Guidelines on STANDARDS FOR AGRICULTURAL PESTICIDE APPLICATION EQUIPMENT AND RELATED TEST PROCEDURES

Volume Two
Vehicle-mounted and trailed sprayers

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

VOLUME TWO

VEHICLE-MOUNTED AND TRAILED SPRAYERS

FOOD AND AGRICULTURE ORGANIZATION

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CONTENTS

VOLUME TWO
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VEHICLE-MOUNTED AND TRAILED SPRAYERS: TEST PROCEDURES

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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.

VOLUME TWO
VEHICLE-MOUNTED AND TRAILED SPRAYERS

INTRODUCTION

Volume two of the guidelines on standards covers the principal vehicle-mounted and trailed field crop sprayers and orchard sprayers. Portable (operator-carried) equipment: lever-operated knapsack, motorised knapsack, compression sprayer, mistblower and rotary atomizers are covered in volume one. Each part contains specifications for each type of sprayer and a series of test procedures to determine whether a candidate sprayer meets the specifications.

These guidelines 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.

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 international sprayer standards of the expert assigned to the project and on the authors' experience of pesticide application in the developing world.

Specification Format

The specifications are arranged 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 spraying machines can be compiled. The various modules for vehicle-mounted and trailed sprayers, which are generally referred to as tractor sprayers, are shown in Figure 3.

The modules are divided into 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 design freedom of the manufacturer.

Wherever 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 basic hydraulic nozzle module is used 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 with the standards

A key element of the system is the method for establishing 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."

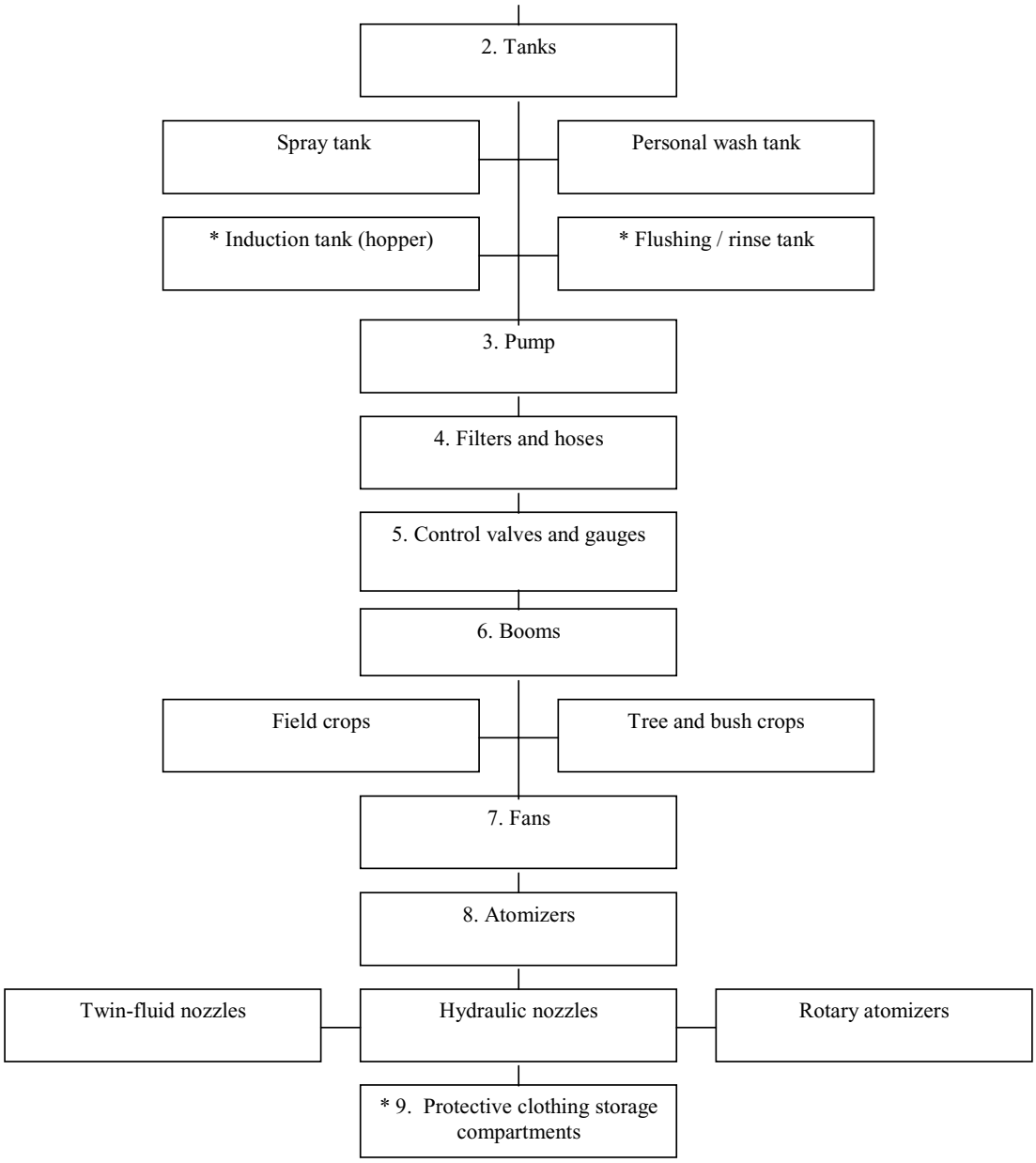
MEASURE — Where a simple measurement e.g. volume, thickness, length, pressure is all that is needed.

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 1 in 7, irrespective of the amount of liquid in the tank".

TEST PROCEDURE — A sequence of step-by-step actions, which should be followed as described in this volume.

Figure 3

TRACTOR SPRAYER COMPONENT MODULES



* required for sprayers with tank volumes over 1000 litres

VEHICLE MOUNTED AND TRAILED SPRAYERS (TR): SPECIFICATIONS

The following specifications apply to all terrestrial agricultural spraying equipment operated in conjunction with a tractor, mounted on a purpose built chassis unit or within a multi-purpose agricultural/horticultural vehicle. Throughout this document, for convenience, these types of spraying equipment are referred to as "the sprayer".

1. TR Module 1 - GENERAL REQUIREMENTS

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 sprayer should comply with the following requirements.

