# SOP: Calibration for Backpack and Truck-Mounted Sprayers

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**Version Control**[1]

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| 1 | 04/07/23 | Annabel Murphy | Updated: Format and structure of content under sub-headings and footnotes, |

[1] Historical versions of SOPs can be found on the I2I website (https://innovationtoimpact.org/)

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| | | | added glossary of terms and references |

**Related documents**

- I2I Best Practice SOP Library, 30 October 2020 (https://innovationtoimpact.org/)
- Operation and Maintenance of the Track Sprayer, I2I-SOP-025

# 1. Purpose

All spray equipment must be properly calibrated to ensure accurate application of the compound. There is a large range of equipment available with many different designs[2]:

# 2. Background

### 2.1. Backpack Sprayers

Each sprayer must be calibrated to ensure that the correct amount of insecticide is delivered with the prescribed droplet size distribution. The output rate depends on the walking speed of the operator and the effective track spacing. Track spacing is the distance between each spray line and is the measure required for calibration. Swath width is the effective application distance downwind. For backpack sprayers, it is often easier to find the natural pace of the operator and adjust the flow rate to achieve the required application rate per unit area (ml/ha or l/ha). Flow can be controlled manually by a valve or fixed restrictor orifices. Most backpack aerosol generators have an integrated flow meter & flow control valve, and the calibration is accomplished by means of viscosity charts to identify the appropriate settings. It is recommended, however, that the flow rate is still tested with the method below. Note that different chemicals have different viscosities at different temperatures. Calibrate flow rate at a temperature relevant to the conditions during operation. A flowrate equation can be used.[3]

[2] refer to the manufacturer's user manual for specific details on calibration procedures and operation.

[3] Flowrate (mL/min)=(WS*TS*AR)/10 where WS (m/min) = Applicator normal walking speed with sprayer where WS (m/min) = Applicator normal walking speed with sprayer, TS (m) = Track spacing or

### 2.2. Sprayer Calibration Truck Sprayer

Each sprayer must be calibrated to ensure that the correct amount of insecticide is delivered with the prescribed droplet size distribution. The output rate depends on the driving speed and the effective track spacing (or swath width, if practically feasible). Track spacing is the distance between each spray line and is the measure required for calibration: this should conform to street spacing distance in each country. Swath width is the effective application distance downwind. Once this is known, the required flow rate from the vehicle can be calculated. The flow from the sprayer (l/min) equals the coverage (ha/min) multiplied by the application rate (l/ha). Flow can be controlled manually by either a valve or fixed restrictor orifices, or electronically by means of a variable speed pump. See the manufacturer's instructions for the appropriate method of controlling flowrates. A flowrate equation can be used.[4]

Spray emanating from a cold fogging nozzle cannot be captured into a container. Most truck mounted cold foggers come with a method to either insert a calibration tube into the nozzle head or detach the feeder tube from the nozzle assembly for flow rate measurement.

All persons involved with the transfer of the chemical must wear overalls, protective gloves and goggles. Those persons involved with the operation of the machinery should also wear a suitable respirator and ear protection (when standing within 2 m of the sprayer). Operators must follow national regulations on pesticide use and the recommendations of the manufacturer, paying attention to the personal protective equipment (PPE) section.

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distance between walking tracks, AR (L/ha) = Target application rate, 10 is used for unit conversion. Example: If an operator walks at a speed of 60 meters per minute with a track spacing of 10 m (600 m2 in one min) for an application rate of 0.5 l/ha, the flow rate should be 30 ml/min.

[4] Flowrate (mL/min)=VS*TS*AR*1.67, where VS (km/hr) = Vehicle speed during normal spray operations, TS (m) = Track spacing or distance between walking tracks, AR (L/ha) = Target application rate, 1.67 is used for unit conversion. Example: If a vehicle's speed is 12 km/hour and track spacing is 50 m with a target application rate of 0.5 l/ha, the flow rate would be 500ml/min.

