Smithco

ILLUSTRATED GUIDE TO TURF SPRAYING

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INTRODUCTION

This guide is intended to offer practical guidelines for the distribution of liquid chemicals over an area of turfgrass such as golf courses, parkland, school grounds and lawns. It offers two procedures for Boom Sprayer Calibration. There are other proven procedures available. Smithco makes no representation as to the suitability of any procedure or product for any particular situation.

This Guide is suitable for self-propelled Spray Vehicles, sprayers towed by vehicles and tractors or sprayers mounted onto vehicles.

This guide is intended to be used in conjunction with:

1. The Sprayer Owners Manual
2. The Spray Boom Owners Manual
3. The Electronic Spray Control System Owners Manual (if the sprayer is so equipped)
4. It may also be useful to the user to refer to the catalogs produced by nozzle manufacturers (Spraying Systems Co., TeeJet and others)

SAFETY PRECAUTIONS

Persons engaged in the handling, preparation or application of chemicals must follow accepted practices to insure the safety of themselves and others.

- WEAR protective clothing including: gloves; hat; respirator, eye protection and skin covering suitable for protection from chemicals being used.

- BATHE thoroughly after any exposure to chemicals, giving particular attention to eyes, nose, ear and mouth.

- CLEAN equipment and materials in accordance with employer, municipal and state regulations, using only approved areas and drains.

- DISPOSE of chemicals and rinse solutions by approved and legal methods

- PROVIDE methods and materials for operators to wash eyes and hands immediately during the spraying process.

- PROVIDE methods and materials for control, safe dilution & neutralization of chemical spills during preparation, spraying, transporting and clean up.

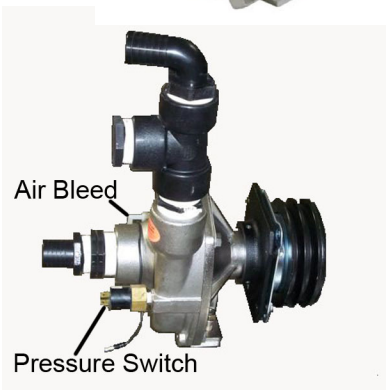
APPLICATION

A. – PUMPS USED FOR SPRAYING TURF

The type of pump selected for the spraying is usually the determining factor in selecting pressure variables used in spraying tasks.
Most dedicated spray vehicles (e.g., Smithco Spray Star 2000 & 3180, Toro Multipro 1100 & 5500) are fitted with *Centrifugal* pumps. These are known as high volume/low pressure pumps. Typically 60-70 gallons of flow per minute at pressures up to 100 PSI.

Positives

1. They are relatively inexpensive.
2. Easy to replace and rebuild.
3. Can be pumped against a closed system, as they will bypass within the volute.
4. Has a relatively small size to fit in many places.
5. Requires little horsepower to run.
6. Can use less expensive hydraulic agitation due to high flow rates.
7. 316 Stainless Steel for no corrosion.
8. Pressure Switch port, when pump gets low pressure, buzzer on dash will ring.
9. Air bleed port, to eliminate air lock.
10. Life Guard silicon carbide seals standard.



Negatives

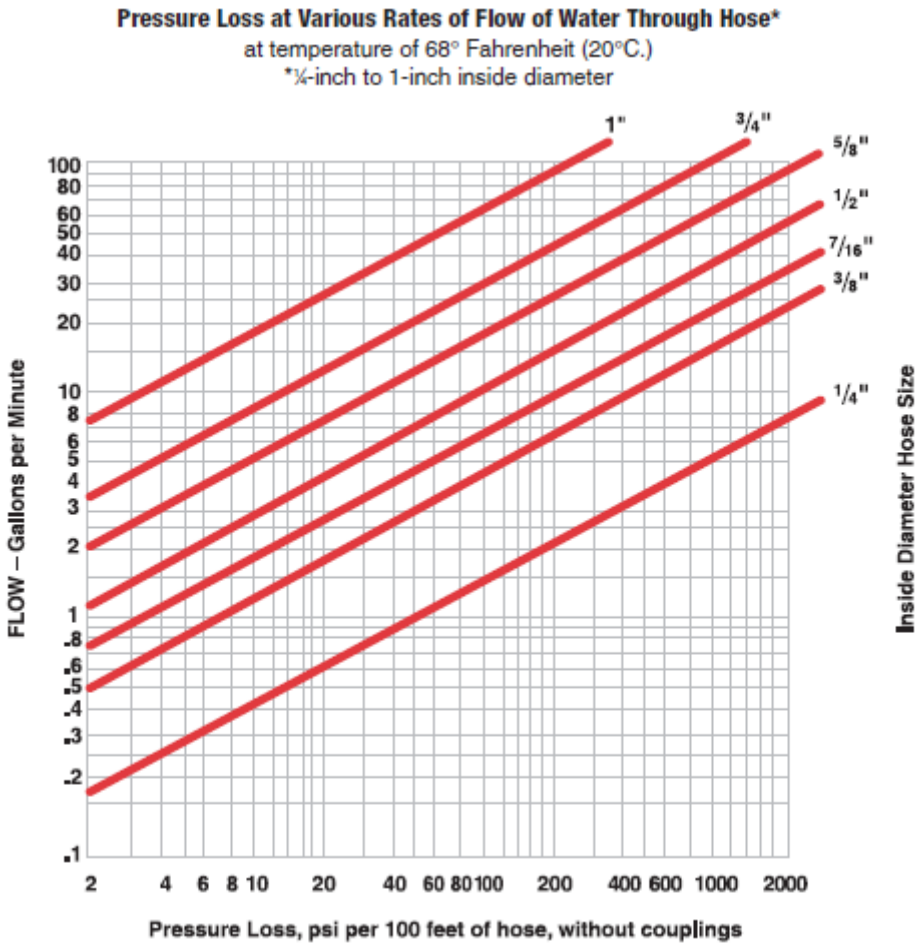
1. All the material pumped passes through the heart and critical components, so wear can be a factor if a lot of abrasives (wetable powders) are used.
2. Considered a “throw-away” pump by a lot of end users.
3. Low Pressure means it cannot be used in some applications.

		You can use these pump types:				
If your power source is:		**Roller**	**Centrifugal**	**Turbine**	**Diaphragm**	**Piston**
540 rpm PTO	direct coupled:	✓			✓	✓
	through gear drive:		✓			
	through belt/pulley:		✓			
1000 rpm PTO	direct coupled:	✓				
	through gear drive:		✓	✓		
	through belt/pulley:		✓			
Hydraulic Motor		✓	✓			
12 Volt DC Motor		✓			✓	✓
Gas Engine	direct coupled:	✓	✓			
	through gear reduction:	✓			✓	✓
	through belt/pulley:	✓	✓		✓	✓
Electric Motor	direct coupled:	✓	✓			
	through belt/pulley:	✓	✓		✓	✓

B. - HOSE AND HANDGUN SPRAYING

A hand gun (or hand-nozzle or hand-lance) is used to control and direct the spray pattern to the ground, shrub or tree. They must be constructed of long lasting and non-corrosive materials such as brass, stainless and aluminum
The hand gun fits to a hose of any length from the sprayer allowing operator mobility. The hose should be as short as possible while still permitting operator mobility.

Liquid loses pressure due to friction as it travels through the hose, from 1 to 3 PSI for each foot (30 cm) of hose length.



For most hand gun chemical spraying, 40 psi at the nozzle is typical. To properly select a pump that can deliver the right nozzle pressure, you must consider the normal pressure drop that occurs within the length of hose. The amount of pressure drop through the hose depends on the hose length, hose diameter and flow rate. For example, as the chart shows, 300' of ½" hose, spraying at 6 gpm, will have a pressure drop of approximately 120 psi. That means you need a pump delivering at least 160 psi in order to ensure 40 psi a the nozzle.

Note: When determining the total pump pressure requirement for high tree spraying, you must also consider the spray height/reach you need to attain. Generally, pumps of up to 700 psi are used for this purpose. (see chart below)

Desired pressure at gun nozzle: _____ psi
Hose pressure loss: + _____ psi
TOTAL PUMP PRESSURE NEEDED: = _____ psi

Gun Position	Orifice Size	Performance	Pressures (psi)						
			200	300	400	500	600	700	800
VERTICAL	10	Flow (GPM)	5.2	7.2	8.2	9.5	10.3	11.5	12.1
		Throw (ft.)	25.0	27.0	29.0	32.0	34.0	36.0	36.0
	20	Flow (GPM)	10.1	12.6	14.6	16.3	17.6	19.1	20.3
		Throw (ft.)	34.0	42.0	46.0	48.0	48.0	46.0	46.0
	30	Flow (GPM)	15.4	22.0	23.2	24.3	26.7	29.0	30.6
		Throw (ft.)	33.0	38.0	46.0	46.0	48.0	55.0	55.0
	40	Flow (GPM)	20.8	25.6	29.6	32.9	35.8	38.8	41.3
		Throw (ft.)	48.0	48.0	53.0	53.0	57.0	57.0	55.0
	50	Flow (GPM)	25.0	31.0	35.4	39.7	43.3	46.8	50.1
		Throw (ft.)	55.0	62.0	67.0	70.0	71.0	73.0	75.0
HORIZONTAL	10	Flow (GPM)	6.0	7.4	8.6	9.6	10.5	11.3	12.1
		Throw (ft.)	41.0	43.0	48.0	50.0	51.0	44.0	42.0
	20	Flow (GPM)	12.8	14.0	15.3	16.8	18.0	18.8	20.0
		Throw (ft.)	40.0	55.0	57.0	58.0	58.0	63.0	63.0
	30	Flow (GPM)	17.0	20.3	22.5	24.5	27.0	29.3	31.0
		Throw (ft.)	56.0	59.0	60.0	64.0	66.0	65.0	69.0
	40	Flow (GPM)	23.0	27.0	31.0	34.0	36.8	39.3	41.0
		Throw (ft.)	57.5	63.0	64.0	71.0	74.0	77.0	79.0
	50	Flow (GPM)	28.0	32.5	36.3	39.3	44.3	46.8	50.0
		Throw (ft.)	58.0	61.0	69.0	71.0	71.0	74.0	75.0

Calculating Pump Flow for Hand Gun Spraying

For low-level spraying with a hand gun, such as for lawn and turf care, proffessional applicators typically "walk" the lawn at about 1000 sq. ft. per minute. That means the "gpm" rate of hte hand gun wil lgenerally be the same as the "gallons per 1000 sq. ft." To determine your total pump flow requirement:

Flow required for gun/nozzle: _____ gallons per 1,000² (same as gpm)
Flow required for agitation: + _____ gpm
Sub-total = _____ gpm
Excess flow requirement: x 1.20
TOTAL PUMP FLOW NEEDED: = _____ gpm

C - BOOM SPRAYING

Boom Spraying is the most effective, accurate and efficient method of applying chemicals to large turf areas.