1.1 The sprayer unit should be securely attached to the vehicle system. CHECK

1.2 All shaft drives should be adequately guarded so that no moving parts are exposed. CHECK

1.3 Potential trapping points, which could cause physical injury e.g. created by the boom folding or height adjustment mechanism, should be fitted with guards. In positions where guards are not

practical, the sprayer should be fitted with appropriate, clear warning signs. CHECK

1.4 All handles, grips or handholds should be at least 300 mm from any point of articulation. MEASURE

1.5 Hydraulic oil connections should be via connector systems, which limit any leakage to a maximum of 2.5 ml for each make/break operation at pressures up to 175 bar.

Leakage should be measured at the nominal (manufacturer's recommended) maximum pressure at each "make/break" action using clean, absorbent swabs of a known weight. The amount of leakage is measured by recording the weight increase of the swabs after absorbing the leaked liquid. TEST

1.6 Sprayers with a tank capacity of 1000 litres or more should be fitted with low-level filling systems for water and for chemicals. CHECK

1.7 Where filling of either water or chemical is manual, it should be possible to add the chemical or water to the tank, with the operator standing either on the ground or on a purpose-built platform with a minimum floor area of 0.5 m2. MEASURE.

1.8 Platforms, should be made from anti-slip flooring and have guardrails. CHECK

1.9 Reach distances should not exceed 1.0 m vertically from the ground or platform and there should be a 0.3m horizontal obstruction-free zone around the fill opening.

MEASURE

1.10 The filling system for the spray tank(s) should permit safe, easy filling at the manufacturer's recommended maximum rate without overflowing or splashing. CHECK

1.11 The sprayer should not leak under working conditions at nominal pressures and flow rates. TEST PROCEDURE 1

1.12 The sprayer should be easy to clean thoroughly both inside and out. Rough surfaces and awkward recesses, should be avoided. CHECK

1.13 The outer surfaces of the sprayer should not trap or retain spray liquid. CHECK

1.14 There should be no sharp edges, abrasive areas or unnecessary projections, which could injure the operator. CHECK

1.15 The volume of spray liquid retained in the sprayer (tank, pump, hoses and boom) when the sprayer is normally considered "empty", should not exceed the specified limit. TEST PROCEDURE 6

1.16 In the case of a trailed sprayer, it should be stable when disconnected from the towing vehicle. It should remain upright when positioned on a 15% (1 in 7) slope in any direction irrespective of the amount of liquid in the tank(s). TEST

1.17 Adjustments to the sprayer, routine maintenance, drainage and cleaning should be easily carried out without the use of specialised tools (i.e. tools specifically designed for the sprayer). CHECK

1.18 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

1.19 The manual should contain procedures for:

- identification of replacement parts, including appropriate "exploded diagrams";
- setting and calibration;
- minimizing the need to dispose of dilute pesticide;
- washing pesticide bottles via the induction hopper;
- cleaning and safe disposal of any washings;
- routine maintenance and storage;
- safe, accurate field use.

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 rates and spray quality (see Module 8);

- the maximum nozzle size and operating pressure to be used in the sprayer;
- precautions to minimise the risk of operator and environmental contamination, especially through spray drift.

CHECK

1.20 All controls should be clearly marked and within easy reach of the operator from the normal working position. CHECK

1.21 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

1.22 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 1.18). CHECK

1.23 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 2

1.24 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 1.18). CHECK

1.25 The sprayer should be reliable and durable in use. After 1000 hours of simulated field use on a "rolling road " test rig, with the spray circuit switched off and with the boom sections in their normal working positions, the sprayer should comply with the complete standard. TEST

2. TR Module 2 - TANKS

There are often several tanks, or similar structures fitted to a sprayer: These include:

- the main sprayer tank(s) which contain the spraying water or diluted pesticide solution;
- a rinsing or flushing tank containing clean water to help wash out the inside of the tank and spray liquid circuits;
- a clean water tank for use by the operators for personal washing;
- an induction hopper to assist in the safe transfer of chemicals into the sprayer.

2.1 The FAO standard requires that a sprayer should be equipped with:

- a main spray tank (s);
- a clean water, personal washing tank;

CHECK

2.2 Sprayers with a tank (s) capacity of 1000 litres or more should also be equipped with:

- an induction hopper;
- a flushing / rinse tank.

CHECK

Spray tank(s)

There may be one or more spray tanks fitted to a vehicle mounted or trailed sprayer. All spray tanks should comply with the following specifications, however, for the purposes of the guidelines "the tank" will denote one or more tanks.

2.3 The tank should be constructed so that it is mechanically durable. TEST PROCEDURE 3

2.4 Fill openings should be closed with tight-sealing lids, which are securely attached to the spray tank. CHECK

2.5 Lids should be fitted with a positive mechanical closure system, which can be operated with gloved hands (gloves for test purposes, should have a minimum thickness of 0.5 mm). CHECK

2.6 Fill openings greater than 400 mm in diameter or, if rectangular, greater than 400 mm x 300 mm, should be fitted with a grating, which cannot be removed without using tools. CHECK

2.7 Fill openings should be fitted with a strainer with a maximum mesh aperture size of 1.0 mm. MEASURE

2.8 Strainers should be easy to remove and fit with gloved hands (see Section 2.5 re gloves). CHECK

2.9 Strainers should be close fitting and should not lift from their seating during filling. TEST

2.10 The spray tank should be clearly and durably marked with the nominal (manufacturer's recommended) maximum filling level, which should not exceed 95% of the total volume of the tank. MEASURE

2.11 The sprayer should be fitted with a means of indicating the level of liquid in the spray tank. CHECK

2.12 The liquid level indicator system should have a scale interval of no more than 20% of the nominal volume of the tank and a scale accuracy of better than 1.5 % of the nominal tank volume. TEST

2.13 The accuracy of the scale interval should be checked, by weighing the sprayer with five levels of water in the tank to cover the range 10% to 80% of the nominal capacity. MEASURE

2.14 Liquid level indicator(s) should be clearly visible to the sprayer operator from the normal working position. CHECK

2.15 To facilitate cleaning of the tank, the internal and external surfaces should have a surface finish of better than r = 100 mm, which is a measure of surface roughness. MEASURE

2.16 The spray tank should incorporate a safe and convenient system to enable the drained liquid to be collected or discharged for safe disposal. CHECK

2.17 The amount of liquid remaining in the tank after routine draining should not exceed 1.5% of the nominal tank volume or 5.0 litres. MEASURE

2.18 The pressure in a spray tank should not differ from the atmospheric pressure by more than 0.3 bar under all working conditions. TEST.

N.B. The pressure should be measured in the top of the tank. The pressure gauge connection should be via a sealed pipe into the top of the tank and the test should be conducted with the lid tightly sealed.

