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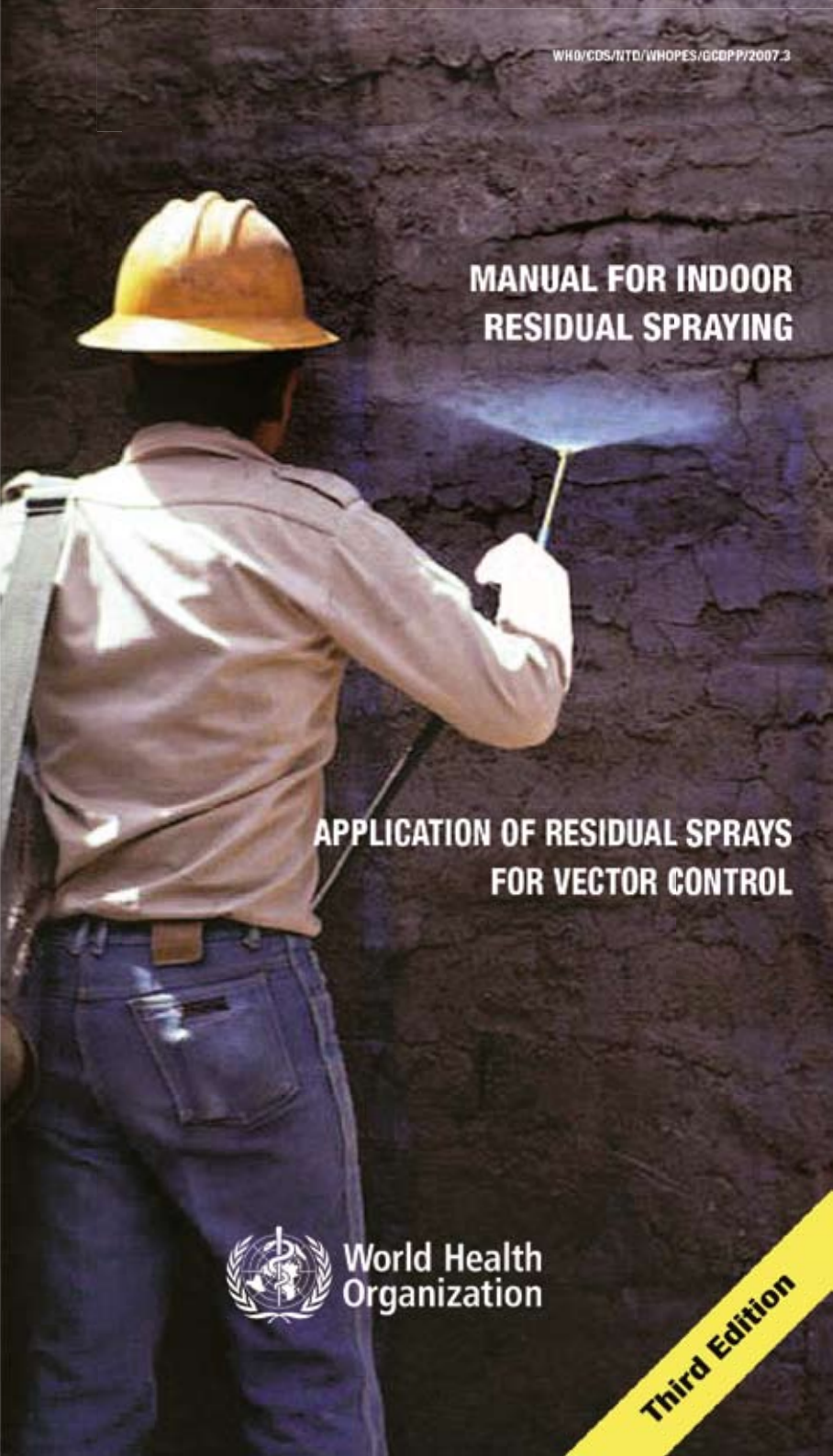

MANUAL FOR INDOOR RESIDUAL SPRAYING

APPLICATION OF RESIDUAL SPRAYS FOR VECTOR CONTROL

World Health Organization

Third Edition

WHO/CDS/NTD/WHOPES/GCDPP/2007.3

MANUAL FOR INDOOR RESIDUAL SPRAYING

APPLICATION OF RESIDUAL SPRAYS FOR VECTOR CONTROL

THIRD EDITION

Vector Ecology and Management
WHO Pesticide Evaluation Scheme

First edition, 2000
Second edition, 2005
Third edition, 2007

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Preface

The World Health Organization (WHO) specifications for public health pesticides are part of the International Code of Conduct on the Distribution and Use of Pesticides, and are used for quality control and international trade.

The WHO Pesticide Evaluation Scheme (WHOPES) develops specifications for public health pesticides once they have been fully tested for their safety and efficacy in the laboratory and in the field.

WHOPES promotes the safe, judicious and proper use of pesticides, including their safe and proper application. Such application relies mainly on the quality and working conditions of the equipment, as well as the skills and knowledge of the operators using the equipment. WHOPES has developed and published specifications for pesticide application equipment for vector control to provide the minimum standards and requirements for safe and proper performance.

Indoor residual spraying is used especially for control of malaria and Chagas disease vectors. However, where indoor residual spraying is used, it is essential that staff are fully trained in application techniques and maintenance of the application equipment. With good skills and high-quality application equipment, hazards to human health and the environment as well as financial losses can be avoided.

This manual is intended to serve as a model for developing relevant training manuals and procedures at country level to ensure safe and effective use of insecticides in vector control programmes.

As specified in the latest *Equipment for vector control – Specification guidelines*,[1] users should fit a control flow valve to the nozzle to ensure constant output of spray for more uniform application of the insecticide.

This third edition also contains easy-to-follow steps in the preparation of insecticide sprays.

[1] *Equipment for vector control – Specification guidelines*. Geneva, World Health Organization, 2005 (WHO/CDS/NTD/WHOPES/GCDPP/2006.5).

