



Droplet Size - Chemigation

Goal of Drift Reduction

When applying any product through an irrigation system the goal is to minimize the amount of off-target drift, reduce or eliminate damage to the surrounding environment, and to lessen human health concerns.

Drift occurs in two forms: particle drift and vapor drift. Particle drift is the physical movement of spray droplets at the time of application. With irrigation systems, particle drift is directly influenced by nozzle selection, release height, pressure, initial droplet velocity, deflection-plate shape and kinematics (motion), and meteorological conditions (atmospheric stability, wind speed, air temperature, and relative humidity). Many factors affect particle movement, but the most influential factors affecting drift are initial droplet size, a function of pressure and orifice size, and wind velocity, as well as release height.

Vapor drift occurs when an applied product volatilizes – that is, changes to a gaseous form – and moves off-target. Drift can occur after the application, but may also take place when small droplets vaporize after release from the nozzle and before contact with the target site takes place.

Drop Size and Potential

Droplets smaller than 100 microns are considered highly “driftable.” Droplets less than 150 microns are very susceptible to drift. Drift is more dependent on the irregular movement of turbulent air than on gravity. The longer a droplet is airborne, the greater the potential for drift.

Unless spray particles are electrostatically charged, only two forces act upon the droplet, gravity and air resistance. Besides reducing droplet speed, air resistance also breaks up the droplet. Hence, a spinning deflector-plate may increase the volume percentage of smaller droplets. In general, the more grooves on a deflection plate, the smaller the droplet sizes for a particular nozzle orifice size and operating pressure.

Evaporation increases drift potential. Evaporation is greater with small droplets because small droplets have greater surface area relative to their volume (surface area to mass ratio) as compared with larger droplets. As droplet diameter decreases, so does

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mass. With less mass and greater surface area, small droplets will fall much slower than larger droplets, due to more friction with the surrounding air. Maintaining a downward velocity longer than smaller droplets, larger droplets are less susceptible to drift and are more likely to be deposited on the intended target.

Ambient air temperature and relative humidity influence the evaporation rate of a droplet. As temperature increases and relative humidity decreases, the droplet will evaporate more rapidly. As evaporation occurs, droplet diameter decreases, as does its mass, affecting a droplet’s size, flight time, velocity, and drift distance. In contrast, high relative humidity greatly increases the longevity (and drift distance) of small diameter droplets before they evaporate.

The influence of wind velocity on drift distance increases as droplet size decreases. With a greater proportion of the total spray volume in smaller droplets, the potential drift onto off-target sites increases. The amount of product lost from the target area and the distance it moves both increase with an increase in wind velocity and in release height (Table 1).

Droplet Diameter, in Microns	Type of Droplet	Time Required to fall 10 Feet	Lateral Distance Droplets Travel in Falling 10 Feet in a 3 mph Wind
5	Fog	66 minutes	3 miles
20	Very fine spray	4.2 minutes	1,100 feet
100	Fine spray	10 seconds	44 feet
240	Medium spray	6 seconds	28 feet
400	Coarse spray	2 seconds	8.5 feet
1,000	Fine rain	1 second	4.7 feet

Source: Akesson & Yates, Kingman, and Potts.

In atmospheric inversion conditions, decreasing the number of small droplets will reduce the potential for drift, since small droplets do not settle quickly, given the limited influence of gravity because of the particles small mass.

National Standard for Measuring Droplet Size

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 is measured in microns (micrometers). One micron equals 0.001 mm (.0000394 inch). ASABE Standard S572 stipulates

strict conditions for spray droplet measurement, which is used to formulate the droplet size classification: very fine, fine, medium, coarse, very coarse, and extremely coarse (Table 2).

Table 2. Nozzle Droplet Size Classification, in microns.

Droplet Size*	Very Fine	Fine	Medium	Coarse	Very Coarse	Extremely Coarse
D _{v0.5}	≤182	183-280	281-429	430-531	532-655	>655

* American Society of Agricultural and Biological Engineers (ASABE) Standard, S572.

The standard is based upon the average size droplets, known as the volume median diameter, that are produced at a particular operating pressure from a nozzle. Volume median diameter (VMD) is a droplet size diameter at which one-half of the total output volume is contained in droplets larger than the VMD, and one-half of the volume is in droplets smaller than the VMD. Hence, VMD is often referenced as $D_{v0.5}$. Since many more small droplets comprise one-half the spray volume, there always will be more small droplets in a spray pattern. An indication of the mid-point droplet size, VMD is used as a basis from which to compare different nozzles.