2.19 The tank should be fitted with an agitation system to comply with the requirements in TEST PROCEDURE 4. The exception to this requirement is where the sprayer operates exclusively with control systems in which the diluent (water) and the concentrated pesticide are separately controlled. CHECK

Personal wash tank

2.20 The personal wash tank and associated plumbing circuit should handle clean water only and should be totally independent of the main sprayer circuits, which contain chemical solution. CHECK

2.21 The personal wash tank should have a minimum volume of 15 litres. CHECK

2.22 The personal wash tank should be securely fixed to the sprayer. CHECK

2.23 The personal wash tank should be constructed from materials, which will not rust or corrode thereby contaminating the water. CHECK

Induction hopper

An induction hopper/bowl is a conveniently located receptacle into which undiluted pesticide formulations can be safely poured or placed. Water is introduced into the hopper to dissolve or dilute the pesticide and to transfer it into the main liquid flow circuit of the sprayer.

Where the sprayer is supplied with an induction hopper, it is the responsibility of the sprayer manufacturer to ensure that it meets the requirements even though it is probable that this information will originate from the hopper manufacturer.

To comply, sprayers with tank capacities of 1000 litres or more must be fitted with an induction hopper, which meets the following requirements.

2.24 The hopper should efficiently handle all commonly used pesticide formulation, liquids, powders, granules, soluble sachets and bags. CHECK

2.25 The hopper should have a minimum working volume of 15 litres. MEASURE

2.26 The hopper should be clearly and durably marked to show the nominal, filling level, which should be no more than 95% of the total volume of the hopper. MEASURE

2.27 The hopper should be fitted with a lid, which is permanently and securely attached to the hopper. CHECK

2.28 The fill hole should have a minimum dimension of 250 mm. MEASURE

2.29 The fill hole should be between 0.5 and 1.0 m from the ground. MEASURE

2.30 There should be a minimum clearance zone (i.e. an area free from obstacles) of 500 mm around the hopper, as shown in Figure 4. MEASURE

2.31 The hopper should include a device for cleaning original pesticide containers so that less than 0.01% of the original contents remain in the container following a defined procedure, which should be included in the sprayer manual. (see Section 1.18). TEST

2.32 Parts of the hopper 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 2

2.33 Instructions related to the operation of the induction hopper should be clearly and durably marked on either the sprayer or the hopper. CHECK

2.34 The manufacturer should provide details of the hopper in the sprayer manual (see Section 1.18). CHECK

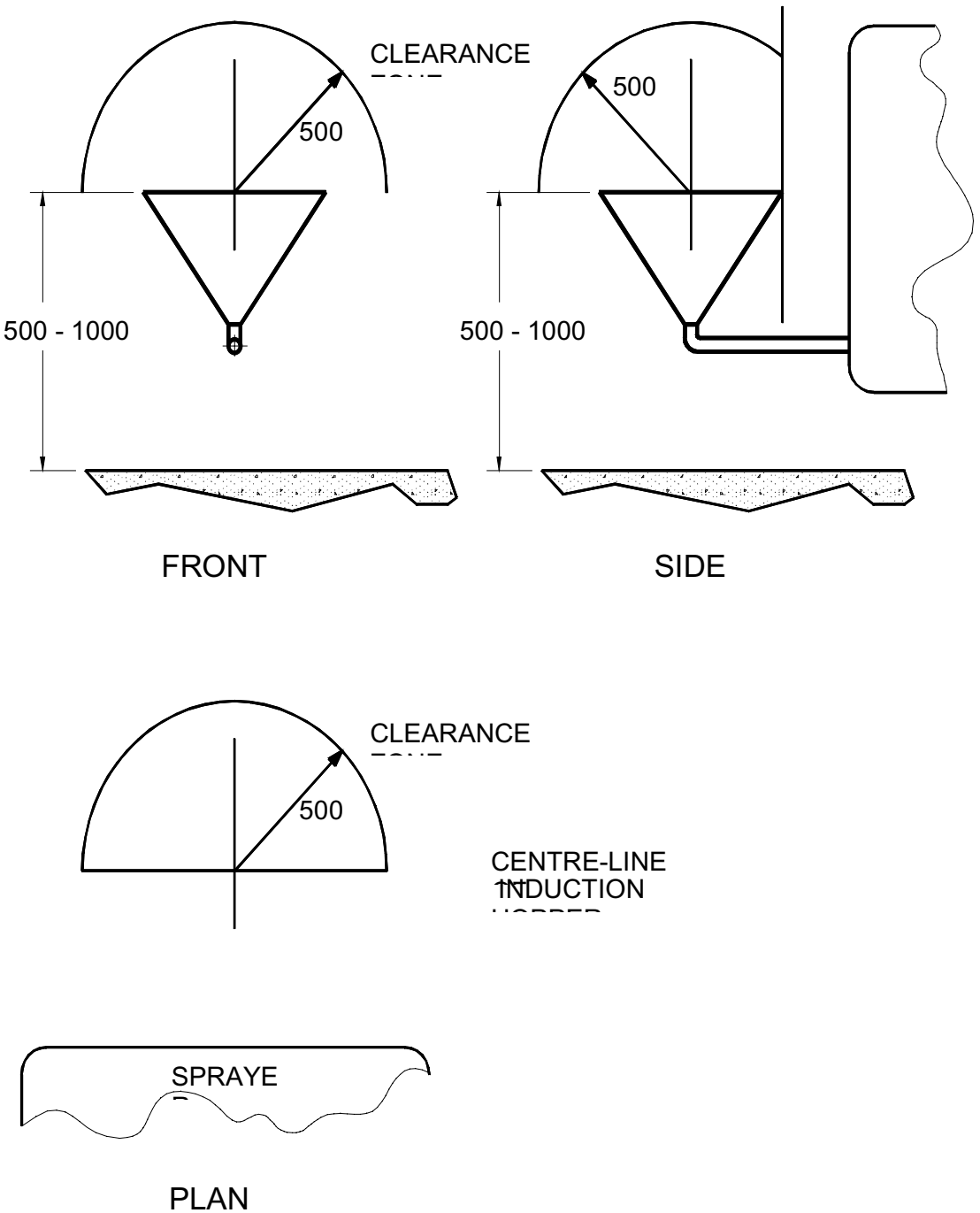
2.35 The manual should also include:

- details of the types and sizes of pesticide container for which the induction hopper is designed to operate;
- clear, simple, illustrated instructions on the safe and effective installation on to the sprayer without the use of specialized tools (i.e. tools specifically designed for the sprayer);
- instructions on operating flows, pressures, and any other specific requirements;
- appropriate cleaning procedures.