Acknowledgements

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- Dr P. Guillet, Global Malaria Programme, WHO, Geneva, Switzerland
- Mr R. C. Hudson, Jr., H.D. Hudson Manufacturing Company, Chicago, IL, USA
- Dr M. Lluberas, H.D. Hudson Manufacturing Company, Jacksonville, FL, USA
- Emeritus Professor G. Matthews, International Pesticide Application Research Centre, Imperial College, Ascot, England
- Dr S. Nalim, National Institute for Vector Control Research, Salatiga, Indonesia
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- Mr E. Thornhill, Silwood Pest Management, Imperial College, Ascot, England
- Dr V.P. Sharma, Malaria Research Centre, Delhi, India
- Dr M. Zaim, Vector Ecology and Management, NTD, WHO, Geneva, Switzerland

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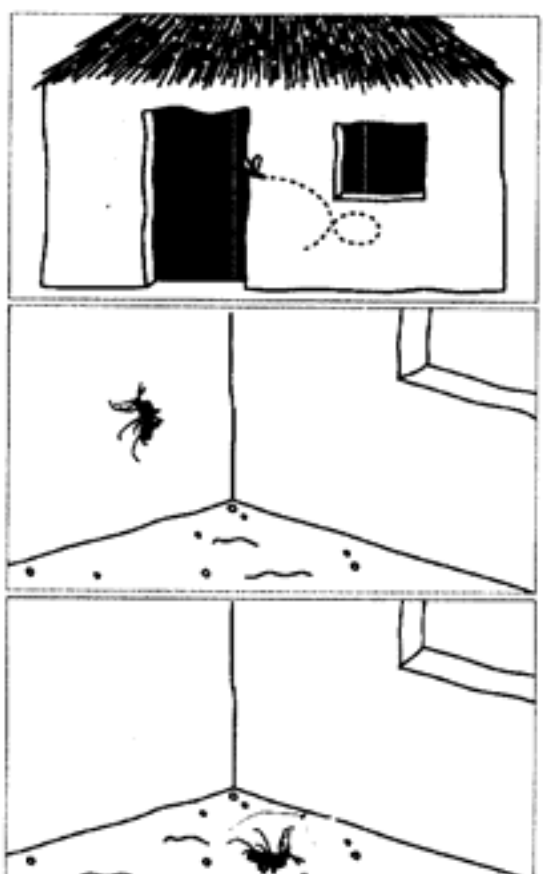
This publication was funded by the Global Collaboration for Development of Pesticides for Public Health.

1. Objective

To ensure the safe and correct application of a residual insecticide to indoor surfaces on which malaria vectors may rest.

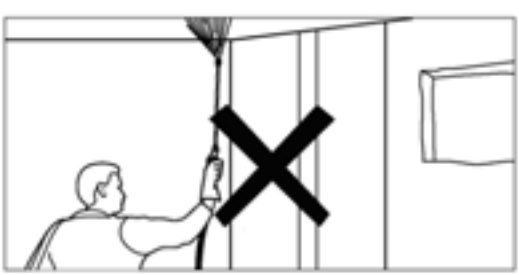


2. Safety

Exposure to insecticides may occur when handling and spraying insecticides as follows:

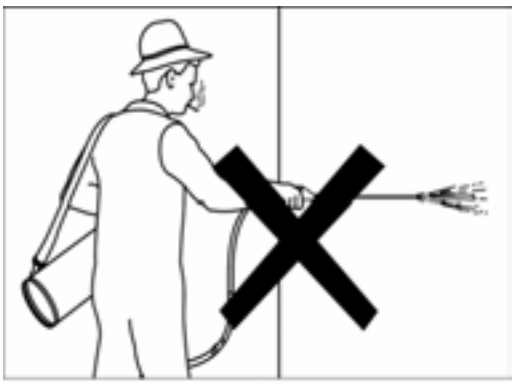
- When handling the insecticide product during opening of the package, mixing and preparation of the spray.

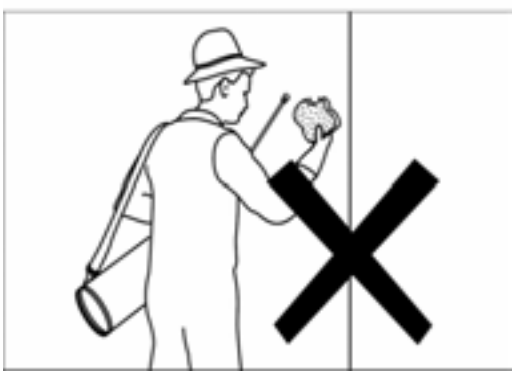
- When spraying the insecticide, especially in high places, the operator should wear a protective hat and face-shield or goggles.



Safety precautions

- Do not eat, drink or smoke while working.

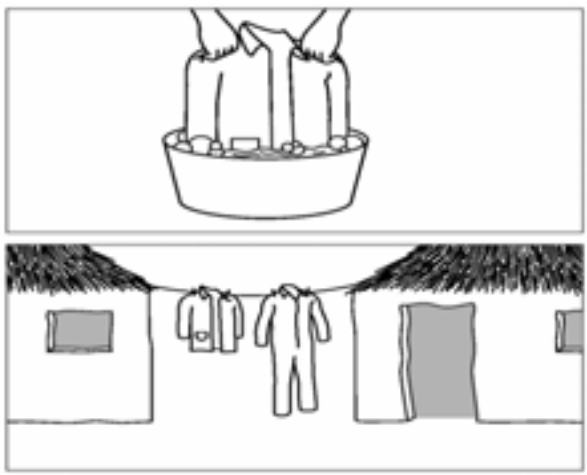




- Wash your hands and face with soap and water after spraying and before eating, smoking or drinking.

- Shower or bathe at the end of every day's work and change into clean clothes.

- Wash your overalls and other protective clothing at the end of every working day in soap and water and keep them separate from the rest of the family's clothes.



- If the insecticide touches your skin, wash off immediately with soap and water.

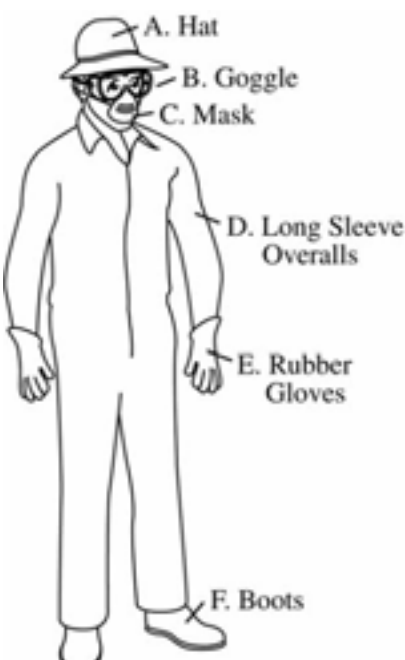
- Change your clothes immediately if they become contaminated with insecticides.

