# Pesticide Applicator Safety for Structural Applicators 

## Calculations

## Calibrating Pesticide Application Equipment

## What You'll Learn!

The purpose of this lesson is to explain what calibration is, why it is required and how to calibrate the pesticide application equipment. You will also learn how to calculate the amount of pesticide to buy.

By the time you complete this lesson, you should be able to:

- explain terms used in equipment calibration;
- describe how to inspect, set up, test, adjust, and calibrate pesticide application equipment that may be used;
- calculate the amount of pesticide to add to a spray tank mix;
- calculate the amount of pesticide to buy for a specific area and application rate.


## Introduction to Calibration

You know that to control a pest it's important to select the right pesticide and apply it at the right time. But equally important is applying the right amount. That's why calibration is essential.

Calibration is a procedure for checking and adjusting the sprayer output of application equipment. Calibration is done to ensure a pesticide will be applied accurately and uniformly at the recommended application rate.

## Why Calibrate?

Time spent calibrating is a necessity! If you're not applying a pesticide at the recommended application rate you can suffer some serious problems:

If less than the correct application rate is actually being applied:

- You may not get good pest control
- Money spent on pesticide and application may be wasted.

If more than the correct application rate is actually being applied:

- Excess pesticide residues may be harmful to people
- Money spent on excess pesticide and application is wasted.

Most pesticide application equipment comes with charts or tables to help when first setting up the equipment or making adjustments. These should only be used as guides. You must still calibrate your equipment to check that it is applying pesticide accurately and uniformly.

## Calibrating for Accurate Application

There are many factors which affect the sprayer output (the rate at which pesticide is actually applied by your equipment). These include:

- Spray or granule output - sprayer nozzles or granule metering devices may not have the exact output specified by the manufacturer, and they gradually wear over a period of use.
- $\quad$ Speed - sprayer output is directly affected by speed.
- Pressure - actual pressure at the nozzle may be lower than indicated by the line pressure gauge due to hydraulic friction losses. This will result in a sprayer output which is lower than expected.


## Calibrating for Uniform Application

Calibration also includes steps to ensure that the pesticide is being applied uniformly. Constant spray pressure and speed, and an even spray pattern from nozzles, are needed for an overall uniform application.

If pesticide application is not uniform, some areas may get better control then others.

## When Should You Calibrate?

Calibration of equipment should be done:

- before new or altered equipment is used;
- when making changes that affect the sprayer output ;
- at regular intervals to see if wear is affecting output.


## What Does Calibration Include?

Calibration involves three and possibly four procedures.

1. Set-up: making sure all parts of the equipment are set up and working properly and that output is being evenly distributed by the spray or granule pattern.
2. Measuring Sprayer Output : finding the actual amount of spray or granules being applied by the equipment under typical operating conditions. Two common methods are described here:

Method \#1-Test Area: measuring the amount actually applied to a test area;
Method \#2 - Timed Output: measuring the actual output/minute and speed of equipment.

You may use either of these or any method you prefer as long as you get an accurate result. (All are essentially the same if you closely examine the math involved.)
3. Adjustment: changing the sprayer output, if necessary, so that it is the same as the recommended rate on the pesticide label. If adjustments are made, it will be necessary
to repeat Step 2 to measure the new sprayer output.
For granular pesticides and concentrate sprays, this is the final procedure. A fourth is required when the pesticide is mixed with water.
4. Calculating Amount of Pesticide to Add to a Spray Tank: determining the area which one spray tank will cover and the amount of pesticide concentrate to add to a tank of spray mixture.

## Terms Used in Calibration

Application rate is the recommended amount of pesticide for a specified area or volume. You can find the application rate on the pesticide label. Sometimes a range will be given.

$$
\begin{array}{ll}
\text { Examples: } & \text { - apply at } 1.1 \mathrm{ml} / 100 \mathrm{~m}^{2} \\
& \text { - apply at } 4.5 \mathrm{~g} / 1000 \mathrm{~m}^{2} \\
& \text { - apply at } 1.1 \mathrm{ml} / 100 \mathrm{~m}^{3} \\
& \text { - apply } 5 \text { grams in } 20 \mathrm{l} \text { of water, } 1 \text { litre covers } 10 \mathrm{~m}^{2} \\
& \text { - apply a } 1 \% \text { solution }
\end{array}
$$

Spray volume is the recommended amount of spray mixture to be applied to a specified area. This spray mix is usually a pesticide concentrate diluted in water. You can find the spray volume on the pesticide label together with the application rate. Sometimes the label may recommend you spray until wet or spray till point of runoff.

Example: apply pesticide at $2.5 \mathrm{ml} / 100 \mathrm{~m}^{2}$ in $\mathbf{4 0} \mathrm{L}$ of water
The spray volume in this example is 40 litres per $100 \mathrm{~m}^{2}$. The application rate is 2.5 millilitres of pesticide per $100 \mathrm{~m}^{2}$.

Sprayer Output is the amount of spray or granules which the equipment actually applies to a specified area, distance, or volume. During calibration you are trying to ensure that the actual sprayer output is the same as the recommended rate on the pesticide label.

Output is the amount of spray or granules which the equipment discharges during a measured period of time.

Example: 16 L/min
$200 \mathrm{~g} / \mathrm{min}$

Speed is the walking speed of the applicator expressed in kilometres per hour (km/h).

Test strip or test area is an accurately measured distance or area. It is used to measure the sprayer output or speed of the application equipment or applicator.

Swath width is the width over which spray droplets or granules are distributed in one pass of the applicator.

## Metric or Imperial Measure?

You may do your calculations in either metres (m) and hectares (ha) or in feet (ft) and acres since recommended application rates in the production guides are currently provided in both.

Formulas are provided that will work with either measurement system. Examples are given for both systems. Whichever system you select, be consistent - use metres, kilometres, and hectares or use feet, miles, and acres. Don't mix them. Many formulas rely on ratios between two measurements so they must be in the same units.

Only kilograms (kg) and grams (g) are used for granules and powders, and only litres (L) and millilitres ( mL ) are used for liquid measure since they are standard in labels and production guides.

## Measuring Tank Size and Levels

If you have a spray tank you will need a way to measure how many litres are in a partially-full tank. Some tanks have an outside clear tube which shows the level of tank liquid; make sure this gauge is accurate. If a tank does not have an accurate gauge, make a calibrated dip stick by adding a measured amount of water at a time (e.g., 20 L ) and marking the stick as the level rises.

You may also find it easier to work in litres. To convert from gallons to litres:
1 imperial gallon $=4.54$ litres $\quad 1$ U.S. gallon $=3.78$ litres

| cm | = | centimetres | in | = | inches |
| :---: | :---: | :---: | :---: | :---: | :---: |
| m | = | metres | ft | = | feet |
| $\mathrm{m}^{2}$ | = | square metres | $\mathrm{ft}^{2}$ | = | square feet |
| $\mathrm{m}^{3}$ | = | cubic metres | $\mathrm{ft}^{3}$ | = | cubic feet |
| ha | = | hectares | acre | = | acres |
| kPa | = | kilopascals | psi | = | pounds per square inch |
| km/h | = | kilometres/hour | mph | = | miles per hour |
| mls | = | millilitres | sec | = | seconds |
| L | = | litres |  |  |  |

## Useful Numeric Values

| 1 kilometre | $=1,000 \mathrm{~m}$ |  | 1 mile | 5,280 ft |
| :---: | :---: | :---: | :---: | :---: |
| 1 hectare | $=10,000 \mathrm{~m}^{2}$ | 1 acre |  | 43,560 ft ${ }^{2}$ |
| 1 litre | $=1,000 \mathrm{~mL}$ |  | 1 imperial gallons | $=4.54 \mathrm{~L}$ |
| 1 kilogram | $=1,000 \mathrm{~g}$ |  | 1 U.S. gallon | $=3.78 \mathrm{~L}$ |

Conversion tables between metric and imperial measures are provided in most production guides.

