

Guidelines on

STANDARDS FOR AGRICULTURAL PESTICIDE
APPLICATION EQUIPMENT AND
RELATED TEST PROCEDURES

Volume One
Portable (operator-carried) sprayers



GUIDELINES ON STANDARDS FOR
AGRICULTURAL PESTICIDE
APPLICATION EQUIPMENT AND
RELATED TEST PROCEDURES

VOLUME ONE

PORTABLE (OPERATOR-CARRIED)
SPRAYERS



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BACKGROUND

Safety and quality standards for agricultural pesticide 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 FAO guidelines on standards are based on existing international, European and national standards and other published references. They also draw on the in-depth knowledge and experience of international sprayer standards of the experts assigned to the project and on the authors' experience of pesticide application in the developing world.

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.

This publication is the first revision of these guidelines, which incorporate comments and suggestions received from member states and new international developments since 1997. There are two guidelines; the first covers minimum requirements and the second covers more precise standards and test procedures to determine compliance.

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 meet minimum standards of safety and durability.

The FAO minimum requirements take into account sprayers that are already on the market, many of which already meet the requirements. The prime objective therefore is that member countries should adopt them 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, including rotary atomizers, vehicle-mounted and trailed (tractor) sprayers and others.

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 detailed specifications and requirements, supported by test procedures to measure compliance with the FAO standard, for the major types of agricultural pesticide sprayers manufactured or used in FAO member countries. These standards reflect current manufacturing practice, other national and international standards and the practical reality in the field in member states.

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.

The entire series consists of the following other guidelines:

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 standard of safety and durability, it should be possible to gradually reduce and eventually 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, which is safe and fully functional. The issue applies to both large, field crop and orchard sprayers as well as 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 most well 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;

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

The FAO guideline standards aim to provide growers, manufacturing industry and government agencies with an appropriate, practical and consistent quality assurance system for all major crop sprayers supplied to or manufactured in the developing world. Special attention is paid to operator and environmental safety, and durability tests are included where there are safety implications.

Volume One of this guideline 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. Each part contains specifications for each type of sprayer and a series of test procedures to determine whether a candidate sprayer meets the specifications.

The specifications and tests are based on existing international, European and national standards and other published references. They also draw on the in-depth knowledge and experience of sprayer standards of the expert assigned to the project, on information supplied by international experts and manufacturers and on the authors' experience of pesticide application in the developing world.

Specification Format

Specifications are in a modular format, which was developed by the authors as the basis for the FAO document to guide FAO and other buying agencies in the selection of crop sprayers: *FAO basic guidelines for the selection of agricultural pesticide sprayers*, June 1995.

Each module relates to a major component or a functional group of components from which consistent specifications for complete sprayers can be compiled. The modules for portable sprayers are shown in Figure 1.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

The modules consist of numbered sections each addressing a separate specification or requirement. 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.

When requirements or procedures are the same, wherever practical, the same modules, sections and wording are used. This applies irrespective of the type of sprayer. For example, the hydraulic nozzle is included for both portable and tractor sprayers.

Test Procedures

These are presented as step-by-step sequences to assist testers and to provide clarity and consistency. The aim is to use clear, uncomplicated language without compromising technical precision.

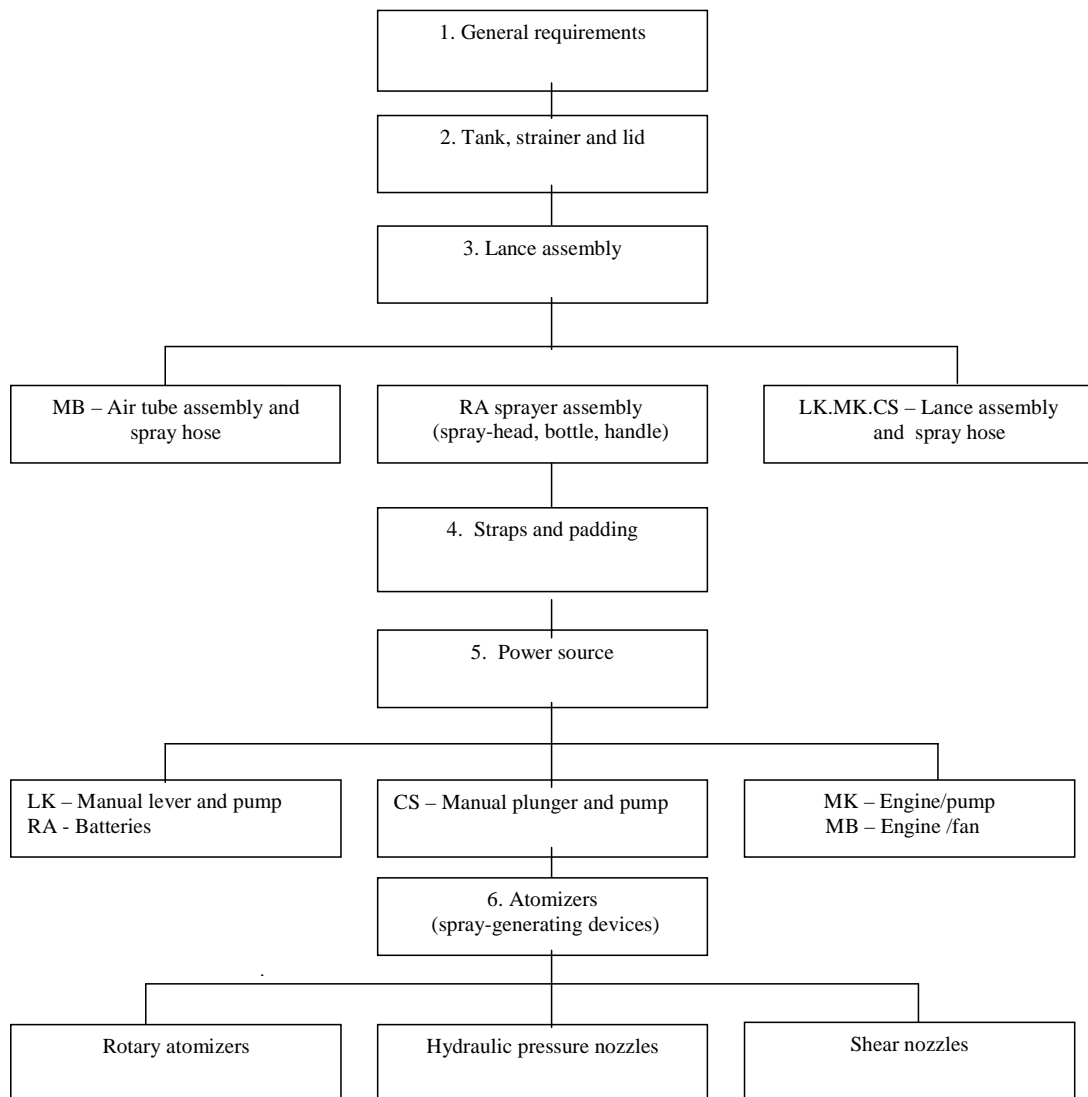
Compliance

A key element of the system is the method for determining compliance, which is a simple YES / NO system. Where numerical values are included, these are based either on accepted norms in published standards or on the judgement of the authors and their advisers, always bearing in mind that the criteria used must relate to the needs of the practical field and factory situation. The system involves stating at the end of each section (clause) in a specification (i.e. for each design or performance criterion) the action or series of actions required. The actions fall into four categories: check, measure, test and test procedure, which are defined as follows.

CHECK Where a simple observation or action is all that is needed to establish whether the sprayer complies or not, e.g. “all hoses should be durably marked to indicate the rated pressure”.

MEASURE	Where a simple measurement is all that is needed, e.g. volume, thickness, length or pressure.
TEST	In some cases simple tests are required, which are generally obvious and do not warrant a written test sequence, e.g. “the sprayer should be stable and stand upright on slopes of 15% (1 in 7), irrespective of the amount of liquid in the tank.”
TEST	
PROCEDURE	A sequence of step-by-step actions as described in each part of this volume.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

Figure 1 COMPONENT MODULES

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

PORTABLE (OPERATOR-CARRIED) SPRAYERS: SPECIFICATIONS

LEVER-OPERATED KNAPSACK SPRAYERS (LK)

1. LK Module 1 - GENERAL REQUIREMENTS

Lever-operated knapsack 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 during field use, thereby adversely affecting safety and lowering efficiency due to corrosion, rust, distortion or premature wear.

To meet the FAO standard, a lever-operated knapsack sprayer should comply with the following requirements.

- 1.1. Total mass when filled to nominal (manufacturer's recommended) maximum capacity should not exceed 25 Kg. MEASURE
- 1.2. The sprayer should not leak. TEST PROCEDURE 1
- 1.3. The sprayer should be easy to clean thoroughly both inside and out. Rough surfaces and awkward recesses should be avoided. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.4. The outer surfaces of the sprayer should not trap nor retain spray liquid. TEST PROCEDURE 2
- 1.5. There should be no sharp edges, abrasive areas or unnecessary projections, which could injure the operator. CHECK
- 1.6. The sprayer should incorporate a conveniently located handle to enable it to be safely carried when not in use. CHECK
- 1.7. The sprayer should be stable and stand upright on slopes up to 15% (1 in 7), irrespective of the amount of liquid in the tank. TEST
- 1.8. 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). CHECK
- 1.9. 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. CHECK
- 1.10. 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 manual (see Section 1.17). CHECK
- 1.11. The sprayer if dropped should continue to function normally and should not leak. TEST PROCEDURE 7

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.12. Parts of the sprayer that come into constant direct contact with the spray liquid should be made from non-absorbent materials, which are suitable for use with approved pesticide formulations. TEST PROCEDURE 8
- 1.13. The manufacturer should provide written assurance in the sprayer manual (see section 1.17) that parts of the sprayer that are exposed routinely to direct sunlight should be made from materials which do not unduly deteriorate. CHECK
- 1.14. All pressure and flow control devices should be adjustable from outside the spray tank. CHECK
- 1.15. A safety device should be incorporated into the sprayer to prevent the maximum pressure exceeding 5 bar in any part of the sprayer. Vented liquid should be discharged inside the tank. TEST
- 1.16. The sprayer should be reliable and durable in use. TEST PROCEDURE 12
- 1.17. The manufacturer should provide with the sprayer a clear, simple, illustrated manual in the language of the country of manufacture and in English, French or Spanish. CHECK
- 1.18. The manual should contain 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;
- safe release of residual pressure in the lance when a spray management valve is used.

CHECK

It should also provide information on:

- safe handling of undiluted agrochemicals, mixing chemicals and filling the tank;
- disposal of leftover spray liquid and empty pesticide containers;
- nozzle flow rate and spray quality (see Section 6.1);
- the maximum nozzle size and operating pressure to be used in the sprayer;
- precautions to minimise the risk of operator and environmental contamination.