- Inform your supervisor immediately if you feel unwell.

3. Protective clothing and equipment

Absorption of insecticide occurs mainly through the skin, lungs and mouth. Specific protective clothing and equipment must be worn in accordance with the safety instructions on the product label.

A. Broad-rimmed hat (protects head, face and neck from spray droplets).
B. Face-shield or goggles (protects face and eyes against spray fall-out).
C. Face mask (protects nose and mouth from airborne particles).
D. Long-sleeved overalls (worn outside of boots).
E. Rubber gloves.
F. Boots.



4. Preparation – The household

Inform the household of the spraying schedule and the purpose of spraying, giving the occupants time to prepare and vacate the house.

Occupants MUST leave houses before spraying. Rooms occupied by sick people who cannot be moved must NOT be sprayed.

Remove all household items, including water, food, cooking utensils and toys, from the house. Move and cover, or remove, any furniture to allow easy access for spraying walls. Items that cannot be removed should be well covered.

Cage or tether pets and domestic animals away from the house.

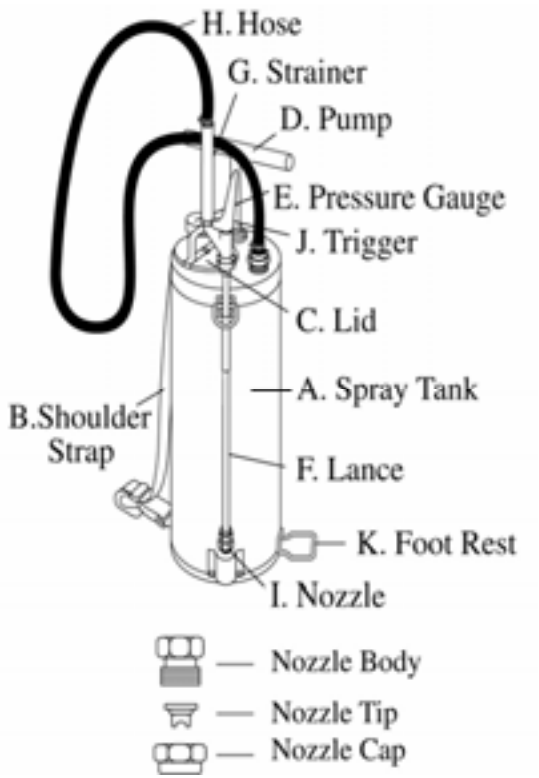
5. Preparation – Equipment

Indoor residual spraying of insecticides is normally done using portable compression sprayers. Before starting a spray operation, the equipment must be checked. Faulty sprayers may result in poor control or over-treatment.

Examine the sprayer visually to ensure that all parts are present, assembled correctly and in good working order.

A. Sprayer tank
B. Shoulder strap
C. Lid
D. Pump (handle)
E. Pressure gauge
F. Lance
G. Strainer
H. Hose
I. Nozzle – check that correct type of nozzle is fitted and is not damaged or worn out (flat fan nozzle with 80^{o} swathe and output of 550 ml/min at 1.5 bar or 650 ml/min at 2-bar pressure. The nozzle tip should be of hardened stainless steel, ceramic or equivalent material to withstand erosion of the nozzle where water contains sand particles.[1]
J. Trigger on/off valve. Is the strainer inside the valve handle clean?
K. Foot rest

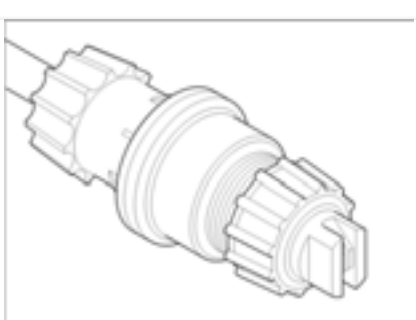
[1] Where water is likely to contain sand, it should be collected the day before spraying and allowed to stand so that the sand sediments fall to the bottom of the container – water is then carefully removed from the top of the container.


H. Hose
G. Strainer
D. Pump
E. Pressure Gauge
J. Trigger
C. Lid
A. Spray Tank
B.Shoulder Strap
F. Lance
K. Foot Rest
I. Nozzle
Nozzle Body
Nozzle Tip
Nozzle Cap

Note. The sprayer should be fitted with a control flow valve (CFV). The recommended valve operates at either 2 or 1.5 bar and gives a constant output at the nozzle until the tank pressure is below the stated pressure of the CFV. Spraying will then stop, indicating that the operator must re-pressurize the tank.

The CFV must be fitted between the tank outlet and the nozzle. Usually, it is fitted next to the nozzle.

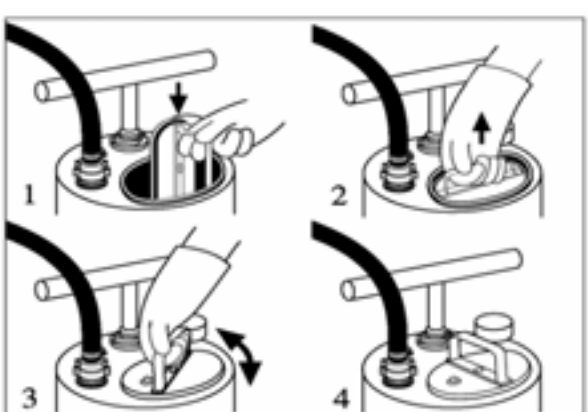
- Fit the valve by first removing the nozzle tip and cap. Fit a washer, if not present, into the end of the CFV that is screwed to the end of the lance. Then, with another washer if necessary, screw back the nozzle body, tip and cap onto the CFV.
- Alternatively, for other lances, fit the valve by first removing the nozzle body. Fit a washer, if not present, into the end of the CFV that is screwed to the end of the lance. Then, with another washer if necessary, screw back the nozzle body, tip and cap onto the CFV.