## Tips on Doing Formulas

The math used in these formulas is very simple. If you're not sure about which parts to do first, here are some guidelines:

- First do everything above a fraction line and below a fraction line.
- Then solve the fraction... the top is divided by the bottom.
- Then do any remaining multiplication (shown as X ).
- Round off numbers up or down to the closest useful number (for example, 2.666666 may become 2.67 or even 2.7). Don't round off if you need the accuracy (for example, 0.0127 should not be rounded to 0.01 ).


## How Much Pesticide to Purchase

Before you begin calibration, you should know what pesticide you will use and the recommended application rate. One of the first calculations you'll need to perform is figuring out how much pesticide to buy.

Generally it is a good idea to buy only as much pesticide as will be used in one year.

## Broadcast Treatments

Broadcast treatments apply a solid swath so that all of an area is covered. A simple calculation will tell you how much to buy: multiply the application rate times the area to be treated times the anticipated number of applications.

Amount to buy
for broadcast $\quad=$ application rate $x$ area $x$ number of applications treatment

Example: The pesticide you need has an application rate of $\mathbf{2 0} \mathbf{~ m l s} / \mathbf{m}^{\mathbf{2}}$, your field is $\mathbf{2 5} \mathbf{m}^{\mathbf{2}}$, and you expect to make two applications during the year.

```
Amount to buy \(\quad=\) application rate \(x\) area \(x\) number of applications
    \(=20 \mathrm{mls} / \mathrm{m}^{2} \times 25 \mathrm{~m}^{2} \times 2\) applications
    \(=500 \mathrm{mls}\)
```


## Quiz 1-Introduction to Calibration

1. What is meant by equipment calibration?
$\qquad$
$\qquad$
2. List three reasons why a sprayer output rate may be different dealer specifications, therefore making calibration necessary.
$\qquad$
$\qquad$
3. List three situations when you should calibrate.
$\qquad$
$\qquad$
4. What is the "application rate"? How does it differ from "spray volume"?
$\qquad$
5. What is the difference between "sprayer output " and "output"?
$\qquad$
$\qquad$
$\qquad$
6. What are the four main procedures of calibration?
$\qquad$
$\qquad$
$\qquad$
$\qquad$
7. How much pesticide should you buy for a broadcast treatment if:

- The application rate is $\mathbf{3 0} \mathbf{g} / \mathbf{1 0 0} \mathrm{m}^{2}$.
- The area is $200 \mathbf{~ m}^{2}$
- You expect to do two applications this year.

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

## Hand-Operated Sprayers

Hand-operated sprayers include hand-carried compressed air sprayers and backpack sprayers. They may be used for spot treatment or broadcast, and for many applications in nurseries and greenhouses.

## When the Application Rate Is Given as a Dilution Rate

Frequently, hand-operated sprayers are used for situations where the application rate is given as an amount of pesticide to mix (dilute) with a measured quantity of water and the amount applied is judged by eye.

Example: $\quad 175 \mathrm{~g} / 100$ L water, spray to runoff
(Runoff is the point where the spray begins to drip off the foliage.)
You do not need to follow all the calibration steps for these types of applications, but you should set up the sprayer as described later in this lesson.

You will also need to calculate how much pesticide to mix with the water in the spray tank. Use the following formula when the application rate specifies a dilution rate only:

| Amount of pesticide |
| :--- |
| to add to tank |$\quad=\quad$| application |
| :--- |
| dilution rate |$\quad$| volume of spray |
| :--- |
| mixture in tank |

Example: The label application rate specifies a mixture of $\mathbf{1 7 5}$ grams of pesticide per 100 litres of water $(\mathbf{1 7 5} \mathrm{g} / \mathbf{1 0 0} \mathrm{L})$. Your tank holds 12 litres, but you decide that 10 litres of spray mix is all you need to prepare for now. The amount of pesticide to add is calculated as follows:

$$
\begin{array}{ll}
\text { Amount of pesticide } & =\frac{175 \mathrm{~g} \times 10 \mathrm{~L}}{100 \mathrm{~L}} \\
& =\quad 17.5 \mathrm{~g}
\end{array}
$$

## When the Application Rate Is for an Area

Hand-operated sprayers may also be used in cases where the application rate specifies an amount of pesticide per unit area.

Example: apply 2.5 litres per $1000 \mathrm{~m}^{2}$

In such cases, you must follow all the steps in calibration as shown in this lesson, in order to ensure that the sprayer will deliver the recommended rate. All four procedures are required: set-up, measuring delivery rate, making adjustments, and calculating how much pesticide to add to a tank.

## Sprayer Set-up

Hand-operated sprayers should be checked to make sure there are no leaks, especially where the hose enters the tank and around the trigger valve. The nozzle should deliver a uniform spray pattern. Many nozzles can be adjusted to produce the desired droplet size. Adjust the nozzle to produce a coarse spray (larger droplets) for herbicides and a medium to fine spray (smaller droplets) for insecticide and fungicide applications.
For uniform spray application it is important that you maintain constant spray pressure and co-ordinate your walking speed with uniform back and forth movements of the nozzle.

## Measuring Sprayer Delivery Rate

Hand-operated sprayers are calibrated by measuring the volume of water applied to a test area.

Step 1 Measure and mark a conveniently-sized test strip, for example, 20 metres (or 65 feet). Walking conditions should be similar to where you are going to spray.

Step 2 Find the spray swath by accurately measuring the width that you spray; for example, 0.5 m (or 1.6 ft ). Calculate the area of the test strip: length times swath width times number of runs.

Step 3 Fill the spray tank about half full with water and record the level. (Half full represents average pressure and weight conditions.) Pump a hand-held tank to the pressure level you'll be using.

Step 4 Carefully spray the measured test strip while maintaining a steady forward speed and, for a backpack sprayer, a steady pumping pace. If you vary either of these you will vary your output.

Step 5 Measure the amount of water needed to refill the spray tank to its starting level. Use an accurate measuring container. The amount needed to refill is the amount sprayed on the test strip. For example, if you need 5.5 litres to refill to the starting level, then 5.5 L is the amount sprayed on the test area.

Step 6 Calculate sprayer output per $100 \mathrm{~m}^{2}$ or per $100 \mathrm{ft}^{2}$ using the following formula.

| Sprayer Output |
| :---: |
| $\mathrm{mls} / 100 \mathrm{~m}^{2}$ |$=\quad$| amount sprayed |
| :---: |
| in test (mls) |$\quad$ x $\quad \underline{\text { test area }\left(\mathbf{m}^{2}\right)}$

Sprayer Output $=$

$\mathrm{mls} / 1,000 \mathrm{ft}^{2}$$\quad$| amount sprayed |
| :---: |
| in test $(\mathrm{mls})$ |$\quad \mathbf{x} \quad \frac{1,000 \mathrm{ft}^{\mathbf{2}}}{\text { test area }\left(\mathrm{ft}^{2}\right)}$

Example: The test strip is 20 m long, the swath width is 0.5 m , and you spray it one time so the test area is $10 \mathrm{~m}^{2}(20 \times 0.5 \times 1)$. The amount of water sprayed during the test is 3.5 mls . The sprayer output is:

```
\(\underset{\text { Sprayer Output }}{\text { mls } / 100 \mathrm{~m}^{2}} \quad=3.5 \mathrm{mls} \times \frac{100 \mathrm{~m}^{2}}{10 \mathrm{~m}^{2}}\)
    \(=35 \mathrm{mls}\)
```

Because we used the $100 \mathrm{~m}^{2}$ conversion factor in our formula, we must express the output as $\mathbf{3 5} \mathrm{mls} / \mathbf{1 0 0} \mathrm{m}^{2}$.

