

# **GUIDELINES ON MINIMUM REQUIREMENTS FOR GROUND-BASED LOCUST AND GRASSHOPPER SPRAYERS**

**FOOD AND AGRICULTURE ORGANIZATION OF  
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## **BACKGROUND**

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Safety and quality standards for ground-based locust and grasshopper sprayers do not exist in all FAO member countries and existing international standards for this type of equipment are often inappropriate for many member countries. Since 1995 FAO-AGSE has worked on the formulation of guidelines to improve the safety and efficiency of the most commonly used types of spray equipment.

The first versions of the FAO guidelines on pesticide application equipment were approved for publication in May 1997 by: the FAO Panel of Experts on Pesticide Specifications, Registration Requirements, Application Standards and Prior Informed Consent; and the FAO Panel of Experts on Agricultural Engineering.

These current FAO guidelines on minimum requirements for locust and grasshopper sprayers are based on existing international, European and national standards, and other published references. They also build on the other FAO guidelines relating to other more mainstream agricultural sprayer types.

The other guidelines on minimum requirements and standards are presented in separate volumes covering different categories of spray equipment, such as the principal types of portable (operator-carried) sprayers, vehicle-mounted and trailed (tractor) sprayers and others.

However, locust and grasshopper spraying uses a special technique known as ultra low volume spraying (ULV). This generally uses very small droplets of pesticide formulations that are oil or solvent based to prevent evaporation, and utilizes the wind to transport and deposit the spray. ULV spraying requires specialized sprayers, not normally useable for other types of agricultural spraying, nor are conventional sprayers suitable for ULV spraying. The preliminary specifications for these specialist locust and grasshopper requirements took place at two workshops held in Cairo in 1994 and 2002, which set some initial design and performance criteria and evaluated the main locust sprayers

available commercially. In addition, two academic studies (Al Alawi, 2001 and Ishfaque, 2004) informed the process of development of these guidelines.

This publication is the First Part of the FAO locust and grasshopper sprayer guidelines. There are two parts to each guideline; the first covers minimum requirements – a baseline qualifying level of safety, performance and reliability that locust and grasshopper sprayers must reach - and the second covers more precise standards and rigorous test procedures to determine compliance with them.

### ***Guidelines on minimum requirements***

An important objective of the guidelines on minimum requirements is to assist FAO and other agencies to ensure that sprayers purchased are safe to users and to the environment as well as being efficient and durable in operation. Price will always play an important part in purchase decisions on equipment but even the cheapest sprayer models should satisfy minimum requirements for safety, performance and durability.

The FAO minimum requirements take into account sprayers that are already commercially available, some of which already meet the requirements. The prime objective therefore is that locust-affected member countries should adopt these minimum requirements immediately, to begin to eliminate substandard and unsafe sprayers from national markets and ultimately from the international scene.

The guidelines on minimum requirements are presented in separate volumes covering different categories of spray equipment, such as the principal types of portable (operator-carried) sprayers, vehicle-mounted and trailed (tractor) sprayers and others. This is the first specialized FAO guideline relating to one particular category of pest and application method – namely ULV spraying of locusts and grasshoppers.

### ***Guidelines on standards and test procedures***

The guidelines on standards are more demanding than the minimum requirements and provide more precise safety targets for spray equipment. They consist of more detailed design and performance specifications, supported by test procedures to assess compliance with these specifications. These standards reflect current manufacturing practice, other national and international standards and the practical reality in the field. Separate volumes of the standards cover different categories of sprayers manufactured or used in FAO member countries.

The aim of both the minimum requirements and the standards guidelines is to provide manufacturers and governments with a practical and consistent quality assurance system. Each member country can then decide on the form and speed of introduction of the respective guidelines into national practice and into legislation where appropriate.

## **OTHER GUIDELINES**

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There are some other FAO guidelines related to registration, testing, certification and good user practice for sprayers. The guideline series consists of the following additional titles:

***Guidelines on procedures for the registration, certification and testing of new pesticide application equipment;***

These guidelines outline a further way by which governments can influence pesticide safety by controlling the quality of the pesticide application equipment manufactured in or imported into the country. By incorporating into national legislation, a requirement for manufacturers and importers to declare that application equipment meets standards of safety and durability, it should be possible gradually to reduce and eventually to eliminate sub-standard equipment from the market.

***Guidelines on the organization of schemes for testing and certification of agricultural pesticide sprayers in use***

This publication covers the testing and certification of the sprayers currently applying pesticides on commercial farms. They address an urgent need in many countries to ensure that where pesticides are used in crop production, they are applied through equipment that is safe and fully functional. The issue applies to both large field crop and orchard sprayers, as well as to operator-carried equipment.