CHECK

Figure 4

CLEARANCE ZONES AROUND AN INDUCTION HOPPER



Flushing / rinse tank

2.36 This tank(s) is required to provide water to clean the spray tank(s) and the plumbing circuits on the sprayer, which contain pesticide solution. To meet the FAO standard, sprayers with spray tank capacities of 1000 litres or more, must be equipped with a flushing tank(s), which complies with this module. CHECK

2.37 The sprayer must be designed so that it is not possible to use the liquid from the flushing / rinse water tank for personal washing. CHECK

2.38 The volume of the flushing / rinse tank should be a minimum of 10% of the main sprayer tank(s). MEASURE

3. TR Module 3 - PUMPS

3.1 When operating at its nominal rotational speed, the pump should have sufficient capacity to supply the boom, when fitted with the largest nozzle size and operated at the manufacturer's maximum recommended working pressure, plus 20%. TEST

3.2 It should be possible to remove the pump from the sprayer without draining the tank(s). CHECK

3.3 The pump should be permanently marked with:

- maximum flow rate and operating pressure;

- nominal and maximum rotational speed;
- name and address of manufacturer;
- serial number.

CHECK

4. TR Module 4 - FILTERS AND HOSES

4.1 When the sprayer is fitted with a pump, which operates with valves, there should be a filter on the suction side of the pump with a maximum mesh aperture size of 0.5 mm. MEASURE.

4.2 The pressure feed line of the sprayer should be fitted with a filter with a maximum mesh aperture size of 0.3 mm. MEASURE

4.3 The pressure line filter(s) should have a filter screen surface area large enough to permit the maximum required flow to pass through the filter when it is 50% blocked, without increasing the pump operating pressure by more that 10%. MEASURE

4.4 Filters should be readily accessible for cleaning and maintenance. CHECK

4.5 Filters should be easy to clean without needing to empty the spray tank(s). CHECK

4.6 Hoses fitted to the sprayer should have a rated pressure equal to or greater than the maximum operating pressure of the sprayer plus 20%. CHECK

4.7 All hoses should be durably marked to indicate their rated pressure. CHECK

4.8 Hoses should be positioned so that, in the event of leakage or bursting, the risk of operator contamination is minimized. They should not pass through the tractor/vehicle cab. When there is no cab, hoses close to the operator should have guards to prevent operator contamination. CHECK

4.9 Hoses used to fill the sprayer should be fitted with a strainer with a mesh size aperture not exceeding 1.0 mm. MEASURE

4.10 Hoses should be positioned so that they are not bent sharply (or kinked), which could reduce the effective bore of the hose. CHECK

4.11 Hose connections should be easily adjustable and removable with standard tools using gloved hands (see Section 2.5 re. gloves) and should not leak when reconnected. CHECK

5. TR Module 5 - CONTROL VALVES AND GAUGES

5.1 All sprayers should be fitted with a pressure safety device to prevent the pressure in any part of the circuit exceeding the maximum operating pressure by more than 20%. MEASURE

5.2 When the pressure safety device is activated, all liquid flows should discharge into the main tank. CHECK

5.3 The boom should be fitted with spray pipe lines and valves so that the supply of liquid to each boom section can be controlled independently. CHECK

5.4 When operated to supply different combinations of boom section, the mean flow rate measured at any nozzle position (up to the largest recommended nozzle size), should not deviate by more than ± 5% from the nominal value. TEST PROCEDURE 5

5.5 The delivery from a boom section should return to a steady state within 10 seconds of a step-change in demand. TEST PROCEDURE 5.

5.6 There should be a single master control valve for turning on/off the supply to all boom sections. CHECK

5.7 "Anti-drip" valves should be incorporated in the sprayer circuit to minimise the loss of spray liquid from nozzles once the liquid supply to a boom section has been turned off. The leakage from a nozzle should not exceed 2 ml in a 5-minute period, commencing 8 seconds after the supply to the boom section has been switched off. MEASURE

5.8 The addition of the "anti-drip" devices in the nozzle supply line (see Section 5.7), should not reduce the flow by more than 2.5% when operating with the largest size of nozzle recommended by the manufacturer. MEASURE

5.9 A fail-safe system should be incorporated into the sprayer to prevent back-flow by siphoning while the spray and rinse tanks are being filled. CHECK

5.10 Sprayers designed to operate with hydraulic pressure nozzles should be fitted with a pressure gauge, which is clearly visible to the operator from the working position. In the case of an analogue dial, this should have a minimum diameter of:

- 63 mm if mounted within hand reach of the operator when in the working (spraying) position;
- 100 mm in all other cases.

Other forms of display, e.g. digital readouts, should be clearly visible to the operator from the working position.
CHECK

5.11 The pressure gauge indicator should provide a stable reading. CHECK

5.12 Pressure gauges fitted to the sprayer should to be calibrated to an accuracy of ±0.2 bar. MEASURE

5.13 The resolution of the pressure display system should also be ±0.2 bar. CHECK

5.14 The housing of pressure gauges should be isolated from the spray liquid so that, in the event of failure leading to leakage, the operator is not contaminated. CHECK

6. TR Module 6 - BOOMS

Field crops

6.1 Booms should be rigidly constructed so that all nozzles along a boom are supported at the same height within 50 mm above the target. CHECK

6.2. A minimum range of height adjustment of 1 metre should be provided. MEASURE

6.3 The force required to adjust the boom height should not exceed 250 N. MEASURE

6.4 The mechanism for height adjustment should incorporate a fail-safe feature so that in the event of failure of the height adjustment mechanism, the boom height will not change by more than 0.2 m. TEST

6.5 Where a manually operated system for boom height adjustment is used, it should be of a self-arresting type. CHECK

6.6 For powered height adjustment systems; the sprayer should be fitted with either:

- an arresting (anti-fall) device, CHECK or
- a stop which limits the boom to a minimum height of 0.5 m above ground level. MEASURE

6.7 Boom height settings of less than 0.5 m should only be possible by manually overriding the 0.5m stop control. CHECK

6.8 All height adjustment systems should be fitted with a locking device. CHECK

6.9 Booms more than 10 m wide should incorporate a mechanism, which will isolate the boom from the movements of the spray vehicle, i.e. they should have some form of boom suspension which complies with the requirements in TEST PROCEDURE 9

6.10 The boom should also be isolated from the yawing movements of the vehicle. With the boom extended and the machine stationary, it should be possible to displace the boom tip by a horizontal distance of 20 mm for each 1m of boom width, without distorting the boom structure. MEASURE

6.11 The boom should be fitted with a "break-back" device so that when the outer 10% width of the boom strikes a solid obstacle when travelling forwards, the boom displaces i.e. "breaks back", without mechanical damage to the boom structure or to any other part of the sprayer. After striking the obstacle, the boom should return to its original working position automatically and quickly. TEST

This test should be conducted with the tractor travelling forward at a speed of 2.5 m per second.