However, drift potential depends not only on the VMD, but also on the total spectrum of droplet sizes. Thus, two other values are also important. They are the 10 percent volume and 90 percent volume droplet size and are represented by $D_{v0.1}$ and $D_{v0.9}$. The $D_{v0.1}$ value indicates that 10 percent of the spray volume is in droplets smaller than this value and may be a major part of the driftable fines. The $D_{v0.9}$ value indicates that 90 percent of the spray volume is in droplets smaller than this value; conversely, 10 percent of the spray volume is in droplets larger than this value.

Strategies to Sustain Large Droplet Diameter

The most important factor in reducing drift is the size of the droplets produced by the nozzle. Droplets with a diameter of 150 microns and smaller are susceptible to drift due to wind, temperature, relative humidity, and release height (Bode, 1984).

Droplets of 200 microns or larger in diameter are less prone to drift influencing factors. Practices to diminish off-target movement are summarized below.

1. Decrease Release Height or Distance Between Sprinkler and Target.

- ▶ Less distance means less travel time from nozzle to target.
- ▶ With little inertial energy, the fall time of small droplets is much greater when compared with larger droplets.
- ▶ Wind velocity is often greater as height above the ground increases; spray droplets released from a lower nozzle height will be affected by a lower wind velocity.
- ▶ High temperature and low relative humidity have less of an evaporative effect.
- ▶ Drift distance increases with an increase in discharge high, regardless of droplet size.

2. Decrease System Operating Pressure.

- ▶ Pressure fractures a droplet into smaller droplets. The relationship between flow rate (gpm) and pressure (psi) is not linear, but a square root. For example, to double the flow rate would require the pressure to be increase by four times.
- ▶ Reducing droplet diameter by one-half will result in eight-times the number of droplets.

3. Be Aware of Wind Direction and Speed.

- ▶ As wind speed increases, so does the potential for droplet movement and distance.
- ▶ Applications should not occur if wind is blowing toward a nearby susceptible crop, a crop in a vulnerable stage of growth, or a sensitive area.
- ▶ During atmospheric suspension, wind velocity has a greater influence on changes in droplet size on smaller droplets than on larger droplets, especially if droplets are smaller than 200 microns.

4. Use Larger Orifice Sprinklers or Nozzles, Install Deflector Plates that Create Larger Droplets.

- ▶ A larger flow or stream of water will produce larger drops.
- ▶ In general, the more grooves on a deflection plate sprinkler, the smaller the droplet size for a particular nozzle size and pressure.
- ▶ Flat, smooth deflector plates increase the percent volume of smaller droplet sizes.
- ▶ With impact sprinklers, droplet size is highly influenced by the nozzle size and pressure, with nozzle pressure having a greater affect on the droplet than nozzle size.
- ▶ Conversely, sprayheads where the water stream is deflected and divided by a deflection plate is influenced by nozzle size and by plate shape, with the later appearing to have more of an effect on droplet size (Kincaid, Solomon, & Oliphant, 1996).

5. Do not Chemigate During Inversions or Stable Air Conditions.

- ▶ Both horizontal and vertical air movement contribute to off-target movement and distribution of spray droplets.
- ▶ Under inversion conditions, little vertical mixing of air occurs; as a result, small droplets fall slowly or may remain suspended and move significant horizontal distances.
- ▶ Larger droplet size, due to its greater mass, is more predisposed to gravitational forces.

6. Relative Humidity and Temperature.

- ▶ Low relative humidity and/or high temperature conditions cause faster evaporation of spray droplets, increasing the potential for drift.
- ▶ Evaporative potential is greater with small droplets because smaller droplets have greater surface area relative to their volume.
- ▶ Drift distance increases with increasing temperature due to a faster evaporation rate, resulting in a smaller droplet size and increased travel distance before deposition.
- ▶ Because smaller droplets have greater surface area-to-volume ratios and longer flight times than larger droplets, temperature and relative humidity have greater influence on the drift distance of smaller droplets. Ambient temperature and relative humidity have little influence on drift distances of 200-micron diameter and larger water droplets.

References:

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