CHECK

2. LK Module 2 - TANK, STRAINER AND LID

2.1 The tank should be clearly and durably marked with:

- the nominal maximum filling level, which should be equivalent to no more than 95% of the total volume of the tank;
- appropriate intermediate filling levels.

MEASURE

2.2 During filling, the level of liquid in the tank should be clearly visible as it approaches the nominal maximum level. TEST

- 2.3 The tank should include a strainer, located in the fill opening, to filter the water or spray solution as it enters the tank. CHECK
- 2.4 The strainer should be easy to remove and fit with gloved hands (for test purposes, gloves should have a minimum thickness of 0.5 mm). CHECK
- 2.5 The strainer should have a mesh aperture size no greater than 1.0 mm.
MEASURE
- 2.6 The strainer mesh should be securely fitted to, or form part of, the strainer body.
CHECK
- 2.7 The strainer should be close fitting and permit safe, easy filling without overflowing, splashing or lifting from its seat. As a guide: it is suggested that the strainer should be recessed into the fill opening, which should be no less than 100 mm across the smallest dimension. TEST PROCEDURE 4
- 2.8 To avoid overfilling, when the strainer extends below the nominal, maximum filling level, it should incorporate a marker, which remains clearly visible as the liquid level approaches the nominal maximum level during filling. TEST

- 2.9 The tank fill opening should be sealed with a lid, which can be opened and securely closed with gloved hands without tools (see Section 2.4 re. gloves). CHECK
- 2.10 When closed, the lid should not collect spray liquid. TEST
- 2.11 Either the lid or the tank should have a ventilation valve. CHECK
- 2.12 When the sprayer is normally considered “empty”, the volume of spray liquid retained in the sprayer (tank, pump, compression chamber, hose and lance) should not exceed the specified limit. TESTPROCEDURE 9
- 2.13 When a sprayer includes an agitator device; it should move freely, should not catch on other parts of the sprayer and should be easily removed and refitted with gloved hands (see Section 2.4 re. gloves). CHECK

3. LK Module 3 - LANCE ASSEMBLY AND SPRAY HOSE

- 3.1 The hose, when bent through 180 degrees with an unsupported bend radius of 50 mm at temperatures up to 30°C, should not kink (flatten). TEST
- 3.2 Hose connections should be easily adjustable and removable with gloved hands (see Section 2.4 re gloves) and should not leak when reconnected. TEST

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 3.3 The hose should be of sufficient length to allow free movement and appropriate positioning of the lance for spraying. CHECK
- 3.4 The minimum length of the lance from the front of the hand trigger grip to the nozzle should be 500 mm. MEASURE
- 3.5 The sprayer should incorporate a robust “parking system” to secure the lance when it is not in use. CHECK
- 3.6 The lance should be fitted with a trigger-type on/off valve, which can be locked in the “off” position. CHECK
- 3.7 The length of the trigger valve lever measured from the pivot point should be no less than 100 mm. MEASURE
- 3.8 The trigger valve should require no more than 1.5 N/m torque to open. MEASURE
- 3.9 The trigger valve should be reliable. TEST PROCEDURE 5
- 3.10 The lance assembly should include a removable filter with a mesh aperture size not exceeding 0.3 mm, which is easy to install and remove with gloved hands (see Section 2.4 re. gloves). MEASURE
- 3.11 The removable filter (see Section 3.10) should be located upstream of the trigger valve. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 3.12 At the maximum recommended flow rate, the trigger valve filter should not reduce the liquid flow by more than 5%. MEASURE
- 3.13 Interchangeable but not adjustable nozzles should be supplied with the sprayer. CHECK
- 3.14 The maximum operating pressure at the nozzle should not exceed 4 bar. MEASURE
- 3.15 When a pressure indicator is included, it should be downstream of the on/off valve. CHECK

4. LK Module 4 - STRAPS AND PADDING

- 4.1 Straps and fixings should be strong and durable. TEST PROCEDURE 6
- 4.2 Straps and padding should be of non-absorbent material. TEST PROCEDURE 3
- 4.3 Straps and padding should resist undue deterioration from contact with approved pesticide formulations. The manufacturer should provide written assurance of this in the sprayer manual (see Section 1.17). CHECK
- 4.4 The sprayer should be equipped with a load-bearing waist strap. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 4.5 The load-bearing part of the shoulder straps should be a minimum of 50 mm wide. MEASURE
- 4.6 When adjustable shoulder pads are included, they should remain firmly in place in their adjusted positions when the sprayer is in use. CHECK
- 4.7 Straps should be easily adjustable when the sprayer is full and in the working position on the operator's back. TEST
- 4.8 Straps should be equipped with quick release catches, which function efficiently when the sprayer is full and in the working position on the operator's back. TEST

5. LK Module 5 - POWER SOURCE

Manual lever and pump

- 5.1 The lever to operate the pump should be a minimum of 400 mm long and should have an arc of movement not exceeding 400 mm. MEASURE
- 5.2 The lever should function for both left and right-handed use. CHECK
- 5.3 The end of the lever should be firmly and durably equipped with a handgrip with a minimum sectional dimension of 25 mm and a minimum length of 100 mm. CHECK & MEASURE

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 5.4 To achieve the maximum recommended flow rates and operating pressures, the pump should operate within the range of 20-30 lever strokes per minute. The maximum force on the handle should not exceed 85 N at a distance of 400 mm from the pivot point. MEASURE
- 5.5 At the maximum recommended flow rate, the pressure, measured immediately upstream of the nozzle, should not deviate by more than $\pm 10\%$. MEASURE

6. LK Module 6 - HYDRAULIC PRESSURE NOZZLES

It is the responsibility of the sprayer manufacturer to comply with the following requirements for nozzles supplied with or recommended for the sprayer, even though it is probable that this information will originate from the nozzle manufacturer.

- 6.1 The sprayer manufacturer should provide in the manual (see Section 1.17), information on:
- nozzle flow rates at 2, 3 and 4 bar;
 - characteristic spray patterns and spray angles at 2, 3 and 4 bar;
 - spray quality category (as a measure of the drop size distribution) expressed according to the spray categories in Table 1 of TEST PROCEDURE 10;
 - a procedure for determining when nozzles are worn to 125% of their original flow rate at their recommended operating pressure (s), and should be replaced;

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- nozzle heights and spacing to give uniform spray volume distribution at target level, when a horizontal boom with standard flat fan nozzles is recommended.

CHECK

- 6.2 The output from any single nozzle or between nozzles with the same identity code i.e. which claim to have the same characteristics, should not differ by more than $\pm 10\%$ from the nominal output at any recommended pressure. MEASURE
- 6.3 For flat fan nozzles, the nozzle support system should include a method of ensuring correct orientation of the nozzle within the holder. CHECK

MOTORISED KNAPSACK SPRAYERS (MK)

1. MK Module 1 - GENERAL REQUIREMENTS

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

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.3. To meet the FAO standard, a motorised knapsack sprayer should comply with the following requirements.
- 1.4. Total mass when filled to nominal (manufacturer's recommended) maximum capacity should not exceed 25 Kg. MEASURE
- 1.5. The sprayer should not leak. TEST PROCEDURE 1
- 1.6. The sprayer should be easy to clean thoroughly both inside and out. Rough surfaces and awkward recesses should be avoided. CHECK
- 1.7. The outer surfaces of the sprayer should not trap nor retain spray liquid. TEST PROCEDURE 2
- 1.8. There should be no sharp edges, abrasive areas or unnecessary projections, which could injure the operator. CHECK
- 1.9. The sprayer should incorporate a conveniently located handle to enable it to be safely carried when not in use. CHECK
- 1.10. The sprayer should be stable and stand upright on slopes up to 15% (1 in 7), irrespective of the amount of liquid in the tank. TEST
- 1.11. Servicing, maintenance, adjustment and cleaning of all sprayer components should be easily accomplished without needing

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

special tools (i.e. tools specifically designed for the sprayer).
CHECK

- 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.
CHECK
- 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 manual (see Section 1.20). CHECK
- 1.14. The sprayer if dropped should continue to function normally and should not leak. TEST PROCEDURE 7
- 1.15. Parts of the sprayer that come into constant direct contact with the spray liquid should be made from non-absorbent materials, which are suitable for use with approved pesticide formulations.
TEST PROCEDURE 8
- 1.16. Parts of the sprayer that are exposed routinely to direct sunlight should be made from materials which do not unduly deteriorate. The manufacturer should provide written assurance to this effect in the sprayer manual (see section 1.17). CHECK
- 1.17. All pressure and flow control devices should be adjustable from outside the spray tank. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.18. A safety device should be incorporated into the sprayer to prevent the maximum pressure exceeding 5 bar in any part of the sprayer. Vented liquid should be discharged inside the tank. TEST
- 1.19. The sprayer should be reliable and durable in use. TEST
PROCEDURE 12
- 1.20. The manufacturer should provide with the sprayer a clear, simple, illustrated manual in the language of the country of manufacture and in English, French or Spanish. CHECK
- 1.21. The manual should contain 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;
 - safe release of residual pressure in the lance when a spray management valve is used.