6.12 When folded in transport positions, the boom sections should not:

- obstruct access to or from the operator's spraying or filling positions; CHECK
- position nozzles above the access route to or from the operator's working position unless a shielding mechanism is present to avoid spray liquid dripping onto the operator. CHECK

6.13 The sprayer should be fitted with a mechanism to lock the boom sections securely in the transport position. CHECK

6.14 To minimise the risk of contact with overhead power cables during the folding operation, no part of the sprayer or boom should at any time, extend to a height of more than 5.0 m above the ground. MEASURE

6.15 Booms, which when folded extend to a height of more than 3.5 m above the ground, should be fitted with a warning sign pointing out the potential hazard from overhead cables. This sign should be easily understood and clearly visible to the operator from the working position. CHECK

6.16 The design of the boom should ensure protection of the nozzles from damage from contact with the ground. CHECK

6.17 Boom sprayers designed to operate with air-assistance are required to meet all the standard requirements in 6.1 to 6.17. In addition, manufacturers of this type of sprayer should include in the sprayer manual (see Section 1.18):

- details of air speed settings for different operating conditions, including those when no air is needed; CHECK

- specific maintenance requirements related to the air production and distribution system. CHECK

6.18 When the sprayer is equipped with a fan to generate air, it should comply with the requirements in Module 7. CHECK

Tree & bush crops (air assisted)

This module covers boom structures for air-assisted orchard and plantation sprayers.

6.19 The spray boom (delivery arc) should enable:

- the spray liquid delivery to each side of the sprayer to be controlled independently; CHECK
- nozzles of different sizes and blanks to be fitted to the boom. CHECK

6.20 The boom should be rigidly attached to the sprayer. CHECK

6.21 Where the boom is intended to operate in different positions in relation to the air stream, clear, detailed instructions should be included in the manual (see Section 1.18) describing the settings for effective operation in different crop and weather conditions. CHECK

6.22 When the boom can be used without air assistance, detailed instructions should be included in the sprayer manual (see Section 1.18) on how to set up the sprayer for effective operation for different crop targets and conditions.

7. TR Module 7 - FANS (for air-assisted spraying)

7.1 The drive to the fan unit should be capable of disconnection without affecting the mechanism for circulation and agitation of liquid in the sprayer. CHECK

7.2 The inlet to the fan should be designed and positioned so that debris is not drawn into the fan, even at the highest operational speed. CHECK

7.3 The lowest point of the fan inlet must be at least 25 cm above the ground. MEASURE

7.4 The fan should be equipped with a permanent guard with a minimum mesh aperture size of 5 mm and a maximum size of 10 mm. MEASURE

7.5 The noise level should not exceed 85 dB at the operator's ear when the sprayer is running at the maximum airflow. MEASURE.

8. TR Module 8 - ATOMIZERS

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

Hydraulic pressure nozzles

8.1 The sprayer manufacturer should provide in the instruction manual (see Section 1.18), 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 droplet size distribution) expressed according to the spray categories in Table 1 of TEST PROCEDURE 7;
- recommended nozzles, nozzle positions, heights and spacing, to give the required spray volume distribution at the target;
- a procedure for determining when nozzles are worn to 125% of their original flow rates and operating pressure(s), and should be replaced.

CHECK

8.2 Dimensions of nozzle tips should be as shown in Figure 5. MEASURE

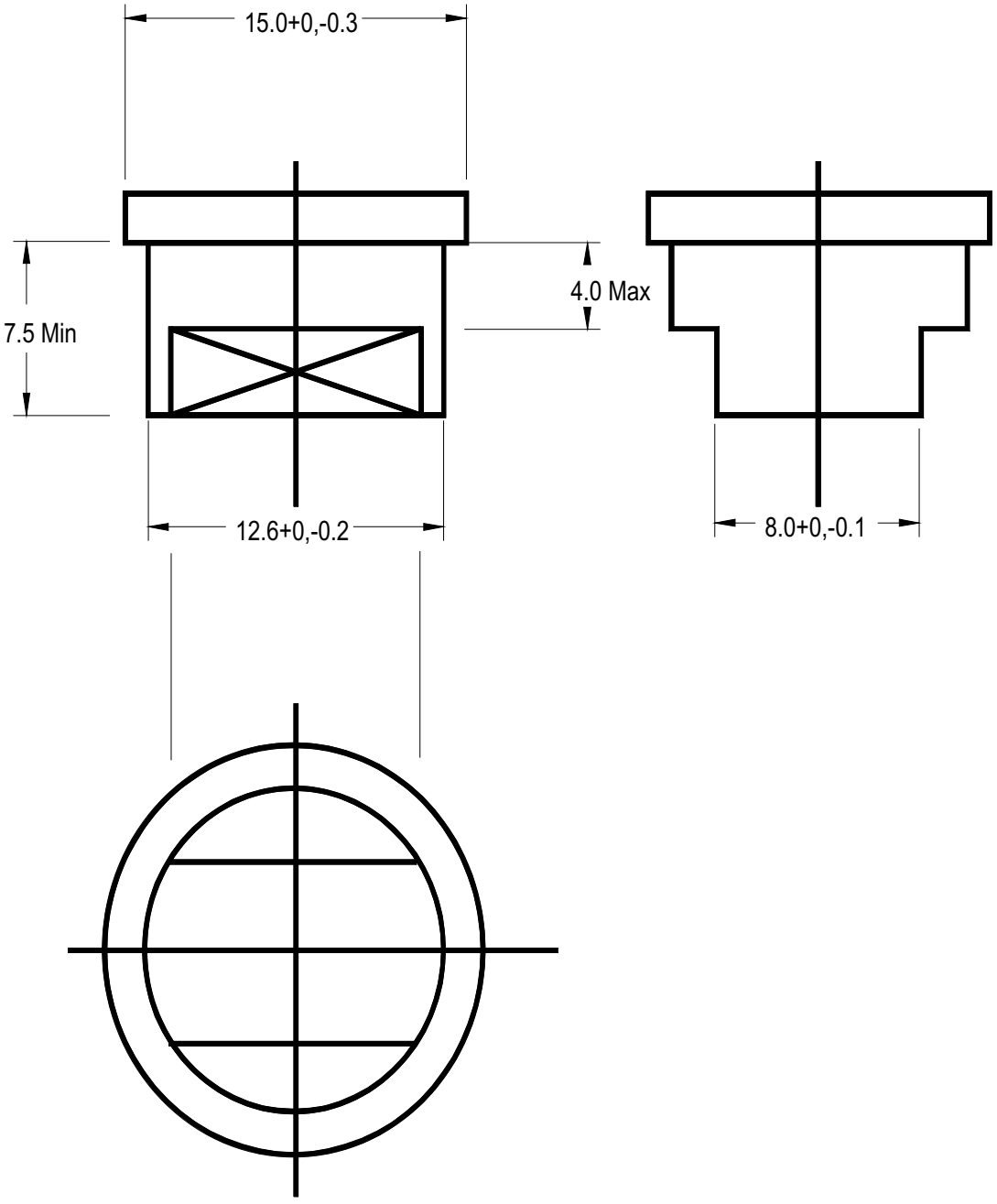
8.3 Output from any single nozzle or between nozzles with the same identity code i.e. which claim to have the same characteristics, should not differ by more than ±10 percent from the nominal output at any recommended pressure. MEASURE