***Guidelines on the organization and operation of training schemes and certification procedures for operators of pesticide application equipment.***

These guidelines consider the training, testing and certification of those who actually operate pesticide application equipment. Even the best-designed and maintained sprayer can do immeasurable damage in the hands of an unskilled operator and the importance of these guidelines should not be underestimated.

A further two guidelines in the series cover application of pesticides using aircraft and field crop sprayers and tree and bush crop sprayers:

***Guidelines on good practice for aerial application of pesticides; and Guidelines on good practice for ground application of pesticides.***

These guidelines have been prepared to offer practical help and guidance to all those involved in using pesticides for food and fibre production or in public health programmes. They cover the main terrestrial and aerial spray application techniques.

## **INTRODUCTION**

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Volume One of these guidelines covers the principal portable (operator-carried) equipment: lever-operated knapsack, motorised knapsack, compression sprayer, mistblower and rotary atomizer. Vehicle-mounted and trailed field crop sprayers and orchard sprayers are covered in Volume Two. Volume Three covers portable (operator-carried) foggers.

Volume Four of the FAO guidelines covers locust and grasshopper sprayers – including portable sprayers (carried in the hands or on the back of the operator) and vehicle-mounted sprayers (fixed to the bed of a pick-up vehicle or small truck). It covers four principal types of sprayer:

- RA - rotary atomizer<sup>1</sup>
- MB – motorised mistblower
- VP – vehicle-mounted passive drift sprayer
- VA – vehicle-mounted air-assisted sprayer

All of these are ULV sprayers i.e. they are designed to apply specialized ULV insecticide formulations undiluted, in volumes ranging from 0.3 – 3 litres/ha. These formulations are oil-based to reduce evaporation, and are atomized by the sprayer into small, evenly-sized droplets so that the wind can disperse them over a wide downwind swath. The independence from supplies of mixing water and the fact that the wide swaths allow a large track spacing and high work rate make them particularly suitable for rapid treatment of large locust and grasshopper targets in arid zones.

## **SPRAYER CHOICE**

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It is important that buying agencies select the type of sprayer that is most appropriate for the intended use. The following notes will assist in the selection process.

### ***Rotary atomizer (RA)***

For the purposes of these guidelines, RA means a portable sprayer with a spinning atomizer - usually a disc or cup – driven by a small electric motor and powered by batteries. Spray liquid flows onto the spinning disc/cup and is thrown off as spray droplets that are dispersed by the wind over a downwind swath. In fact, various types of rotary atomizer are used on the other categories of ULV locust sprayer (vehicle-mounted and aerial), and the term RA is used for this specific sprayer type in order to conform with the definition in previous volumes of the guidelines. RA sprayers are particularly useful – either singly or operated in formation by a team of operators – for control of relatively small hopper band targets (up to 5 ha). Such teams of operators can also be used to apply barriers over much larger areas.

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<sup>1</sup> Most locust and grasshopper sprayers have rotary atomizers, but the term RA is used to describe portable rotary atomiser sprayers and conform to terminology used in previous sprayer guidelines.

### ***Motorized mistblower (MB)***

Motorized mistblowers rely on an airblast from an engine-driven fan to atomize the pesticide and blow it some metres away from the sprayer operator. The term MB has the same meaning here as in the other guidelines, except that any motorized mistblower used for ULV locust control must have some modifications and supplementary features. These are ULV pesticide-resistant pipes, hoses and seals, usually a rotary atomizer mounted in the air tube rather than a standard air shear nozzle, and modified flow restrictors to provide the low flow rates required. They can be used to spray locusts in bushes and low trees or directed upwards in more open terrain to produce a greater effective emission height and therefore a wider swath and faster work rate than an RA sprayers. They are suitable for small hopper bands and fragments of settled swarm targets (up to 10 ha).

### ***Vehicle-mounted passive drift sprayer (VP)***

These can be thought of as RA sprayers adapted for vehicle-mounted use. They operate on the same principle of releasing spray droplets from a rotary atomizer passively into the air and allowing the wind to disperse them downwind over the swath. They differ from RA sprayers only in that vehicles have higher forward speeds, emission heights and carrying capacities. The higher forward speeds and emission heights mean that greater work rates can be achieved, in turn requiring a higher flow rate to take advantage of this. To cope with this higher flow rate and still maintain the quality of the droplet spectrum, atomizers are larger and tanks have greater capacity. A pump is used instead of gravity to feed the pesticide to the atomizer. They are suitable for medium sized targets up to 50 ha

### ***Vehicle-mounted air-assisted sprayer (VA)***

These can be thought of as MB sprayers adapted for vehicle use. They are similar to VP sprayers except that an engine-driven fan blows the spray from the rotary atomizer some metres from the sprayer. Track spacings wider than those for VP sprayers are possible due to the facility to direct the airblast upwards and carry the droplets to a greater effective emission height before they are released into the cross wind. VA sprayers are suitable for medium sized targets up to 100 ha.

