Spray Droplet Sizing – Understanding the Basics

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Droplet Diameter

D = droplet diameter
V = droplet volume

\[ V = \frac{1}{6} \pi D^3 \]

At equal volume with droplets of ½ diameter

\[
\frac{V_1}{V_2} = \frac{D_1^3}{0.5D_1^3} = \frac{1^3}{0.5^3} = \frac{1}{0.125} = 8
\]

8X the # Droplets
Droplet Volume in the Spray Cloud

One 400 µm drop
Droplet Volume in the Spray Cloud

8 - 200 µm drops
Droplet Volume in the Spray Cloud

64 - 100 µm drops
Total Spray Volume

Characteristics of total spray volume.

**Number Distribution**

Or

**Volume Distribution**
Volume vs Number

\[
V_{400} = 8 \times V_{200} = 64 \times V_{100}
\]

Total Spray Volume of:
\[
V_{400} + 8(V_{200}) + 64(V_{100})
\]
# Why Volume vs Count?

## Count Distribution
We have a total of 73 drops.

\[1 + 8 + 64\]

## Volume Distribution
We have a total Volume \( V \).

\[V_{400} + 8 \times V_{200} + 64 \times V_{100} = V\]

## Amount of active product:

- **Volume** of spray droplets
- **NOT**
- **Number** of droplets

<table>
<thead>
<tr>
<th>Size (µm)</th>
<th>Count Distribution</th>
<th>Volume Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>33.3%</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>87.7%</td>
<td>33.3%</td>
</tr>
</tbody>
</table>

**100 µm**

\[\frac{64}{73} = 87.7\%\]  
\[100 \mu m = \frac{64 \times V_{100}}{V} = 33.3\%\]
Volume Distribution

- $D_{V10}$ or $D_{V0.1}$
- $D_{V50}$ or $D_{V0.5}$ or VMD
- $D_{V90}$ or $D_{V0.9}$
- %Vol<100µm
- %Vol<200µm

How do we get to the numbers we typically deal with?

Using some measurement system, the percentage of the total spray volume that is in each droplet size range is determined.
**Review**

- $D_{V10}$, $D_{V50}$ or VMD, $D_{V90}$
  - The diameter for which 10% of the total spray volume is made up of droplets of equal or lesser diameter.

This diameter is the $D_{V10}$
This diameter is the VMD
Relative Span

\[ RS = \frac{D_{v90} - D_{v10}}{D_{v50}} \]

An indicator of the \textbf{width} of distribution.
VMD = 300µm

RS = 0.67
RS = 1.4
RS = 2.2

$D_{V10}$ 90 µm
$D_{V10}$ 165 µm
$D_{V10}$ 200 µm
$D_{V90}$ 400 µm
$D_{V90}$ 435 µm
$D_{V90}$ 510 µm
Take Home

• At equal volume:
  – Halving the diameter creates 8X droplets
  – Quartering creates 64X droplets
    • The smaller the diameter, the greater the number of droplets, and the less control you have over them.

• Volume Distribution corresponds to available product and efficacy
  – $D_{V10}$, $D_{V50}$ (VMD), $D_{V90}$, RS, %<100µm, etc…
Measurement

Groundspeed?
It’s All About How You Measure…

Likely Will Get Different Exact Numbers
It’s All Relative

Slowest

Fastest
While Numerical Diameters may differ, Relative Size will be consistent
Reference Sprays

- Establish Reference Nozzles/Sprays

### ANSI/ASAE S572.1 MAR2009
Approved March 2009 as an American National Standard

#### Spray Nozzle Classification by Droplet Spectra

Developed by the ASAE Pest Control and Fertilizer Application Committee; approved by the Power and Machinery Division Standards Committee; adopted by ASAE August 1999; reaffirmed February 2004; revised March 2009; approved as an American National Standard March 2009.

**Keywords:** Chemicals, Drop size, Droplet, Fertilizer, Nozzle, Spray

1. **Purpose and scope**

1.1 This Standard defines droplet spectrum categories for the classification of spray nozzles, relative to specified reference fan nozzles discharging spray into static air or so that no stream of air enhances atomization. The purpose of classification is to provide the nozzle user with droplet size information primarily to indicate off-site spray drift potential and secondarily for application efficacy.