Example: The test strip is 65 ft long, the swath width is 1.5 ft , and you spray it one time so the test area is $97.5 \mathrm{ft}^{2}(65 \times 1.5 \times 1)$. The amount of water applied during the test is $\mathbf{2 . 5} \mathbf{~ m l s}$. The delivery rate for an acre is:

Sprayer Output $\quad=2.5 \mathrm{mls} \mathrm{x} \quad 1,000 \mathrm{ft}^{2}$
$\mathbf{m l s} / \mathbf{1 , 0 0 0} \mathbf{f t}^{\mathbf{2}}$

$$
97.5 \mathrm{ft}^{2}
$$

$=\mathbf{2 5 . 6} \mathrm{mls}$

Because we used the $1,000 \mathrm{ft}^{2}$ conversion factor in our formula, we must express the output as $25.6 \mathrm{mls} / \mathbf{1 , 0 0 0} \mathrm{ft}^{2}$.

## Calculating the Amount of Pesticide to Add to a Spray Tank

When your sprayer output is known you can calculate how much pesticide to add to the spray tank. This requires two steps.

Step 1 Find the area sprayed by one tank. Divide the volume of spray you are mixing (it may be a full tank or a partial one) by the sprayer output.

Area sprayed by one tank $=$ volume of spray mixture in tank
sprayer output

Example: You want to make up 12 L in a tank. The sprayer output was found to be 11.67 $L / 100 \mathrm{~m}^{2}$. The area one tank will spray is:

Area sprayed by one tank $\left(\mathrm{m}^{2}\right)=\frac{12 \mathrm{~L}}{11.67 \mathrm{~L} / 100}$,
$=\quad 102.82 \mathrm{~m}^{2}$
This can be rounded to:

$$
=\quad 102.8 \mathrm{~m}^{2}
$$

Example: You want to make up 12 L in a tank. The sprayer output was found to be 10.76 $L / 1,000 \mathrm{ft}^{2}$. The area one tank will spray is:

Area sprayed by one tank (ft ${ }^{2}$ ) =

$$
\begin{aligned}
& =\frac{12 \mathrm{~L}}{10.76 \mathrm{~L} / 1,000 \mathrm{ft}^{2}} \\
& =1,115.2 \mathrm{ft}^{2}
\end{aligned}
$$

NOTE: When doing calculations for hand-operated sprayers you will find that one spray tank covers only a small portion of the total area to be sprayed. For accuracy, you should use four figures after the decimal point, as shown above, when working with decimal fractions of hectares or acres. Then round to 1 or 2 places on your final answer.

Step 2 Find the amount of pesticide to add to a spray tank. Multiply the pesticide application rate by the area sprayed by one tank (remember to use the same units).
Amount of pesticide

to add to a tank $\quad$\begin{tabular}{c}
application <br>
rate

$\quad x \quad$

area sprayed <br>
by one tank
\end{tabular}

Example: The application rate on the label is $\mathbf{4 m l s} / \mathbf{1 0 0} \mathbf{m}^{2}$ and you calculated that one $\mathbf{1 2}$ $L$ spray tank will cover $35 \mathrm{~m}^{2}$. The amount of pesticide to add for 12 L of spray would be:

Amount of
pesticide to add $\quad=4 \mathrm{mls} / 100 \mathrm{~m}^{2} \times 35 \mathrm{~m}^{2}$ to a full tank

$$
=1.4 \mathrm{mls}
$$

Example: The application rate on the label is $36.7 \mathrm{mls} / 1000 \mathrm{ft}^{2}$ and you calculated that one 12 L spray tank will cover $1115 \mathrm{ft}^{2}$. The amount of pesticide to add for 12 L of spray would be:

| Amount of <br> pesticide to add <br> to a full tank | $=36.7 \mathrm{mls} / 1,000 \mathrm{ft}^{\mathbf{2}} \quad$ x $1,115 \mathrm{ft}^{2}$ |
| :--- | :--- | :--- |
|  | $=40.9 \mathrm{mls}$ |

Do not forget to divide by $\mathbf{1 , 0 0 0} \mathrm{ft}^{2}$ or $100 \mathrm{~m}^{2}$, to get your final answer in each example!

## Quiz 2 - Hand-Operated Sprayers

Now try this quiz.

1. The pesticide application rate says you are to add 66 mL per 100 L of spray and wet the foliage. How much pesticide would you add to make 15 L of spray in a tank?
$\qquad$
2. Describe the five steps you would follow to find how much spray was applied to a test area in preparation for calculating sprayer output .
$\qquad$
$\qquad$
$\qquad$
$\qquad$
$\qquad$
3. Your need to spray a commercial building for silverfish. The insecticide application rate is $5 \mathrm{mls} / 100 \mathrm{~m}^{2}\left(5 \mathrm{mls} / 1000 \mathrm{ft}^{2}\right)$. You test your hand-operated sprayer on a 10 m ( $\mathbf{3 3} \mathbf{f t}$ ) strip which is $\mathbf{2 . 5}$ metres ( 8 ft ) wide. In spraying the strip twice, you use up $\mathbf{2} \mathbf{L}$ of water. What is the spray output per hectare?
4. To apply an insecticide to a small area, your sprayer has been calibrated and has a sprayer output of $11.85 \mathrm{~L} / 100 \mathrm{~m}^{2}\left(11 \mathrm{~L} / 1000 \mathrm{ft}^{2}\right)$. The spray tank holds 15 L . How much of a area will a full tank cover?
5. You have a sprayer with a 10 L tank. You have measured its sprayer output and calculated that a full tank will cover $220 \mathrm{~m}^{\mathbf{2}}\left(\mathbf{2 3 5 2} \mathrm{ft}^{2}\right)$. If your insecticide should be applied at 30 mls per $100 \mathrm{~m}^{2}\left(27.5 \mathrm{mls} / 1,000 \mathrm{ft}^{2}\right)$, how many millilitres $(\mathrm{mL})$ of herbicide must be added to a full tank?

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

## Checking Nozzle Spray Pattern

Set the proper spray pressure and visually check that each nozzle has a uniform spray pattern. Nozzles which do not produce a uniform spray pattern should be cleaned using a soft brush. If they still produce streaking or distortion after being cleaned, replace them. (Remember to wear rubber gloves when handling and testing sprayer nozzles.)

## Measuring Nozzle Output

This test provides you with output per minute for the timed output method of finding sprayer output. You will need a measuring container calibrated in millilitres and a stopwatch or watch which shows seconds.

Step 1 Place a collecting cup under the nozzle for an exact time (such as 30 seconds or 1 minute).

Step 2 Measure and record the volume of spray collected from the nozzle.

Step 3 If nozzle output is more than $10 \%$ higher than (i.e., over 1.10 times) the manufacturer's specifications, replace the nozzle.

Step 4 Clean any nozzle which is $5 \%$ below the manufacturer's specifications, (i.e., under 0.95 times the manufacturer's specifications).

Step 5 Retest if the nozzle has been changed or cleaned.