### ***Using the guidelines on minimum requirements***

For the purposes of these guidelines, locust sprayers can be divided into several “component modules”. Each module relates to a major component or a functional group of components from which consistent specifications for complete sprayers can be compiled. The specifications do not dictate or prescribe engineering design; they define functional or operational requirements and should not restrict the engineering design freedom of the manufacturer. The modules for locust and grasshopper sprayers are shown in Figure 1.

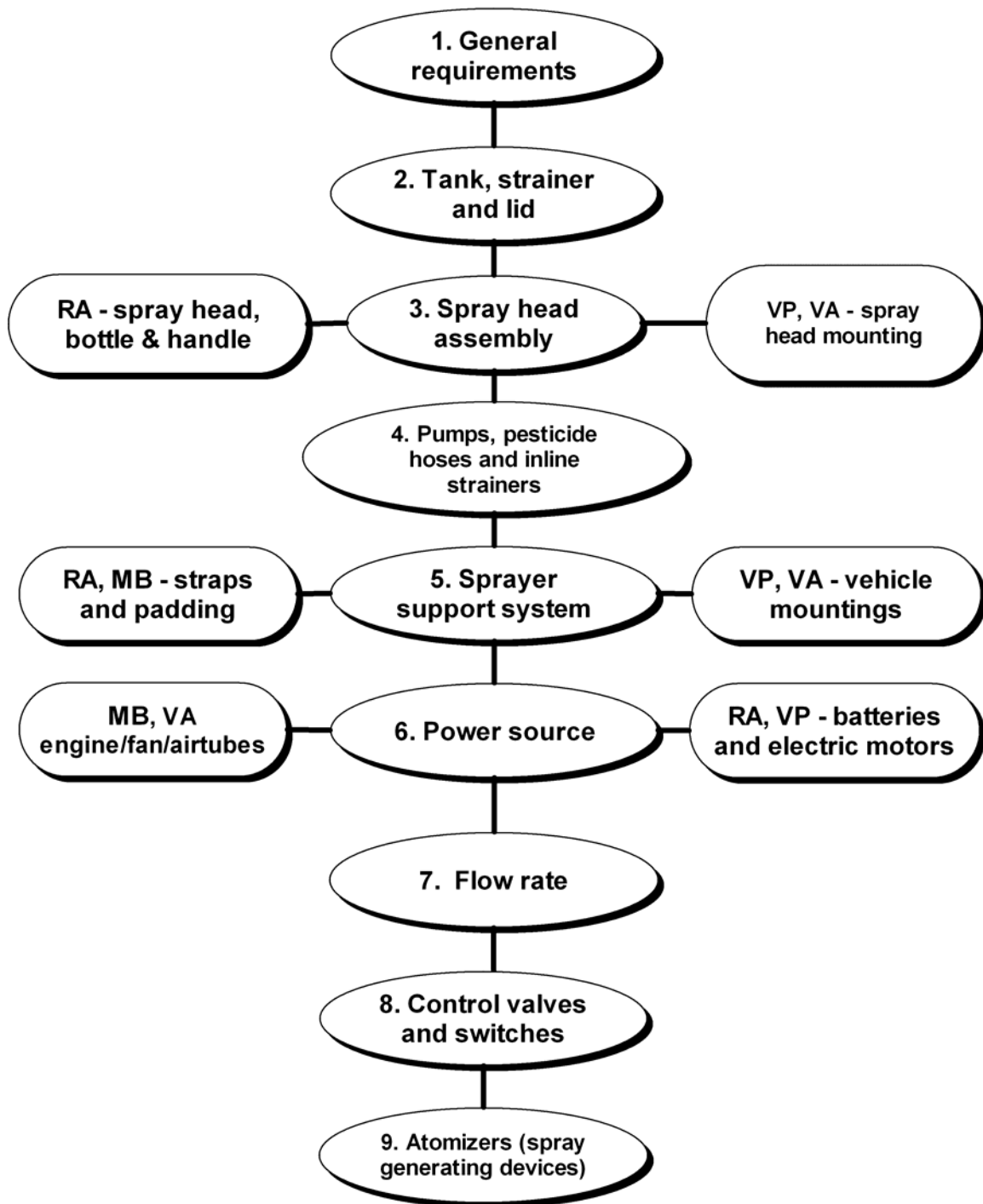


Figure 1. Component modules of locust and grasshopper sprayers

## MINIMUM REQUIREMENTS FOR GROUND-BASED LOCUST AND GRASSHOPPER SPRAYERS

Locust and grasshopper sprayers should be safe, reliable and capable of working efficiently under practical field conditions. They should be robustly constructed from strong, durable materials, which will not obviously be prone to undue deterioration from corrosion, rust, distortion or premature wear during field use, thereby adversely affecting safety, efficiency and reliability.