### 3.3 Classification categories, symbols, and corresponding color codes are the following:

<table>
<thead>
<tr>
<th>Classification category</th>
<th>Symbol</th>
<th>Color code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely fine</td>
<td>XF</td>
<td>Purple</td>
</tr>
<tr>
<td>Very fine</td>
<td>VF</td>
<td>Red</td>
</tr>
<tr>
<td>Fine</td>
<td>F</td>
<td>Orange</td>
</tr>
<tr>
<td>Medium</td>
<td>M</td>
<td>Yellow</td>
</tr>
<tr>
<td>Coarse</td>
<td>C</td>
<td>Blue</td>
</tr>
<tr>
<td>Very coarse</td>
<td>VC</td>
<td>Green</td>
</tr>
<tr>
<td>Extremely coarse</td>
<td>XC</td>
<td>White</td>
</tr>
<tr>
<td>Ultra coarse</td>
<td>UC</td>
<td>Black</td>
</tr>
</tbody>
</table>
MEDIUM Spray
DV10: 80 to 110 um
DV50: 190 to 280 um

MEDIUM Spray
DV10: 105 to 155 um
DV50: 230 to 350 um
# Be Cautious with Numbers

## ASABE S572 Standard

<table>
<thead>
<tr>
<th>Category and code</th>
<th>VMD (microns)</th>
<th>Color code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Fine (XF)</td>
<td>&lt;50</td>
<td>Purple</td>
</tr>
<tr>
<td>Very Fine (VF)</td>
<td>50 – 150</td>
<td>Red</td>
</tr>
<tr>
<td>Fine (F)</td>
<td>150 – 250</td>
<td>Orange</td>
</tr>
<tr>
<td>Medium (M)</td>
<td>250 – 350</td>
<td>Yellow</td>
</tr>
<tr>
<td>Coarse (C)</td>
<td>350 – 450</td>
<td>Green</td>
</tr>
<tr>
<td>Very Coarse (VC)</td>
<td>450 – 550</td>
<td>Blue</td>
</tr>
<tr>
<td>Extremely Coarse (XC)</td>
<td>550 – 650</td>
<td>White</td>
</tr>
<tr>
<td>Ultra Coarse (UC)</td>
<td>&gt;650</td>
<td>Black</td>
</tr>
</tbody>
</table>
Labels – Beware of Conflict

Apply only as a medium or coarser spray (ASAE standard 572) or a volume mean diameter of 300 microns or greater.

**IMPORTANCE OF DROPLET SIZE**
The most effective way to reduce drift potential is to apply large droplets (>150 microns). The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. The presence of sensitive species nearby, the environmental conditions, and pest pressure may affect how an applicator balances drift control and coverage.

Use sufficient carrier volume and appropriate equipment set-up to form droplets large enough to avoid drift potential. Coarse droplets in the 300 to 500 (VMD) micron range are recommended.

Coarse sprays are less likely to drift; therefore, do not use nozzles or nozzle configurations which dispense spray as fine spray droplets. Do not angle nozzles forward into the airstream and do not increase spray volume by increasing nozzle pressure.

**Aerial Application:** Poor coverage will result in reduced weed control. For optimal weed control, apply Liberty 280 SL Herbicide in a minimum of 10 gallons per acre. Apply Liberty 280 SL Herbicide using nozzles and pressures that generate MEDIUM (about 300 to 400 microns) spray droplets category as reported by the nozzle manufacturer and in accordance to ASABE S 572 based upon the selected air speed. Do not use nozzles and pressures that result in COARSE sprays. FINE sprays should also be avoided to minimize spray drift risk. See the Spray Drift Management section of this label for additional information on proper application of Liberty 280 SL Herbicide.

**Better to go by Class than Size**
Take Home

• **Droplet Size Number** can vary from lab to lab, company to company....

• BUT

• **Droplet Size Classification** is consistent.
Differences Within a Class

MEDIUM Spray – USDA ARS Current Nozzle Models

- DV10: 141 µm
- DV50: 280 µm
- DV10: 180 µm
- DV50: 429 µm
2 MEDIUM Sprays

Medium #1
8°, 60 psi and 150 mph
$D_{V10} = 184$
VMD = 322
$D_{V90} = 543$
%<$100um = 2.7%

Medium #2
38°, 60 psi and 150 mph
$D_{V10} = 146$
VMD = 282
$D_{V90} = 433$
%<$100um = 5.6%

CP11TT with 4015 FF
What Happens in the Field?

Downwind Drift

Medium #1
1.6%

Medium #2
2.4%
Take Home

Consider Size Class first.
Then
Optimize setups to decrease fines.

Remember
Not all MEDIUM or COARSE sprays are equal