CHECK

It should also provide information on:

- safe handling of undiluted agrochemicals, mixing chemicals and filling the tank;
- disposal of leftover spray liquid and empty pesticide containers;
- nozzle flow rate and spray quality (see Section 6.1);

- maximum nozzle size and operating pressure to be used in the sprayer;
- precautions to minimise the risk of operator and environmental contamination.
- CHECK

2. MK Module 2 - TANK, STRAINER AND LID

2.1 The tank should be clearly and durably marked with:

- the nominal maximum filling level, which should be equivalent to no more than 95% of the total volume of the tank;
- appropriate intermediate filling levels. MEASURE

2.2 During filling, the level of liquid in the tank should be clearly visible as it approaches the nominal maximum level. TEST

2.3 The tank should include a strainer, located in the fill opening, to filter the water or spray solution as it enters the tank. CHECK

2.4 The strainer should be easy to remove and fit with gloved hands (for test purposes, gloves should have a minimum thickness of 0.5 mm). CHECK

2.5 The strainer should have a mesh aperture size no greater than 1.0 mm. MEASURE

- 2.6 The strainer mesh should be securely fitted to, or form part of, the strainer body. CHECK
- 2.7 The strainer should be close fitting and permit safe, easy filling without overflowing, splashing or lifting from its seat. As a guide: it is suggested that the strainer should be recessed into the fill opening, which should be no less than 100 mm across the smallest dimension. TEST PROCEDURE 4
- 2.8 To avoid overfilling, when the strainer extends below the nominal, maximum filling level, it should incorporate a marker, which remains clearly visible as the liquid level approaches the nominal maximum level during filling . TEST
- 2.9 The tank fill opening should be sealed with a lid, which can be securely closed with gloved hands without tools (see Section 2.4 re. gloves). CHECK
- 2.10 When closed, the lid should not collect spray liquid. TEST
- 2.11 Either the lid or the tank should have a ventilation valve. CHECK
- 2.12 When the sprayer is normally considered “empty”, the volume of spray liquid retained in the sprayer (tank, pump, hose and lance) should not exceed the specified limit. TEST PROCEDURE 9

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

3. MK Module 3 - LANCE ASSEMBLY AND SPRAY HOSE

- 3.1 The hose, when bent through 180 degrees, with an unsupported bend radius of 50 mm at temperatures up to 30°C, should not kink (flatten). TEST
- 3.2 Hose connections should be easily adjustable and removable with gloved hands (see Section 2.4 re. gloves) and should not leak when reconnected. TEST
- 3.3 The hose should be of sufficient length to allow free movement and appropriate positioning of the lance for spraying. CHECK
- 3.4 The minimum length of the lance from the front of the hand trigger grip to the nozzle should be 500 mm. MEASURE
- 3.5 The sprayer should incorporate a robust “parking system” to secure the lance when it is not in use. CHECK
- 3.6 The lance should be fitted with a trigger-type on/off valve, which can be locked in the “off” position. CHECK
- 3.7 The length of the trigger valve lever measured from the pivot point should be no less than 100 mm. MEASURE

- 3.8 The trigger valve should require no more than 1.5 N/m torque to open. MEASURE
- 3.9 The trigger valve should be reliable. TEST PROCEDURE 5
- 3.10 The lance assembly should include a removable filter with a mesh aperture size not exceeding 0.3 mm, which is easy to install and remove with gloved hands (see Section 2.4 re gloves). MEASURE
- 3.11 The removable filter (see Section 3.10) should be located upstream of the trigger valve. CHECK
- 3.12 At the maximum recommended flow rate, the trigger valve filter should not reduce the liquid flow by more than 5%. MEASURE
- 3.13 Interchangeable but not adjustable nozzles should be supplied with the sprayer. CHECK
- 3.14 The maximum operating pressure at the nozzle should not exceed 4 bar. MEASURE
- 3.15 Where a pressure indicator is included, it should be downstream of the on/off valve. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

4. MK Module 4 - STRAPS AND PADDING

- 4.1 Straps and fixings should be strong and durable. TEST PROCEDURE 6
- 4.2 Straps and padding should be of non-absorbent material. TEST PROCEDURE 3
- 4.3 Straps and padding should resist undue deterioration from contact with approved pesticide formulations. The manufacturer should provide written assurance of this in the sprayer manual (see Section 1.17). CHECK
- 4.4 The load bearing part of the shoulder straps should be a minimum of 50 mm wide. MEASURE
- 4.5 When adjustable shoulder pads are included, they should remain firmly in place in their adjusted position when the sprayer is in use. CHECK
- 4.6 Straps should be easily adjustable when the sprayer is full and in the working position on the operator's back. TEST
- 4.7 Straps should be equipped with quick release catches, which function efficiently when the sprayer is full and in the working position on the operator's back. TEST

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

5. MK Module 5 - POWER SOURCE

Engine

- 5.1 The throttle lever must remain firmly fixed in any pre-set position during operation. TEST
- 5.2 The engine should have an instant “cut-out” mechanism, which is readily accessible to the operator when the sprayer is in the working position on his/her back. CHECK
- 5.3 The engine should have a safe, robust starting mechanism. TEST
PROCEDURE 15
- 5.4 The exhaust should be:
- directed away from the operator’s body;
 - positioned on the opposite side of the sprayer to the controls
 - robustly shielded to prevent burning the operator, an assistant or a third party.
- CHECK
- 5.5 The engine should be isolated from the carrying frame by anti-vibration mountings. CHECK
- 5.6 The engine should be robustly protected against accidental physical damage. CHECK

- 5.7 The fuel tank and the fuel on/off valve should be positioned to minimise the risk of fuel spilling onto the engine. CHECK
- 5.8 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 on his/her back. CHECK
- 5.9 An easily serviceable fuel filter should be located in the line between the tank and the carburettor. CHECK
- 5.10 An easily replaceable air filter should be located directly on the carburettor intake. CHECK
- 5.11 Carburettor adjusting screws should be readily accessible without needing to remove parts or use special tools (i.e. tools specifically designed for the sprayer). CHECK
- 5.12 The noise level at the ear of the operator should not exceed 85 dB. MEASURE
- 5.13 The fuel tank should have sufficient capacity for a minimum of one hour of continuous operation. TEST
- 5.14 Where a two-stroke engine is present, the fuel tank should be durably marked with the required fuel/oil ratio. CHECK
- 5.15 Moving parts should be well shielded to prevent injury. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

Pump

- 5.16 The pump should have the capacity to supply the maximum recommended number of nozzles, at a flow rate equivalent to 25% above the highest recommended rate. MEASURE
- 5.17 The drive between the engine and the pump should be well shielded to prevent injury. CHECK

6. MK Module 6 - HYDRAULIC NOZZLES

It is the responsibility of the sprayer manufacturer to comply with the following requirements for nozzles supplied with or recommended for the sprayer, even though it is probable that this information will originate from the nozzle manufacturer.

- 6.1 The sprayer manufacturer should provide in the instruction manual (see Section 1.17), information on:
- nozzle flow rates at 2, 3 and 4 bar;
 - characteristic spray patterns and spray angles at 2, 3 and 4 bar;
 - spray quality category (as a measure of the drop size distribution) expressed according to the spray categories in Table 1 of TEST PROCEDURE 10;
 - a procedure for determining when nozzles are worn to 125% of their original flow rate at their recommended operating pressure(s), and should be replaced;
 - nozzle heights and spacing to give uniform spray volume distribution at target level, when a horizontal boom with standard flat fan nozzles is recommended.

CHECK

- 6.2 The output from any single nozzle or between nozzles with the same identity code i.e. which claim to have the same characteristics, should not differ by more than $\pm 10\%$ from the nominal output at any recommended pressure. MEASURE
- 6.3 For flat fan nozzles, the nozzle support system should include a method of ensuring correct orientation of the nozzle within the holder. CHECK

COMPRESSION SPRAYERS (CS)

1. CS Module 1 - GENERAL REQUIREMENTS

Portable compression 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 during field use, thereby adversely affecting safety and lowering efficiency due to corrosion, rust, distortion or premature wear.

To meet the FAO standard, a compression sprayer should comply with the following requirements.

- 1.1 For back-carried sprayers, the total mass when filled to nominal (manufacturer's recommended) maximum capacity should not exceed 25 Kg. For hand-carried sprayers, the total mass when filled to nominal capacity should not exceed 10 Kg. MEASURE
- 1.2 The sprayer should not leak. TEST PROCEDURE 1

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.3 The sprayer should be easy to clean thoroughly both inside and out. Rough surfaces and awkward recesses should be avoided. CHECK
- 1.4 The outer surfaces of the sprayer should not trap nor retain spray liquid.
TESTPROCEDURE 2
- 1.5 There should be no sharp edges, abrasive areas or unnecessary projections, which could injure the operator. CHECK
- 1.6 The sprayer should incorporate a conveniently located handle to enable it to be safely carried when not in use. CHECK
- 1.7 The sprayer should be stable and stand upright on slopes up to 15% (1 in 7), irrespective of the amount of liquid in the tank. TEST
- 1.8 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). CHECK
- 1.9 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. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.10 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 manual (see Section 1.15). CHECK
- 1.11 The sprayer if dropped should continue to function normally and should not leak. TEST PROCEDURE 7
- 1.12 Parts of the sprayer that come into constant direct contact with the spray liquid should be made from non-absorbent materials, which are suitable for use with approved pesticide formulations. TEST PROCEDURE 8
- 1.13 The manufacturer should provide written assurance in the sprayer manual (see section 1.15) that parts of the sprayer that are exposed routinely to direct sunlight should be made from materials which do not unduly deteriorate. CHECK
- 1.14 The sprayer should withstand 10,000 pressure cycles. TEST PROCEDURE 13
- 1.15 The manufacturer should provide with the sprayer a clear, simple, illustrated instruction manual in the language of the country of manufacture and in English, French or Spanish. CHECK
- 1.16 The manual should contain procedures for:
- initial assembly;
 - identification of all replacement parts including an “exploded “ diagram;
 - setting and calibration;

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- filling the sprayer;
- minimising the need to dispose of dilute pesticide;
- cleaning and safe disposal of any washings;
- routine maintenance and storage;
- safe, accurate field use;
- safe release of residual pressure in the lance when a spray management valve is used.

CHECK

It should also provide information on:

- safe handling of undiluted agrochemicals, mixing chemicals and filling the tank;
- the disposal of leftover spray liquid and empty pesticide containers;
- nozzle flow rate and spray quality (see Section 6.1);
- the maximum nozzle size and operating pressure to be used in the sprayer;
- precautions to minimise the risk of operator and environmental contamination;
- precautions when using external pressure sources.

CHECK

2. CS Module 2 - TANK, STRAINER AND LID

2.1 The tank should have a minimum capacity of 5 litres. MEASURE

2.2 The tank should be clearly and durably marked to show the nominal (manufacturer's recommended) maximum filling level, which should be equivalent to no more than 75% of the total volume of the tank.
MEASURE

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 2.3 When, during filling the spray liquid level in the tank is not clearly visible:
- a pre-measured volume of spray liquid equivalent to the nominal volume should be used to fill the tank; MEASURE
 - the nominal volume should be clearly displayed in litres on the tank and in the sprayer manual (see Section 1.15). CHECK
- 2.4 A funnel, with an integral strainer should be supplied with the sprayer, to filter the water or spray solution as it enters the tank. CHECK
- 2.5 The funnel strainer should have a mesh aperture size no greater than 1.0 mm. MEASURE
- 2.6 The funnel strainer mesh should be securely fitted to, or form part of, the funnel body. CHECK
- 2.7 The funnel should permit safe, easy filling, without overflowing or splashing. TEST PROCEDURE 4
- 2.8 The tank fill opening should be sealed with a tank lid, which can be opened and securely closed with gloved hands without tools (for test purposes gloves should be a minimum thickness of 0.5 mm). CHECK
- 2.9 The tank should be fitted with a pressure-indicating device. CHECK