It may be done my means of:

1. A dedicated spray vehicle
2. A sprayer mounted upon a utility vehicle
3. A sprayer drawn behind a tractor or other towing vehicle

These sprayers are equipped with wide spray booms. Generally these booms are between 15 feet (4.5 m) and 20 feet (6 m) in width. They are divided into 3 sections with hinges, which permit the long outer sections to be moved out of the way if an obstacle such as a tree or fence is struck.

There are essentially three types of booms in use today. The first is called a “wet boom” in that the material to be sprayed is carried to the individual nozzles through a structural element of the boom. Secondly is a “dry boom” (above) in which the structural elements are used to support sections of hose between nozzle body sections. Lastly, “boomless” nozzles are used to put out wider spray paths from a single (or cluster of specialized nozzles) nozzles from a single, center mounted location. The most typical boomless nozzles used are a “flood-jet” or “field-jet” type nozzle. Also available is a “Boom-Jet” (right) nozzle capable of delivering widths up to 70 feet. They all have positives and negatives, but there is no right or wrong boom type. Individual preference usually takes priority with the superintendent’s choice.

Along the length of the boom are located some type of spray nozzles, usually spaced 10" (25 cm) or 20" (51 cm) apart. *Smithco booms are factory set for 20" high with 110°nozzles at 20" spacing.* There are a vast number of nozzle types, shapes and sizes available. They are made of many materials. Stainless steel, nylon and ceramic are best suited for turf spraying. Brass is not satisfactory due to shorter useful life. These nozzles are usually mounted on “*nozzle bodies*” of a specific type. Nozzle bodies accomplish the following tasks:

1. Provide clamp or mount to the boom structure.
2. Provide “Drip-less Diaphragm” with a spring and check valve to prevent material leaking out when boom is shut off.
3. Provide “Quick-Cap” mount for spray tips so that tip alignment when cleaning and replacing nozzles is easy, automatic and foolproof.
4. Nozzles are color-coded. Each size has its own color. An operator can see at a glance if all nozzles are identical.

Nozzle bodies are now available with multiple tip capabilities. Each nozzle body can be mounted with three, four or five tip configurations. This allows the spray tech to change the nozzle tip quickly and simply to the right one for the particular job he's performing. He also has extra tips always on board and can easily switch a broken or damaged one to complete a critical application without having to return to the maintenance area.

The SPRAY BOOM NOZZLE has 3 functions:

1. To regulate the flow of liquid (the volume)
2. To form the liquid into droplets which will be sprayed over the turf.
3. To disperse a specific pattern in order to insure proper coverage on the turf.

The first function - to regulate the flow is done through the size of the orifice opening within the nozzle.

All nozzles, regardless of type, have some point within them that regulates the flow of liquid. Obviously, the larger the opening the greater the rate of flow volume. Volume is expressed in Gallons Per Minute or Liters Per Minute. Tips are rated for flow and if a flat fan type tip, it's operating angle. When discussing tips and flow rates, the industry standard is to assume that the operating pressure is forty-PSI. The first two, or three numbers (Tee-Jets are available in 65º, 80º &110º) express the angle the tip applies material. The last two numbers are the flow rate at forty PSI. Therefore, a flat fan tip rated as an 8008 has a spray angle of eighty degrees and a flow rate of eight-tenths of a gallon per minute. A Tee-Jet 11008 would have an angle of 110 degrees and the same flow rating. Complete nozzle charts are available at the end of this guide for some of the most popular tips used in the Turf industry.

Do not confuse the term volume with application rate, which will be covered later.

As pressure increases, the flow volume through a given nozzle also increases. For example, an average size nozzle which discharges .52 GPM (1.4 LPM) at 30 PSI (2 BAR), will discharge .73 GPM (2 LPM) at 60 PSI (4 BAR). In this example, an increase in pressure of 100% has caused an increase in discharge of 40%
Some nozzles deliver a small volume (for example, 0.2 GPM [.75 LPM]). Some nozzles deliver a relative large volume (for example, 1.5 GPM [5.7 LPM]), or 7 1/2 times as much as the smaller nozzle in this example.

We will discuss more on the types of nozzles as we address the nozzle's other functions.
The amount of material (volume) to be applied is determined by the type of effect the chemical is to have on the turf.

Just some brief general comments on turf management chemicals. They are made for four general purposes:

1. Fungicides — Prevent or cure fungus on turfgrass.
   They are made in 2 general types:
   a. Systemic Chemicals enter the plant system and protect or cure it of fungus.
   b. Contact Kills fungus with which it comes into contact
2. Insecticides — Eliminate damaging insects and worms (such as grubs, beetles, ants, etc.)
3. Herbicides — Control and eliminate undesirable weeds and grass from turf areas and non-turf areas such as bunkers, trails, fences, etc.
4. Nutrients & Fertilizer — Promote growth, beauty and color in turfgrass

Some materials have to be applied so that they get into the soil below the plant leaves. (This is called "soil application") In order to do this; they are best applied with a large volume of water. They are often then watered in" using the irrigation system. This type of chemical material includes systemic chemicals and chemicals designed to destroy pests, which live in the thatch and the soil.

Other materials must be applied to reach a problem that is present on the plant leaves. This is called Foliar Application and requires a lower volume of water. Instead of irrigation water, dry air and sunshine further activate these materials. They include contact fungicide and many herbicides.

Above all, the user of sprayers and chemicals must follow the directions provided with the spray material. It is the only way to insure safe and effective results. It provides information on how much chemical and how much water is to be applied to the area to be sprayed.
The second function of a nozzle on a sprayer is to form the liquid into droplets.
The size of the droplet is determined by two factors:

1. The design of the nozzle
2. The system operating pressure (PSI / BAR)

Some applications are done best by big droplets such as systemic fungicides and insecticides and some herbicides in order to reduce drift. Other applications require small droplets like contact fungicides and some herbicides.

TeeJet TECHNOLOGIES

Color Code	Classification
XF	Extremely Fine
VF	Very Fine
F	Fine
M	Medium
C	Coarse
VC	Very Coarse
XC	Extremely Coarse
UC	Ultra Coarse

Spray Quality*	Size of Droplets	VMD Range (Microns**)	Color Code	Retention on Difficult to Wet Leaves	Drift Potential
Extremely Fine	Small	<60	Purple	Excellent	High
Very Fine		61-105	Red	Excellent	
Fine		106-235	Orange	Very Good	
Medium		236-340	Yellow	Good	
Coarse		341-403	Blue	Moderate	
Very Coarse		404-502	Green	Poor	
Extremely Coarse		503-665	White	Very Poor	
Ultra Coarse	Large	>665	Black	Very Poor	Low

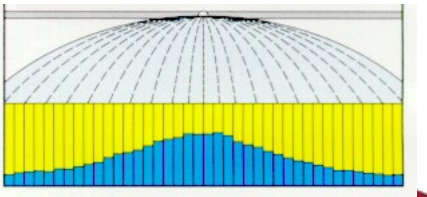
*Always read the pesticide label to determine which spray quality is required.
** Estimated from sample reference graph in ASABE/ANSI/ASAE Standard S572.1.

This, again, often is determined by whether the chemical is foliar applied or soil applied. Large droplets for soil applied material, small droplets, which more fully cover plant for foliar applied materials.

Pressure also affects droplet size. More pressure at the same nozzle produces smaller droplets, more subject to drift. The general rule on pressure is to use the lowest pressure possible with just enough to form adequate spray nozzle patterns.
Though there are many types and sizes of nozzles, two specific types have proven most successful in turfgrass management..

The first type is target directed. It sprays the material in a direct line downward to the target turf grass These are flat fan nozzles, commonly referred to as TeeJet nozzles. They are available in a wide variety of sizes for any required discharge volume rate. They are the best for many contact or foliar applied pesticides. They are spaced either 10" (25 cm) or 20" (51 cm) apart. They overlap one another by about 50%.

A graph of the pattern formed by flat fan (TeeJet) nozzles would show most liquid concentrated at the center, then tapering off where it begins to overlap with the next nozzle approximately 30%.

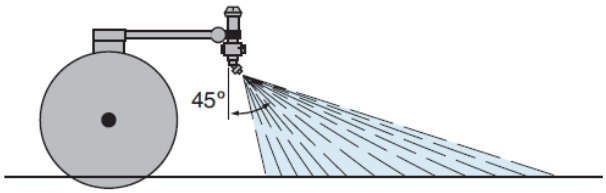


The second types useful in turf management are broadcast type nozzles. They are commonly referred to as raindrop or floodjet nozzles. They spray a hollow-cone shaped pattern of much larger droplets, which fall quickly to the turf under their own weight. They are best for systemic pesticides or any material requiring a large volume of water for soil application.

The larger droplets are not subject to drift from wind and are a safer, environmentally friendly choice in many situations. The nozzle's third function is to disperse the material at a specific pattern, which will insure an even distribution of chemical across the swath covered by the boom.

NOZZLE TILT - Research has proven that a tilt of about 45° for Flood nozzles will significantly improve the spray pattern uniformity.

The nozzle tilt reduces the effect of boom height variation. By tilting the nozzle, the effect of boom height variations, which occur while traveling through the field, are dramatically reduced.



Side View

NOZZLE SPACING - In order to properly develop their spray pattern, each nozzle must be the proper distance from the next nozzle (spacing) and the proper height above the ground. Turf spray nozzles are normally 10" (25 cm) or 20' (51 cm) apart (some cases 30" / 76 cm), depending on the type of spray boom and type of area to be sprayed. Very fine, level areas (golf greens & tees, bowling lawns, tennis courts, etc.) may be sprayed with nozzles spaced every 10" (25 cm).

BOOM HEIGHT is very important in permitting spray nozzles to develop their proper spray pattern. If nozzles are too high, excessive overlap develops. If nozzles are too low, there is not enough overlapping of nozzle spray patterns.