Before using an insecticide, use clean water to ensure that the equipment operates properly and does not leak. Wear protective clothing. To check that the sprayer works properly, follow the steps below:

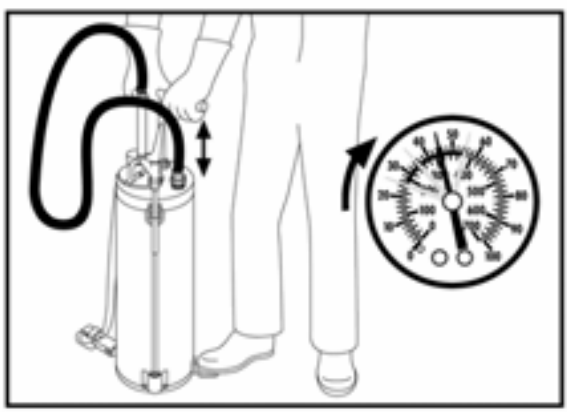
- Pour clean water into the tank (never fill the tank more than 3/4 full).

- Fit the lid and lock it in position by turning the handle.



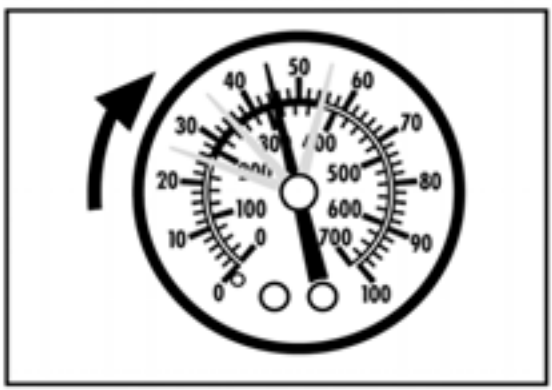
- Operate the pump using both hands and with foot on the foot rest. Pump until the tank pressure is 4 bar (58 pounds per square inch (psi)). Every full stroke gives about 1 psi.

  Note. 1 bar = 100 millibar = 14.5 psi = 100 kpa.

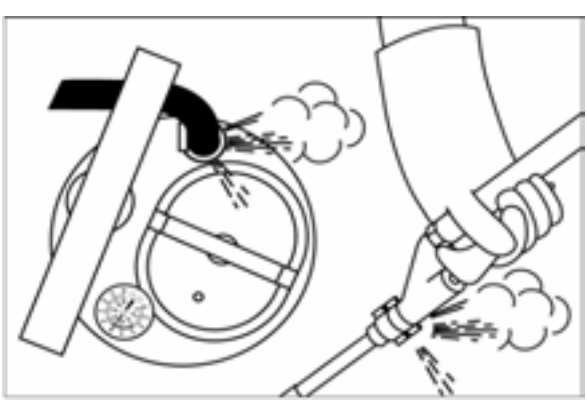


- Check that the tank is holding pressure. Listen for the hissing sound of escaping air.

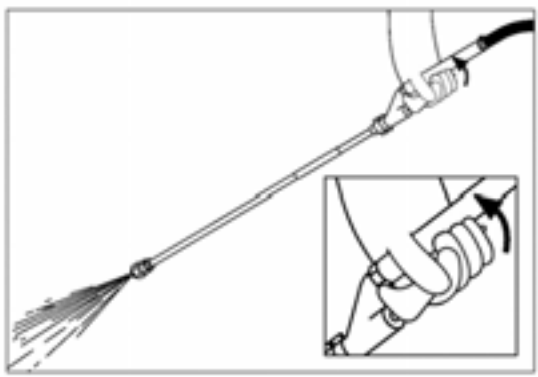
- Does the pressure gauge show an increase in pressure as you pump?



- Check to make sure there are no leaks along the lance and hose, especially where the hose joins the tank and trigger on/off valve.



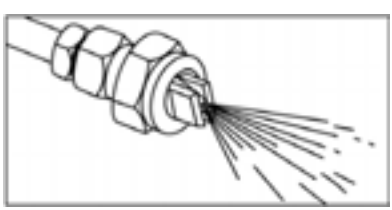
- Operate the trigger on/off valve to make sure that spray is emitted from the nozzle.



- Check the spray pattern from the nozzle by spraying a dry wall surface. Look to see that the spraying pattern is even and without streaks. Ensure that the nozzle does not drip when the trigger on/off valve is released.

- Calibrate the nozzle with water in the tank. Pump until the tank pressure is 4 bar (58 psi). Open the trigger on/off valve for one minute, collect the discharge and measure the amount in a measuring jug. Empty the jug. Discharge for a further minute and measure the amount. Repeat for a third discharge. Calculate the average of the three one-minute measurements.

- With the above procedure if the nozzle is fitted with a CFV at 2 bar, the discharge of a 80^{o} flat fan nozzle (usually referred to as 8002) should be 650 ml/min $\pm$10 ml/min. When a different CFV is used at 1.5 bar, the output of the same nozzle will be 550 ml/min $\pm$10 ml/min.



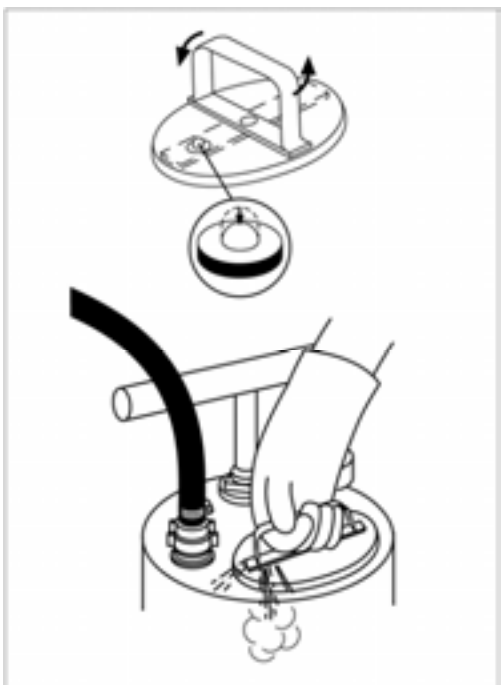
If the discharge rate is incorrect, check the nozzle and the screen filters to ensure they are not clogged. If necessary, replace the nozzle. Repeat the calibration. The addition of a CFV set on the lance will ensure that the flow rate does not decrease as the pressure in the tank falls.

Note. The dose of active ingredient of the insecticide in the spray has to be adjusted to ensure the correct dose per square metre.

If the nozzle is clogged

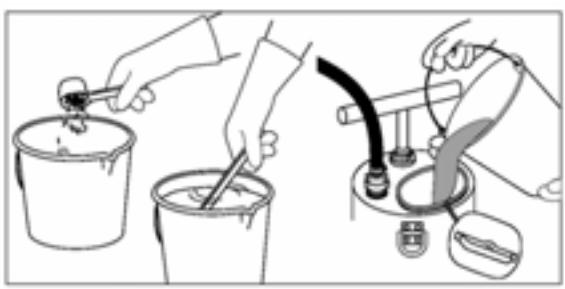
The opening in a nozzle is very small and must not be damaged. Clogged nozzles should be put in a container and immersed in water for several hours before the blockage is removed with a very soft toothbrush. NEVER clean a nozzle with a hard pin or piece of wire and NEVER put a nozzle to your mouth to blow through it.