- 2.10 The tank should be fitted with a pressure relief /safety valve to prevent the pressure in the tank from exceeding 6 bar. TEST
- 2.11 The tank should be fitted with a pressure release valve, which is easily operated with gloved hands (see Section 2.8 re. gloves). TEST
- 2.12 After spraying, it should not be possible to remove the lid (or pump) before the residual pressure in the tank has been released. TEST
- 2.13 Threaded fittings to the pressurised parts of the tank with a diameter greater than 13 mm, should include a channel to ensure that the pressure in the tank is released before the lid (or pump) can be removed. CHECK
- 2.14 When the sprayer is normally considered “empty”, the volume of spray liquid retained in the sprayer (tank, pump, compression chamber, hose and lance) should not exceed the specified limit. TEST PROCEDURE 9
- 2.15 When the pump is solely hand operated and there is no possibility of pressurising from an outside source, the tank should withstand twice the maximum working pressure (8 bar) without deforming or leaking. TEST PROCEDURE 11

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 2.16 When the sprayer is fitted with a connection to allow it to be pressurised from an outside source, the tank should withstand five times the maximum working pressure (20 bar) without deforming or leaking. TEST PROCEDURE 11

3. CS Module 3 - LANCE ASSEMBLY AND SPRAY HOSE

- 3.1 The hose, when bent through 180 degrees with an unsupported bend radius of 50 mm at temperatures up to 30°C, should not kink (flatten). TEST
- 3.2 Hose connections should be easily adjustable and removable with gloved hands (see Section 2.8 re. gloves) and when removed should not leak when reconnected. TEST
- 3.3 The hose should be of sufficient length to allow free movement and appropriate positioning of the lance for spraying. CHECK
- 3.4 The minimum length of the lance from the front of the hand trigger grip to the nozzle should be 500 mm. MEASURE
- 3.5 The sprayer should incorporate a robust “parking system” to secure the lance when it is not in use. CHECK
- 3.6 The lance should be fitted with a trigger-type on/off valve, which can be locked in the “off” position. CHECK

- 3.7 The length of the trigger valve lever measured from the pivot point should be no less than 100 mm long. MEASURE
- 3.8 The trigger valve should require no more than 1.5 N/m torque to open. MEASURE
- 3.9 The trigger valve should be reliable. TEST PROCEDURE 5
- 3.10 The lance assembly should include a removable filter with a mesh aperture size not exceeding 0.3 mm, which is easy to install and remove with gloved hands (see Section 2.8 re. gloves). CHECK & MEASURE
- 3.11 The removable filter (see Section 3.10) should be located upstream of the trigger valve. CHECK
- 3.12 At the maximum recommended flow rate, the trigger valve filter should not reduce the liquid flow by more than 5%. MEASURE
- 3.13 Interchangeable but not adjustable nozzles should be supplied with the sprayer. CHECK
- 3.14 The maximum operating pressure at the nozzle should not exceed 4 bar. MEASURE
- 3.15 When a pressure indicator is included, it should be downstream of the on/off valve. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

4. CS Module 4 - STRAPS AND PADDING

- 4.1 Straps and fixings should be strong and durable. TEST PROCEDURE 6
- 4.2 Straps and padding should be of non-absorbent material. TEST PROCEDURE 3
- 4.3 Straps and padding should resist undue deterioration from contact with approved pesticide formulations. The manufacturer should provide written assurance of this in the sprayer manual.(see Section 1.15) CHECK
- 4.4 The load-bearing part of the shoulder straps should be a minimum of 50 mm wide. MEASURE
- 4.5 When adjustable shoulder pads are included, they should remain firmly in place in their adjusted position when the sprayer is in use. CHECK
- 4.6 Straps should be easily adjustable when the sprayer is full and in the working position on the operator's back. TEST
- 4.7 Straps should be equipped with quick-release catches, which function efficiently when the sprayer is full and in the working position on the operator's back. TEST

5. CS Module 5 - POWER SOURCE

Manual plunger and pump

- 5.1 When the pump is manual, it should produce a pressure of 4 bar in the spray tank on completion of not more than 60 complete plunger strokes with the tank filled to nominal capacity. MEASURE
- 5.2 Where the pump is located inside the spray tank, it should meet the following requirements:
- when the spray tank is pressurised to 4 bar and the pump outlet valve is fully submerged in the spray liquid; over a 15-minute period, the check valve in the pump should not permit liquid to leak into the pump cylinder; TEST
 - the pump handle should be comfortable and convenient to use; TEST
 - the internal length of the handle grip should be no less than 100 mm with a minimum section dimension of 25 mm. MEASURE
 - The sprayer should be fitted with a device, which locks the plunger assembly in the lowest operating position so that the sprayer can be safely carried using the pump handle. CHECK

6. CS Module 6 - HYDRAULIC NOZZLES

It is the responsibility of the sprayer manufacturer to comply with the following requirements for nozzles supplied with or recommended for the sprayer, even though it is probable that this information will originate from the nozzle manufacturer.

- 6.1 The sprayer manufacturer should provide in the instruction manual (see Section 1.15), information on:
- nozzle flow rates at 2, 3 and 4 bar;
 - characteristic spray patterns and spray angles at 2, 3 and 4 bar;
 - spray quality category (as a measure of the drop size distribution) expressed in accordance with the spray categories in Table 1 of TEST PROCEDURE 10;
 - a procedure for determining when nozzles are worn to 125% of their original flow rate at their recommended operating pressure(s), and should therefore be replaced;
 - nozzle heights and spacing to give a uniform spray volume distribution at target level, when a horizontal boom with standard flat fan nozzles is recommended.

CHECK

- 6.2 The output from any single nozzle or between nozzles with the same identity code i.e. which claim to have the same characteristics, should not differ by more than $\pm 10\%$ from the nominal output at any recommended pressure. MEASURE

- 6.3 For flat fan nozzles, the nozzle support system should include a method of ensuring correct orientation of the nozzle within the holder. CHECK

MOTORISED MISTBLOWERS (MB)

1. MB Module 1 - GENERAL REQUIREMENTS

Motorised mistblowers 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 during field use, thereby adversely affecting safety and lowering efficiency due to corrosion, rust, distortion or premature wear.

To meet the FAO standard, a motorised mistblower (the sprayer), should comply with the following requirements.

- 1.1 Total mass when filled to nominal (manufacturer's recommended maximum) capacity should not exceed 25 Kg. **MEASURE**
- 1.2 The sprayer should not leak. **TEST PROCEDURE 1**
- 1.3 The sprayer should be easy to clean thoroughly both inside and out. Rough surfaces and awkward recesses should be avoided. **CHECK**
- 1.4 The outer surfaces of the sprayer should not trap nor retain spray liquid. **TEST PROCEDURE 2**
- 1.5 There should be no sharp edges, abrasive areas or unnecessary projections, which could injure the operator. **CHECK**

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.6 The sprayer should incorporate a conveniently located handle to enable it to be carried safely when not in use.
- 1.7 The sprayer should be stable and stand upright on slopes up to 15% (1 in 7), irrespective of the amount of liquid in the tank. TEST
- 1.8 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). CHECK
- 1.9 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. CHECK
- 1.10 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 manual (see Section 1.15). CHECK
- 1.11 The sprayer if dropped should continue to function normally and should not leak. TEST PROCEDURE 7
- 1.12 Parts of the sprayer that come into constant direct contact with the spray liquid should be made from non-absorbent materials, which are suitable for use with approved pesticide formulations. TEST PROCEDURE 8

- 1.13 Parts of the sprayer that are exposed routinely to direct sunlight should be made from materials which do not unduly deteriorate. The manufacturer should provide written assurance of this in the sprayer manual (see Section 1.15). CHECK
- 1.14 The sprayer should be reliable and durable in use. TEST PROCEDURE 12
- 1.15 The manufacturer should provide with the sprayer a clear, simple, illustrated manual in the language of the country of manufacture and in English, French or Spanish. CHECK
- 1.16 The manual should contain procedures for:
- initial assembly;
 - identification of all the replacement parts including an “exploded” diagram;
 - setting and calibration;
 - minimizing the need to dispose of dilute pesticide;
 - cleaning and safe disposal of washings;
 - routine maintenance and storage;
 - accurate field use.

CHECK

It should also provide information on:

- safe handling of undiluted agrochemicals, mixing chemicals and filling the tank;
- disposal of leftover spray liquid and empty pesticide containers;
- maximum restrictor size, and operating pressure (where a pump is fitted);

- precautions to minimize the risk of operator and environmental contamination.

CHECK

2. MB Module 2 - SPRAY TANK, STRAINER AND LID

2.1 The tank should be clearly and durably marked with:

- the nominal maximum filling level, which should be equivalent to no more than 95% of the total volume of the tank:
- appropriate intermediate filling levels.

MEASURE

2.2 During filling, the level of liquid in the tank should be clearly visible as it approaches the nominal maximum level. TEST

2.3 The tank should include a strainer, located in the fill opening, to filter the water or spray solution as it enters the tank. CHECK

2.4 The strainer should be easy to remove and fit with gloved hands (for test purposes, gloves should have a minimum thickness of 0.5 mm). CHECK

2.5 The strainer should have a mesh aperture size no larger than the smallest restrictor orifice size recommended by the manufacturer. MEASURE

- 2.6 The strainer mesh should be securely fitted to, or form part of, the strainer body. CHECK
- 2.7 The strainer should be close fitting and permit safe, easy filling without overflowing, splashing or lifting from its seat. As a guide: it is suggested that the strainer should be recessed into the fill opening, which should be no less than 100 mm across the smallest dimension. TEST PROCEDURE 4
- 2.8 To avoid overfilling, when the strainer extends below the nominal, maximum filling level, it should incorporate a marker, which remains clearly visible as the liquid level approaches the nominal maximum level during filling. TEST
- 2.9 The tank fill opening should be sealed with a lid, which can be opened and securely closed with gloved hands without tools (see section 2.4 re. gloves). CHECK
- 2.10 When closed, the lid should not collect spray liquid. TEST
- 2.11 When the sprayer is not fitted with a pump, the spray tank must be pressurised to enable spray liquid to flow to the nozzle and the lid must make a complete, effective seal with the tank. CHECK.
- 2.12 The pressure in the tank and the delivery hose should not exceed 0.5 bar. MEASURE

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 2.13 When the sprayer incorporates a pump, either the tank lid or the tank should have a ventilator valve. CHECK
- 2.14 When the sprayer is normally considered “empty”, the volume of spray liquid retained in the sprayer (tank, pump and hose) should not exceed the specified limit. TEST PROCEDURE 9

3. MB Module 3 - AIR TUBE ASSEMBLY AND SPRAY HOSE

The air tube assembly is defined as, the whole air tube from the elbow of the fan casing to the air outlet.