## Measuring Sprayer Output

Sprayer output is the amount of spray your equipment actually applies per unit area. You need to check that the sprayer output is within the recommended range of spray volume for the pesticide you are using. You also need to know the sprayer output in order to determine tank coverage and calculate how much pesticide to add to your spray tank.

There are two basic methods for measuring sprayer output: using a test area and using timed output. Both methods are described below. Choose the method that you are most comfortable with.

Measuring Sprayer Output : Method 1 - Using a Test Area
In this method, you find sprayer output by measuring spray applied to a test area.

Step 1 Accurately measure a reasonably long test strip (e.g., 60 metres or 200 feet - the longer the test strip, the more accurate the calibration). Mark it with two stakes. Write down the measurements for your records.

Step $2 \quad$ Fill the sprayer half full of water and measure the amount in the tank. Write down the amount. Half a tank is used because that's the average sprayer weight. Note exactly where you filled the spray tank so you can return to the same position to accurately measure how much spray was applied to the test strip.

Step 3 Check the pressure setting and the speed you want. As you approach the test strip, ensure that the tractor has reached the desired speed and that the pressure is consistent.

Step 4 Start to spray as you pass the first stake and close it as you pass the second stake. Do the same for a second run.

Step $5 \quad$ Return to the filling site and set the spray tank in the same spot you marked when filling. Determine the litres of water used to spray the test area by measuring how much is needed to refill the tank to the starting level in Step 2 (use an accurate measuring container);

Step 6 Calculate the test area as follows:

Test area $=$ length $x$ swath width $x$ number of runs
Step 7 Determine the sprayer output in either litres per hectare ( $\mathbf{L} / \mathbf{1 0 0} \mathbf{~ m}^{2}$ ) or litres per acre ( $L / 1,000 \mathrm{ft}^{2}$ ) depending on the spray volume units you are using.

| Sprayer Output $\left(\mathrm{L} / 100 \mathrm{~m}^{2}\right)$ |  | amount sprayed in test (L) | $\mathbf{x}$ | $\frac{100 \mathrm{~m}^{2}}{\text { test area }}\left(\mathrm{m}^{2}\right)$ |
| :---: | :---: | :---: | :---: | :---: |
| Sprayer Output ( $\mathrm{L} / \mathbf{1 , 0 0 0} \mathrm{ft}^{\mathbf{2}}$ ) | $=$ | amount sprayed in test (L) | x | $\frac{1,000 \mathrm{ft}^{2}}{\text { test area }\left(\mathrm{ft}^{2}\right)}$ |

Example: You measured a test strip 60 metres long. Your swath width is 0.5 metres. You started spraying the test strip with a tank that was half full of water and after making two runs you needed 4 litres of water to refill the tank half full. The sprayer output (per $100 \mathrm{~m}^{2}$ ) can be found as follows:

Sprayer Output $\left(\mathrm{L} / 100 \mathrm{~m}^{2}\right) \quad=\quad \underline{4 \mathrm{~L} \times 100 \mathrm{~m}^{2}}$ $60 \mathrm{mx} 0.5 \mathrm{~m} \times 2$ runs
$=\frac{4 \mathrm{Lx} 100 \mathrm{~m}^{2}}{60 \mathrm{~m}^{2}}$
$=\quad 6.67 \mathrm{~L} / 100 \mathrm{~m}^{2}$

Example: Your test strip is $\mathbf{2 0 0}$ feet long. Your swath width is $\mathbf{0 . 8}$ feet. After two runs you needed 4 litres of water to refill the tank half full. The sprayer delivery rate per $1,00 \mathrm{ft}^{2}$ can be found as follows:

| Sprayer Output $\left(\mathrm{L} / 1,000 \mathrm{ft}^{2}\right)$ | $=\quad$$\mathbf{2 0 0} \mathbf{~ f t \times 1 , 0 0 0} \times \mathrm{ft}^{2} \times 2 \mathrm{runs}$ |
| ---: | :--- |
|  | $=\quad \frac{4 \mathrm{~L} \times 1,000 \mathrm{ft}^{2}}{320 \mathrm{ft}^{2}}$ |
|  | $=12.5 \mathrm{~L} / 1,000 \mathrm{ft}^{2}$ |

Measuring Sprayer Output : Method 2 - Timed Output
In this method, you find sprayer output by using speed and output per minute. Knowing the exact speed is critical to accuracy. Test speed for various gears as follows:

Step 1 Accurately measure a test strip which is reasonably long (at least 60 metres or 200 feet).

Step 2 Fill your tank about half full - you won't be spraying now, but this gives an average weight. Move to the test strip.

Step 3 Reach and hold your walking peed before entering the test strip.
Step 4 Using a stopwatch or watch with a second hand, determine the exact time in seconds required to travel the measured distance. Write it down. Do the same for a second pass and add the two times together.

Step $5 \quad$ Calculate speed using one of the following formulas for $\mathbf{k m} / \mathrm{h}$ or $\mathbf{m p h}$.

$$
\begin{aligned}
& \text { Speed }(\mathrm{km} / \mathrm{h})=\frac{\text { total distance travelled }(\mathrm{m})}{\text { total time required }(\mathrm{sec})} \times 3.6(\text { for } \mathrm{km} / \mathrm{h}) \\
& \text { Speed }(\mathrm{mph})=\frac{\text { total distance travelled }(\mathrm{ft})}{\text { total time required }(\mathrm{sec})} \times 0.68 \text { (for mph) }
\end{aligned}
$$

Example: A 60 metre test strip took $\mathbf{2 7}$ seconds for the first run and 27 seconds for the second run, so total time was 54 seconds and total distance was 120 metres ( 60 x 2 ).

$$
\begin{aligned}
\text { Speed }(\mathrm{km} / \mathrm{h})= & \frac{120 \mathrm{~m} \times 3.6}{54 \mathrm{sec}} \\
& =\quad 8 \mathrm{~km} / \mathrm{h}
\end{aligned}
$$

Example: A 200 foot test strip took 27 seconds the first run and 27 seconds the second run, so total time was 54 seconds and total distance was 400 feet ( $200 \times 2$ ).

$$
\begin{aligned}
\text { Speed }(\mathrm{mph}) \quad & =\frac{400 \mathrm{ft} \times 0.68}{54 \mathrm{sec}} \\
& =5 \mathrm{mph}
\end{aligned}
$$

Step 6 Determine sprayer output per minute using the following method:
Another method is spray into a measuring jug for a measured time such as 1 minute. Divide the amount of spray by the length of time of the spray test to get output per minute.

