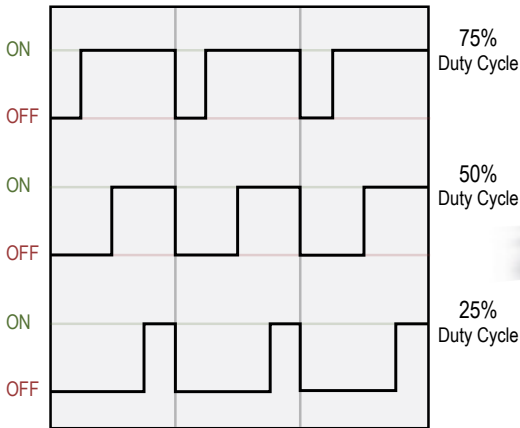


FIGURE 23:
PWM Duty Cycle



FIGURE 24:
PWM Equipped Nozzle Body


Mobile Apps

A wide range of mobile apps related to spraying are available today. Consult your app store regularly to see what new, and often times free, tools are available.

A few worth investigating include:

- **TeeJet Spray Select** – provides recommended nozzle and operating pressure based on ground speed, tip spacing, target rate & droplet size requirements
- **Ground Spray** – provides droplet size data for a wide range of spray tips spraying water or active ingredient
- **Mix Tank** – provides the proper sequence for adding various active ingredients into tank mixes
- **Calibrate My Sprayer** – used to assist in calibrating sprayers when doing a volume collection test.



A red spray nozzle is shown in the upper left corner, spraying a wide, fan-shaped stream of water. The water droplets are captured in motion, creating a soft, misty effect. The background is a solid, deep blue color. The text is overlaid on the right side of the image.

Parting Thoughts. As you can see, there are many considerations when selecting spray nozzles. In the whole scheme of things, nozzle selection may not seem that important. However, when you consider the cost of putting a crop in the ground each year, the investment in proper nozzle technology is quite small and can generate significant returns. We urge you to study this guide, give thoughtful consideration to the nozzles you use, and wish you the best of luck for long-term success in your operation.


For more information, please visit: www.teejet.com



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