Having checked the sprayer, de-pressurize by rotating the lid handle so that it stops on top of the pressure release button valve on top of the lid. During this process, hold the handle to prevent the lid from falling into the tank. Empty the clean water you have used for testing the sprayer.

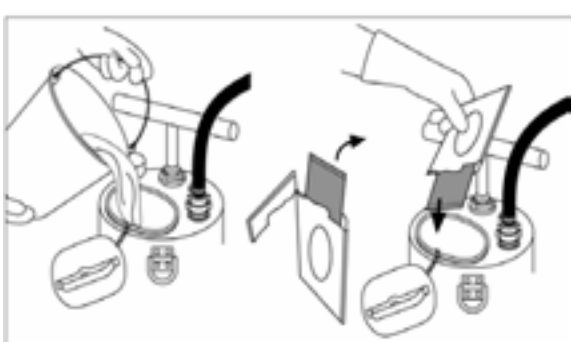


6. Mixing, handling and spraying techniques

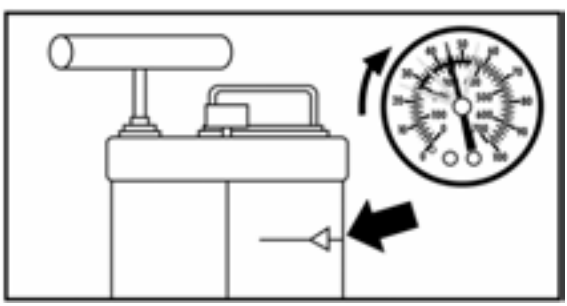
Prepare the insecticide spray according to the manufacturer's instructions. The insecticide may be mixed separately in a bucket and poured into the sprayer (see section 11).



Water-soluble sachets, tablets and insecticide granules are added directly to the water-filled tank. These formulations mix readily with water and reduce the hazards associated with handling and mixing in a separate container.



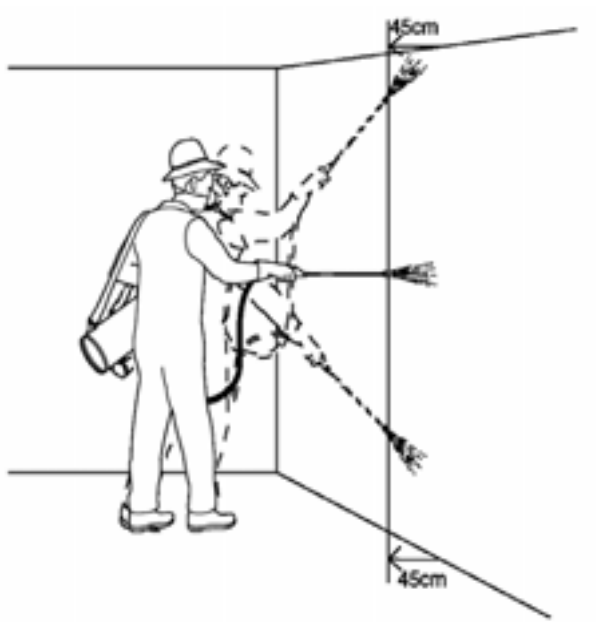
When the sprayer has been filled with water to the maximum level indicated on the tank, fit the lid of the tank and pump the sprayer until the pressure gauge shows 4 bar (58 psi). Every full stroke gives about 1 psi. About 58 full strokes are required to reach the working pressure.



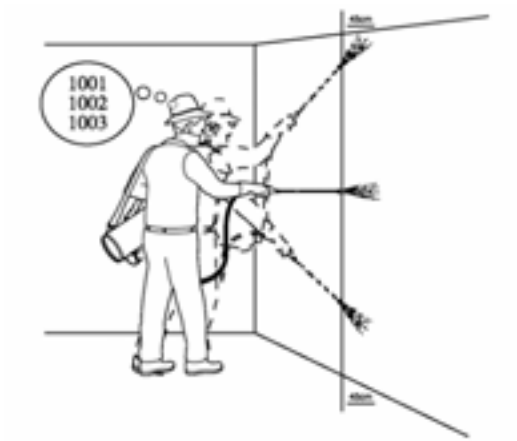
When the tank has been pressurized, mix the contents of the tank thoroughly by shaking the tank before starting to spray.

Apply spray in vertical swathes 75 cm wide, with an overlap of 5 cm. Spray from roof to floor, using a downward motion, to complete one swathe. Step sideways and spray upwards from floor to roof.

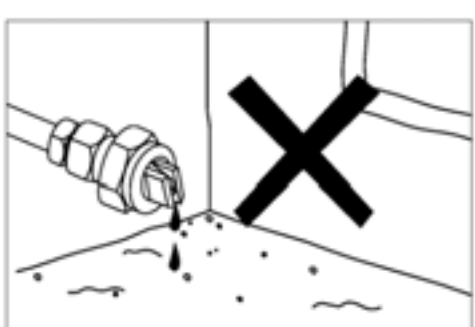
To ensure the correct swathe width, keep the spray tip about 45 cm from the wall. Lean forwards as you spray from top of the wall and move back as you bring the nozzle downwards. Continue the procedure, moving in a clockwise direction until spraying of the room is completed.



Time your spray speed to cover one metre every 2.2 seconds, i.e. 4.5 seconds for a 2 m high wall. Timing may be aided by mentally counting “one thousand and one – one thousand and two – one thousand and three – …”. Adjust the mental counting procedure according to the local language.



If spraying stops because of a blockage in the nozzle, unscrew the nozzle cap, remove the blocked nozzle and replace with a new one. The blocked nozzle should be cleaned as explained above. Do not let spray drip onto the floor.



When the CFV stops the spraying, re-pressurize the tank to 4 bars.

After spraying has been completed for the day, the spray operator returns to the central location where spray operations are organized, and where tanks are emptied and cleaned, as per instructions provided in section 9.

7. Procedures after spraying

Advise the occupants to stay outside the house until the spray is dry.