NOZZLE TYPE	NOZZLE SPACING	HEIGHT AB0VE THE GROUND
80° Flat Fan	20" (51 cm)	30" (45-46 cm)
110° Flat Fan	20" (51 cm)	20" (50-51 cm)
45° Turbo Floodjet	20" (51 cm)	20-23" (50-58 cm)
Turbo Floodjet	30" (76 cm)	16" (40-41 cm)
PWM Wilger	20" (51 cm)	24" (61-62 cm)

Improper nozzle height or spacing prevents proper application of chemical. Some areas are under-treated and chemicals are ineffective. Some areas are over-treated with wasted chemical and possible turf damage. It is very important to remember that flat fan nozzles **MUST** be angled at five degrees from the line of the boom. This is so the overlap areas do not collide with each other, disrupting the pattern. With current nozzle bodies and quick caps, this alignment is automatic. Observe nozzles in operation while the sprayer is parked. This a good time to look for tip pattern alignment, it will be very evident if the fan pattern is colliding between tips. This is also a good time to visually inspect the overlap area. For flat fans, it is approximately thirty percent.

If the boom pattern checks out so far, a good method of further checking spray pattern consistency to operate the sprayer at desired speed and pressure on a hard, dry surface (i.e., a parking lot), applying water to the pavement. Observe if the area dries evenly. If alternating wet and dry streaks are apparent, raise or lower the spray boom. If the wet streaks are directly under the nozzle, the boom is too low, raise it. If the wet streaks are between the nozzles, the boom is too high, lower it. It is important to check for pattern alignment prior to spraying water, as colliding patterns will give misleading information as it dries unevenly.

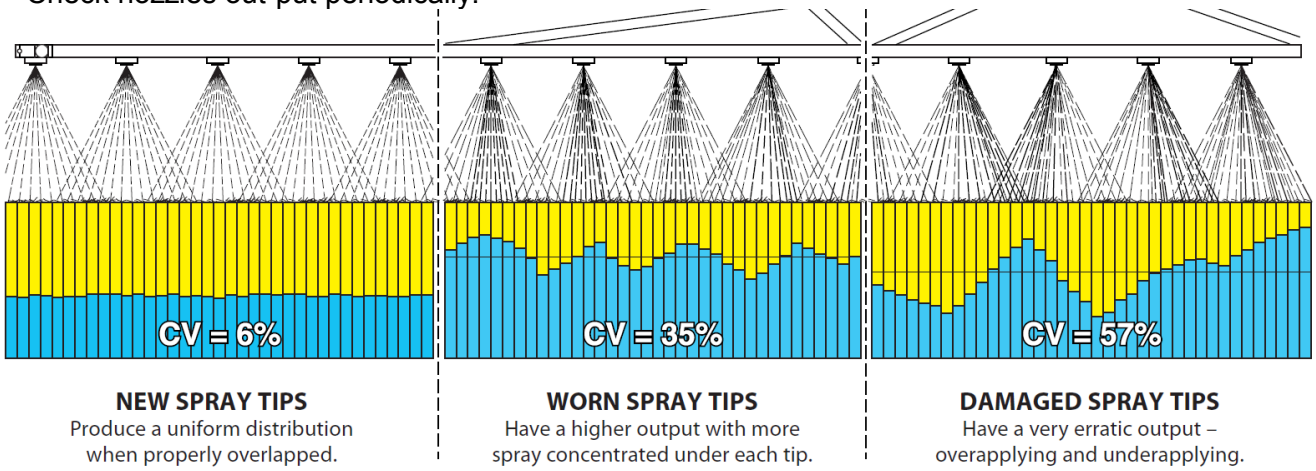
The most precise method is to use the two tools made by Spraying Systems, the Tee-Jet Tip Tester and Tee-Jet Pattern Checker. Use the Tip Tester to quickly check each tip for consistency of flow. At this point, it doesn't matter what the flow is, just that it's the same from tip to tip. Then operate the spray boom while the Pattern Checker is lying flat on the ground, applying water. When the Checker is lifted, the balls in the chambers will float, giving a very accurate representation of the sprayed patterns accuracy.

FURTHER NOZZLE INFORMATION

- NOZZLE SCREENS (STRAINERS): Smaller nozzles require nozzle screens or strainers to prevent clogging.

  - ❖ Teejet type nozzles from size 8001 and 80015 and RF Flat Spray Raindrop Nozzles require 100 mesh screens
  - ❖ Teejet type nozzles from size 8002 through 8008 and RF Flat Spray Raindrop Nozzles require 50 mesh screens
  - ❖ Raindrop Hollow Cone Nozzles Size RA-2 through RA-6 require 50 mesh screens
  - ❖ Raindrop Hollow Cone Nozzles Size RA-8 and larger **<u>does not</u>** require strainers.
  - ❖ Turbo Floodjet Nozzles TF-VS2 through TFVS-3 require 50 mesh screens. Turbo Floodjet Nozzles TF-VS4 and larger do not require screens.

- Always be alert to the possibility of a plugged or damaged nozzle. Serious misapplication may result.
- Check nozzles out-put periodically.



D – AGITATION

The question often comes up whether hydraulic or mechanical agitation is superior. There is really no correct answer. Both are very acceptable if they perform the required job and that is to keep the insoluble materials used, suspended in the carrier. The often misconstrued feeling that mechanical agitation is better stems from the fact that it became popular when fiberglass tanks and small volume piston-diaphragm pumps became popular. Because the small volume output of the diaphragm pump precluded the use of hydraulic agitation, mechanical means had to be devised. These were considerably more expensive, due to the cost of the pump, as well as the costs associated with fiberglass tanks and stainless steel mechanical systems. Over time, the more expensive systems became misconstrued as superior

Review the capacity of nozzles being used. Total capacity of all nozzles plus agitation system must not exceed pumping system capabilities. FLUSH PUMP AFTER USE

Shut-Off	20GPM	40GPM	60GPM	80GPM	100GPM
120psi	100psi	80psi	60psi	30psi	10psi
100psi	95psi	76psi	52psi	26psi	5psi
80psi	75psi	62psi	45psi	21psi	-
60psi	55psi	40psi	25psi	5psi	-

The point is, as long as there is enough volume to provide adequate turbulence to keep particulate matter suspended, there is no difference in quality of agitation. To further this end, devices such as “Venturi” tips or “Eductor” nozzles continue to reduce the differences in effectiveness. These nozzles literally double to triple the flow through them by “Venturi” action.

The case could be made that mechanical agitation is considered inferior as the need to have rigid walls to mount shafts, packing glands to prevent leaks and extra horsepower to turn the shafts are required.

E – SPRAY CONTROLLERS

The spraying industry have grown considerable more sophisticated since the days of the “Ratchet Valve” was the standard to turn spray booms on and off. Today, computers are being used more and more to control the spraying event. They have become popular because they increase efficiency and productivity, especially in large scale operations. The level and sophistication of these devices ***brief*** descriptions of the various controllers in use today. Remember that computers really only do two things: 1. Monitor and adjust flow to keep application rate constant as it senses changes in ground speed; and 2. Keep track of volume sprayed and acreage covered.

Computers can be either “flow” based, “pressure” based or in one unique instance, both. Smithco is not a supporter of pressure based control systems due to the earlier explained loss of pressure due to friction through lines, fittings and solenoids. Pressure based systems would be accurate only if the pressure transducer was placed at the tip, and then only for that tip. Most systems mount the transducer up around the solenoids, so they are only relatively accurate. That is, they will accurately read and report pressure and pressure changes where the transducer is mounted, but that ***may*** have nothing to do with what is going on at the tip.

When do you have forty PSI at the tip on a boom mounted with 8008 nozzles? Only when that tip delivers eight tenths of a gallon in one minute!

1. TeeJet 744A

Designed to control sprayer booms from the tractor cab. The Pressure Adjust Switch, when connected to a 244 Regulating Valve, allows the operator to increase or decrease system pressure. Master Switch provides on/off control of all nozzles. Boom Control Switch allows on/off control of individual sections of the boom for edge spraying or spot spraying.

2. TeeJet Radion 8140

Simply set your target application rate and the unique VisiFlo display on the controller helps select the right TeeJet tip for the application. Once spraying begins, the large display shows application rate, volume sprayed, system pressure, sprayer speed, and area covered. Radion's built-in planning tool automatically displays the available speed range for the target rate and spray tip that have been selected.

3. TeeJet Aeros 9040

A fully Integrated Field Computer for Optimal Productivity and Precision. Aeros is a complete field computer that offers precision guidance, auto-steering, application rate control, mapping, variable rate application, Automatic Boom Section Control (ABSC) and even wireless data transfer.

4. The DynaJet Flex 7120

Nozzle Control System uses pulse width modulation (PWM) technology with solenoid operated tip shutoffs allowing the operator to control tip flow rate and droplet size independent of one another

F – ACCESSORIES

Many accessories are now available for sprayers in the turf industry. This will be by no means a complete list, but will address the most popular options selected by our end users. These options are listed randomly, in no particular order.

1. Hose Reel

Hose reels are often used for handgun spraying or walking boom (Spray Hawk) use. Other tasks performed might be with root feeders, tree guns and other specialized attachments. They are available in either manual or electric rewind, and usually can carry approximately 200 feet of ½" or 100 feet of $^{5}/_{8}$" hose. Please remember the discussion earlier concerning pressure loss due to friction through hose. See Spray Hawk Flow Chart at the end of this publication.

2. Foam Markers

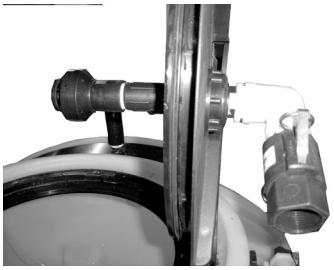
A good spray practice is the use of some device to mark the outside boundaries of each spray swath. Foam markers are advisable. Foam Markers are used to mark the overlap area of the end of the boom for making a return pass. They minimize the chance for missed areas or double application.

They are devices that generate foam balls using a water and soap mixture in a tank by pumping air into the mixture. Pressure forces it out through some hosing from the foam generator to the ends of each boom. Foam markers usually only can drop foam balls on one side of a boom at one time. A newer foam marker made by Spraying System differs in that the mixture and the air are both pumped out to the end of the boom in smaller, separate tubes. Electric switches with red indicator lights control the side that foam is dropped. This allows the user to generate foam much more quickly (in as little as 10 seconds) to insure that the overlap patterns are accurate. And because it quickly and reliably generates foam, balls can be dropped on both sides of the boom by switching left and right sides on and off so that the first pass can be down the middle of the fairway.

3. Dye Markers

For many years, Blue dye has been added to spray tanks to mark where an operator has already sprayed chemicals. Although very accurate, it leaves unsightly colored patches where it's been put down. It can also come off on the shoes and clothing of club members as well as being quite expensive. Many members of golf clubs don't like its use for these reasons. Dye markers are similar to foam markers in function as these are devices are essentially small sprayers mounted to a larger spray rig. They pump concentrated dye out of a pony tank to the end of the boom to put down a thin strip of blue dye to mark the overlap pattern. It uses Tee-Jet flat fan tips mounted in the direction of travel to keep the width of the mark to a minimum. While new to the market, its use is sure to grow.