- 3.1 The length of the tube from the on/off valve lever, to the air outlet should be no less than 400 mm. MEASURE
- 3.2 The air tube should be fitted with a handle. CHECK
- 3.3 The air tube should be connected to the fan casing elbow by a length of large diameter flexible tube of a non-absorbent material to allow easy movement in horizontal and vertical planes. CHECK.
- 3.4 The mechanisms used to connect the flexible tube to the rigid air tube and to the fan casing, should be re-usable and easily adjusted with gloved hands (see Section 2.4 re. gloves). CHECK

- 3.5 The sprayer should incorporate a robust “parking system” to firmly secure the rigid air tube assembly in a near-vertical position when the sprayer is not in use. CHECK
- 3.6 Hose connections should be easily adjustable and removable with gloved hands (see Section 2.4 re gloves), and should not leak when reconnected. TEST
- 3.7 The liquid hose, when bent through 180 degrees with an unsupported bend radius of 50 mm at temperatures up to 30°C, should not kink (flatten). TEST
- 3.8 The liquid supply line to the nozzle should incorporate an on/off valve. CHECK
- 3.9 When the on/off valve incorporates a lever, this should be no less than 100 mm long, measured from the pivot point. MEASURE
- 3.10 The on/off valve should require no more than 1.5 N/m torque to open. MEASURE.
- 3.11 To control the rate of flow of spray liquid the sprayer should be equipped with colour-coded, interchangeable restrictors. CHECK
- 3.12 Flow rates for restrictors with the same identity code and colour (i.e. which claim to have the same characteristics), should not differ by more than $\pm 10\%$ from the nominal flow rate. MEASURE

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 3.13 The sprayer should meet the minimum spraying performance requirement. TEST PROCEDURE 14.

4. MB Module 4 - STRAPS AND PADDING

- 4.1 Straps and fixings should be strong and durable. TEST PROCEDURE 6
- 4.2 Straps and padding should be of non-absorbent material. TEST PROCEDURE 3
- 4.3 Straps and padding should resist undue deterioration from contact with approved pesticide formulations. The manufacturer should provide written assurance of this in the sprayer manual (see Section 1.15). CHECK
- 4.4 The load-bearing parts of the shoulder straps should be a minimum of 50 mm wide. MEASURE
- 4.5 When adjustable shoulder pads are included, they should remain firmly in place in their adjusted position when the sprayer is in use. CHECK
- 4.6 Straps should be easily adjustable when the sprayer is full and in the working position on the operator's back. TEST

- 4.7 Straps should be equipped with quick release catches, which function efficiently when the sprayer is full and in the working position on the operator's back. TEST

5. MB Module 5 - POWER SOURCE

Engine

- 5.1 The throttle lever must remain firmly fixed in any pre-set position during operation. TEST
- 5.2 The engine should have an instant "cut out" mechanism, which is readily accessible to the operator when the sprayer is in the working position on his/her back. CHECK
- 5.3 The engine should have a safe, robust starting mechanism. TEST
PROCEDURE 15
- 5.4 The exhaust should be:
- directed away from the operator's body;
 - positioned on the opposite side of the sprayer to the controls;
 - robustly shielded to prevent burning the operator, an assistant or a third party.
- CHECK
- 5.5 The engine should be isolated from the carrying frame by anti-vibration mountings. CHECK

- 5.6 The engine should be robustly protected against accidental physical damage.
CHECK
- 5.7 The fuel tank and the fuel on/off valve should be positioned to minimise the risk of fuel spilling onto the engine. CHECK
- 5.8 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 on his/her back. CHECK
- 5.9 An easily serviceable fuel filter should be located in the line between the tank and the carburettor. CHECK
- 5.10 An easily replaceable air filter should be located directly on the carburettor intake. CHECK
- 5.11 Carburettor adjusting screws should be readily accessible without needing to remove parts or use special tools (i.e. tools specifically designed for the sprayer). CHECK
- 5.12 The noise level at the ear of the operator should not exceed 85 dB.
MEASURE
- 5.13 The fuel tank should have sufficient capacity for a minimum of one hour of continuous operation. TEST

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 5.14 Where a two-stroke engine is present, the fuel tank should be durably marked with the required fuel/oil ratio. CHECK
- 5.15 Moving parts should be well shielded to prevent injury. CHECK

Fan

- 5.16 The fan should be protected by a casing measuring no more than 45 cm. in diameter. MEASURE
- 5.17 The inlet to the fan should be equipped with a guard with a minimum mesh- aperture size of 5 mm and a maximum size of 10 mm. MEASURE

Pump

- 5.18 When a pump forms part of the sprayer, it should be capable of delivering the manufacturer's maximum recommended flow rate to the largest recommended restrictor with the rigid air-tube held vertically and fitted with a 1-metre extension. TEST

6. MB Module 6 - SHEAR NOZZLES

- 6.1 When mistblowers are fitted with shear nozzles, the sprayer manufacturer should include in the sprayer manual (see Section 1.15) information on the recommended range of flow rates for different crop targets. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

ROTARY ATOMIZER SPRAYERS (RA)

For the purposes of this Guideline, a portable rotary atomizer sprayer consists of a spinning atomizer onto which flows spray liquid, to produce spray droplets. The rotational speed of the atomizer and the liquid flow, control the drop size.

Rotary atomizer sprayers are usually driven by a small electric motor powered by a series of dry cells (torch batteries) or by rechargeable batteries carried either within the carrying handle, on the operator's belt, or on a strap slung over the operator's shoulder.

Spray liquid flows onto the atomizer by gravity from a small bottle mounted on the spray head, and /or from a backpack or shoulder-slung tank.

1. RA Module 1 - GENERAL REQUIREMENTS

Rotary atomizer 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 during field use, thereby adversely affecting safety and lowering efficiency due to corrosion, rust, distortion or premature wear.

To meet the FAO standard, a rotary atomizer sprayer should comply with the following requirements.

- 1.1 Total mass when filled to nominal (manufacturer's recommended maximum) capacity should not exceed 25 kg MEASURE.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

The following are acceptable guidelines for division of the total mass.

- 20 kg maximum for a backpack (or shoulder-slung) tank and battery power source carried on a waist belt, or on a shoulder strap.
- 7 kg for a lance / battery case, spray head, spray bottle and a tank (where this is hand-carried).

- 1.2 The sprayer should not leak. TEST PROCEDURE 1
- 1.3 The sprayer should be easy to clean thoroughly both inside and out. Rough surfaces and awkward recesses should be avoided. CHECK
- 1.4 The outer surfaces of the sprayer should not trap nor retain spray liquid. TEST PROCEDURE 2
- 1.5 There should be no sharp edges, abrasive areas or unnecessary projections, which could injure the operator. CHECK
- 1.6 The sprayer should be easy to carry safely when not in use. CHECK
- 1.7 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). CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.8 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. CHECK
- 1.9 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 manual (see Section 1.14). CHECK
- 1.10 Parts of the sprayer that are routinely exposed to direct sunlight should be made from materials, which do not unduly deteriorate. The manufacturer should provide written assurance of this in the sprayer manual (see Section 1.14). CHECK
- 1.11 The sprayer if dropped should continue to function normally and should not leak. TEST PROCEDURE 7
- 1.12 Parts of the sprayer that come into constant direct contact with the spray liquid should be made from non-absorbent materials, which are suitable for use with approved pesticide formulations. TEST PROCEDURE 8
- 1.13 The sprayer should be reliable and durable in use. TEST PROCEDURE 12

1.14 The manufacturer should provide with the sprayer a clear, simple, illustrated manual in the language of the country of manufacture and in English, French or Spanish. CHECK

1.15 The manual should contain 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;
- safe field use including lane separation.

CHECK

It should also provide information on:

- safe handling of undiluted agrochemicals, mixing chemicals 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;
- batteries recommended and their installation;
- a system for determining when batteries should be replaced.

CHECK

2. RA Module 2 - TANK, STRAINER AND LID

In this module, the tank refers to any container used to contain the spray liquid to be applied through a rotary atomizer, which is hand-held, carried on straps on the operator's back or slung on a strap over a shoulder.

- 2.1 The tank should be clearly and durably marked with:
- the nominal (manufacturer's recommended) maximum filling level, which should be equivalent to no more than 95% of the total volume of the tank;
 - appropriate intermediate filling levels.
- MEASURE
- 2.2 During filling, the level of liquid in the tank should be clearly visible as it approaches the nominal maximum level. TEST
- 2.3 The tank should include a strainer, located in the fill opening, to filter the water or spray solution as it enters the tank. CHECK
- 2.4 The strainer should be easy to remove and replace with gloved hands (for test purposes gloves should be a minimum thickness of 0.5 mm). CHECK
- 2.5 The strainer should have a mesh aperture size no greater than the smallest restrictor orifice recommended by the manufacturer. MEASURE

- 2.6 The strainer mesh should be securely fitted to, or form part of, the strainer body. CHECK
- 2.7 The strainer should be close fitting and permit safe, easy filling without overflowing, splashing or lifting from its seat. As a guide: it is suggested that the strainer should be recessed into the fill opening, which should be no less than 100 mm across the smallest dimension. TEST PROCEDURE 4
- 2.8 To avoid overfilling, when the strainer extends below the nominal (manufacturer's recommended) maximum filling level, it should incorporate a marker, which remains clearly visible as the liquid level approaches the nominal maximum during filling. TEST
- 2.9 The tank fill opening should be sealed with a lid, which can be opened and securely closed with gloved hands without tools (see Section 2.4 re. gloves). CHECK
- 2.10 When closed, the lid should not collect spray liquid. TEST
- 2.11 Either the lid or the tank should have a ventilation valve. CHECK
- 2.12 When the sprayer is normally considered "empty", the volume of spray liquid retained in the sprayer (tank and hose) should not exceed the specified limit. TEST PROCEDURE 9
- 2.13 The tank, liquid-supply hose and associated connections should not leak. TEST PROCEDURE 1

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 2.14 Hose connections should be easily adjustable and removable with gloved hands (see 2.4 re gloves) and should not leak when reconnected. TEST
- 2.15 The tank should be stable and stand upright on slopes up to 15% (1 in 7), irrespective of the amount of liquid in the tank. TEST
- 2.16 The tank if dropped should continue to function normally and should not leak. TEST PROCEDURE 7
- 2.17 The hose when bent through 180 degrees with an unsupported bend radius of 50 mm at temperatures up to 30°C, should not kink (flatten). TEST
- 2.18 The hose should be of sufficient length to allow free movement and appropriate positioning of the atomizer for spraying. CHECK
- 2.19 The hose should be fitted with a shut-off valve. CHECK
- 2.20 The shut-off valve should require no more than 1.5 N/m torque to open. MEASURE