Instruct the householder to sweep or mop the floor before children or pets are allowed to re-enter.

Instruct the householder not to clean the sprayed surfaces.

8. Disposal of remains of insecticides and empty packaging

At the end of the day's work, the inside of the sprayer should be washed and any residual insecticide flushed from the lance and nozzle. The rinsate[1] should be collected and carefully contained in clearly marked drums with a tightly fitting lid. This rinsate should be used to dilute the next day's tank loads or disposed properly by the supervisor.

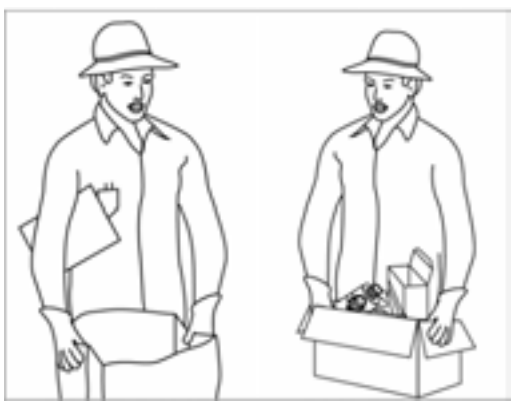
Note. It is advisable to prepare only sufficient amounts of insecticide to avoid disposal of any amount of insecticide spray liquid remaining in the tank. Supervisors should be provided with national guidelines for safe disposal of any remaining liquid.

Never pour the remaining insecticide into rivers, pools or drinking-water sources.

[1] Rinsate is the mixture of water that has been contaminated with low concentrations of pesticide products.

Decontaminate containers where possible. For glass, plastic or metal containers this can be achieved by triple-rinsing, i.e. part-filling the empty container with water three times and emptying into a sprayer for the next application.

All empty packaging should be returned to the supervisor for SAFE disposal according to national guidelines.

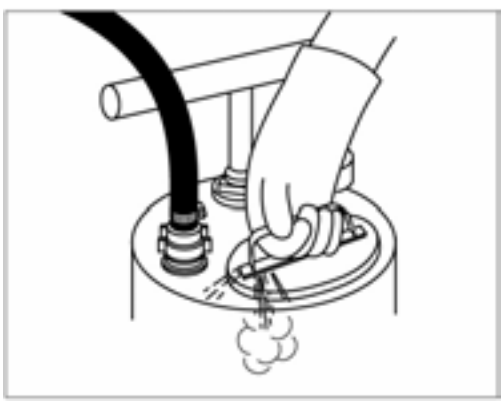


Never re-use empty insecticide containers.

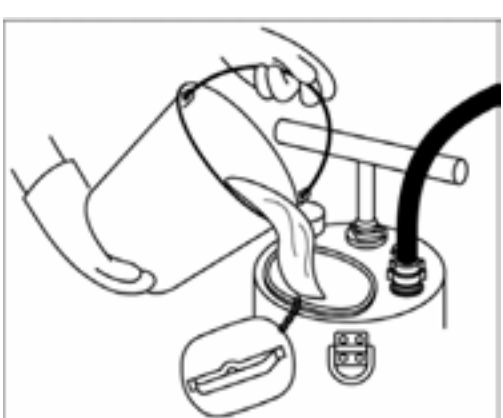
9. Maintenance of equipment

After completing the day's work, de-pressurize the tank and empty any remaining insecticide, following the instructions given in section 8. Clean the tank as explained below.

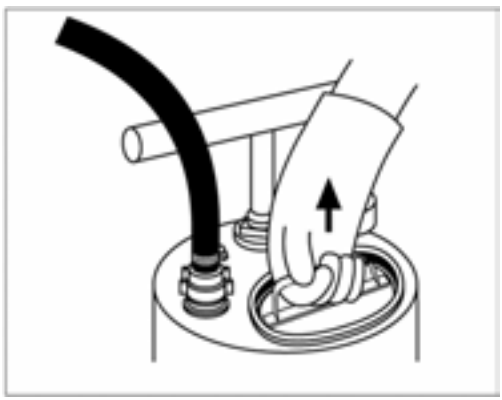
1. De-pressurize the tank.



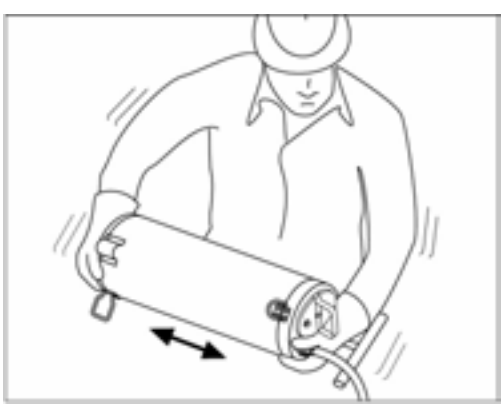
2. Fill the tank half-full with clean water.



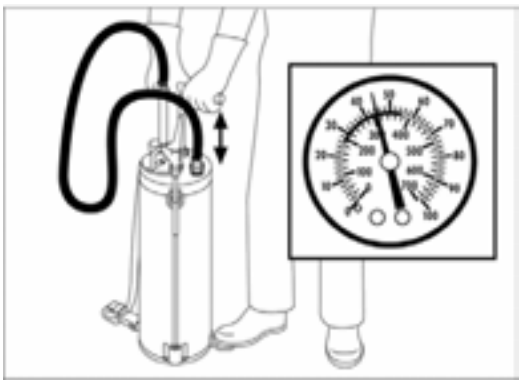
3. Replace the lid.



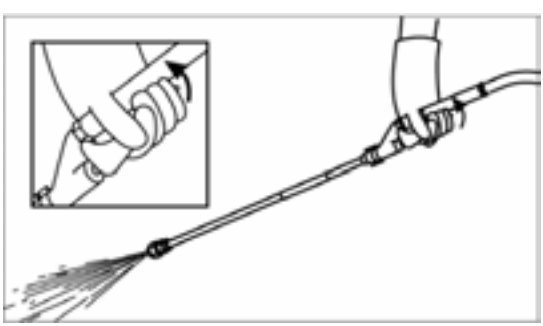
4. Pressurize the tank slightly and then shake the tank to ensure all inside surfaces are washed.