4. Tank Rinse Systems



To properly dispose of chemical left over in spray tanks, many EPA regulations state that the tank must be rinsed with a neutralizing agent (Cleary's, Neutrasol, etc.) and then the sprayer driven back out onto the course to boom spray the rinse out at the original rate. Tank rinse systems have been designed to easily solve this problem. Again, a pony tank is mounted in a suitable position on the sprayer so that the operator can pre-mix the neutralizing agent to take out on the golf course (or other turf area). The system includes an electric diaphragm pump and hose that connects to a special nozzle mounted inside the tank. The nozzle has opposed jets that spin when the hydraulic pressure of the pump is turned on. When the operator is finished spraying for that event, instead of returning to the maintenance area to mix and rinse, he simply flips a switch on the dash of the sprayer, engaging the system. It takes approximately three minutes to empty the tank, the nozzles cover 100 percent of the interior of the tank (up to 300 gallons), and then the operator turns on the boom to drain the rinse out. The time saving is substantial, as well as showing any regulatory agency that your procedures exceed their requirements.

5. Electric/Hydraulic Lift Booms

Booms come with electric over hydraulic linear actuators to raise and lower the left and right boom wings. Electric over hydraulic linear actuators feature a integrated motor, pump, valve nad cylinder. It is self contained unit with no external piping, thus eliminatin the possiblility of oil leakage. It enables the operator to transport and spray without getting off the machine. It also lets the spray tech lift and lower the boom to match changes in contours of terrain.

6. Enclosed Boom Systems

Enclosed boom systems use is going to see a leap in growth in the next few years and Smithco wants to be at the forefront of this development. Enclosed booms do the following:

- Permit spraying in windy (or windier) conditions by reducing the opportunity for drift.
- Protect the operator, the golfing member, and the environment plus reduce liability risks.
- Provide an increase in efficiency by more accurately applying chemicals when they're needed, regardless of weather conditions.

They can be electric or manual lift and should include some way to indicate flow to each tip to ensure the spray pattern is being applied correctly.

7. Air-gap fillers

Air Gap fillers are required in many municipal districts to prevent chemical from siphoning back into the water system through the filling hose.

8. Water Fill Meters

As pictured on the air gap filler, an electronic water flow meter allows for very accurate filling of tanks on any area, whether level or not. Water meters are available in gallons or liters. Note: only designed for flows from 1-30 gpm.

9. Fresh Water Wash Tanks

Fresh water wash tanks are small (3-9 gallon) tanks mounted on a sprayer to allow the operator to have clean, fresh water available in the event there is a spill of chemicals on the operator, or to rinse out eyes that may have come in contact with a chemical.

10. Automatic Air Bleed Device

This device is intended to allow the non-self-priming centrifugal pump to re-prime itself with low volumes of material in the tank. A fitting is installed in one of the pipe plugs on the pump casing and a small hose is run to the top of the tank to allow air to bleed back up into the tank, eliminating the loss of prime problems usually associated with centrifugal pumps.

11. Low Pressure Alarm System

If air is sucked into the suction side of the pump, as when the tank is emptied, this pressure switch senses the pressure drop and through a transducer, sends a signal to a warning alarm located at the operator's station. This alarm sounding allows the spray tech to shut off the pump before damage can be done to pump by running it dry.

12. Chemical Cleanload

The Cleanload is self-contained eductor system, which allows the operator the use one system to mix liquid and dry chemicals safely and quickly. Chemicals are mixed at ground level, ensuring safety of both the operator and the environment.

13. Auto Steer Field Pilot

Field Pilot interfaces with your Aeros console to provide automatic steering of your machine. This keeps your hands free during busy headland turns. Steering automatically disengages when the operator turns the steering wheel.

14. ClearPath RX520 Antenna

ClearPath uses very accurate carrier phase calculations to provide ultra smooth positions and excellent, pass-to-pass accuracy for agricultural applications. Use with Aeros only. Requires subscription.

TECHNICAL INFORMATION

Useful Formulas

$$\text{GPM (Per Nozzle)} = \frac{\text{GPA} \times \text{MPH} \times \text{W}}{5{,}940}$$

$$\text{GPM (Per Nozzle)} = \frac{\text{GAL/1000FT}^2 \times \text{MPH} \times \text{W}}{136}$$

$$\text{GPA} = \frac{5{,}940 \times \text{GPM (Per Nozzle)}}{\text{MPH} \times \text{W}}$$

$$\text{GAL/1000FT}^2 = \frac{136 \times \text{GPM (Per Nozzle)}}{\text{MPH} \times \text{W}}$$

GPM – Gallons Per Minute

GPA – Gallons Per Acre

$GAL/1000FT^2$ – Gallons Per 1000 Square Feet

MPH – Miles Per Hour

W – Nozzle spacing (in inches) for broadcast spraying

– Spray width (in inches) for single nozzle, band spraying or boomless spraying

– Row spacing (in inches) divided by the number of nozzles per row for directed spraying

Useful Formulas for Roadway Applications

$$\text{GPLM} = \frac{60 \times \text{GPM}}{\text{MPH}} \qquad \text{GPM} = \frac{\text{GPLM} \times \text{MPH}}{60}$$

GPLM = Gallons Per Lane Mile

Note: GPLM is not a normal volume per unit area measurement. It is a volume per distance measurement. Increases or decreases in lane width (swath width) are not accommodated by these formulas.

Measuring Travel Speed

Measure a test course in the area to be sprayed or in an area with similar surface conditions. Minimum lengths of 100 and 200 feet are recommended for measuring speeds up to 5 and 10 MPH, respectively. Determine the time required to travel the test course. To help ensure accuracy, conduct the speed check with a partially loaded (about half full) sprayer and select the engine throttle setting and gear that will be used when spraying. Repeat the above process and average the times that were measured. Use the following equation or the table at right to determine ground speed.

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

Miscellaneous Conversion Factors

One Acre = 43,560 Square Feet
= 43.56 $1000FT^2$ Blocks
= 0.405 Hectare

One Hectare = 2.471 Acres

One Gallon Per Acre
= 2.9 Fluid Ounces per $1000FT^2$
= 9.35 Liters Per Hectare

One Gallon Per $1000FT^2$ = 43.56 GPA

One Mile = 5,280 Feet
= 1,610 Meters
= 1.61 Kilometers

One Gallon = 128 Fluid Ounces
= 8 Pints
= 4 Quarts
= 3.79 Liters
= 0.83 Imperial Gallon

One Pound Per Square Inch
= 0.069 bar
= 6.896 Kilopascals

One Mile Per Hour = 1.609 Kilometers Per Hour

SPRAYER CALIBRATION

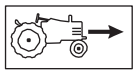
Broadcast Application

Sprayer calibration (1) readies your sprayer for operation and (2) diagnoses tip wear. This will give you optimum performance of your tips.

Equipment Needed:

- Calibration Container
- Calculator
- Cleaning Brush
- One new spray tip matched to the nozzles on your sprayer
- Stopwatch or wristwatch with second hand.

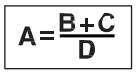
STEP NUMBER 1



Check Your Tractor/Sprayer Speed!

Knowing your real sprayer speed is an essential part of accurate spraying. Speedometer readings and some electronic measurement devices can be inaccurate because of wheel slippage. Check the time required to move over a 100- or 200-foot strip on your field. Fence posts can serve as permanent markers. The starting post should be far enough away to permit your tractor/sprayer to reach desired spraying speed. Hold that speed as you travel between the “start” and “end” markers. Most accurate measurement will be obtained with the spray tank half full. Refer to the table on page 140 to calculate your real speed. When the correct throttle and gear settings are identified, mark your tachometer or speedometer to help you control this **vital** part of accurate chemical application.

STEP NUMBER 2



The Inputs

Before spraying, record the following:

EXAMPLE

Nozzle type on your sprayer ..... TT11004 Flat

(All nozzles must be identical)

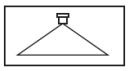
Recommended application volume ..... 20 GPA

(From manufacturer’s label)

Measured sprayer speed ..... 6 MPH

Nozzle spacing ..... 20 Inches

STEP NUMBER 3



Calculating Required Nozzle Output

Determine GPM nozzle output from formula.

FORMULA: $GPM = \frac{GPA \times MPH \times W}{5940 \text{(constant)}}$

EXAMPLE: $GPM = \frac{20 \times 6 \times 20}{5940} = \frac{2400}{5940}$

ANSWER GPM = 0.404

STEP NUMBER 4

Setting the Correct Pressure

- Turn on your sprayer and check for leaks or blockage. Inspect and clean, if necessary, all tips and strainers with brush. Replace one tip and strainer **with an identical new tip and strainer** on sprayer boom.
- Check appropriate tip selection table and determine the pressure required to deliver the nozzle output calculated from the formula in Step 3 for your new tip. Since all of the tabulations are based on spraying water, conversion factors must be used when spraying solutions that are heavier or lighter than water.
- Turn on your sprayer and adjust pressure. **Collect and measure the volume of the spray from the new tip for one minute in the collection jar.** Fine tune the pressure until you collect .40 GPM.
- You have now adjusted your sprayer to the proper pressure. It will properly deliver the application rate specified by the chemical manufacturer at your measured sprayer speed.

STEP NUMBER 5

Checking Your System

Problem Diagnosis: Now, check the flow rate of a few tips on each boom section. If the flow rate of any tip is 10 percent greater or less than that of the newly installed spray tip, recheck the output of that tip. If only one tip is faulty, replace with new tip and strainer and your system is ready for spraying. However, if a second tip is defective, replace all tips on the entire boom. This may sound unrealistic, but two worn tips on a boom are ample indication of tip wear problems. Replacing only a couple of worn tips invites potentially serious application problems.

Banding and Directed Applications

The only difference between the above procedure and calibrating for banding or directed applications is the input value used for "W" in the formula in Step 3.

For single nozzle banding or boomless applications:

W = Sprayed band width or wath width (in inches).

For multiple nozzle directed applications:

W = Row spacing (in inches) divided by the number of nozzles per row.

INTRODUCTION TO CALIBRATION

A number of acceptable methods for calibrating a turf sprayer are widely available. Two methods are described later in this guide. Calibrating simply means to adjust a set of variables on the sprayer in order to deliver the desire amount of chemical to a known area of turf.