To meet the FAO minimum requirements, a locust and grasshopper sprayer should comply as follows:

| Module 1. General requirements |  | RA | MB | VP | VA |
|--------------------------------|--|----|----|----|----|
| 1.1                            | Total mass for RA and MB sprayers when filled to the manufacturer's recommended maximum capacity should not exceed 25 kg.<br><br>For RA sprayers, the following are acceptable guidelines for the division of the total mass: <ul style="list-style-type: none"> <li>■ 20 kg maximum for a backpack (or shoulder-slung) tank and battery power source carried on a waist belt, or on a shoulder strap.</li> <li>■ 7 kg for a lance / battery case, spray head, spray bottle and a hand-carried tank, where present.</li> </ul> | ✓  | ✓  |    |    |
| 1.2                            | The sprayer unit should be securely attached to the vehicle system.  |    |    | ✓  | ✓  |
| 1.3                            | The filling system for the spray tank(s) should permit safe, easy filling without overflowing or splashing (see later specific requirements for tank, strainer and lid).   | ✓  | ✓  | ✓  | ✓  |
| 1.4                            | When filled to the manufacturers recommended maximum capacity, the backpack/shoulder-slung sprayer/tank should not leak either when upright or when tilted forward 90 degrees from the vertical (laid down on the straps).   | ✓  | ✓  |    |    |
| 1.5                            | When filled to the manufacturers recommended maximum capacity, the backpack/shoulder-slung sprayer/tank should not leak either when upright or when tilted 45 degrees from the vertical in all directions.   |    |    | ✓  | ✓  |
| 1.6                            | The sprayer should be easy to clean both inside and out. Rough surfaces and awkward recesses should be avoided.  | ✓  | ✓  | ✓  | ✓  |
| 1.7                            | There should be easy access to service components such as engine oil, spark plug, pump, taps. Filters (air, fuel, pesticide) must be accessible and easily removable without tools.  | ✓  | ✓  | ✓  | ✓  |



| Module 1. General requirements |  | RA | MB | VP | VA |
|--------------------------------|--|----|----|----|----|
| 1.8                            | The outer surfaces of the sprayer should not trap or retain spray liquid.  | ✓  | ✓  | ✓  | ✓  |
| 1.9                            | There should be no sharp edges, abrasive areas or unnecessary projections, which could injure the operator.  | ✓  | ✓  | ✓  | ✓  |
| 1.10                           | The backpack/shoulder slung sprayer/tank should be stable and stand upright on slopes up to 15% (1 in 7), irrespective of the amount of liquid in the tank, or the direction of the slope.   | ✓  | ✓  |    |    |
| 1.11                           | Servicing, maintenance, adjustment and cleaning of all sprayer components should be easily accomplished without needing special tools (i.e. tools specifically designed for the sprayer).  | ✓  | ✓  | ✓  | ✓  |
| 1.12                           | To facilitate the accurate identification of replacement parts, the sprayer should be clearly and durably marked to indicate the manufacturer's name and address and the sprayer name and model.   | ✓  | ✓  | ✓  | ✓  |
| 1.13                           | There should be a practical system in place to assist in the provision of replacement parts for a minimum of five years after the date of manufacture. The manufacturer should provide written assurance of this in the sprayer instruction manual (see Section 1.18).             | ✓  | ✓  | ✓  | ✓  |
| 1.14                           | All controls should be clearly marked and within easy reach of the operator from the normal driving/spraying position.   | ✓  | ✓  | ✓  | ✓  |
| 1.15                           | A supply of commonly required spares should be supplied with a new sprayer.  | ✓  | ✓  | ✓  | ✓  |
| 1.16                           | There should be a tool kit supplied as standard equipment by sprayer manufacturer with all necessary tools for installation, adjustment and operation.   |    | ✓  | ✓  | ✓  |
| 1.17                           | All sprayer components that come into constant direct contact with ULV pesticide should be resistant to deterioration from contact with ULV pesticide formulations The manufacturer should provide written assurance of this in the sprayer instruction manual (see Section 1.18). | ✓  | ✓  | ✓  | ✓  |
| 1.18                           | The manufacturer should supply with the sprayer, a clear, simple, illustrated, instruction manual in English, French and Arabic. (See Appendix 1 for detail on what the instruction manual should cover).  | ✓  | ✓  | ✓  | ✓  |