8.4 For hydraulic pressure nozzles, creating a flat fan, including those termed "even spray", the volume distribution pattern should meet the requirements in TEST PROCEDURE 8

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

Figure 5

DIMENSIONS OF NOZZLE TIPS (according to ISO)



Twin fluid nozzles

These devices create a spray within a nozzle body via pressurized supplies of both liquid and air.

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

8.6 Sprayers fitted with twin fluid nozzles should be equipped with separate pressure control valves and gauges to allow independent control of the liquid and air supplies. CHECK

8.7 The sprayer manufacturer should provide data in the sprayer manual (see Section 1.18) indicating:

- the range of pressures and flows over which the nozzles are designed to operate; CHECK
- the flow rate and spray quality, based on TEST PROCEDURE 7 that can be achieved with defined pressures of liquid and air to the nozzle; CHECK
- specific maintenance requirements for the nozzles supplied or recommended; CHECK
- specific operating instructions for the nozzles supplied or recommended. CHECK

8.8 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 ±10 percent from the nominal output at any recommended pressure. MEASURE

Rotary atomizers

8.9 In addition to the information required in the sprayer manual under Section 1.18, the manufacturer should provide in the manual the following information:

- flow rates (measured with water);
- characteristic drop sizes produced at the manufacturer's recommended restrictor flow rates and atomizer speeds;
- details of specific operating speeds and settings for the principal targets and field conditions;
- spacing of atomizers on the boom for recommended operating parameters;
- a method for checking the atomizers to determine when they should be replaced.

CHECK

8.10 Output from a single rotary atomizer restrictor or between restrictors with the same identity code i.e. which claim to have the same characteristics, should not differ by more than ± 10 % from the nominal output. MEASURE

8.11 Atomizers should withstand 50 hours of continuous operation at maximum speed without loss of performance or maintenance. TEST

9. TR Module 9 - PROTECTIVE CLOTHING STORAGE COMPARTMENTS

9.1 Sprayers with tank capacities of 1000 litres or more, must be equipped with protective clothing storage compartments. CHECK

9.2 The sprayer should be equipped with two compartments; one for clean clothes and the other for contaminated clothes. CHECK

9.3 The compartments should be located on the sprayer as far away as practical from the point of chemical loading. CHECK

9.4 The minimum internal dimensions of the compartments should be 450 mm x 450 mm x 300 mm. MEASURE

9.5 The compartments should be clearly and durably marked:

- stating their purpose, i.e. to store protective clothes: clean or contaminated; CHECK
- warning against the storage of chemicals in this compartment. CHECK

VEHICLE-MOUNTED AND TRAILED SPRAYERS:TEST PROCEDURES

TR TEST PROCEDURES

1. TR Test procedure 1 - LEAKAGE FROM THE COMPLETE SPRAYER

1.1 Position the sprayer, mounted on or attached to the tractor in the normal work position, on a firm level standing.

1.2 Before commencing the test, thoroughly clean the outer surfaces of the sprayer, paying particular attention to the areas around joints and pipe connections.

1.3 Fit blanking nozzle components to all nozzle positions, except the position furthest downstream on each boom section.

1.4 Fit a tube over each of the end downstream nozzles to allow liquid to be collected from the nozzles during the test to avoid contaminating the area.

1.5 Fill the sprayer to its nominal (maximum recommended) working capacity with a suitable tracer dye solution, e.g. Orange G (i.e. one which is stable and quantifiable to better than 0.1% in solution) mixed with a non-ionic surfactant at 0.1%.

1.6 Clean from the surface of the sprayer any tracer solution that spills during filling.

1.7 Carefully position, under the sprayer and boom, clean absorbent material that will permit recovery of the tracer dye, e.g. cotton padding or chromatography paper.

1.8 Run the sprayer in its normal working position at its maximum rated pressure for a period of 15 minutes.

1.9 At the end of the 15-minute test period, inspect the machine for evidence of leaks. Where leakage is noted or suspected, thoroughly clean the leaking parts of the machine and the catchments around the leak point with additional clean absorbent swabs.

1.10 Collect the absorbent material from the catchment surfaces under the leak point and keep this together with the extra swabs used to clean the area of the machine around the same leak point.

1.11 Taking the contents of the tank as a reference, determine from the absorbent material and swabs by spectrophotometry or fluorimetry, the quantity of leaked tracer dye solution at each leak point.

To comply:

- the leakage from any single leak point on the sprayer should be no more than 2.5 ml;

- the total of all measured leakage should be no more than 10.0 ml.

2. TR Test procedure 2 - CHEMICAL RESISTANCE

This test applies to seals and other components, which come into direct contact with the concentrated or diluted pesticide formulation.

2.1 Weigh and measure the individual components.

2.2 Immerse the components in a solution of 40o v/v kerosene, 20% v/v toluene and 40% v/v xylene for 12 hours at 20°C.

2.3 Rinse the components in clean water, dry them and store them for 24 hours in air at 20o C.

2.4 Re-weigh and re-measure the individual components.

To comply:

- Weight and dimension changes from the original state should be no more than ± 5%;
- Components should be capable of reassembly and of fulfilling their original design function.