The variables are:

- OPERATING PRESSURE
- NOZZLE ORIFICE SIZE
- TRAVEL SPEED
- NOZZLE SPACING (Previously discussed in this guide)

The job of calibrating the sprayer consists of balancing these variables so that your sprayer delivers the desired application rate. That is, an amount of chemical on a given area. It is expressed as:

Gallons Per Acre (GPA) (1 US GPA = .83 UK GPA)
or Gallons Per 1,000 Square Feet (GPT)
or Liters Per Hectare (LPH) (1 US GPA = 9.3 5 LPH)

The calibration methods chosen must take these variables into account. They must include known ground speed (by measurement or from an accurate speedometer) and nozzle output (GPM or LPM) from a nozzle chart or from actual measurement.

1st VARIABLE- PRESSURE: Just as pressure increases the volume discharge rate, it also increases the application rate. Pressure must increase by 4 times in order to double the application rate. Small pressure changes of 10 PSI (1.4 BAR) or less do not greatly affect performance.

Pressure is established and maintained by a pressure control valve or by a flow control valve located on the sprayer.

2nd VARIABLE - NOZZLE CAPACITY (Volume): We have covered the different types of spray patterns of various nozzles and made our selection of type accordingly. We now have to choose a size, which will provide the correct application rate. Sizes are available for all requirements. Consult the nozzle chart in this guide for your nozzle type in order to select the correct size.

3rd VARIABLE- TRAVEL SPEED: Increased travel speed decreases the application rate (GPA or GPT or LPH). Travel speed must be safe and appropriate for the area to be sprayed.

Unlike pressure changes, which have only a minor effect on application rate, ground speed changes have a more major and direct effect. For example: A 50% increase in ground speed means a 100% decrease in application rate. If the vehicle does not have an accurate speedometer, correct speed must be determined by timing the sprayer travel over a measured distance. (Refer to the page in this guide titled, "Useful Formulas".

To calibrate a sprayer, the user must:

1. **Understand** the variables
   - Operating Pressure (PSI/BAR)
   - Nozzle Orifice Size (GPM/LPM)
   - Travel Speed (MPH/KPH)
2. **Set** those variables using one of the proven methods available.
3. **Make** a trial run and measure the output (use water, not chemical)
4. **Determine** the output.
5. **Make** adjustments to the 3 variables until the output is at the desired level.

BOOM SPRAYER CALIBRATION

A. PREPARATION

1. Before adding any chemical, fill the sprayer tank with one-half of the desired amount of water. It is suggested (and required by law in some areas), that water only be added to a sprayer tank through an Anti-Siphon ("Air-Gap") Filler System to prevent contamination of the water supply. Operate the sprayer to be certain all valves, hoses, as well as the pump and engine (or PTO) are operating properly. Make certain that each nozzle is spraying a consistent pattern.

2. Set (or check) the Spray Boom so that the Nozzles are the correct height above the ground for the type of nozzle and the nozzle spacing (distance between each nozzle) that is being used.

NOZZLE TYPE	NOZZLE SPACING	HEIGHT AB0VE THE GROUND
80° Flat Fan	20" (51 cm)	30" (45-46 cm)
110° Flat Fan	20" (51 cm)	20" (50-51 cm)
45° Turbo Floodjet	20" (51 cm)	20-23" (50-58 cm)
Turbo Floodjet	30" (76 cm)	16" (40-41 cm)
PWM Wilger	20" (51 cm)	24" (61-62 cm)

3. Calibration of the sprayer is to be done with water, not chemicals. This insures safety to the operator or individual performing the calibration operation. Only after all calibration procedures are completed should chemicals be added to the sprayer.

4. Carefully measure the amounts of spray material to be added to the tank. Always read the label instructions, then follow these instructions exactly.

5. If the chemical to be sprayed is a dry (powder) material, it is essential that it be thoroughly mixed with water in a small container such as a pail, to form a slurry before adding to the sprayer tank. Then, while the sprayer is running, add the mixture to the tank with the agitation system operating. Always add the material to the sprayer tank through a filter screen in the tank opening. Then, add the balance of the desired amount of water to the tank.

Liquid chemicals may be added directly from their storage container to the tank through a filter screen, with the agitation system in operation.

(**NOTE:** Instructions #4 & #5 do not apply if the sprayer is equipped with a Concentrate Injection System. If your sprayer is equipped with a Concentrate Injection System, refer to the operating instructions provided with that system.)

B. CALIBRATION TECHNIQUES

The 2 Calibration Techniques outlined here are:

I. The Nozzle Chart Method of Calibration
II. The ~128" Method of Calibration

Each method may be useful in various circumstances and conditions.
It is important to note that there are other acceptable and proven methods of calibrating a turf sprayer for application. Other techniques may be more suitable depending on operational needs and technical competence of the operator.

1. THE NOZZLE CHART METHOD OF CALIBRATION

a. Introduction

The Nozzle Chart Method (see sample below) is useful when the sprayer nozzles are new or nearly new. It is also the most useful method to employ when the sprayer is equipped with a Computer Based Spray Control System (CBSCS). The CBSCS does most of the calibration work; it is up to the operator to select the proper combination of nozzle size and ground speed, which will deliver the desire application rate.

Tip Color	Tip No. (Strainer Screen Size) 80° Series	Tip No. (Strainer Screen Size) 110° Series	Liquid Pressure in psi	Capacity 1 Nozzle in GPM	Capacity 1 Nozzle in oz./min.	Gallons Per Acre 20" Spacing 5 mph	6 mph	7 mph	8 mph
ORANGE	XR8001 (100 Mesh)	XR11001 (100 Mesh)	15	.06	8	3.6	3.0	2.5	2.2
			20	.07	9	4.2	3.5	3.0	2.6
			30	.09	12	5.3	4.5	3.8	3.3
			40	.10	13	5.9	5.0	4.2	3.7
			60	.12	15	7.1	5.9	5.1	4.5
GREEN	XR80015 (100 Mesh)	XR110015 (100 Mesh)	15	.09	12	5.3	4.5	3.8	3.3
			20	.11	14	6.5	5.4	4.7	4.1
			30	.13	17	7.7	6.4	5.5	4.8
			40	.15	19	8.9	7.4	6.4	5.6
			60	.18	23	10.7	8.9	7.6	6.7
YELLOW	XR8002 (50 Mesh)	XR11002 (50 Mesh)	15	.12	15	7.1	5.9	5.1	4.5
			20	.14	18	8.3	6.9	5.9	5.2
			30	.17	22	10.1	8.4	7.2	6.3
			40	.20	26	11.9	9.9	8.5	7.4
			60	.24	31	14.3	11.9	10.2	8.9
BLUE	XR8003 (50 Mesh)	XR11003 (50 Mesh)	15	.18	23	10.7	8.9	7.6	6.7
			20	.21	27	12.5	10.4	8.9	7.8
			30	.26	33	15.4	12.9	11.0	9.7
			40	.30	38	17.8	14.9	12.7	11.1
			60	.37	47	22	18.3	15.7	13.7
RED	XR8004 (50 Mesh)	XR11004 (50 Mesh)	15	.24	31	14.3	11.9	10.2	8.9
			20	.28	36	16.6	13.9	11.9	10.4
			30	.35	45	21	17.3	14.9	13.0

The nozzle chart method requires the use of the appropriate nozzle charts, which are found at the end of this guide. (Nozzle Charts 1 through 7).
Nozzle charts are available for:

1. Three different types of nozzles:
   a. Spraying Systems Teejet Flat Fan
   b. Spraying Systems TurfJet
   c. Spraying Systems Turbo TeeJet
2. Three different nozzle spacings:
   a. 10 Inch (25 cm)
   b. 20 Inch (51 cm)
   c. 30 Inch (76 cm) (Turbo Floodjet)
3. Three different expressions of application rate:
   a. US Gallons per acre (GPA)
   b. US Gallons per 1,000 sq. ft. (GPT)
   c. Liters per hectare (LPH)

NOTE: The information provided in the previous pages of this guide should help determine the proper type of nozzle for your needs.
Nozzle charts for other nozzles are available from the manufacturer.

b. CALIBRATION STEPS USING THE NOZZLE CHART METHOD

Determine "HOW" your sprayer is to be calibrated from the list of variable factors available (below).

1. NOZZLE TYPE Teejet, Raindrop, Turbo Flood ?
2. SPACING 10" (25 cm) or 20 (51 cm) or 30" (76 cm).
3. EXPRESSION OF APPLICATION RATE G.P.A. or G.P.T. or L.P.H.

The answers to these three questions will direct you to the appropriate nozzle chart for your application among the charts on the pages in the back of this guide. The correct nozzle chart MUST be used.

c. DETERMINE THE DESIRED APPLICATION RATE.

This is determined from the information on chemical labels or other technical information available from a variety of sources.

d. DETERMINE AN ACCEPTABLE GROUND SPEED

Conditions over which the sprayer will operate generally dictate the appropriate ground speed. Within the limits of practicality and efficiency, spraying should generally be done at the lowest possible speed. This increases operator safety and contributes to more precise application of chemicals. For example, golf greens and tees and hill areas would generally be sprayed in the range of 2 1/2 to 3 1/2 Miles per hour (4-6 kph). Larger, open and more level areas such as golf fairways and open park or school grounds would be sprayed at 4 1/2 to 6 mph (7-10 kph). The best guideline is the fastest speed, which is *"safe and comfortable for the piece of equipment."* Often, operators can withstand more punishment than the sprayer.

The vehicle which carries or tows the sprayer should be equipped with a precise low-speed speedometer. If it is not, exact ground speed at a given engine speed must be determined by timing the travel of the sprayer over a measured course.

e. DETERMINE NOZZLE SIZE

Now refer to the appropriate nozzle chart in this guide for your nozzle TYPE (the type of nozzle you have or the type you wish to use), nozzle SPACING and CALIBRATION TYPE (GPM, GPT or LPH).

You will note from the chart that application rates from any given nozzle decrease as the ground speed increases. In other words, the faster you drive, the less material you are applying.

Application rates are shown in the columns to the right of the charts. Once the desired application rate is decided upon, it should be located, as nearly as possible in one of these columns on the appropriate chart for your operation. It could well be that the approximate rate desired would be obtained from the nozzles already installed in the boom. If this is not possible, then nozzles will need to be changed.