| Module 2. Tank, strainer and lid  |   | RA | MB | VP | VA |
|---|---|----|----|----|----|
| <b>Note: For RA in this module, the tank refers to any separate container that is hand-held, carried on straps on the operator's back or slung on a strap over a shoulder, which is used to contain the spray liquid to be applied through a rotary atomizer. It does not refer to the smaller reservoir bottle attached to the spray head.</b> |   |    |    |    |    |
| 2.1   | Operator reach distances to the tank opening should not exceed 1.0 m vertically from the sprayer platform and there should be no obstructions around the filling area.  |    |    | ✓  | ✓  |
| 2.2   | Spray tanks should be mechanically durable and fixed in such a way that rugged field operations will not puncture them.   | ✓  | ✓  | ✓  | ✓  |
| 2.3   | The tank should be clearly and durably marked with: <ul style="list-style-type: none"> <li>■ the manufacturer's recommended maximum filling level, which should be equivalent to no more than 95% of the total volume of the tank;</li> <li>■ appropriate intermediate filling levels.</li> </ul> | ✓  | ✓  | ✓  | ✓  |
| 2.4   | Further to Section 2.3, during spraying, the level of liquid in the tank should be clearly visible as it approaches empty.  | ✓  | ✓  | ✓  | ✓  |
| 2.5   | Further to Section 2.3, during filling, with the strainer fitted the level of liquid in the tank should be clearly visible as it approaches the nominal maximum filling level.  | ✓  | ✓  | ✓  | ✓  |
| 2.6   | The tank should include a strainer, located in the fill opening to filter the pesticide as it enters the tank.  | ✓  | ✓  | ✓  | ✓  |
| 2.7   | The strainer should be easy to remove and fit with gloved hands. For this and for other checks where gloves are recommended, the gloves should have a minimum thickness of 0.5 mm.  | ✓  | ✓  | ✓  | ✓  |
| 2.8   | The strainer should have a mesh aperture size no greater than the smallest restrictor orifice recommended by the manufacturer.  | ✓  | ✓  | ✓  | ✓  |
| 2.9   | The strainer mesh should be securely fitted to, or form part of, the strainer body.   | ✓  | ✓  | ✓  | ✓  |
| 2.10  | The tank strainer should be close fitting and permit safe, easy filling from a non-profiled container (i.e. one without a lip or spout) at a rate of 25 litres per minute without overflowing, splashing or lifting from its seat. Opening diameter should not be less than 100 mm across.        | ✓  | ✓  |    |    |
| 2.11  | For vehicle sprayers, the strainer should be close fitting and permit safe, easy filling from a non-profiled container (i.e. one without a lip or spout) without overflowing, splashing or lifting from its seat. Tank opening diameter should not be less than 200 mm.                           |    |    | ✓  | ✓  |

| Module 2. Tank, strainer and lid |   | RA | MB | VP | VA |
|----------------------------------|---|----|----|----|----|
| 2.12                             | The tank fill opening should be sealed with a lid that can be opened and securely closed with gloved hands and without tools.   | ✓  | ✓  | ✓  | ✓  |
| 2.13                             | When closed, the lid should not collect spray liquid.   | ✓  | ✓  | ✓  | ✓  |
| 2.14                             | The tank lid should have a ventilation valve that allows air in but does not allow any spray liquid to come out.  | ✓  | ✓  | ✓  | ✓  |
| 2.15                             | There should be a separate flushing tank for cleaning fluid which can be switched into the spray line by use of clearly marked valves so that hoses, pumps, strainers and atomizers can be cleaned safely and easily. |    |    | ✓  | ✓  |
| 2.16                             | Volume of the sprayer tank should be a minimum of 60 l and a maximum of 110 l. This allows prolonged spraying without being excessive, and is also a convenient size for filling from 25 and 50 litre drums.          |    |    | ✓  | ✓  |
| 2.17                             | The spray tank should incorporate a safe and convenient system to enable unused spray liquid to be discharged and collected safely. Any drain pipe should be fitted at the lowest point on the pesticide tank.        |    |    | ✓  | ✓  |
| 2.18                             | It should be possible to drain the tank to leave a total residual volume in the sprayer (including tank, pipes, etc) of less than 1% of total tank volume.  | ✓  | ✓  | ✓  | ✓  |

| Module 3. Spray head assembly |  | RA | MB | VP | VA |
|-------------------------------|--|----|----|----|----|
| 3.1                           | In all recommended working positions, the spray head should be a minimum of 500 mm from all parts of the operator's body to ensure that there is no direct contamination of the operator from the spray droplets.  | ✓  |    |    |    |
| 3.2                           | The length of the air tube from the on/off lever to the air outlet should be no less than 400 mm.  |    | ✓  |    |    |
| 3.3                           | The sprayer should incorporate a robust "parking system" to secure the air tube when it is not in use.   |    | ✓  |    |    |
| 3.4                           | The airtube should be fitted with a handle.  |    | ✓  |    |    |
| 3.5                           | The liquid supply line to the nozzle should incorporate an on/off valve.   |    | ✓  |    |    |
| 3.6                           | If the atomizer is exposed, a shield or cover should be supplied with the sprayer to protect it from physical damage in transit and in storage.  | ✓  | ✓  | ✓  | ✓  |
| 3.7                           | For VP and VA sprayers, there should be a device to protect the atomizer from damage by low hanging branches or other obstacle.  |    |    | ✓  | ✓  |
| 3.8                           | When the spray liquid to the atomizer is supplied solely from the bottle on the spray head (i.e. not re-filled from a spray tank), it should be possible to fill the bottle via a funnel with an integral strainer, without spilling or splashing, at a rate of 5 litres per minute. | ✓  |    |    |    |