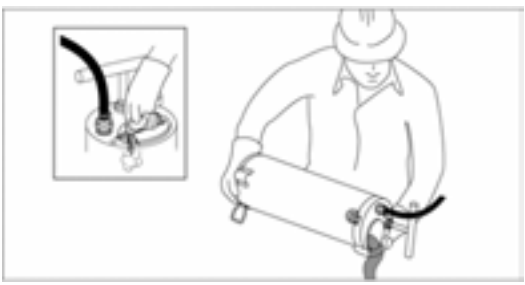
5. Pump up to 2.5 bar (=36 psi) pressure.



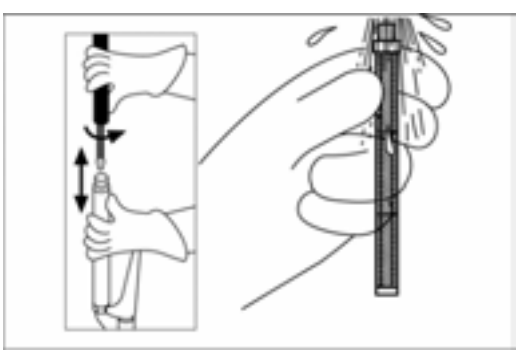
6. Spray water through nozzle.



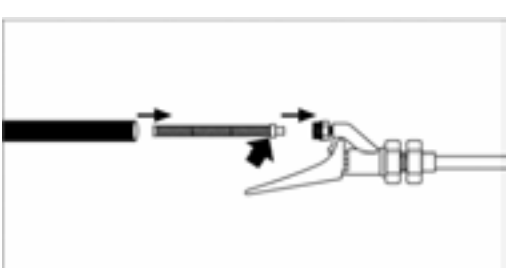
7. De-pressurize the tank and pour out any remaining liquid (see section 8 for disposal of rinse water).



8. Unscrew the trigger on/off valve handle and check and clean the strainer.



9. Reassemble the trigger on/off valve.

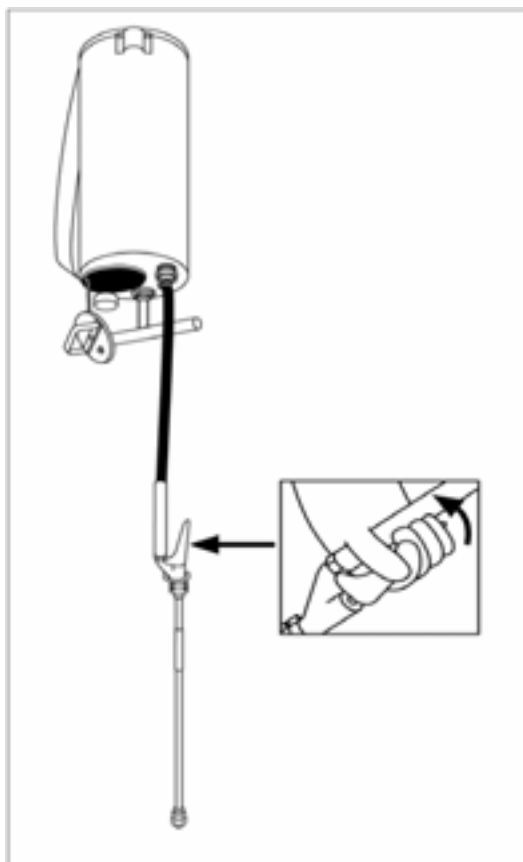


10. Remove the nozzle tip and wash.

11. Refit the nozzle.

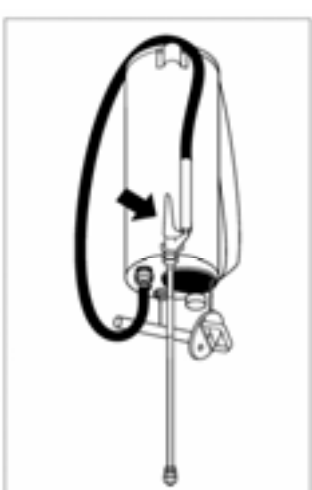
12. Clean the outside of the tank.

13. With the lid open, turn the tank upside down, open the on/off valve and let all the water drain out of the hose and lance.



Ensure the lance is parked to protect the nozzle when not in use.

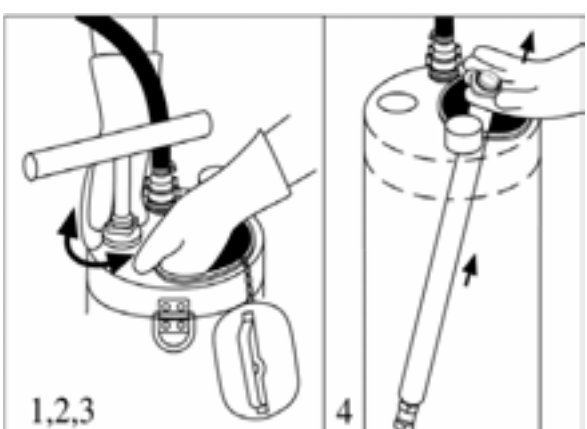
When storing the sprayer for a long period, hang it upside down with the lid open to allow air circulation. Allow lance to hang from the D-ring on the tank with the trigger valve kept open.



10. Troubleshooting

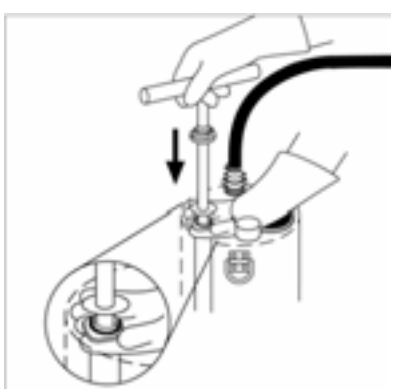
If the pump fails to pressurize the tank

1. Remove the pump plunger from the sprayer by loosening the nut holding the pump on the top of the tank
2. Insert a gloved hand into the tank and hold the pump cylinder.
3. Unscrew the cap holding the pump and pull the plunger from the tank.
4. Remove the pump cylinder from inside the tank.



5. If the leather pump plunger cup is dry, soften it by rubbing in some clean engine oil. If it is damaged and needs replacing, unscrew the disc holding the plunger cup and replace.