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

3. RA Module 3 - SPRAYER ASSEMBLY (spray-head, bottle and handle)

- 3.1 In all recommended working positions, the spray head should be a distance from all parts of the operator's body, which minimises the risk of direct contamination of the operator from the spray droplets. CHECK
- 3.2 To control the rate of flow of the spray liquid to the nozzles, the sprayer should be supplied with colour-coded, interchangeable restrictors, which can be changed without special tools (i.e. tools specifically designed for the sprayer). CHECK
- 3.3 A shield should be supplied with the sprayer to protect the atomizer from physical damage when it is not in use. CHECK
- 3.4 When the spray liquid to the atomizer is supplied solely from the bottle on the spray head (i.e. which is not re-filled from a spray tank), a funnel should be provided with the sprayer to enable the bottle to be filled easily and without spilling or splashing. TEST PROCEDURE4

4. RA Module 4 - STRAPS AND PADDING

- 4.1 Straps and fixings should be strong and durable. TEST PROCEDURE6

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 4.2 Straps and padding should be of non-absorbent material. TEST PROCEDURE 3
- 4.3 Straps and padding should resist undue deterioration from contact with approved pesticide formulations. The manufacturer should provide written assurance of this in the sprayer manual (see Section 1.14). CHECK
- 4.4 The load-bearing part of shoulder straps fitted to a backpack or shoulder-slung tank should be:
- a minimum of 30 mm. wide for a tank of less than 10 litres;
 - a minimum of 50 mm. wide for a tank of over 10 litres.
- MEASURE
- 4.5 When adjustable shoulder pads are included, they should remain firmly in place in their adjusted position when the sprayer is in use. CHECK
- 4.6 Straps should be easily adjustable when the tank is full and in the working position on the operator's back. TEST
- 4.7 Straps for back-carried tanks should be equipped with quick-release catches, which function efficiently when the tank is full and in the working position on the operator's back. TEST

5. RA Module 5 - POWER SOURCE

Battery powered sprayers

The majority of rotary atomizer sprayers use either dry cell or equivalent batteries.

Sprayers powered in other ways, are not fully covered by this module.

- 5.1 The electric motor and electrical connections should be of a suitable rating for the intended use. CHECK
- 5.2 The electric motor and electrical connections should be protected from corrosion due to moisture ingress. CHECK
- 5.3 The electric motor and electrical connections should be able to be replaced and repaired without the need for special tools (i.e. tools specifically designed for the sprayer). CHECK
- 5.4 When small batteries are used, e.g. D size dry batteries / R20 batteries, the power consumption of the atomizer motor should not exceed 3 watts. TEST
- 5.5 The manufacturer should provide clear simple instructions in the manual (see Section 1.14) for connecting the motor to the battery power source and for inserting batteries. CHECK
- 5.6 Instructions on how to insert the batteries should be durably marked on the sprayer. CHECK

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

5.7 The power on/off switch should be located so that the operator can easily switch off the sprayer when it is in the working position. CHECK

5.8 The power on/off switch should be positive and should be capable of 500 complete on/off actions without any deterioration in function. TEST

6. RA Module 6 - ROTARY ATOMIZERS

6.1 The sprayer manufacturer should provide in the instruction manual (see Section 1.14) information on:

- flow rates (measured with water);

- characteristic drop sizes produced at nominal (manufacturer's recommended) restrictor flow rates and atomizer speeds;
- a method to check the atomizer to determine when it should be replaced.

CHECK

6.2 Output from any restrictor or between restrictors with the same identity code i.e. which claim to have the same characteristics, should not differ by more than $\pm 10\%$ from the nominal output.

MEASURE

PORTABLE (OPERATOR-CARRIED) SPRAYERS: TEST PROCEDURES

TEST PROCEDURES

The test procedures associated with these standards concern safety, principally in relation to the operator but also to the environment. Unlike other items of farm equipment, the principle hazard associated with the use of agricultural pesticide sprayers is the effect of the pesticides, which are applied through the equipment. In many parts of the developing world, faulty and unsafe application equipment, increase pesticide hazard.

Several of the following procedures address the reliability and durability of the sprayer and in some cases the implications for operator safety may not be immediately obvious. For example, test procedure 14 describes the requirement for mistblower performance. When droplets are not propelled far enough away from the spray outlet of the equipment, there is a danger that the droplet cloud will contaminate the operator. Test procedure 15

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

verifies the reliability of starter mechanisms on engine-driven equipment. This is included because field surveys show that due to breakdown these mechanisms are often removed; resulting in the exposure of rapidly moving engine-driven parts creating a hazard.

Testing sequence

Depending on the purpose of the testing, the order in which the tests are conducted may differ. One approach is to begin with Test procedure 1, the leakage test. In this case should the sprayer fail to comply even when it is new, then the other tests need not be conducted and this can save time and expense. An alternative approach is to carry out the durability-related tests first, treating them as a series of “pre-condition tests”, before embarking on the more critical leakage tests.

It is important to note, however, that to fully comply with the standard, a sprayer must meet all the requirements in the numbered Sections and associated tests for each of the modules.

Test conditions

Unless otherwise stated in a specific test procedure, the tests should be conducted at a temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and at a relative humidity of $60\% \pm 5\%$. All test reports should record the actual temperature and humidity during a test.

1. Test procedure 1 - LEAKAGE

For LK, MK, CS, MB

- 1.1 For MK, empty the fuel tank and seal watertight, the fuel fill hole, carburettor inlet and exhaust outlet.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.2 For all leakage tests, fill the sprayer to its nominal (manufacturer's recommended maximum) capacity with water to which a non-ionic surfactant at 0.1% and suitable tracer dye, (i.e. one that is stable and quantifiable to less than 0.01%), have been added.
- 1.3 Wash, clean and dry the complete outside of the sprayer.
- 1.4 For LK, MK, CS, select a tank, e.g. a large plastic barrel or bin, which is large enough to allow complete immersion of the sprayer without displacing water from the tank.
- 1.5 Fill the tank described in 1.4 with a known volume of clean water and sample the water to determine any background contamination of the tracer dye chosen for the test.

Then carry out the following procedures according to the type of sprayer.

Non-pressurised tests

For LK, MK

- 1.6 Remove the nozzle tip and replace it with a blank disc to seal the outlet.
- 1.7 Stand the sprayer upright on a bench or similar flat surface with a lip around the edge. Place a clean polythene sheet on the bench taking care that it is large enough to cover the lip, i.e. to ensure that leaked liquid does not run off the polythene sheet. Open the on/off valve, position the lance horizontally on the sheet/bench and leave the sprayer for 60 minutes.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.8 Secure the lance in the “parked” position.
- 1.9 Seal the sprayer lid and air inlet to prevent water entering the spray tank.
- 1.10 Immerse the complete sprayer and the polythene sheet in the tank of clean water taking care not to lose any of the leaked liquid.
- 1.11 Move the sprayer and the sheet up and down approximately 25 cm in the water six times and then agitate the water for two minutes.
- 1.12 Remove the sprayer and the polythene sheet from the tank. Suspend the sheet and the sprayer (upright) over the tank and allow them to drain for two minutes.
- 1.13 Stir the water in the immersion tank vigorously with a meter long, 10 cm wide, metal rod for 30 seconds.
- 1.14 Sample the water and determine by fluorimetry or spectrophotometry the quantity of the original dye solution in the water.

To comply, the non-pressurised test should show a reading equivalent to no more than 5 ml of the original dye solution.

For MB

- 1.18 Detach the spray liquid supply hose from the air tube connection. Seal the end of the hose with a screw clip so that it is watertight, then open the on/off valve.
- 1.19 Stand the sprayer upright on a bench or similar flat surface on a clean polythene sheet and leave it for 60 minutes.
- 1.20 Instead of immersing the sprayer in the tank of water, remove all the liquid from the surface of the sprayer (including the air-tube), using cotton swabs. Place the swabs and the polythene sheet into a tank of clean water and assess any leakage following the procedure in Sections 1.11 to 1.14. (i.e. for the swabs and the polythene sheet only).

To comply, the test should show a reading equivalent to no more than 5 ml of the original dye solution.

For RA spray-head assembly and hose junctions

This test is to detect leakage from a bottle fitted to the spray-head or from all hose connections (i.e. to the spray-head, handle or tank), which could contaminate the hands or body of the operator.

- 1.21 Fill the sprayer head bottle and/or tank with water containing a suitable dye as described in Section 1.2.
- 1.22 Remove the atomizer disc

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.23 Position the sprayer over a clean polythene sheet
- 1.24 Operate the sprayer with the spray-head in a normal working position ensuring that none of the liquid from the spray-head falls onto the sheet. Continue until the spray bottle is empty or, where a tank is present, until the tank is empty.
- 1.25 Using cotton swabs remove the liquid from the surface of the sprayer handle and hose junctions.
- 1.26 Immerse the swabs and the polythene sheet in a large container of clean water
- 1.27 Stir the water in the container vigorously with a meter long, flat metal rod for 30 seconds.
- 1.28 Sample the water and determine by fluorimetry or spectrophotometry the quantity of the original dye solution in the water.

To comply, the test should show a reading equivalent to no more than 2 ml of the original dye solution.

Pressurised test

For LK, MK CS

- 1.29 Remove the nozzle tip and replace it with a blank disc to seal the outlet.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.30 Pressurise the sprayer to 4 bar with the on/off valve open.
- 1.31 Wash, clean and dry the complete outside of the sprayer.
- 1.32 Stand the sprayer upright with the lance placed horizontally on a bench or similar flat surface on a clean polythene sheet and leave for 60 minutes.
- 1.33 Seal the sprayer lid and air inlet (LK and MK) to prevent water from entering the spray tank.
- 1.34 Immerse the complete sprayer and the polythene sheet in a tank of water as described in Section 1.4, and assess any leakage following the procedure in Sections 1.11 to 1.14.

To comply, the pressurised test should deliver a reading equivalent to no more than 5 ml of the original spray solution.

Tilt test

For LK, MK, MB, RA (tank only)

- 1.35 For this test, do not pressurise the sprayer or seal the air inlet or lid.
- 1.36 For RA detach the spray liquid-supply hose from the spray-head and seal it watertight with a screw clamp. Alternatively, detach the hose from the tank and plug the tank outlet so that it is watertight.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 1.37 Prepare a tank of water following the procedure as described in Section 1.4 to 1.5.
- 1.38 Position the sprayer upright over the tank (see Section 1.32) and tilt it forward 90 degrees (i.e. with the strap-side down).
- 1.39 Maintain the sprayer in the tilted position for 1 minute then return it to the vertical (upright) position.
- 1.40 Repeat the tilting process 5 times, as described in Sections 1.39 and 1.39.
- 1.41 Seal the sprayer tank lid and the air inlet.
- 1.42 For LK, MK, RA: immerse the complete sprayer and the polythene sheet in a tank of water as described in Section 1.4, and assess any leakage following the procedure in Sections 1.11 to 1.14.
- 1.43 For MB remove all the liquid from the surface of the sprayer using cotton swabs and immerse the swabs and the polythene sheet in a tank of water as described in Section 1.4, and assess any leakage following the procedure specified in Sections 1.11 to 1.14. (i.e. for the swabs and the polythene sheet only).