IMPORTANT NOTE: When selecting a new nozzle size refer to the Discharge Rate Column" on the nozzle charts. The Discharge Rate (GPM or LPM) multiplied by the number of nozzles should not exceed 75% of the actual discharge volume of the sprayer pump. (i.e., if you need to use nozzles which discharge 0.8 gallons per minute [3.0 Liters per minute], and the spray boom is equipped with 12 nozzles, the sprayer pump would have to produce an actual discharge volume of 13 GPM ~49 LPM] in order to properly supply these nozzles.) If the collective volume of the spray boom nozzles exceeds the actual discharge volume of the pump, inadequate pressure and poor nozzle distribution patterns may result.

Once nozzle type and size have been determined, those nozzles are installed in the sprayer boom. Nozzles could be expected to be replaced after 15-20 hours of actual sprayer operation if made of softer materials. After nozzles are installed, make trial application of water over a known area to check application rate.

f. FOR SPRAYERS WITH ELECTRONIC SPRAY CONTROL SYSTEMS

On sprayers equipped with Electronic Spray Control Systems ("Spray Computers") such as those manufactured by Spraying Systems (Tee-Jet) Raven Ind., Micro-Trak Co. & Dickey-John Co., it is still important to select the right type and size of nozzle for the required operation. Electronic Spray Control Systems cannot function properly if the nozzles are not capable of delivering the programmed (desired) application rate. Nozzles which are too large will not develop adequate pressure or satisfactory spray patterns. Nozzles which are too small will not allow the discharge of spray material at the programmed application rate.

Further, when calibrating sprayers which are equipped with Electronic Spray Control Systems, care must be taken to use the mode of operation on the Spray Control System (Gallons per Acre ["US" Mode]; Gallons per 1,000 sq. ft. ["Turf" Mode]; or Liters per Hectare [Std. International Mode], which corresponds with the nozzle calibration charts (GPA, GPT or LPH).

g. USING THE NOZZLE CHARTS

Select the correct chart based on your nozzle type, nozzle spacing and desired expression of application rate (GPA, GPT, LPH). If the desired operating speed is not found on the nozzle chart, it is simple to determine application rates at different speeds by extrapolating from the application rates at the given speed.

For example: If the desired speed is 2 1/2 MPH (4 kph) on a sprayer using Raindrop nozzles (Chart 5). The average between the application rates for 2 MPH and 3 MPH may be assumed to be the application rate for 2 1/2 MPH. For example: RA-5 Nozzle, 50 PSI, the application rate for 2 MPH is 74 GPA and the application rate for 3 MPH is 50 GPA. Add 74 + 50 (124) then divide by 2 (62). Therefore, the application rate at 2 1/2 MPH is 62 GPA. Another example: The desired speed is 6 MPH. Use the application rate column for 3 MPH and divide by 2.

h. CONVERTING NOZZLE CHART METHOD TO BRITISH GALLONS

To convert any of the Gallon Per Acre rates to Imperial Gallons per acre, (ImpGPA) multiply by .83. To convert any of the liter Per Hectare rates to Imperial Gallons Per Hectare (ImpGPH), multiply by .22.

i. CHECKING THE ACTUAL APPLICATION RATE

After the combination of ground speed, nozzle size and operating pressure has been selected, the sprayer should be operated to determine if the target application rate is being achieved. The following "128" method is one way to validate the Nozzle Chart Method of calibration.

2. THE "128" METHOD OF BOOM SPRAYER CALIBRATION

a. INTRODUCTION

The "128" Method is useful for calibrating sprayers and also for checking the calibration of sprayer calibrated by the nozzle chart method and sprayers using electronic spray control systems. The "128" is based on a convenient mathematical relationship that exists between US gallons, liquid ounces and acres.

An ounce is 1/128th of a (US) gallon. If and area which was "1/128th of a nacre" could be found, the number of ounces applied to that small area would be equal to the number of gallons applied to the acre. Thus, no mathematical computation would b required

To determine an area which is 1/128 of an acre:

- On nozzles with 20 inch (51 cm) spacing, measure off a distance of 204 ft. (62 meters). Mark a "START" and a "STOP" line. The rectangle formed by this distance and the spraying width of one nozzle (20" 51 cm) is equal to 340 square feet which is equal to 1/128 acre. Therefore, the amount of material applied to this area by one nozzle in OUNCES is the same amount of material applied to an acre in GALLONS (GPA).
- On nozzles with 10 inch (25 cm) spacing, the measure distance is 408 feet (124 meters).
- On nozzles with 30 inch (76 cm) spacing the measured distance is 136 feet (41 meters).

b. CALIBRATING FOR APPLICATION

1. Fill the sprayer tank with water. Run the sprayer, inspect it for leaks and make sure all systems function properly.

2. Drive the sprayer through the measured distance discussed above at normal spraying speed, record the travel time required to cover the measured distance in seconds with a stopwatch. The carrying or towing vehicle is to be traveling at the desired speed when it crosses the start line of the measured course. Repeat this procedure and determine the average of the two times.

3. With the sprayer parked, run the sprayer at the required pressure level. Catch the output of each nozzle in a container, which is marked or graduated in Ounces for the same period of time which it took the sprayer to cover the measured course in step #2.

4. NOTE: If a Dedicated Spray Vehicle or a sprayer which is powered by a vehicle's PTO/Hydraulic system is used, it will be necessary to operate the vehicle engine at spraying speed using a hand throttle.

5. Observe the volume of water in the collection bottle. The number of OUNCES collected in the time it takes to cover the marked course. Take the average nozzle output by adding the outputs of each nozzle and then dividing that sum by the number of nozzles.

6. The NUMBER OF OUNCES collected in the time required to cover the SMALL AREA is equal to the NUMBER OF GALLONS applied per ACRE. For example: if an average of 40 ounces of water are collected in the time required to cover the 1/128 acre area, the application rate is 40 gallons per acre (GPA).

AVERAGE OUTPUT (OUNCES) = APPLICATION RATE (GPA)

7. NOTE: As a practical matter, if high application rates are desired (above 75 GPA), the measured course length should be reduced by half (i.e. 102-ft [31 m] for 20-inch (52 cm) spaced nozzles). The volume collected (above) is then doubled (multiplied by 2).

8. Observe individual nozzle output volumes. If an individual nozzle's is 10% above or below the average output, check for blockages in the nozzle or in the nozzle strainer. If the nozzle is worn or damaged, replace it.

9. Compare this actual application rate with the recommended rate. If the actual rate is more than 5% higher or lower than the intended rate, adjustments must be made.

10. Increasing or decreasing the spraying pressure may make minor adjustments in application rate. Lowering spraying pressure decreases application rate. Increasing spraying pressure increases application rate. This procedure normally does not apply to spray systems controlled by an electronic spray control system that governs flow rate.

11. Increasing or decreasing the travel speed of the sprayer if conditions permit may make adjustments in application rate. Slower speeds increase application rate. Faster speeds decrease application rate.

12. Nozzle sizes can be changed to provide the correct application rate. Refer to the nozzle charts in this book for the desired nozzle type.

13. Re-calibrate the sprayer (steps 2-6) after any adjustments are made.

14. As previously discussed, there are other acceptable methods of Turf Sprayer Calibration. Chemical suppliers, Agricultural Extension Agents, Universities and consultants of various types offer helpful advice on this subject. Technical catalogues are available from nozzle manufacturers.

3. TRANSFERRING THE "128" METHOD OF CALIBRATION INTO METRIC (LITERS PER HECTARE)

The same steps are used that are used when calibrating in gallons per acre. First a relationship between a measurable amount (milliliters) and the calibration amount (liter) is determined. That ratio is 1: 1,000.

Now an area which is 1/1,000 th of a hectare must be measured. On spray booms with 51 cm (20 inch) spacing, mark off an area which is 20 meters (65.6 feet) long. The area formed by that length and the width of one spray nozzle (20 meters by .5 meters) is 10 square meters which is 1/1,000 of a hectare. Therefore, the amount of spray material applied to this small area in milliliters is equal to the amount applied to one hectare in liters.

Then, follow the remaining steps 2-10, substituting milliliters for ounces, liters for gallons, square meters for square feet and hectares for acres.

AVERAGE OUTPUT (MILLILITERS) = APPLICATION RATE (LITERS/HA)

Maximum Target Rates for Spray Hawk with Smithco Spray Star Centrifugal Pump Systems

All Rates Calculated at 3 MPH

1/2 Inch Hose

	Max Pressure	GPT	GPA
04 Tips			
100 Feet	55 PSI	1.05 GPT	46 GPA
200 Feet	52 PSI	1.005 GPT	44 GPA
08 Tips			
100 Feet	40 PSI	1.8 GPT	78 GPA
200 Feet	30 PSI	1.6 GPT	70 GPA
15 Tips			
100 Feet	35 PSI	3.15 GPT	137 GPA
200 Feet	23 PSI	2.5 GPT	109 GPA

5/8 Inch Hose

04 Tips			
100 Feet	70 PSI	1.2 GPT	52 GPA
200 Feet	65 PSI	1.05 GPT	46 GPA
08 Tips			
100 Feet	52 PSI	2.05 GPT	89 GPA
200 Feet	42 PSI	1.85 GPT	80 GPA
15 Tips			
100 Feet	46 PSI	3.6 GPT	157 GPA
200 Feet	36 PSI	3.15 GPT	137 GPA