| Module 4. Pumps, pesticide hoses and inline strainers |   | RA | MB | VP | VA |
|---|---|----|----|----|----|
| 4.1   | Spray hoses, when bent through 180 degrees at temperatures up to 40°C, should not kink (flatten) permanently.   | ✓  | ✓  | ✓  | ✓  |
| 4.2   | Hose connections should be easily adjustable and removable with gloved hands and should not leak when reconnected.  | ✓  | ✓  | ✓  | ✓  |
| 4.3   | Spray hoses should be of sufficient length to allow free movement and appropriate positioning of the spray head for spraying.   | ✓  | ✓  | ✓  | ✓  |
| 4.4   | It should be possible to remove the pump without draining the tank.   |    |    | ✓  | ✓  |
| 4.5   | When the sprayer has a pump which operates with valves, there should be a strainer on the suction side of the pump with a maximum mesh aperture size of 0.5 mm.   |    |    | ✓  | ✓  |
| 4.6   | Strainers should be readily accessible for cleaning and maintenance.  |    | ✓  | ✓  | ✓  |
| 4.7   | Strainers should be easy to clean without needing to empty the sprayer tank(s).   |    | ✓  | ✓  | ✓  |
| 4.8   | Hoses should be positioned so that, in the event of leakage or bursting, the risk of operator contamination is minimized. On vehicle-mounted sprayers, they should not pass through the vehicle cab.              | ✓  | ✓  | ✓  | ✓  |
| 4.9   | Hoses should be fitted to the sprayer so that they are not bent sharply (kinked), which could reduce the effective internal diameter of the hose.   | ✓  | ✓  | ✓  | ✓  |
| 4.10  | Hose connections should be easily adjustable and removable using gloved hands without needing special tools (i.e. tools specifically designed for the sprayer) and should not leak when reconnected.              | ✓  | ✓  | ✓  | ✓  |
| 4.11  | The sprayer should have a partially pressurised tank (3-5 psi) or be fitted with a pesticide pump resistant to ULV formulations to ensure reliable flow to the spray head even when it is being directed upwards. |    | ✓  |    |    |

| <b>Module 5. Sprayer supporting systems</b>    |   | <b>RA</b> | <b>MB</b> | <b>VP</b> | <b>VA</b> |
|--|---|-----------|-----------|-----------|-----------|
| <b><i>RA and MB straps and padding</i></b>     |   |           |           |           |           |
| 5.1  | Straps and fixings should be strong, durable and made of non-absorbent material.  | ✓         | ✓         |           |           |
| 5.2  | Straps and padding should resist undue deterioration from contact with ULV pesticide formulations. The manufacturer should provide written assurance of this in the sprayer instruction manual (see Section 1.18).                            | ✓         | ✓         |           |           |
| 5.3  | The load-bearing part of shoulder straps should be a minimum of 50 mm wide, except in the case of those RA sprayers that have a pesticide tank with less than 10 litres capacity, in which case the straps should be a minimum of 30 mm wide. | ✓         | ✓         |           |           |
| 5.4  | When adjustable shoulder pads are included, they should remain firmly in place in their adjusted positions when the sprayer is in use.  | ✓         | ✓         |           |           |
| 5.5  | Straps fitted to a backpack sprayer or tank should be easily adjustable without assistance when the sprayer is full and in the working position on the operator's back.   | ✓         | ✓         |           |           |
| 5.6  | Straps should be equipped with quick release catches that function efficiently when the tank is full and in the working position on the operator's back.  | ✓         | ✓         |           |           |
| 5.7  | Backpack tanks when in the working position should be designed to be comfortable for the operator, either through the shape of the tank or through the provision of a back-frame.   | ✓         | ✓         |           |           |
| <b><i>VP and VA mountings and supports</i></b> |   |           |           |           |           |
| 5.8  | The sprayer should have a transport position to ensure the atomizer head or its supporting structure is not damaged in transit.   |           |           | ✓         | ✓         |
| 5.9  | The sprayer should be able to direct the spray upwards and downwards by a minimum of 45 degrees in order to take advantage of light winds or to improve targeting in windier conditions.  |           |           |           | ✓         |
| 5.10   | The sprayer should have at least four boltholes in the base of the frame so that it can be bolted to the bed of the vehicle.  |           |           | ✓         | ✓         |