3. TR Test procedure 3 - MECHANICAL STRENGTH OF THE TANK

3.1 Support the sprayer tank in a safe test area so that it can be struck by a rounded weight of 50 kg suspended on a 3 m line released from 45 degrees from the vertical with the pivot point vertically above the face to be struck.

3.2 Where the sprayer has its own wheels it should be raised so that the wheels do not touch the ground.

3.3 Allow the weight to strike the tank five times on each of three faces i.e.:

- one side of the tank;
- a face at right angles to the above (i.e. the back or the front);
- a corner between the two struck faces.

To comply, after the 15 impacts, the tank should continue to meet the requirements of the leakage test. TR TEST PROCEDURE 1.

4. TR Test procedure 4 - TANK AGITATION

4.1 For this test, use a suspension of copper oxychloride of approximately 1% i.e. a rate equivalent to 1.0 kg for every 100 l of water in the tank (for composition see Appendix 1).

4.2 Half fill the tank with water and prepare a slurry at a concentration of 1 kg of copper oxychloride in 2.5 l of water. Add the required

amount of copper oxychloride to the tank (see Section 4.1) in this slurry form through the fill strainer or induction hopper then top up the tank with water to its nominal capacity.

4.3 Agitate the contents of the tank using the normal sprayer agitation system operating at a normal working speed for a period of 10 minutes.

4.4 Immediately take reference samples at three levels in the tank: at the top approximately 50 mm below the surface of the liquid; at the mid point of the tank section and 50 mm above the bottom of the tank.

4.5 Allow the suspension in the tank to remain undisturbed for 16 hours.

4.6 Recommence the agitation as described in Section 4.3 and continue for 10 minutes. Re-sample the tank contents at the same three levels using the same procedure as in Section 4.4.

4.7 Dry the samples at a temperature of 100°C ±5°C, then determine gravimetrically, the quantity of copper oxychloride in each sample.

To comply, the concentration of copper oxychloride from any of the samples (i.e. taken either before or after the 16 hour settling period in Section 4.5) should be within ± 10% of the calcu-lated concentration, based on the original amount of copper oxychloride added and the nominal capacity of the sprayer.

5. TR Test procedure 5 - PRESSURE/FLOW CONTROL SYSTEM

This test covers the performance of devices on a sprayer that enable it to:

- maintain consistent spray delivery to the nozzles irrespective of the number of boom sections in operation;
- maintain a constant volume rate of application irrespective of changes in forward speed (within defined ranges).

Measurements

5.1 Measurement times should begin from the completion of any adjustment procedure.

5.2 Measuring times should be taken from the time of completion of any adjustment.

5.3 Once a steady state is reached, values for measured parameters should not differ by more than the resolution of the measuring instrument when sampled at a frequency of 2.0 Hz or greater.

To measure boom and boom section output

5.4 Install flow meters in the boom section liquid supply lines to monitor the total flow to each boom section.

5.5 Fit all nozzle positions with nozzles of a size recommended by the sprayer manufacturer to give an approximate individual nozzle output of:

- 2 litres per minute for field crop sprayers;
- 4 litres per minute for orchard sprayers.

5.6 Run the sprayer for 2 minutes with the liquid supply to the boom switched off.

5.7 Switch on the supply to the boom and record the time taken for the flow rate to reach ± 10% of the total expected flow rate.

Take measurements for:

- the complete boom;
- each boom section;
- two paired combinations of boom section.

5.8 Following the above procedure, once a steady state has been reached, switch off the liquid supply to the boom section(s), wait 10 seconds then switch the supply back on. Measure the time taken in each case for the flow to return to a steady state.

5.9 Repeat the process (see Section 5.6 to 5.8) three times for each boom section.

To comply, the time taken to reach steady state for each section should be no more than 10 seconds in all cases.

To measure output adjustment systems for changes in forward speed

5.10 Operate the sprayer at a steady state with the full boom fitted with medium sized nozzles and at the following reference settings:

Forward speed:	2.0 metres per second
Power take-off speed:	400 revolutions per minute
Volume application rate:	300 litres per hectare

5.11 Make step changes of 20% above and below the reference operating speed (2.0 metres per second) as follows:

- from 2.0 to 1.6 metres per second;
- from 2.0 to 2.4 metres per second.

5.12 In each case, record the time taken for the flow to the boom (all sections) to reach ± 10% of the total expected flow rate.

5.13 Carry out the test three times and take the average value.

To comply, the time between the steady states should be no more than 10 seconds.

6. TR Test procedure 6 - LIQUID RETENTION IN THE SPRAYER

6.1 Position the nominally empty sprayer (i.e. after routine draining procedures) securely on a firm level standing with the boom and all liquid lines in their normal working positions.

6.2 Remove the nozzles and fit blanks in all except the most downstream position on each boom section. Fit tubes to these open downstream positions to enable the spray liquid to return to the spray tank while the sprayer is operating.

6.3 For large tanks, add 250 litres of water plus a tracer dye as specified in TR Test procedure 1, Section 1.5. No surfactant is required in this case. For smaller capacity tanks, top up with only sufficient water to half fill the tank.Carefully mark the level of water in the tank.

6.4 Thoroughly mix the tracer dye with the water in the sprayer by operating the sprayer for 2 minutes with the liquid supply to all boom sections open. The liquid in the tank should circulate freely through the pump and supply lines and back into the spray tank. This will ensure thorough mixing of the tank contents with the liquid in the spray circuit.

6.5 Take a reference sample of the liquid in the tank.

6.6 Fit all nozzle positions with nozzles of the sizes recommended by the sprayer manufacturer to give an approximate output of:

- 2 litres per minute per nozzle for field crop sprayers;
- 4 litres per minute per nozzle for orchard sprayers

Other specific output volumes within normal practical ranges are acceptable.

6.7 Operate the sprayer at the same setting as was used in 6.4 until it is nominally empty, i.e. until the first pressure drop of 25% in one second is noted.

6.8 Switch off the sprayer and fill the spray tank to the level recorded in Section 6.3.

6.9 Record the exact amount of water added.

6.10 Refit the blanks and the re-circulation tubes as in 6.2 and operate the sprayer for 2 minutes.

6.11 Sample the liquid in the tank and determine, using fluorimetry or spectrophotometry, the amount of liquid that remained in the sprayer by comparing the final sample reading with the reference sample taken (see Section 6.5).

6.12 Repeat the test three times and use the average of the three readings as the value to determine compliance.

To comply, there should be no more than 2% of the tank volume or 30 litres of liquid remaining in the complete sprayer.