Universal Application Rate Chart for 20" Tip Spacing

TIP CAPACITY	LIQUID PRESSURE IN PSI	CAPACITY 1 NOZZLE IN GPM	CAPACITY 1 NOZZLE IN OZ./MIN.	GALLONS PER ACRE – 20" NOZZLE SPACING											
				4 MPH	5 MPH	6 MPH	7 MPH	8 MPH	10 MPH	12 MPH	14 MPH	16 MPH	18 MPH	20 MPH	22 MPH
01	15	0.061	7.8	4.5	3.6	3.0	2.6	2.3	1.8	1.5	1.3	1.1	1.0	0.91	0.82
	20	0.071	9.1	5.3	4.2	3.5	3.0	2.6	2.1	1.8	1.5	1.3	1.2	1.1	0.96
	30	0.087	11	6.5	5.2	4.3	3.7	3.2	2.6	2.2	1.8	1.6	1.4	1.3	1.2
	40	0.10	13	7.4	5.9	5.0	4.2	3.7	3.0	2.5	2.1	1.9	1.7	1.5	1.4
	50	0.11	14	8.2	6.5	5.4	4.7	4.1	3.3	2.7	2.3	2.0	1.8	1.6	1.5
	60	0.12	15	8.9	7.1	5.9	5.1	4.5	3.6	3.0	2.5	2.2	2.0	1.8	1.6
	75	0.14	18	10.4	8.3	6.9	5.9	5.2	4.2	3.5	3.0	2.6	2.3	2.1	1.9
	90	0.15	19	11.1	8.9	7.4	6.4	5.6	4.5	3.7	3.2	2.8	2.5	2.2	2.0
015	15	0.092	12	6.8	5.5	4.6	3.9	3.4	2.7	2.3	2.0	1.7	1.5	1.4	1.2
	20	0.11	14	8.2	6.5	5.4	4.7	4.1	3.3	2.7	2.3	2.0	1.8	1.6	1.5
	30	0.13	17	9.7	7.7	6.4	5.5	4.8	3.9	3.2	2.8	2.4	2.1	1.9	1.8
	40	0.15	19	11.1	8.9	7.4	6.4	5.6	4.5	3.7	3.2	2.8	2.5	2.2	2.0
	50	0.17	22	12.6	10.1	8.4	7.2	6.3	5.0	4.2	3.6	3.2	2.8	2.5	2.3
	60	0.18	23	13.4	10.7	8.9	7.6	6.7	5.3	4.5	3.8	3.3	3.0	2.7	2.4
	75	0.21	27	15.6	12.5	10.4	8.9	7.8	6.2	5.2	4.5	3.9	3.5	3.1	2.8
	90	0.23	29	17.1	13.7	11.4	9.8	8.5	6.8	5.7	4.9	4.3	3.8	3.4	3.1
02	15	0.12	15	8.9	7.1	5.9	5.1	4.5	3.6	3.0	2.5	2.2	2.0	1.8	1.6
	20	0.14	18	10.4	8.3	6.9	5.9	5.2	4.2	3.5	3.0	2.6	2.3	2.1	1.9
	30	0.17	22	12.6	10.1	8.4	7.2	6.3	5.0	4.2	3.6	3.2	2.8	2.5	2.3
	40	0.20	26	14.9	11.9	9.9	8.5	7.4	5.9	5.0	4.2	3.7	3.3	3.0	2.7
	50	0.22	28	16.3	13.1	10.9	9.3	8.2	6.5	5.4	4.7	4.1	3.6	3.3	3.0
	60	0.24	31	17.8	14.3	11.9	10.2	8.9	7.1	5.9	5.1	4.5	4.0	3.6	3.2
	75	0.27	35	20	16.0	13.4	11.5	10.0	8.0	6.7	5.7	5.0	4.5	4.0	3.6
	90	0.30	38	22	17.8	14.9	12.7	11.1	8.9	7.4	6.4	5.6	5.0	4.5	4.1
025	15	0.15	19	11.1	8.9	7.4	6.4	5.6	4.5	3.7	3.2	2.8	2.5	2.2	2.0
	20	0.18	23	13.4	10.7	8.9	7.6	6.7	5.3	4.5	3.8	3.3	3.0	2.7	2.4
	30	0.22	28	16.3	13.1	10.9	9.3	8.2	6.5	5.4	4.7	4.1	3.6	3.3	3.0
	40	0.25	32	18.6	14.9	12.4	10.6	9.3	7.4	6.2	5.3	4.6	4.1	3.7	3.4
	50	0.28	36	21	16.6	13.9	11.9	10.4	8.3	6.9	5.9	5.2	4.6	4.2	3.8
	60	0.31	40	23	18.4	15.3	13.2	11.5	9.2	7.7	6.6	5.8	5.1	4.6	4.2
	75	0.34	44	25	20	16.8	14.4	12.6	10.1	8.4	7.2	6.3	5.6	5.0	4.6
	90	0.38	49	28	23	18.8	16.1	14.1	11.3	9.4	8.1	7.1	6.3	5.6	5.1
03	15	0.18	23	13.4	10.7	8.9	7.6	6.7	5.3	4.5	3.8	3.3	3.0	2.7	2.4
	20	0.21	27	15.6	12.5	10.4	8.9	7.8	6.2	5.2	4.5	3.9	3.5	3.1	2.8
	30	0.26	33	19.3	15.4	12.9	11.0	9.7	7.7	6.4	5.5	4.8	4.3	3.9	3.5
	40	0.30	38	22	17.8	14.9	12.7	11.1	8.9	7.4	6.4	5.6	5.0	4.5	4.1
	50	0.34	44	25	20	16.8	14.4	12.6	10.1	8.4	7.2	6.3	5.6	5.0	4.6
	60	0.37	47	27	22	18.3	15.7	13.7	11.0	9.2	7.8	6.9	6.1	5.5	5.0
	75	0.41	52	30	24	20	17.4	15.2	12.2	10.1	8.7	7.6	6.8	6.1	5.5
	90	0.45	58	33	27	22	19.1	16.7	13.4	11.1	9.5	8.4	7.4	6.7	6.1
04	15	0.24	31	17.8	14.3	11.9	10.2	8.9	7.1	5.9	5.1	4.5	4.0	3.6	3.2
	20	0.28	36	21	16.6	13.9	11.9	10.4	8.3	6.9	5.9	5.2	4.6	4.2	3.8
	30	0.35	45	26	21	17.3	14.9	13.0	10.4	8.7	7.4	6.5	5.8	5.2	4.7
	40	0.40	51	30	24	19.8	17.0	14.9	11.9	9.9	8.5	7.4	6.6	5.9	5.4
	50	0.45	58	33	27	22	19.1	16.7	13.4	11.1	9.5	8.4	7.4	6.7	6.1
	60	0.49	63	36	29	24	21	18.2	14.6	12.1	10.4	9.1	8.1	7.3	6.6
	75	0.55	70	41	33	27	23	20	16.3	13.6	11.7	10.2	9.1	8.2	7.4
	90	0.60	77	45	36	30	25	22	17.8	14.9	12.7	11.1	9.9	8.9	8.1
05	15	0.31	40	23	18.4	15.3	13.2	11.5	9.2	7.7	6.6	5.8	5.1	4.6	4.2
	20	0.35	45	26	21	17.3	14.9	13.0	10.4	8.7	7.4	6.5	5.8	5.2	4.7
	30	0.43	55	32	26	21	18.2	16.0	12.8	10.6	9.1	8.0	7.1	6.4	5.8
	40	0.50	64	37	30	25	21	18.6	14.9	12.4	10.6	9.3	8.3	7.4	6.8
	50	0.56	72	42	33	28	24	21	16.6	13.9	11.9	10.4	9.2	8.3	7.6
	60	0.61	78	45	36	30	26	23	18.1	15.1	12.9	11.3	10.1	9.1	8.2
	75	0.68	87	50	40	34	29	25	20	16.8	14.4	12.6	11.2	10.1	9.2
	90	0.75	96	56	45	37	32	28	22	18.6	15.9	13.9	12.4	11.1	10.1
06	15	0.37	47	27	22	18.3	15.7	13.7	11.0	9.2	7.8	6.9	6.1	5.5	5.0
	20	0.42	54	31	25	21	17.8	15.6	12.5	10.4	8.9	7.8	6.9	6.2	5.7
	30	0.52	67	39	31	26	22	19.3	15.4	12.9	11.0	9.7	8.6	7.7	7.0
	40	0.60	77	45	36	30	25	22	17.8	14.9	12.7	11.1	9.9	8.9	8.1
	50	0.67	86	50	40	33	28	25	19.9	16.6	14.2	12.4	11.1	9.9	9.0
	60	0.73	93	54	43	36	31	27	22	18.1	15.5	13.6	12.0	10.8	9.9
	75	0.82	105	61	49	41	35	30	24	20	17.4	15.2	13.5	12.2	11.1
	90	0.90	115	67	53	45	38	33	27	22	19.1	16.7	14.9	13.4	12.2
08	15	0.49	63	36	29	24	21	18.2	14.6	12.1	10.4	9.1	8.1	7.3	6.6
	20	0.57	73	42	34	28	24	21	16.9	14.1	12.1	10.6	9.4	8.5	7.7
	30	0.69	88	51	41	34	29	26	20	17.1	14.6	12.8	11.4	10.2	9.3
	40	0.80	102	59	48	40	34	30	24	19.8	17.0	14.9	13.2	11.9	10.8
	50	0.89	114	66	53	44	38	33	26	22	18.9	16.5	14.7	13.2	12.0
	60	0.98	125	73	58	49	42	36	29	24	21	18.2	16.2	14.6	13.2
	75	1.10	141	82	65	54	47	41	33	27	23	20	18.2	16.3	14.9
	90	1.20	154	89	71	59	51	45	36	30	25	22	19.8	17.8	16.2
10	15	0.61	78	45	36	30	26	23	18.1	15.1	12.9	11.3	10.1	9.1	8.2
	20	0.71	91	53	42	35	30	26	21	17.6	15.1	13.2	11.7	10.5	9.6
	30	0.87	111	65	52	43	37	32	26	22	18.5	16.1	14.4	12.9	11.7
	40	1.00	128	74	59	50	42	37	30	25	21	18.6	16.5	14.9	13.5
	50	1.12	143	83	67	55	48	42	33	28	24	21	18.5	16.6	15.1
	60	1.22	156	91	72	60	52	45	36	30	26	23	20	18.1	16.5
	75	1.37	175	102	81	68	58	51	41	34	29	25	23	20	18.5
	90	1.50	192	111	89	74	64	56	45	37	32	28	25	22	20
15	15	0.92	118	68	55	46	39	34	27	23	19.5	17.1	15.2	13.7	12.4
	20	1.06	136	79	63	52	45	39	31	26	22	19.7	17.5	15.7	14.3
	30	1.30	166	97	77	64	55	48	39	32	28	24	21	19.3	17.6
	40	1.50	192	111	89	74	64	56	45	37	32	28	25	22	20
	50	1.68	215	125	100	83	71	62	50	42	36	31	28	25	23
	60	1.84	236	137	109	91	78	68	55	46	39	34	30	27	25
	75	2.05	262	152	122	101	87	76	61	51	43	38	34	30	28
	90	2.25	288	167	134	111	95	84	67	56	48	42	37	33	30
20	15	1.22	156	91	72	60	52	45	36	30	26	23	20	18.1	16.5
	20	1.41	180	105	84	70	60	52	42	35	30	26	23	21	19.0
	30	1.73	221	128	103	86	73	64	51	43	37	32	29	26	23
	40	2.00	256	149	119	99	85	74	59	50	42	37	33	30	27
	50	2.24	287	166	133	111	95	83	67	55	48	42	37	33	30
	60	2.45	314	182	146	121	104	91	73	61	52	45	40	36	33
	75	2.74	351	203	163	136	116	102	81	68	58	51	45	41	37
	90	3.00	384	223	178	149	127	111	89	74	64	56	50	45	41

Note: Always double check your application rates. Tabulations are based on spraying water at 70°F (21°C).