| Module 6. Power source |  | RA | MB | VP | VA |
|------------------------|--|----|----|----|----|
| 6.1                    | The engine should have a safe, robust starting mechanism.  |    | ✓  |    | ✓  |
| 6.2                    | The exhaust should be: <ul style="list-style-type: none"> <li>■ directed away from the operator's body;</li> <li>■ positioned on the opposite side of the sprayer to the controls;</li> <li>■ well-shielded to prevent burning the operator or a third party.</li> </ul> |    | ✓  |    |    |
| 6.3                    | The engine should be isolated from the carrying frame by anti-vibration mountings.   |    | ✓  |    |    |
| 6.4                    | The engine should be robustly protected against accidental physical damage.  |    | ✓  |    |    |
| 6.5                    | The fuel tank and the fuel on/off valve should be positioned to minimise the risk of fuel spilling onto the engine.  |    | ✓  |    |    |
| 6.6                    | The fuel on/off valve should be close to the fuel tank outlet and easily accessible to the operator when the sprayer is in the working position.   |    | ✓  |    |    |
| 6.7                    | An easily serviceable fuel filter should be located in the line between the fuel tank and the carburettor.   |    | ✓  |    | ✓  |
| 6.8                    | An easily replaceable air filter should be located directly on the carburettor intake.   |    | ✓  |    | ✓  |
| 6.9                    | Carburettor adjusting screws should be readily accessible without needing to remove parts or use special tools (i.e. tools specifically designed for the sprayer).   |    | ✓  |    |    |
| 6.10                   | The noise level at the ear of the operator should not exceed 85 dB.  |    | ✓  |    | ✓  |
| 6.11                   | The fuel tank should have sufficient capacity for a minimum of one hour of continuous operation.   |    | ✓  |    | ✓  |
| 6.12                   | When a two-stroke engine is present, the fuel tank should be durably marked with the required fuel/oil ratio.  |    | ✓  |    | ✓  |
| 6.13                   | All moving parts (including pumps driven by gears or pulleys) should be well shielded to prevent injury.   |    | ✓  |    | ✓  |
| 6.14                   | The fan should be protected by a casing measuring no more than 45 cm. in diameter.   |    | ✓  |    |    |
| 6.15                   | The inlet to the fan should be equipped with a guard with a mesh-aperture size of between 5 mm and 10 mm.  |    | ✓  |    | ✓  |
| 6.16                   | The engine should still run after being exposed to heavy rain.   |    | ✓  |    | ✓  |
| 6.17                   | The power consumption of the atomizer electric motor should not exceed 4 watts when loaded.  | ✓  |    |    |    |

| Module 7. Flow rate |  | RA | MB | VP | VA |
|---------------------|--|----|----|----|----|
| 7.1                 | Flow rate should be controlled by a positive system of interchangeable but not adjustable restrictors. These should be clearly marked or colour coded and it should be possible to change them without special tools (i.e. without tools developed specifically for the sprayer).  | ✓  | ✓  |    |    |
| 7.2                 | Where the flow rate is controlled by a positive system of interchangeable but not adjustable restrictors, these should be clearly marked or colour coded and it should be possible to change them without special tools (i.e. without tools developed specifically for the sprayer). Where there is an infinitely variable system of flow control such as a needle valve, this should be marked with graduations and there must be a system of locking it in place to prevent it being accidentally altered. |    |    | ✓  | ✓  |
| 7.3                 | Flow rate from restrictors with the same identity code and/or colour, i.e. which claim to have the same characteristics, should not differ by more than $\pm 5\%$ from the nominal output.   | ✓  | ✓  | ✓  | ✓  |
| 7.4                 | Flow rate range should be 0.03 – 0.13 l/min  | ✓  |    |    |    |
| 7.5                 | Flow rate range should be 0.05 – 0.4 l/min   |    | ✓  |    |    |
| 7.6                 | Flow rate range should be 0.07 – 1.0 l/min   |    |    | ✓  |    |
| 7.7                 | Flow rate range should be 0.1 – 1.6 l/min  |    |    |    | ✓  |
| 7.8                 | Variation in flow rate should be no more than 5% regardless of terrain, speed of movement, volume of pesticide in the tank or height of emission.  | ✓  | ✓  | ✓  | ✓  |
| 7.9                 | It should be possible to collect pesticide directly during flow rate measurement (rather than using a 'loss' technique involving assessing the volume missing from the tank after a given time).   | ✓  | ✓  | ✓  | ✓  |
| 7.10                | There should be minimal operator contact with pesticide when adjusting flow rate.  | ✓  | ✓  | ✓  | ✓  |
| 7.11                | There should be no dripping from the atomizer after a period of 10 seconds after switching off.  | ✓  | ✓  | ✓  | ✓  |