Step $7 \quad$ Use one of the following formulas to determine sprayer output in either litres per hectare ( $\mathrm{L} / \mathrm{ha}$ ) or litres per acre ( $\mathrm{L} / \mathrm{acre}$ ), depending on the units you are using.
$\underset{(\mathrm{L} / \mathrm{ha})}{\text { Sprayer Ouput }} \quad=\quad \frac{\text { output }(\mathrm{L} / \mathrm{min}) \times 600}{\text { speed }(\mathrm{km} / \mathrm{h}) \times \text { swath width }(\mathrm{m})}$
Sprayer Ouput output (L/min) x 495
(L/acre) $\quad=\quad$ speed (mph) $\times$ swath width (ft)

Example: In calculations you found the speed to be eight kilometres per hour and the nozzle sprayer output to be 44 millilitres per minute. Swath width is 15 metres.

$$
\begin{aligned}
\text { Delivery Rate }(\mathrm{L} / \mathrm{ha}) \quad & =\frac{44 \mathrm{~L} / \mathrm{min} \times 600}{8 \mathrm{~km} / \mathrm{h} 15 \mathrm{~m}} \\
& =\quad 220 \mathrm{~L} / \mathrm{ha}
\end{aligned}
$$

Example: In calculations you found the speed to be 5 miles per hour and the total sprayer output to be 44 litres per minute. Swath width is $\mathbf{3 0}$ feet.
$\begin{aligned} \text { Delivery Rate (L/acre) } & =\frac{44 \mathrm{~L} / \mathrm{min} \times 495}{5 \mathrm{mph} \times 30 \mathrm{ft}} \\ & =145 \mathrm{~L} / \text { acre }\end{aligned}$

## Calculating the Amount of Pesticide to Add to a Spray Tank

When your delivery rate is known, you can calculate how much pesticide to add to the spray tank. This requires two steps:

Step 1 Find the area that can be sprayed by one tank. Divide the volume of spray in the tank by the delivery rate as follows:

Area sprayed by one tank $=\frac{\text { volume of spray mixture in tank }}{\text { delivery rate }}$

Step 2 Calculate the amount of pesticide you need to add to your tank:

Amount of pesticide $=$ application $\mathbf{x}$ area sprayed to add to a tank rate by one tank

Example: You have found that the sprayer output is $8.19 \mathrm{~L} / 100 \mathrm{~m}^{2}$, the tank capacity is 20 L , and your pesticide must be applied at $50 \mathrm{mls} / 100 \mathrm{~m}^{2}$. First calculate the area that can be sprayed by one tank as follows:

Area sprayed by one $20 \mathrm{~L} \operatorname{tank}\left(\mathrm{~m}^{2}\right) \quad=\frac{20 \mathrm{~L}}{8.19 \mathrm{~L} / 100 \mathrm{~m}^{2}}$

$$
=244.2 \mathrm{~m}^{2}
$$

When rates are expressed per $100 \mathrm{~m}^{2}$ or per $1,000 \mathrm{ft}^{2}$, you must remember to simply this fraction by dividing.

N 0
w you can find out how much pesticide to add to the spray tank:
Amount of
pesticide to add $=50 \mathrm{mls} / 100 \mathrm{~m}^{2} \times 244.2 \mathrm{~m}^{2}$
to one 20 L tank

$$
=122.1 \mathrm{mls}
$$

Example: Your sprayer delivery rate is $60 \mathrm{mls} / 1,000 \mathrm{ft}^{2}$, the tank capacity is 20 L and you are using a pesticide that must be applied at $45.9 \mathrm{mls} / 1,000 \mathrm{ft}^{2}$. First calculate the area that can be sprayed by one tank as follows:

Area sprayed by one 20 L tank $\quad=\quad \underline{20 L}$
$60 \mathrm{mls} / 1000 \mathrm{ft}^{2}$

## 20 L

$0.06 \mathrm{mls} / \mathrm{ft}^{2}$
$=333.3 \mathrm{ft}^{2}$

Now you can find out how much pesticide to add to the sprayer tank:

$$
\begin{aligned}
& \text { Amount of } \\
& \text { pesticide to add } \\
& \text { to one } 20 \mathrm{~L} \text { tank }
\end{aligned} \quad=45.9 \mathrm{mls} / 1,000 \mathrm{ft}^{2} \times 333.3 \mathrm{ft}^{2}
$$

$=15.3 \mathrm{mls}$

## Quiz 3

1. What are the three factors that affect sprayer output ?
$\qquad$
2. Which three of the following would double your sprayer output?
a) increasing the speed to twice as fast
b) slowing the speed to half as fast
c) doubling the pressure
d) increasing the pressure by four times
e) changing nozzles to ones designed for twice the output
3. Which of the three is the best way to double output? Why?
$\qquad$
4. When testing spray nozzles, what two things are you checking for?
$\qquad$
$\qquad$
5. Your sprayer has a swath width of $10 \mathrm{~m}(33 \mathrm{ft})$. On two passes over a 50 metre ( 165 ft ) test strip you use 20 litres of water. What is the sprayer output?
6. Your pesticide must be applied at $20 \mathrm{mls} / 100 \mathrm{~m}^{2}\left(18 \mathrm{mls} / 1,000 \mathrm{ft}^{2}\right)$ in 1 to $2 \mathrm{~L} / 100 \mathrm{~m}^{2}$ ( 1 to $2 \mathrm{~L} / 1,000 \mathrm{ft}^{2}$ ) of water. You have calculated the sprayer output of your sprayer to be $0.5 \mathrm{~L} / 100 \mathrm{~m}^{2}\left(4.5 \mathrm{~L} / 1,000 \mathrm{ft}^{2}\right)$ and tank capacity to be 20 L .
a) How much area will a full tank cover?
b) How much pesticide must you add to a full tank of spray?
7. To test speed you measure a test strip of 60 metres ( $\mathbf{2 0 0} \mathbf{~ f t ) . ~ T h e ~ t i m e ~ t o ~ t r a v e l ~ i t ~ w a s ~}$ 29 seconds the first pass and 31 seconds the second pass. What is the speed in either $\mathrm{km} / \mathrm{h}$ or mph?
8. If your sprayer's speed is $4 \mathrm{~km} / \mathrm{h}(2.5 \mathrm{mph})$, your swath width is $0.35 \mathrm{~m}(1.5 \mathrm{ft})$, and the total output is $\mathbf{4 0} \mathbf{~ m l s}$ per minute. What is the sprayer output?

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, continue with the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

## Area and Volume Calculations

Some application rates are based on area to be treated. Area is found by multiplying length times width. Triangular areas are found by multiplying length times width and dividing by two. If the layout is irregular, find the area of the whole by adding the area of each part.

| Area of a rectangular area $=\quad$ length x width |  |
| :--- | :--- |
| Area of a triangular area | $=\quad($ width/2) $\mathbf{x}$ height |

Many application rates are based on volume of the enclosed space for space treatments. Volume of a flat-roofed structure is its area times its height. However, many buildings have sloping or Quonset roofs, so the total volume is found by finding the volume of the lower wall-height shape and the volume of the roofed shape above it and adding them together.

## Volume of a Quonset Hut

If length of a quonset hut is $\mathbf{1 2 5}$ feet (or meters) and the height is $\mathbf{1 2}$ feet (or meters). What is the volume under the quonset hut? Note: the height of 12 feet (or meters) is really the radius (r) of a circle.)

Hint: Try to imagine the quonset as half a cylinder lying on it's side. Then all you need to do is figure out the volume of a cylinder and get half that amount!


$$
\begin{aligned}
\text { Cylinder Volume } & =\text { area of a circle } x \text { height } \\
& =\pi r^{2} \times \text { height }
\end{aligned}
$$

where $\boldsymbol{\pi}=\mathbf{3 . 1 4}$

## Quonset Hut

Since the cylinder is lying on the side, height in the formula will now be the length of the building. The volume will be divided by 2 since it is only half a cylinder!

| Quonset Volume $=\pi r^{2} \times$ height $\div 2$ | where $\pi$ is 3.14 |
| :--- | :--- |

Now if your building looks like this:

You need to figure out the volume of the quonset roof as above, then figure out the volume of the rectangle below.