It is essential that the droplet size distribution is known and adjusted if necessary. The required droplet size distribution could range between Dv0.5[5] 10-40 µm (WHO, 2018; Equipment for Vector Control Specification Guidelines, second edition, Geneva) depending on the machinery, the chemical formulation or other application parameters. Follow the label and instructions by the equipment manufacturer. The statistics requested from droplet sizing analysis are the Dv0.1,Dv0.5 and Dv0.9[6], where 10%, 50% and 90% of the spray volume is in droplets of a smaller diameter. For backpack sprayers, the two most relevant techniques are hotwire anemometry and a slide wave technique for microscopic analysis. Laser based techniques are also available but highly specialized and cost prohibitive. However, droplet size data for Page 4 of 8 several backpacks are available using the Vector Sprays app for iPhones[7]

For hot wire anemometry, the most common instrument for these measurements are the DC-III and DC-IV systems available from KLD labs https://www.kldlabs.com/compliance-testing/aerosol-dispersion/. This is an electronic technique where a fine (5 µm) wire, typically platinum, is electrically heated to a uniform temperature. As a droplet impinges on the surface of the wire the temperature drops proportionally to the size of the droplet and is measured by a change in resistance. This technique requires that the operator be close to the nozzle as the sensor is velocity dependent, droplets must be traveling at 5-7 m/s for the measurement to be accurate. Hotwire anemometers are not suitable for calibrating thermal foggers.

## 3. Materials and equipment

### 3.1. For measuring flow rate

- Personal Protective Equipment

[5] Dv represents a diameter of which a % of droplets are smaller than e.g., Dv0.1 would represent the diameter of which 10% of droplets are smaller than and Dv0.9 would represent the diameter that 90% of droplets are smaller than

[7] This data was collected by the USDA-ARS

- Graduated cylinder
- Stopwatch
- Collection jug or large container

### 3.2. Slide wave technique

- Microscope slides
- Stick and tape
- Rotating impactor
- Stand for rotating impactor

### 3.3. For using the DC-III

- Hot Wire Anemometer
- Computer

## 4. Procedure

### 4.1. Measuring flow rate: Backpack sprayers

- Put on gloves, overalls, respirator, and protective goggles.
- Run the equipment for a suitable time to ensure the lines are primed with insecticide solution.
- Operate the equipment under the same conditions as during actual spray operations. Most equipment is operated at full throttle during spray operations;

therefore, the sprayer should be operated similarly during the calibration measurements.

- Disconnect the discharge tube from the spray nozzle and hold the tube in the graduated cylinder. Turn the sprayer on and let it flow for one minute. If the nozzle head must remain attached, a larger measuring vessel will be required, one that will cause minimal loss due to the velocity of the spray. After one minute of discharge into the measuring container, measure the liquid volume.

- Measure flow rate as ml/min.

- Repeat this a minimum of three times and calculate the average value, aiming to have a coefficient of variation of less than 10% between replicates.

- Return insecticide collected to the main tank and wash all measuring containers following an appropriate protocol according to the insecticide used. The graduated cylinder and additional tubing should be dedicated to this task and not used for anything else.

**4.2. Measuring flow rate: Truck sprayer**

- Put on gloves, overalls, a face mask, and protective glasses.

- Run the equipment for a suitable time, until all the lines are primed with insecticide solution.

- Disconnect the discharge tube or the calibration tube inserted and hold in the graduated cylinder. Turn the spray on and let it flow for one minute. At the end of the minute measure the liquid volume in the graduated cylinder.

- Measure and record flow rate as ml/min.

- Repeat this a minimum of three times and calculate the average value, aiming to have a coefficient of variation of less than 10% between replicates.

- Return insecticide collected to the main tank and wash all measuring containers following an appropriate protocol according to active ingredient. The graduated cylinder and additional tubing should be dedicated to this role and not used for anything else.

**4.3. Procedure for using the DC-III (KLDlabs.com)**

- Ensure hot wire equipment is set-up to the spray solution type according to the manufacturer's instructions.

- Wear gloves, overalls, respirator and protective goggles.

- Turn on the sprayer and let it run to ensure that it is primed with insecticide solution.

- Place the sensor away from the nozzle where air velocity is estimated to be.