| Module 8. Control valves and switches |  | RA | MB | VP | VA |
|---------------------------------------|--|----|----|----|----|
| 8.1                                   | The engine throttle lever must remain firmly fixed in any pre-set position during operation.   |    | ✓  |    | ✓  |
| 8.2                                   | The engine should have an instant “cut out” mechanism that is readily accessible to the operator when the sprayer is in use.                               |    | ✓  |    | ✓  |
| 8.3                                   | Controls should be on the air tube handle, not on the body of the sprayer.   |    | ✓  |    |    |
| 8.4                                   | Vehicle mounted sprayer controls (pump and atomizer) should be located in the vehicle cab, not on the body of the sprayer.                                 |    |    | ✓  | ✓  |
| 8.5                                   | There should be a separate means of switching the pesticide flow and the atomizer rotation on and off.   | ✓  | ✓  | ✓  | ✓  |
| 8.6                                   | There should be well labelled controls with instructions to operator always to turn the atomizer on before the pump (except during flow rate calibration). |    |    | ✓  | ✓  |
| 8.7                                   | It should be possible to isolate the controls so that atomizer and pump are not accidentally switched on in transit.                                       |    |    | ✓  | ✓  |
| 8.8                                   | Controls should have lights or other clear system to indicate when they are switched on.   |    |    | ✓  | ✓  |
| 8.9                                   | The sprayer should have a system to ensure that the positive and negative wires cannot be connected the wrong way round.                                   |    |    | ✓  | ✓  |

| Module 9. Atomizers (spray generating devices) |  | RA | MB | VP | VA |
|--|--|----|----|----|----|
| 9.1  | The atomizers should be capable of 50 hours of operation at maximum operating speed without loss of performance or needing maintenance. The manufacturer should provide written assurance of this in the sprayer instruction manual (see Section 1.18).  | ✓  | ✓  | ✓  | ✓  |
| 9.2  | The sprayer must be capable of producing a droplet spectrum with VMD between 60 and 80 um when spraying UL formulations or equivalent blank formulations, as determined by laser droplet analysis. The manufacturer should provide written assurance of this in the sprayer instruction manual (see Section 1.18). | ✓  | ✓  | ✓  | ✓  |
| 9.3  | At least 50% of the spray volume must be in the size range 50 – 100 um when spraying UL formulations or equivalent blank formulations, as determined by laser droplet analysis. The manufacturer should provide written assurance of this in the sprayer instruction manual (see Section 1.18).                    | ✓  | ✓  | ✓  | ✓  |
| 9.4  | The sprayer should have a means of altering the VMD to cope with different weather conditions. No major dismantling should be required.  | ✓  | ✓  | ✓  | ✓  |

## REFERENCES

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FAO, 1994. Workshop on spray equipment used in Desert Locust control, 21 – 23 August 1994, Cairo Egypt, FAO Commission for Controlling the Desert Locust in the Near East.

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Al Sarai al Alawi, M., 2002. Reviewing and testing old and new Desert Locust control technologies with a view to recommending technologies for the future. MSc Thesis at University of Greenwich, UK.

Ishfaque, M., 2004. Review and critical assessment of spray technology for control of the Desert Locust *Schistocerca gregaria* (Forskål) to establish minimum requirements. PhD Thesis, University of Faisalabad, Pakistan.

## **APPENDIX 1. SPRAYER MANUAL CONTENTS**

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The manufacturers sprayer manual should contain the following information:

Procedures for:

- initial assembly;
- identification of all replacement parts including an “exploded “ diagram;
- setting and calibration;
- minimising the need to dispose of dilute pesticide;
- cleaning and safe disposal of washings;
- routine maintenance and storage;
- accurate field use.

Information on:

- safe handling of pesticides and filling the tank;
- disposal of leftover spray liquid and empty pesticide containers;
- restrictor flow rate, atomizer speed and droplet sizes;
- maximum restrictor size to be used in the sprayer;
- precautions to minimise the risk of operator and environmental contamination;
- recommended batteries (for battery-powered sprayers) and their installation;
- a system for determining when batteries should be replaced.

It should also provide specific assurances that:

- there is a practical system in place to assist in the provision of replacement parts for a minimum of five years after the date of manufacture;
- all sprayer components that come into constant direct contact with ULV pesticide are resistant to undue deterioration from contact with ULV pesticide formulations;
- straps and padding will resist undue deterioration from contact with ULV pesticide formulations;
- the atomizers should be capable of 50 hours of operation at maximum operating speed without loss of performance or needing maintenance;
- the sprayer must be capable of producing a droplet spectrum with VMD between 60 and 80  $\mu\text{m}$ , as determined by laser droplet analysis;
- at least 50% of the spray volume must be in the size range 50 –100  $\mu\text{m}$ , as determined by laser droplet analysis.