$\square$

Volume $\quad=40^{\prime} \times 16^{\prime} \times 8^{\prime}=5,120 \mathrm{ft}^{3}$
OR
$=40 \mathrm{~m} \times 16 \mathrm{~m} \times \mathbf{8 m}=\mathbf{5 , 1 2 0} \mathrm{m}^{\mathbf{3}}$
The volume of the quonset roof would be

$$
\text { Quonset Volume }=\pi r^{2} \times \text { height } \div 2
$$

$$
\begin{array}{lc}
=3.14 \times\left(8^{\prime} \times 8^{\prime}\right) \times 40^{\prime} \div 2 & \text { OR } \\
=4,019.2 \mathrm{ft}^{3} & =3.14 \times(8 \mathrm{~m} \mathrm{x} 8 \mathrm{~m}) \times 40 \mathrm{~m} \div 2 \\
=4,019.2 \mathrm{~m}^{3}
\end{array}
$$

Don't forget to add the top and bottom parts together!
$\mathbf{5 , 1 2 0} \mathrm{ft}^{3}+4019.2 \mathrm{ft}^{\mathbf{3}}=\mathbf{9 , 1 3 9 . 2} \mathrm{ft}^{3}$
OR
$5,120 \mathrm{~m}^{3}+4019.2 \mathrm{~m}^{3}=\mathbf{9 , 1 3 9 . 2} \mathrm{m}^{3}$

Volume of an Even or Uneven Span
 Gable Roof

The formula for the volume of an even span gable roof is the same as it is for an uneven span. Volume is the area of a triangle which is $1 / 2$ the width $x$ the height multiplied by the length.

Even Span Gable Roof

$$
\begin{aligned}
& \text { Even Span }=1 / 2(\text { width } \mathbf{x} \text { height } \mathbf{x} \text { length }) \\
& \text { Gable Roof } \\
& \text { Volume }
\end{aligned}
$$

```
Even Span Gable Roof Volume
\(=1 / 2 x(\) width \(\mathbf{x}\) height \(\mathbf{x}\) length \()\)
\(=1 / 2\left(20^{\prime} \times 88^{\prime} \times 40^{\prime}\right)\)
\(=3200 \mathrm{ft}^{3}\)
\[
\begin{aligned}
\text { OR } & =1 / 2(20 \mathrm{~m} \times 8 \mathrm{~m} \times 40 \mathrm{~m}) \\
& =3200 \mathrm{~m}^{3}
\end{aligned}
\]
```

Length x width x height

$$
40^{\prime} \times 20^{\prime} \times 8^{\prime}=6400 \mathrm{ft}^{3} \quad \text { OR } \quad 40 \mathrm{~m} \times 20 \mathrm{~m} \times 8 \mathrm{~m}=6400 \mathrm{~m}^{3}
$$

Add the $\mathbf{2}$ sections together

$$
\text { Total Volume }=6400 \mathrm{ft}^{3}+3200 \mathrm{ft}^{3}=9600 \mathrm{ft}^{3} \quad \text { OR } \quad=6400 \mathrm{~m}^{3}+3200 \mathrm{~m}^{3}=9600 \mathrm{~m}^{3}
$$

## Sprayers

Many applications are based on a "spray-to-wet" application rate which requires a well-trained eye rather than calibration for an area rate. A spray mixture dilution rate is usually all that's provided.

Example: apply at $\mathbf{6 0} \mathbf{g} / \mathbf{1 0 0} \mathbf{L}$
However, you will still need to know how much spray mixture to prepare. This can be found by using a small test area as described for handsprayer calibration.

## Thermal Foggers

Thermal foggers are usually gasoline-powered portable backpack or wheel-mounted units that are moved throughout the building as they are operating. Some thermal foggers have a dial to select the output in $m \mathrm{~L}$ per minute.

The pesticide is sprayed onto a hot element and evaporates. As it condenses it produces a heavy fog which drifts through the building. The fog effectively reaches insects in high areas.

The pesticide used with this equipment is purchased either as a ready-to-apply product or may require mixing with an oil-based carrier.

## Calculating Output Setting

To find the output setting ( $\mathrm{mL} / \mathrm{min}$ ) for your fogger you need to find how long it takes (in minutes) to walk with your equipment through the building. Do a preliminary walk through the building to determine this time. Use the same route and walking speed that you will use for the actual application.

Output
$(\mathrm{mL} / \mathrm{min}) \quad=\quad$ pesticide needed for building (mls) time to move through building (min)

Example: As in the preceding example, 150 mL of a pesticide is needed to treat the building. You find that it takes three minutes to move your equipment through the area. Now you can find the output setting for your fogger as follows:
$\begin{aligned} \text { Output (mL/min) } & =\frac{150 \mathrm{mls}}{3 \mathrm{~min}} \\ & =\quad 50 \mathrm{mls} / \mathrm{min}\end{aligned}$

## Quiz 4 - Area and Volume Calculations

1. A building is 10 m wide and 30 m long with side walls which are 2.5 m high. Its roof is a gable (a typical house shape, high in the middle and sloping down each side) which is 1.5 m high in the peaked section. What is the volume of the building in $\mathbf{m}^{3}$ ?
2. The area you are going to treat with a thermal fogger is $\mathbf{2 5} \mathbf{m}$ by $\mathbf{1 2} \mathbf{~ m}$. The pesticide application rate is $5 \mathrm{~L} / \mathrm{ha}$. How much pesticide will you need to treat that area?
3. For the area described in Question 2, you walk your portable fogging equipment through the route you are going to take and find it takes you 2.5 minutes. To what output setting will you set your fogger?
4. A quonset hut building is 5 m wide and 25 m long. What is the volume of the building in $\mathbf{m}^{3}$ ?

After completing the quiz, check the Answer Key at the end of this lesson. If you've done well, proceed to the next section or lesson. If not, review the appropriate material and try problem questions again before proceeding.

## Answer Key

## Quiz 1 - Introduction to Calibration

1. What is meant by equipment calibration?

Checking and adjusting the equipment to make sure it is applying pesticide uniformly and at the correct application rate.
2. List three reasons why a sprayer delivery rate may be different than dealer specifications, therefore making calibration necessary.

1. Spray nozzles may not have the output specified.
2. Speed may not be accurately shown by the speedometer or tachometer.
3. Spray pressure may not be accurately shown by the gauge.
4. List three situations when you should calibrate.
5. before new or altered equipment is used
6. when changing delivery rate $s$, air speed (for airblast sprayers), granular sizes (for granular applicators), etc.
7. at regular intervals to see if wear is affecting output
8. What is the "application rate"? How does it differ from "spray volume"?

Application rate is the recommended amount of pesticide for an area (field) or volume (greenhouse). Spray volume is the recommended amount of a mixture of pesticide and water or other liquids for an area.
5. What is the difference between "delivery rate " and "output"?

Delivery rate is the amount the equipment applies to an area. Output is the amount it applies in a given time.
6. What are the four main procedures of calibration?

1. set-up
2. measuring the delivery rate
3. adjustment
4. calculating how much pesticide to add to the spray tank
5. How much pesticide should you buy for a broadcast treatment if:

- $\quad$ The application rate is $3 \mathbf{k g} / \mathrm{ha}$.
- Your field is ten hectares.
- You expect to do two applications this year and two the next.