- Move probe closer to the nozzle in short steps, each time measuring the air velocity until it is within the range of 5-7 m/s. Then mark that distance.

- Measure the droplet size at that distance.

- Take five separate samples.

- Turn off the sprayer.

- Carefully clean the anemometer with a solvent by dipping the probe in 50% acetone and 50% xylene. Gently shake the container for 10 seconds to ensure the probe is cleaned, and then repeat with distilled water. Do this after every measurement test.

### 4.4. Slide wave technique

- Turn on the sprayer, let it run to ensure it's primed with insecticide solution.
- For the human powered swing, allow the sprayer to remain stationary. Once primed the operator approaches and rapidly swings the slide through the plume. For the rotating slide, turn the device on and have the sprayer move past the device once it is primed.
- Take five separate samples.
- Turn the sprayer off.
- Remove the slide and return it to the laboratory for microscopic analysis.

### 4.5. Data Analysis

The hotwire anemometer connects to a computer and provides all the required statistics. The slide wave technique requires visual examination of droplets using a compound microscope. As a droplet impacts on a slide it spreads larger than the original spherical drop. Droplet diameter is then determined by multiplying a spread factor that corrects for this anomaly. A common spread factor for many oil-based sprays is 0.62, which means that the droplet measured on the slide was created by a droplet that is 62% smaller. As a droplet impacts on a slide it spreads, and is larger than the original spherical drop, the original size is calculated by applying a spread factor to the data[8]. The diameter of the droplet is multiplied by the spread factor to provide the size of the original droplet. Image analysis software can rapidly compute the required statistics. The manual technique uses an eye piece graticule to measure the diameter of a minimum of 200 droplets per slide. To account for the varying collection efficiencies of different aerosol droplet sizes on waved or spinning slides, the

[8] Oil based formulations have differing spread factors for droplet size analysis, typically between 0.6 – 0.8. Magnesium Oxide slides have a spread factor of 0.8 For 15 -20 µm droplets and 0.75 for 10 – 15 µm droplets.

calculation methods developed by A. H. Yeomans (1949) are used. In this method the volume contributions of each droplet size class are calculated by multiplying the number of droplets (N) by the droplet class diameter (D) rather than the diameter cubed. Then from the cumulative volume fraction calculate the Dv0.1, Dv0.5 and Dv0.9. With both image analysis and manual assessment, ensure that the operator traverses the slide widthwise because smaller droplets will preferentially collect to the outer edge of the slide[9]. Image analysis software is also available from NIKON, NIS-Elements(https://www.microscope.healthcare.nikon.com/products/software/nis-elements).

## 5. Additional data collection

## 6. Deviations from standard protocol

An alternative technique for the procedure of the backpack sprayer for measuring flow rate is to measure the time to discharge of a known volume.

- Put on gloves and protective glasses and overalls.
- Run the equipment for a suitable time to ensure the lines are primed with insecticide solution.
- Mark the tank and spray for one minute, then using a graduated cylinder to refill to the original mark and measure the volume needed to fill the tank. Or, add a known quantity to the tank and time how long it takes to fully discharge the liquid.
- Measure flow rate as ml/min.
- Repeat this a minimum of three times and take the average value, aiming to have a coefficient of variation of less than 10% between replicates.

[9] As the air flows around an object (the slide) suspended particles will continue in their original direction due to their inertia. Smaller particles have less inertia, streamlining with the air, so the impact probability will increase closer to outer the edge

# 7. Glossary of terms

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| AR | Application Rate |
| D | Droplet class diameter |
| ha/min | Hectares per minute |
| Km/hr | Kilometres per hour |
| l/min | Liters per minute |
| m | Metres |
| m/min | Metres per minute |
| $m^2$ | Square metre |
| m/s | Metre per second |
| N | Number of droplets |
| l/ha | Liters per hectare |
| ml/ha | Mililiters per hectare |
| ml/min | Milliliters per minute |

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| PPE | Personal Protective Equipment |
| SOP | Standard Operating Procedure |
| TS | Track Spacing |
| WHO | World Health Organisation |
| WS | Walking Speed |

## 8. References

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