Universal Application Rate Chart for 50 cm Tip Spacing

TIP CAPACITY	LIQUID PRESSURE IN bar	CAPACITY 1 NOZZLE IN l/min	l/ha – 50 cm NOZZLE SPACING											
			4 km/h	6 km/h	8 km/h	10 km/h	12 km/h	14 km/h	16 km/h	18 km/h	20 km/h	25 km/h	30 km/h	35 km/h
01	1.0	0.23	69.0	46.0	34.5	27.6	23.0	19.7	17.3	15.3	13.8	11.0	9.2	7.9
	1.5	0.28	84.0	56.0	42.0	33.6	28.0	24.0	21.0	18.7	16.8	13.4	11.2	9.6
	2.0	0.32	96.0	64.0	48.0	38.4	32.0	27.4	24.0	21.3	19.2	15.4	12.8	11.0
	3.0	0.39	117	78.0	58.5	46.8	39.0	33.4	29.3	26.0	23.4	18.7	15.6	13.4
	4.0	0.45	135	90.0	67.5	54.0	45.0	38.6	33.8	30.0	27.0	21.6	18.0	15.4
	5.0	0.50	150	100	75.0	60.0	50.0	42.9	37.5	33.3	30.0	24.0	20.0	17.1
	6.0	0.55	165	110	82.5	66.0	55.0	47.1	41.3	36.7	33.0	26.4	22.0	18.9
	7.0	0.60	180	120	90.0	72.0	60.0	51.4	45.0	40.0	36.0	28.8	24.0	20.6
015	1.0	0.34	102	68.0	51.0	40.8	34.0	29.1	25.5	22.7	20.4	16.3	13.6	11.7
	1.5	0.42	126	84.0	63.0	50.4	42.0	36.0	31.5	28.0	25.2	20.2	16.8	14.4
	2.0	0.48	144	96.0	72.0	57.6	48.0	41.1	36.0	32.0	28.8	23.0	19.2	16.5
	3.0	0.59	177	118	88.5	70.8	59.0	50.6	44.3	39.3	35.4	28.3	23.6	20.2
	4.0	0.68	204	136	102	81.6	68.0	58.3	51.0	45.3	40.8	32.6	27.2	23.3
	5.0	0.76	228	152	114	91.2	76.0	65.1	57.0	50.7	45.6	36.5	30.4	26.1
	6.0	0.83	249	166	125	99.6	83.0	71.1	62.3	55.3	49.8	39.8	33.2	28.5
	7.0	0.90	270	180	135	108	90.0	77.1	67.5	60.0	54.0	43.2	36.0	30.9
02	1.0	0.46	138	92.0	69.0	55.2	46.0	39.4	34.5	30.7	27.6	22.1	18.4	15.8
	1.5	0.56	168	112	84.0	67.2	56.0	48.0	42.0	37.3	33.6	26.9	22.4	19.2
	2.0	0.65	195	130	97.5	78.0	65.0	55.7	48.8	43.3	39.0	31.2	26.0	22.3
	3.0	0.79	237	158	119	94.8	79.0	67.7	59.3	52.7	47.4	37.9	31.6	27.1
	4.0	0.91	273	182	137	109	91.0	78.0	68.3	60.7	54.6	43.7	36.4	31.2
	5.0	1.02	306	204	153	122	102	87.4	76.5	68.0	61.2	49.0	40.8	35.0
	6.0	1.12	336	224	168	134	112	96.0	84.0	74.7	67.2	53.8	44.8	38.4
	7.0	1.21	363	242	182	145	121	104	90.8	80.7	72.6	58.1	48.4	41.5
025	1.0	0.57	171	114	85.5	68.4	57.0	48.9	42.8	38.0	34.2	27.4	22.8	19.5
	1.5	0.70	210	140	105	84.0	70.0	60.0	52.5	46.7	42.0	33.6	28.0	24.0
	2.0	0.81	243	162	122	97.2	81.0	69.4	60.8	54.0	48.6	38.9	32.4	27.8
	3.0	0.99	297	198	149	119	99.0	84.9	74.3	66.0	59.4	47.5	39.6	33.9
	4.0	1.14	342	228	171	137	114	97.7	85.5	76.0	68.4	54.7	45.6	39.1
	5.0	1.28	384	256	192	154	128	110	96.0	85.3	76.8	61.4	51.2	43.9
	6.0	1.40	420	280	210	168	140	120	105	93.3	84.0	67.2	56.0	48.0
	7.0	1.51	453	302	227	181	151	129	113	101	90.6	72.5	60.4	51.8
03	1.0	0.68	204	136	102	81.6	68.0	58.3	51.0	45.3	40.8	32.6	27.2	23.3
	1.5	0.83	249	166	125	99.6	83.0	71.1	62.3	55.3	49.8	39.8	33.2	28.5
	2.0	0.96	288	192	144	115	96.0	82.3	72.0	64.0	57.6	46.1	38.4	32.9
	3.0	1.18	354	236	177	142	118	101	88.5	78.7	70.8	56.6	47.2	40.5
	4.0	1.36	408	272	204	163	136	117	102	90.7	81.6	65.3	54.4	46.6
	5.0	1.52	456	304	228	182	152	130	114	101	91.2	73.0	60.8	52.1
	6.0	1.67	501	334	251	200	167	143	125	111	100	80.2	66.8	57.3
	7.0	1.80	540	360	270	216	180	154	135	120	108	86.4	72.0	61.7
04	1.0	0.91	273	182	137	109	91.0	78.0	68.3	60.7	54.6	43.7	36.4	31.2
	1.5	1.12	336	224	168	134	112	96.0	84.0	74.7	67.2	53.8	44.8	38.4
	2.0	1.29	387	258	194	155	129	111	96.8	86.0	77.4	61.9	51.6	44.2
	3.0	1.58	474	316	237	190	158	135	119	105	94.8	75.8	63.2	54.2
	4.0	1.82	546	364	273	218	182	156	137	121	109	87.4	72.8	62.4
	5.0	2.04	612	408	306	245	204	175	153	136	122	97.9	81.6	69.9
	6.0	2.23	669	446	335	268	223	191	167	149	134	107	89.2	76.5
	7.0	2.41	723	482	362	289	241	207	181	161	145	116	96.4	82.6
05	1.0	1.14	342	228	171	137	114	97.7	85.5	76.0	68.4	54.7	45.6	39.1
	1.5	1.39	417	278	209	167	139	119	104	92.7	83.4	66.7	55.6	47.7
	2.0	1.61	483	322	242	193	161	138	121	107	96.6	77.3	64.4	55.2
	3.0	1.97	591	394	296	236	197	169	148	131	118	94.6	78.8	67.5
	4.0	2.27	681	454	341	272	227	195	170	151	136	109	90.8	77.8
	5.0	2.54	762	508	381	305	254	218	191	169	152	122	102	87.1
	6.0	2.79	837	558	419	335	279	239	209	186	167	134	112	95.7
	7.0	3.01	903	602	452	361	301	258	226	201	181	144	120	103
06	1.0	1.37	411	274	206	164	137	117	103	91.3	82.2	65.8	54.8	47.0
	1.5	1.68	504	336	252	202	168	144	126	112	101	80.6	67.2	57.6
	2.0	1.94	582	388	291	233	194	166	146	129	116	93.1	77.6	66.5
	3.0	2.37	711	474	356	284	237	203	178	158	142	114	94.8	81.3
	4.0	2.74	822	548	411	329	274	235	206	183	164	132	110	93.9
	5.0	3.06	918	612	459	367	306	262	230	204	184	147	122	105
	6.0	3.35	1005	670	503	402	335	287	251	223	201	161	134	115
	7.0	3.62	1086	724	543	434	362	310	272	241	217	174	145	124
08	1.0	1.82	546	364	273	218	182	156	137	121	109	87.4	72.8	62.4
	1.5	2.23	669	446	335	268	223	191	167	149	134	107	89.2	76.5
	2.0	2.58	774	516	387	310	258	221	194	172	155	124	103	88.5
	3.0	3.16	948	632	474	379	316	271	237	211	190	152	126	108
	4.0	3.65	1095	730	548	438	365	313	274	243	219	175	146	125
	5.0	4.08	1224	816	612	490	408	350	306	272	245	196	163	140
	6.0	4.47	1341	894	671	536	447	383	335	298	268	215	179	153
	7.0	4.83	1449	966	725	580	483	414	362	322	290	232	193	166
10	1.0	2.28	684	456	342	274	228	195	171	152	137	109	91.2	78.2
	1.5	2.79	837	558	419	335	279	239	209	186	167	134	112	95.7
	2.0	3.23	969	646	485	388	323	277	242	215	194	155	129	111
	3.0	3.95	1185	790	593	474	395	339	296	263	237	190	158	135
	4.0	4.56	1368	912	684	547	456	391	342	304	274	219	182	156
	5.0	5.10	1530	1020	765	612	510	437	383	340	306	245	204	175
	6.0	5.59	1677	1118	839	671	559	479	419	373	335	268	224	192
	7.0	6.03	1809	1206	905	724	603	517	452	402	362	289	241	207
15	1.0	3.42	1026	684	513	410	342	293	257	228	205	164	137	117
	1.5	4.19	1257	838	629	503	419	359	314	279	251	201	168	144
	2.0	4.83	1449	966	725	580	483	414	362	322	290	232	193	166
	3.0	5.92	1776	1184	888	710	592	507	444	395	355	284	237	203
	4.0	6.84	2052	1368	1026	821	684	586	513	456	410	328	274	235
	5.0	7.64	2292	1528	1146	917	764	655	573	509	458	367	306	262
	6.0	8.37	2511	1674	1256	1004	837	717	628	558	502	402	335	287
	7.0	9.04	2712	1808	1356	1085	904	775	678	603	542	434	362	310
20	1.0	4.56	1368	912	684	547	456	391	342	304	274	219	182	156
	1.5	5.58	1674	1116	837	670	558	478	419	372	335	268	223	191
	2.0	6.44	1932	1288	966	773	644	552	483	429	386	309	258	221
	3.0	7.89	2367	1578	1184	947	789	676	592	526	473	379	316	271
	4.0	9.11	2733	1822	1367	1093	911	781	683	607	547	437	364	312
	5.0	10.19	3057	2038	1529	1223	1019	873	764	679	611	489	408	349
	6.0	11.16	3348	2232	1674	1339	1116	957	837	744	670	536	446	383
	7.0	12.05	3615	2410	1808	1446	1205	1033	904	803	723	578	482	413

Note: Always double check your application rates. Tabulations are based on spraying water at 70°F (21°C).