You would only buy enough for this year for only two applications, not four.

| Amount to buy <br> for broadcast <br> treatment | $=$ application rate $\times$ area $\times$ numbe |
| :--- | :--- |
| Amount to buy | $=3 \mathrm{~kg} / \mathrm{ha} \times 10 \mathrm{ha} \times 2$ applications |
|  | $=60 \mathrm{~kg}$ |

8. How much pesticide would you need for a band treatment if:

- $\quad$ The application rate is $3 \mathrm{~L} / \mathrm{ha}$.
- Your field is 20 hectares.
- You expect to do three applications this year.
- Each band is $\mathbf{6 0} \mathrm{cm}$ wide.
- Bands (crop rows) are spaced 120 cm apart.

| Amount to <br> buy for <br> band <br> treatment | application <br> rate <br> (broadcast <br> rate) | $x$area <br> total <br> field | number <br> of <br> applications |  |
| :--- | :--- | :--- | :--- | :--- |$\quad$| band width |
| :--- |
| row spacing |

## Quiz 2 - Hand-Operated Sprayers

1. The pesticide application rate says you are to add 66 mL per 100 L of spray and wet the foliage. How much pesticide would you add to make 15 L of spray in a tank?

| Amount of pesticide to add to tank | $=\quad \begin{aligned} & \text { application } \\ & \text { dilution rate } \end{aligned}$ | x | Volume of spray mixture in tank |
| :---: | :---: | :---: | :---: |
| $=$ | $\frac{66 \mathrm{~mL}}{100 \mathrm{~L}} \times 15 \mathrm{~L}$ |  |  |
| = | 10 mL (rounded to | res |  |

2. Describe the five steps you would follow to find how much spray was applied to a test area in preparation for calculating delivery rate .

- $\quad$ Measure a convenient test strip, e.g., 20 m by 1.5 m ( 65 ft by 4 ft$)$.
- $\quad$ Find the spray swath width and calculate the test area.
- Half fill the tank with water and record the level.
- Carefully spray the test strip while maintaining a steady speed and pumping pace.
- Measure the amount of water used to spray the test strip.

3. Your need to spray a commercial building for silverfish. The insecticide application rate is $5 \mathrm{mls} / 100 \mathrm{~m}^{2}\left(5 \mathrm{mls} / 1,000 \mathrm{ft}^{2}\right)$. You test your hand-operated sprayer on a 10 m ( $\mathbf{3 3} \mathbf{f t}$ ) strip which is 2.5 metres ( 8 ft ) wide. In spraying the strip twice, you use up $\mathbf{2} \mathbf{L}$ of water. What is the spray output per hectare?

$$
\begin{aligned}
\text { Area } & =\text { length } \times \text { swath width } \times \text { number of runs } \\
& =10 \mathrm{~m} \times 2.5 \mathrm{~m} \times 2 \text { passes } \\
& =50 \mathrm{~m}^{2}
\end{aligned}
$$

Sprayer Output L/100 m ${ }^{2}=$ amount sprayed in test (L) $\quad \mathbf{x} \quad \underline{100} \mathbf{~ m}^{2}$

$$
\begin{aligned}
& =\quad 2 \mathrm{~L} \times \frac{100 \mathrm{~m}^{2}}{50 \mathrm{~m}^{2}} \\
& =\quad 4 \mathrm{~L} / 100 \mathrm{~m}^{2}
\end{aligned}
$$

When rates are expressed per $100 \mathrm{~m}^{2}$ or per $1,000 \mathrm{ft}^{2}$, you must remember to simply this fraction by dividing.

Are
a $\quad=\quad$ length $x$ swath width $x$ number of runs
$=\quad 33 \mathrm{ft} \times 8 \mathrm{ft} \times 2$ passes
$=\quad 528 \mathrm{ft}^{2}$

Sprayer Output $=\quad$ amount sprayed in test $(\mathrm{L}) \times \underline{1,000} \mathrm{ft}^{2}$
$\left(\mathrm{L} / \mathbf{1 , 0 0 0} \mathbf{~ f t}^{\mathbf{2}}\right) \quad$ Test area $\left(\mathbf{f t}^{\mathbf{2}}\right)$
$=\frac{2 \mathrm{~L} \times 1,000 \mathrm{ft}^{2}}{528 \mathrm{ft}^{2}}$
$=\quad 3.78 \mathrm{~L} / 1,000 \mathrm{ft}^{2}$
4. To apply an insecticide to a small area, your sprayer has been calibrated and has a sprayer output of $11.85 \mathrm{~L} / 100 \mathrm{~m}^{2}\left(11 \mathrm{~L} / 1000 \mathrm{ft}^{2}\right)$. The spray tank holds 15 L . How much of a area will a full tank cover?

Area sprayed by one tank $=\quad$ volume of spray in tank

$$
\text { sprayer output ( } \mathrm{L} / 100 \mathrm{~m}^{2} \text { ) }
$$

$=\quad 15 \mathrm{~L}$

$$
\begin{aligned}
& 11.85 \mathrm{~L} / 100 \mathrm{~m}^{2} \\
= & 126.58 \mathrm{~m}^{2}
\end{aligned}
$$

$$
\begin{array}{r}
\text { Area sprayed by one tank (acres) }=\frac{\text { volume of spray in tank }}{\text { Sprayer output }} \\
=\frac{15 \mathrm{~L}}{11 \mathrm{~L} / 1,000 \mathrm{ft}^{2}} \\
=1363.63 \mathrm{ft}^{2}
\end{array}
$$

5. You have a sprayer with a 10 L tank. You have measured its sprayer output and calculated that a full tank will cover $220 \mathrm{~m}^{2}\left(2352 \mathrm{ft}^{2}\right)$. If your insecticide should be applied at 30 mls per $100 \mathrm{~m}^{2}\left(27.5 \mathrm{mls} / 1,000 \mathrm{ft}^{2}\right)$, how many millilitres $(\mathrm{mL})$ of herbicide must be added to a full tank?

Amount of pesticide to add to a tank

$$
\begin{aligned}
& =\quad \text { application rate }\left(\mathrm{mls} / 100 \mathrm{~m}^{2}\right) \times \begin{array}{c}
\text { area sprayed by } \\
\text { one tank }\left(\mathrm{m}^{2}\right)
\end{array} \\
& =\quad 30 \mathrm{mls} / 100 \mathrm{~m}^{2} \times 220 \mathrm{~m}^{2} \\
& =\quad 66 \mathrm{mls}
\end{aligned}
$$

Amount of pesticide to add to a tank $\quad=\quad$ application rate $\left(\mathbf{m l s} / 1,000 \mathrm{ft}^{2}\right) \times$ area sprayed by one tank ( $\mathrm{ft}^{2}$ )
$=\quad 27.5 \mathrm{mls} / \mathbf{1 , 0 0 0} \mathrm{ft}^{2} \times 2352 \mathrm{ft}^{2}$
$=\quad 64.68 \mathrm{mls}$

There are $\mathbf{1 , 0 0 0}$ millilitres in a litre. To convert millilitres to litres, divide by $\mathbf{1 , 0 0 0}$ :
64.68 mls divide by $1,000=0.064 \mathrm{~L}$

## Quiz 3

1. What are the three factors that affect sprayer delivery rate?

Nozzle size, pressure, and forward speed.
2. Which three of the following would double your delivery rate?
b) slowing the speed to half as fast
d) increasing the pressure by four times
e) changing nozzles to ones designed for twice the output
3. Which of the three is the best way to double output? Why?

Changing nozzles. Changing speed may cause uneven distribution due to bouncing, and higher pressure may result in more drift and pump wear.
4. When testing spray nozzles, what two things are you checking for?
a uniform spray pattern and that the output of each nozzle is satisfactory.
5. Your sprayer has a swath width of $10 \mathrm{~m}(\mathbf{3 3} \mathrm{ft})$. On two passes over a 50 metre ( $\mathbf{1 6 5} \mathbf{f t}$ ) test strip you use 20 litres of water. What is the sprayer output?