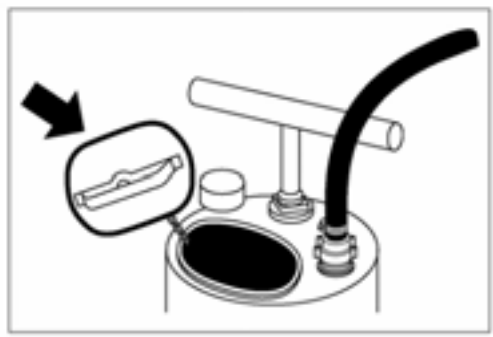
6. Reassemble the pump; check the gasket is in place on the pump cylinder, then hold the pump cylinder inside the tank, with threaded part through opening in the top of the tank; insert the pump plunger into the cylinder, turn the plunger cap counter-clockwise on the cylinder to ensure the threads match, then screw the cap on and tighten.



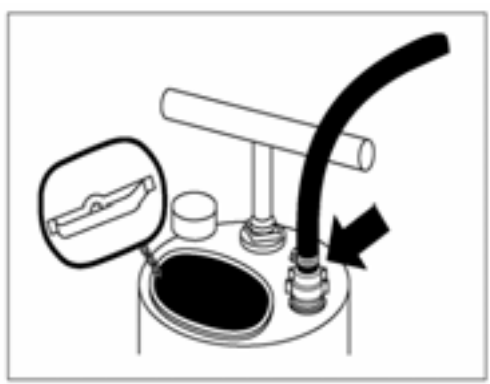
7. Check the relief valve is seated correctly and air does not escape until maximum pressure is reached.

If the tank fails to hold pressure

- Check the rubber seal on the lid and replace if necessary.



- Check the hose connections to the tank are tight.

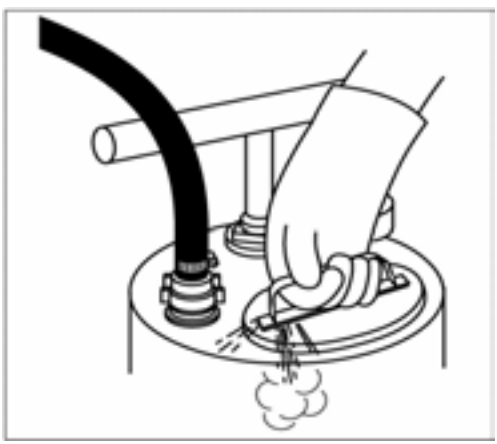


- Check the relief valve is seated correctly to avoid loss of pressure.

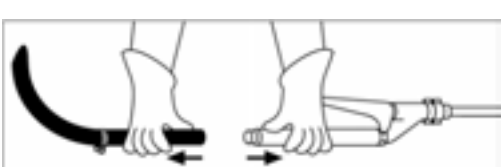
If the sprayer does not shut off

Check the trigger on/off valve.

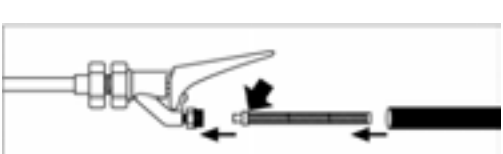
1. De-pressurize the tank.



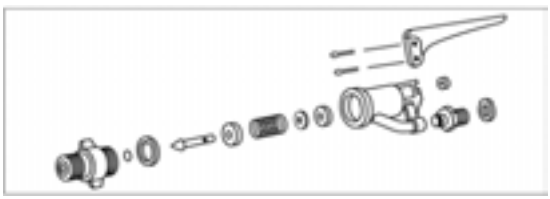
2. Disconnect the trigger valve from the hose.



3. Take the filter out of the handle.



4. Unscrew the remaining assembly to see if spring and washers need to be cleaned or replaced.



11. Preparation of insecticide spray

The amount of formulated insecticide required for the preparation of an insecticide spray is based on the average discharge rate of the sprayer and the speed of application. When the compression sprayer is fitted with a CFV, the output of the nozzle remains the same although the pressure inside the tank decreases as it empties.

	Application rate (ml/m^2)	8 litres of suspension can be sprayed on to (m^2)
CFV 2 bar	35	229 [a]
CFV 1.5 bar	30	267
no CFV	40	200

[a] *Calculation: 8 L / 0.035 L/m^2*

Example 1. Using a CFV with 2-bar pressure
A target application of 25 mg (= 0.025 g) of active ingredient of insecticide/m^2, applying at the rate of 35 ml/m^2 to treat 229 m^2, requires 5.725 g of active ingredient in 8 liters of water (*calculation:0.025 g*/m^2 *x 229* m^2). Therefore, for a formulated insecticide of 10% wettable powder, 57.25 g of the formulated product should be mixed with water to give 8 litres of suspension (*calculation: 5.725 g / 0.10 = 57.25 g*).

Example 2. Using a CFV with 1.5-bar pressure
A target application of 2 g of active ingredient of insecticide/m^2, applying at the rate of 30 ml/m^2 to treat 267 m^2, requires 534 g of active ingredient in 8 liters of water (*calculation:2 g*/m^2 *x 267* m^2). Therefore for a formulated insecticide of 50% wettable powder, 1068 g of the formulated product should be mixed with water to give 8 litres of suspension (*calculation: 534 g / 0.50 = 1068 g*).

Example 3. If sprayer does not have a CFV
An average application rate of 40 ml/m^2 is assumed, noting that the pressure drops while spraying.

A target application of 400 mg (= 0.400 g) of active ingredient of insecticide/m^2, applying at the rate of 40 ml/m^2 to treat 200 m^2, requires 80 g of active ingredient in 8 liters of water (*calculation:0.400 g*/m^2 *x 200* m^2). Therefore for a formulated insecticide of 80% wettable powder, 100 g of the formulated product should be mixed with water to give 8 litres of suspension (*calculation: 80 g / 0.80 = 93.5 g*).

Note 1. The amount of active ingredient (a.i.) in liquid formulations (e.g. SC) may be expressed as weight/weight (w/w) or weight/volume (w/v). In the latter case, the calculations proceed as in the previous examples. However, in the case of w/w, consult the label carefully, it will also give the amount of active ingredient per litre. Convert this to a percentage before proceeding with the calculations, as stated above. For example, if the label indicates that the formulation is 8% w/w, but also indicates that it contains 100 g a.i./L, convert 100 g/L to a percentage (*Calculation: 100 g / 1000 ml = 10%).*

Note 2. In some countries, compression sprayers of 10-litre liquid capacity are used. With such tank capacity, the spray suspension covers a larger area. The surface area to be treated should be calculated based on the application rate and the remaining calculations carried out as detailed above.

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Vector Ecology and Management
WHO Pesticide Evaluation Scheme