To comply, the tilt test should deliver a reading equivalent of not more than 5 ml of the original dye solution for LK, MK, MB and not more than 2 ml for RA.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

2. Test procedure 2 - SURFACE RETENTION

For LK, MK, CS, RA (spray tank only)

- 2.1 Before commencing the test:
- remove the straps and tank lid from the sprayer;
 - wash the surface of the sprayer with a detergent solution and rinse thoroughly with clean water;
 - For MK, empty the fuel tank and seal watertight, the fuel fill hole, carburettor inlet and exhaust outlet;
 - For RA, conduct the test on the tank and hose only. Where possible close the shut-off valve or alternatively detach the spray hose from the spray head and to seal it watertight using a screw clamp;
- 2.2 Select a tank, e.g. a large plastic barrel or bin and fill it with a known volume of clean water and sample the water to determine any background contamination of the tracer dye chosen for the test. N.B. the tank should be large enough to allow complete immersion of the sprayer without displacing any water.
- 2.3 Stand the sprayer upright on a horizontal wire mesh surface and position the lance (LK, MK,CS) horizontally on the mesh alongside the sprayer.
- 2.4 Place a sheet of plastic film over the fill hole so that liquid poured onto the film will not enter the spray tank.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 2.5 Pour carefully, centrally and evenly onto the film, a suitable tracer dye solution in water (i.e. one which is stable and quantifiable to better than 0.01% in solution) at a volume of 10% of the nominal (manufacturer's recommended maximum) volume of the sprayer. The dye solution should flow as evenly as possible over the surface of the spray tank.
- 2.6 Leave the sprayer standing upright to drain for one minute then remove the plastic film from the fill hole.
- 2.7 Replace the tank lid and seal the air inlet to prevent water entering the sprayer.
- 2.8 Secure the lance in the "parked" position.
- 2.9 Immerse the sprayer in the tank of clean water as described in Section 2.2.
- 2.10 Move the sprayer up and down approximately 25 cm in the water six times and then agitate the water for two minutes.
- 2.11 Remove the sprayer from the tank; suspend it upright over the tank and allow it to drain for two minutes.
- 2.12 Stir the water in the immersion tank vigorously with a meter long, 10 cm wide, metal rod for 30 seconds.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 2.13 Sample the water and determine by fluorimetry or spectrophotometry the quantity of the original dye solution in the water.

To comply, there must be no more than the equivalent of 70 ml of the original dye solution for LK, MK, CS or 30 ml of the original dye solution for RA, in the immersion tank, i.e. introduced from the outside of the sprayer.

For MB

Because of the difficulty of sealing the air inlet on the fan to allow immersion in a tank, this test uses a swabbing technique with cotton pads. The test focuses on the amount of spray liquid retained on the spray tank and on the backrest, which are the parts of the sprayer that are in constant contact with the operator and pose most risk of chemical contamination.

- 2.14 Stand the sprayer upright on a horizontal wire mesh surface and position the air tube assembly horizontally on the surface.
- 2.15 Place a sheet of plastic film over the fill hole so that liquid poured onto the film will not enter the spray tank.
- 2.16 Pour the tracer dye solution onto the sprayer as described in Section 2.5
- 2.17 Leave the sprayer standing upright to drain for two minutes then remove the plastic film.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 2.18 Using cotton swabs, remove all the liquid from the front of the backrest padding and from the tank.
- 2.19 Place the swabs into a beaker of water of a known volume.
- 2.20 Sample the water and determine, by fluorimetry or spectrophotometry, the quantity of the original dye solution in the water.

To comply, there must be no more than the equivalent of 5 ml of the original dye solution in the beaker i.e. introduced from the backrest and tank.

3. Test procedure 3 - STRAP AND PADDING ABSORPTION

For LK, CS, MK, MB, RA

- 3.1 Remove the straps and padding from the sprayer and record their dry weight.
- 3.2 Completely immerse the straps and padding in water for two minutes.
- 3.3 Remove from the water and shake off excess water.
- 3.4 Drain for five minutes, then re-weigh.

To comply, the increase in weight should not exceed 10% of the dry weight.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

4. Test procedure 4 - TANK FILLING

For LK, MK, MB, CS, RA,

- 4.1 With the tank strainer or funnel (CS, RA) in the normal position for filling, fill the sprayer to its nominal capacity using a non-profiled bucket (i.e. round and without a pouring lip), pouring from a height of 10 cm.

To comply:

- The tank should fill to its nominal capacity without overflowing, or splashing at a rate of:
 - 25 litres per minute for LK, MK, MB RA
 - 10 litres per minute for CS
 - 5 litres per minute for the spray bottle on RA
- For LK, MK, MB, RA, the tank strainer should not lift from its seating during the filling process.

5. Test procedure 5 - TRIGGER ON/OFF VALVE RELIABILITY

For LK, MK, CS

- 5.1 Fit the trigger valve, with hose and lance attached, to a suitable mechanical on/off device, so that the valve completes 10-15 cycles per minute.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 5.2 Install a spray nozzle with a discharge rate in the range of 0.7 to 0.8 litres per minute at 3.5 bar.
- 5.3 Pump water containing a 20% suspension of silica, as defined in Appendix 1, continuously through the spray circuit for the duration of the test at a pressure of 3 bar at the nozzle.
- 5.4 Operate the valve for 25,000 on/off cycles.
- 5.5 Fill the sprayer to its nominal capacity with tracer dye solution as in 1.1, then repeat the leakage tests in Test procedure 1.

To comply:

- the trigger valve should continue to function normally and efficiently during and after the test.
- the leakage tests (Test procedure 1), should deliver in each case a reading equivalent to no more than 5 ml of the original dye solution.

6. Test procedure 6 - STRAP DURABILITY

For LK, MK, CS, MB, RA (tank)

- 6.1 Fill the sprayer tank with water to its nominal capacity.
- 6.2 Hang the sprayer by its straps from a solid support comprising a horizontal bar of 75 mm outside diameter to simulate the shoulders of an operator.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 6.3 Lift the sprayer 300 mm and allow it to drop 25 times, always allowing it to hang freely by the strap(s) after each drop.

To comply, the sprayer should continue to function normally after the test and all straps, quick release buckles, connectors and hangers should remain fully serviceable

7. Test procedure 7 - SPRAYER DROP TEST

For LK, MK, CS, RA (tank).

- 7.1 Place a solid wooden platform (suggested 20-30 mm thick by 800 mm square) on a level floor and surround it with a metal cage to protect the tester from injury.
- 7.2 Fill the spray tank to its nominal capacity with water.
- 7.3 Park the lance assembly and lever (for LK) in as near vertical positions as possible up the side of the tank.
- 7.4 Allow the sprayer to drop from a height of 0.60 m. on to the platform as follows:
- upright (6 drops)
 - on its base at an angle of 10° to the vertical on one side (3 drops)
 - on its base at an angle of 10° to the vertical on the opposite side (3 drops)

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

To comply, during these tests, no part of the sprayer should break and, following the tests, after only minor adjustments and tightening, the sprayer should continue to function normally and should still meet the leakage requirements in Test procedure 1.

For RA lance, spray head and bottle (i.e. the sprayer)

7.5 Hold the sprayer in the working position (with batteries inside the lance where this forms the battery case), with the lowest point of the sprayer 0.60m above the platform.

7.6 Allow the sprayer to drop vertically 6 times.

To comply, after only minor adjustments and replacement of the atomizer disc where necessary, following the tests the sprayer should continue to function normally and should still meet the leakage requirements in Test Procedure 1.

8. Test procedure 8 - CHEMICAL RESISTANCE

For LK, MK, MB, CS, RA

This test applies to all components, which come into constant direct contact with the concentrated or diluted pesticide formulation. Excluded from this test are straps, padding and any seals, which are not in constant direct contact with the chemical.

8.1 Weigh and measure the individual components.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 8.2 Immerse the components in a solution of 40% v/v kerosene, 20% v/v toluene and 40% v/v xylene for 12 hours at 20-25°C.
- 8.3 Rinse the components in clean water, dry them and store them for 24 hours in air at 20-25°C and a relative humidity of 60% ± 5%.
- 8.4 Re-weigh and re-measure the individual components.

To comply:

- weight and dimension changes from the original state should not exceed ± 5%;
- components should be capable of re-assembly and of fulfilling their original function.

9. Test procedure 9 - LIQUID RETENTION IN THE SPRAYER

For LK, MK, CS, MB

- 9.1 For LK, MK, CS, before commencing the test, operate the sprayer fitted with a nozzle, with the lance and hose in the normal working position, until the sprayer is nominally empty i.e. when the spray pattern is disrupted by air from the nozzle.
- 9.2 For MB, operate the sprayer until there are no more droplets being emitted from the air-tube i.e. when the sprayer is nominally empty.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 9.3 Place the sprayer, on a horizontal surface or mounted so that the tank is upright and level.
- 9.4 Pour 5 litres of clean water in the spray tank.
- 9.5 Operate the sprayer at a normal, recommended operating pressure with the lance and hose in the normal working position, until the sprayer is again nominally empty.
- 9.6 Pour into the tank, a further 5 litres of water containing tracer dye as specified in 1.2.
- 9.7 Operate the sprayer and collect all the liquid in a clean container until it is again nominally empty i.e. no more water can be discharged. For MB, detach the liquid hose from the air-tube to facilitate collection of the liquid
- 9.8 Stir the collected water for 30 seconds.
- 9.9 Sample the water and determine the concentration of dye in it by fluorimetry or spectrophotometry,

To comply, the test should deliver a reading, which indicates that the amount of water remaining from the original 5 litres (see Section 9.3) in the sprayer does not exceed

- 1.5% of the nominal capacity of the sprayer tank for LK, MK, MB.
- 25 ml for CS.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

10. Test procedure 10 - NOZZLES AND SPRAY QUALITY

For LK, MK, CS

For this test, the spray quality category of a candidate nozzle is expressed in terms of drop size distribution compared to the drop size distribution of a series of conventional flat fan reference nozzles as defined in Table 1.