Sprayer Output $=$ amount sprayed in test (L) $\mathbf{x} \underline{100} \mathrm{~m}^{2}$ or $1,000 \mathrm{ft}^{2}$
area sprayed in test
Sprayer Output L/100 m ${ }^{2}=20 \mathrm{~L}$ x $100 \mathrm{~m}^{2}$
$50 \mathrm{mx} 10 \mathrm{~m} \times 2$ runs
$=\quad 20 \mathrm{~L} \times \frac{100 \mathrm{~m}^{2}}{1,000 \mathrm{~m}^{2}}$
$=\quad 2 \mathrm{~L} / 100 \mathrm{~m}^{2}$

When rates are expressed per $100 \mathrm{~m}^{2}$ or per $1,000 \mathrm{ft}^{2}$, you must remember to simply this fraction by dividing.
$\underset{\left(\mathrm{L} / 1,000 \mathrm{ft}^{2}\right)}{\text { Sprayer Output }} \quad=20 \mathrm{~L} \times \quad \frac{1,000 \mathrm{ft}^{2}}{165 \mathrm{ft} \times 33 \mathrm{ft}^{2} 2 \text { runs }}$

$$
\begin{aligned}
& =20 \mathrm{~L} \times \quad \underset{10,890 \mathrm{ft}^{2}}{\underline{1,000} \mathbf{f t}^{2}} \\
& =1.84 \mathrm{~L} / 1,000 \mathrm{ft}^{2}
\end{aligned}
$$

6. Your pesticide must be applied at $20 \mathrm{mls} / 100 \mathrm{~m}^{2}\left(18 \mathrm{mls} / 1,000 \mathrm{ft}^{2}\right)$ in 1 to $2 \mathrm{~L} / 100 \mathrm{~m}^{2}(1$ to $2 \mathrm{~L} / 1,000 \mathrm{ft}^{2}$ ) of water. You have calculated the sprayer output of your sprayer to be $0.5 \mathrm{~L} / 100 \mathrm{~m}^{2}\left(4.5 \mathrm{~L} / 1,000 \mathrm{ft}^{2}\right)$ and tank capacity to be 20 L .
a) How much area will a full tank cover?

Area sprayed by one tank $=\quad$ volume of spray mixture in tank sprayer output

$$
\begin{aligned}
& \text { Area sprayed by one tank }=\underline{20} \mathbf{L} \\
& 0.5 \mathrm{~L} / 100 \mathrm{~m}^{2} \\
& =\quad \underline{20 \mathrm{~L}} \\
& 0.005 \mathrm{~L} / \mathrm{m}^{2} \\
& =\quad 4,000 \mathrm{~m}^{2} \\
& \text { OR } \quad=\quad \underline{20 ~ L} \\
& 4.5 \mathrm{~L} / 1,000 \mathrm{ft}^{2} \\
& =\quad \underline{20 \mathrm{~L}} \\
& 0.0045 \mathrm{~L} / \mathrm{ft}^{2} \\
& =\mathbf{4 , 4 4 4} \mathrm{ft}^{2}
\end{aligned}
$$

b) How much pesticide must you add to a full tank of spray?

Amount of pesticide to add to a tank $\quad=\quad$ application rate $x$ area sprayed by one tank

Amount of pesticide
to add to a full tank

$$
=\quad 20 \mathrm{mls} / 100 \mathrm{~m}^{2} \times 4,000 \mathrm{~m}^{2}
$$

$=\quad 0.2 \mathrm{mls} / \mathrm{m}^{2} \times 4,000 \mathrm{~m}^{2}$
$=\quad 800 \mathrm{mls}$

OR $\quad=\quad 18 \mathrm{mls} / 1,000 \mathrm{ft}^{2} \times 4,444 \mathrm{ft}^{2}$
$=\quad 0.018 \mathrm{mls} / \mathrm{ft}^{2} \times 4,444 \mathrm{ft}^{2}$
$=\quad 79.9 \mathrm{mls}$
7. To test speed you measure a test strip of 60 metres ( $\mathbf{2 0 0} \mathbf{f t )}$. The time to travel it was 29 seconds the first pass and 31 seconds the second pass. What is the speed in either $\mathrm{km} / \mathrm{h}$ or mph?

Speed $(\mathrm{km} / \mathrm{h}) \quad=\quad \frac{\text { total distance travelled }(\mathrm{m})}{\text { total time required }(\mathrm{sec})} \times 3.6($ for $\mathrm{km} / \mathrm{h})$

Speed (mph) = total distance travelled (ft) x 0.68 (for mph) total time required (sec)

Speed $\quad=\quad(60 \mathrm{~m}+60 \mathrm{~m}) \times 3.6$ 60 sec
$=\quad \underline{120 \mathrm{~m} \times 3.6}$ 60 sec
$=\quad 7.2 \mathrm{~km} / \mathrm{h}$

OR $\quad=\quad(200 \mathrm{ft}+\mathbf{2 0 0} \mathrm{ft}) \times 0.68$

60 sec

$$
=\quad \underline{400 \mathrm{~m} \times 0.68}
$$

$$
60 \mathrm{sec}
$$

$$
=\quad 4.5 \mathrm{mph}
$$

8. If your sprayer's speed is $4 \mathrm{~km} / \mathrm{h}(2.5 \mathrm{mph})$, your swath width is $0.35 \mathrm{~m}(1.5 \mathrm{ft})$, and the total output is 40 L per minute. What is the sprayer output?

$$
\text { Sprayer Output }=\frac{\text { output }(\mathrm{L} / \mathrm{min}) \times 600(\text { metric }) \text { or } 495 \text { (imperial) }}{\text { forward speed } \times \text { swath width }}
$$



## Quiz 9.6-Area and Volume Calculations

1. A building is $\mathbf{1 0} \mathrm{m}$ wide and 30 m long with side walls which are 2.5 m high. Its roof is a gable (a typical house shape, high in the middle and sloping down each side) which is 1.5 m from the bottom of the roof section to the peak. What is the volume of the building in $\mathrm{m}^{3}$ ?

Volume of the lower portion (box-shaped) is $10 \mathrm{~m} \times 30 \mathrm{~m} \times 2.5 \mathrm{~m}=750 \mathrm{~m}^{3}$. Volume of the upper portion is half of $10 \mathrm{~m} \times 30 \mathrm{~m} \times 1.5 \mathrm{~m}=225 \mathrm{~m}^{\mathbf{3}}$. Total volume is $750 \mathrm{~m}+\mathbf{2 2 5 m}$ $=975 \mathrm{~m}^{3}$.
2. The area you are going to treat with a thermal fogger is $\mathbf{2 5} \mathbf{m}$ by $\mathbf{1 2} \mathbf{~ m}$. The pesticide application rate is $5 \mathrm{~L} / \mathrm{ha}$. How much pesticide will you need to treat that area?

3. For the area described in Question 2, you walk your portable fogging equipment through the route you are going to take and find it takes you 2.5 minutes. To what output setting will you set your fogger?

| Output (mL/min) | $=\frac{\quad \text { Pesticide needed for building (mL) }}{\text { Time to move equipment through building (min) }}$ |
| ---: | :--- |
| Output $(\mathrm{mL} / \mathrm{min})$ | $=\frac{150 \mathrm{~mL}}{2.5 \mathrm{~min}}$ |
|  | $=60 \mathrm{~mL} / \mathrm{min}$ |

4. A quonset hut building is $5 \mathbf{m}$ wide and 25 m long. What is the volume of the building in $\mathbf{m}^{3}$ ?

Area of a circle $x$ length $\div 2$
( $\pi \mathrm{r}^{2} \mathrm{x}$ length) $\div 2$
$(3.14 \times 2.5 \times 2.5 \times 25) \div 2=245 \mathrm{~m}^{3}$