TABLE 1

Reference nozzles for defining spray quality categories

Nozzle type	Flow rate (litres per minute)	Pressure (bar)	Category boundaries
110° flat fan	0.48	4.5	Very fine and fine
110° flat fan	1.20	3.0	Fine and medium
110° flat fan	1.96	2.0	Medium and coarse
80° flat fan	2.92	2.5	Coarse and very coarse

To evaluate a candidate nozzle

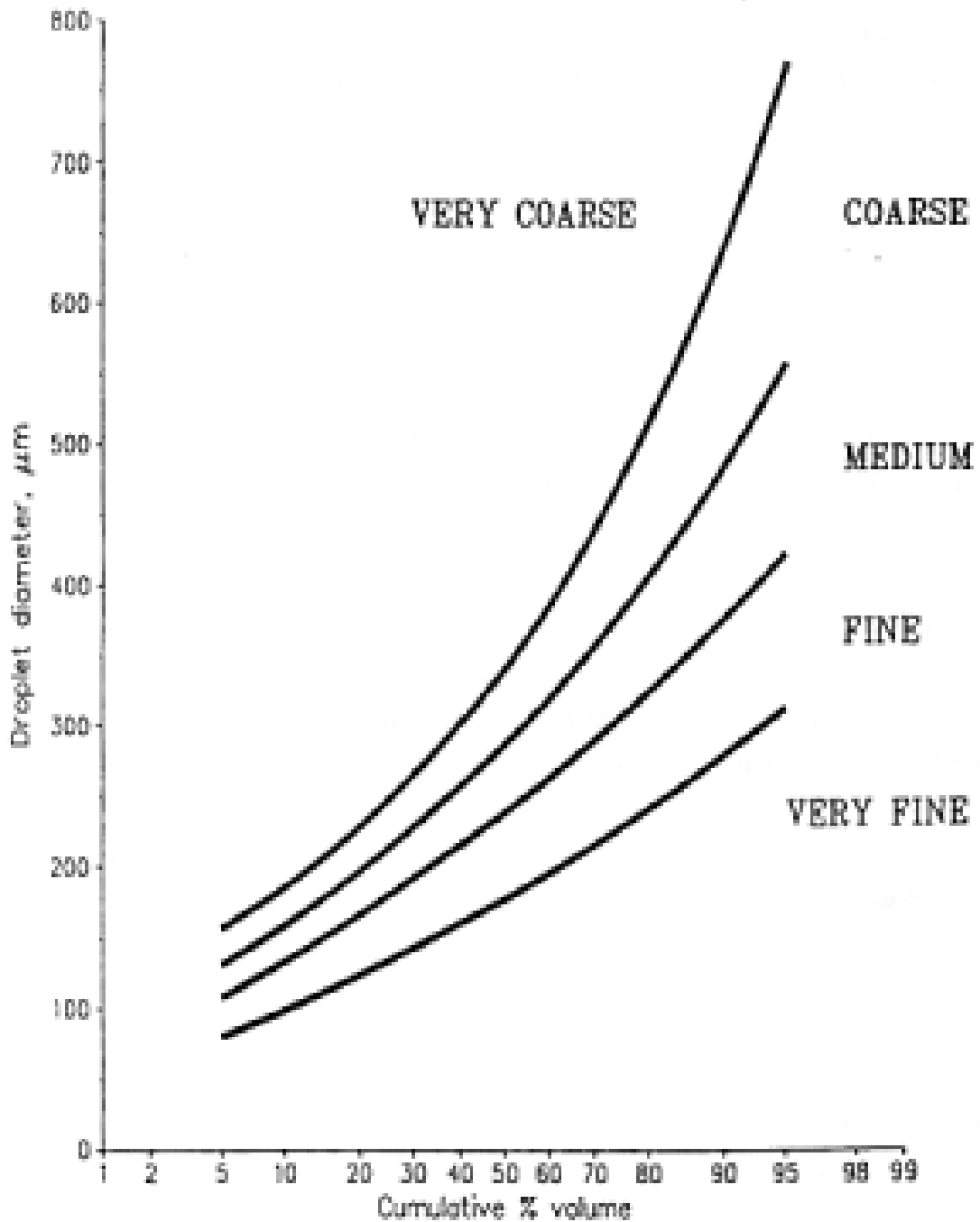
- 10.1 Select at least three examples of the candidate nozzle at random from a minimum batch size of 25 nozzles.
- 10.2 Assess the spray quality of each nozzle using the same procedure as used to calibrate the reference nozzles in Figure 2 as described in Sections 10.3 to 10.7 as follows.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 10.3 Spray clean water through the nozzles at the pressures and flow rates in Table 1.
- 10.4 Determine the drop size distribution at each of the flow rates by sampling the droplets in flight using an appropriate laser-beam instrument.
- 10.5 Sample the whole of the spray-cloud created by the candidate nozzle at a distance of between 350 and 500 mm from the nozzle.
- 10.6 Plot the results as the cumulative spray volume (x-axis) and the measured drop sizes (y-axis) as shown in Figure 2.
- 10.7 Compare the plots obtained for the candidate nozzle with the distribution ranges for the reference nozzles.

To comply, the mean distribution-plot for the three candidate nozzle(s) should match the spray quality category claimed for the candidate nozzle by the sprayer manufacturer. Compliance is achieved when the majority of the cumulative volume, at a given flow rate and pressure, falls in the appropriate category within the range of 10-90%.

**Figure 2 AN EXAMPLE OF SPRAY QUALITY DETERMINATION
BASED ON CUMULATIVE VOLUME/DROPLET SIZE PLOTS**



LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

11. Test Procedure 11 - TANK AND CYLINDER PRESSURE

For CS tank and LK pressure cylinder.

- 11.1 Remove the output hose connection, the pressure-relief valves and pressure indicator and securely seal these and any other orifices in the tank/cylinder with threaded plugs.
- 11.2 Where the tank/cylinder is not fitted with a connection for an external pressure source, substitute an appropriate pressure inlet connection to any one of the above (see Section 11.1), threaded plugs.
- 11.3 Completely, fill the spray tank/cylinder with water and place it in a safety cage.
- 11.4 Couple the tank/cylinder to a hydraulic pump via the pressure inlet connection.
- 11.5 Pressurise the tank/cylinder and hold the pressure for one minute as follows:
 - five times the nominal pressure (20 bar) for CS tanks that permit the use of external pressure sources;
 - two times the nominal pressure (8 bar) for CS tanks with only integral hand pumps and no option to use external pressure sources, and for LK and MK pressure cylinders.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

To comply, the tank or pressure cylinder:

- should not permanently distort;
- should not leak more than 5 ml. TEST PROCEDURE 1

12. Test procedure 12 - SPRAYER DURABILITY

For LK, MK, MB, RA

- 12.1 Fill the sprayer with water to its nominal capacity.
- 12.2 For LK, fit the pump lever to a mechanical activating device so that it does not hit the “stops” at the extreme top and bottom of each stroke.
- 12.3 For petrol engine or electrically driven equipment, (MK, MB, RA) run the engine/motor at the manufacturer’s recommended operating speed to comply with the output requirements in Section 12.4.
- 12.4 Spray the water from the sprayer at the manufacturer’s maximum recommended flow rate and pressure.
- 12.5 Ensure that the spray tank never becomes completely empty during the test period. This can be done, either by collecting the water from the nozzle(s) in a separate container so that the contents siphon back into the sprayer, or by supplying water continuously to the sprayer from an alternative source.
- 12.6 Continue the test:

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- LK for 250 hours
- MK, MB, RA for 50 hours

For petrol engine-driven and electrically-driven equipment, the 50-hour test period need not be continuous. It can be intermittent with a time lapse overnight.

To comply:

- the sprayer should function efficiently during the test period without mechanical breakdown, faults or any need for maintenance other than minor tightening;
- following this test, the sprayer should comply with the leakage requirement in TEST PROCEDURE 1;
- for LK, when filled to nominal capacity, the pump should maintain the pressure at 3 bar at the nominal (manufacturer's recommended maximum) flow rate throughout the test period without exceeding 30 lever strokes per minute;
- for MK, throughout the test period the pump should maintain the pressure at 3 bar at the nominal (manufacturer's recommended maximum) flow rate.

For CS sprayers fitted with manual pumping systems

- 12.7 In this case, do not fill the tank with water.
- 12.8 Fit the pump plunger to a mechanical activating device to operate so that the plunger does not hit the "stops" at the extreme top and bottom of each stroke.
- 12.9 Incorporate a pressure valve into the system, which at 4 bar allows the pressure in the spray tank to vent completely then re-sets.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

12.10 Continue the test for 2,500 venting cycles

12.11 The test should be conducted at a temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$

To comply:

- there must be no mechanical breakdown faults or repair needed to the pump during the test period;
- following the test, the pump should be capable of pressurising the spray tank to 3 bar with no more than 45 plunger strokes with the tank filled to nominal capacity;
- The sprayer should also comply with the tank pressure test requirements in TEST PROCEDURES 11 & 13.

13. Test procedure 13 - COMPRESSION SPRAYER DURABILITY

For CS

This test is to test the durability of the complete sprayer and not just the spray tank.

13.1 Where the tank is not fitted with a connection for an external pressure source fit an appropriate inlet connection.

13.2 Incorporate into the system, a pressure valve, which at 4 bar allows the pressure in the spray tank to vent completely then re-sets.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 13.3 Place the sprayer with all its normal fittings (i.e. complete with hose, and lance, sealed with a blank disc to replace the nozzle) with the trigger valve open, in a safety cage.
- 13.4 Pressurise the tank to 4 bar for 10,000 pressure cycles.
- 13.5 The test should be conducted at a temperature of $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$.

To comply:

- the tank should not permanently distort;
- the sprayer should not leak more than 5 ml. TEST PROCEDURE 1

14. Test procedure 14 - MISTBLOWER PERFORMANCE

This test should be conducted in still air conditions.

- 14.1 Fill the sprayer to its nominal capacity with water.
- 14.2 Position three 1.5 m poles of 12.5 cm diameter, five metres apart in line and place water-sensitive papers near the top of each pole.
- 14.3 Position the sprayer outlet at right angles to the line of poles and spray water at the manufacturer's minimum recommended flow rate.

LK - lever-operated knapsack; MK- motorized hydraulic knapsack; CS - compression sprayer; MB - motorized mistblower; RA - rotary atomizer.

- 14.4 Walk at a speed of 1 metre per second parallel to and 10 metres away from the line of the poles with the sprayer outlet facing the line of poles and the water-sensitive papers. Direct the outlet consistently at the level of the water-sensitive papers.
- 14.5 Repeat the test five times using new target papers each time.

To comply, the mean total number of drops calculated from all the papers should be no fewer than 30 per square cm.

15. Test procedure 15 - ENGINE STARTER MECHANISM RELIABILITY

For MK, MB

- 15.1 Fit the engine to a rig to enable the starter mechanism to perform 2500 successive cycles.
- 15.2 Disconnect the fuel and the engine ignition systems.
- 15.3 Ensure adequate lubrication of two-stroke engines when the fuel is disconnected

To comply, the mechanism should function efficiently during the test period without mechanical breakdown, faults or any need for maintenance.