7. TR Test procedure 7 - SPRAY QUALITY

Determination of spray quality

For this test, the spray quality of a candidate nozzle is defined in terms of drop size distribution in comparison with the drop size distribution of a series of flat fan reference nozzles as defined in Table 2.

TABLE 2

Reference nozzle systems 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

7.1 Select at least three examples of the candidate nozzle at random from a minimum batch size of 25 nozzles.

7.2 Assess the spray quality of each nozzle using the procedure used to calibrate the reference nozzles in Table 2 as follows. (Sections 7.3 to 7.7).

7.3 Spray clean water through the nozzles and at the pressures and flow rates used in Table 2.

7.4 Determine the drop size distribution at each of the flow rates by sampling the droplets in flight using an appropriate laser-beam instrument.

7.5 Sample the whole of the spray-cloud created by the candidate nozzle at a distance of between 350 and 500 mm from the nozzle.

7.6 Plot the results as the cumulative spray volume (x-axis) and the measured drop sizes (y-axis) as shown in Figure 6.

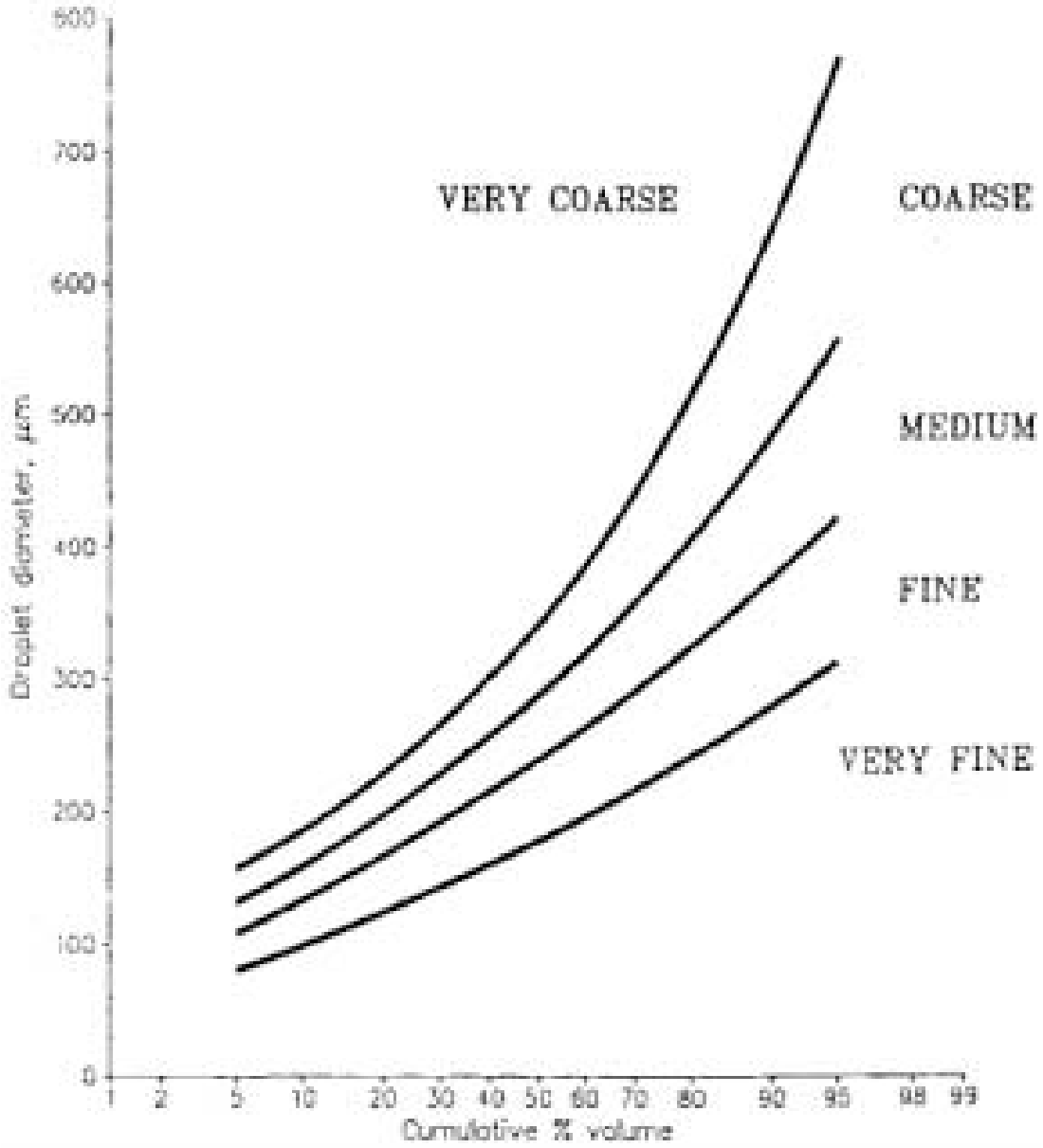
7.7 Compare the plots obtained for the candidate nozzle with the distribution ranges for the reference nozzles.

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. To comply, the majority of the cumulative

volume, at a given flow rate and pressure, should fall in the appropriate category within the range of 10-90%.

Figure 6

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



8. TR Test procedure 8 - SPRAY VOLUME DISTRIBUTION PATTERN

This is a static test to determine the uniformity of spray distribution across a multi-nozzle boom. It does not reflect the biological quality of a spray application, as this is influenced by other factors including the droplet size distribution, forward speed of the sprayer and the wind speed and direction. However, compliance with this test, together with Test Procedure 7, reflects a rational step towards achieving safe and efficient spray application across the boom.

8.1 Conduct the test using water plus 0.1% non-ionic surfactant.

8.2 Install a single candidate nozzle on a standard patternator bench with 100 mm collecting columns. The height of the nozzle above the sampling table, should comply with the manufacturer's recommendation on the height of the nozzle above the target.

8.3 Spray the surfactant solution through the nozzle at a constant pressure, which should not deviate by more than 2.5% at the nozzle throughout the test.

8.4 Record the distribution of the spray liquid in the patternator when the height of the liquid in the fullest column reaches 90%. Take recordings at 2,3, and 4 bar.

8.5 By computer analysis, from the levels recorded in the patternator tubes for the single candidate nozzle, calculate the distribution for a 3-metre width (i.e. 30 columns) excluding the ends where there is no overlap. Calculate the coefficient of variation using the following formula:

$$CoV = \frac{s}{\bar{x}} \times 100$$

where

$$\bar{x} = \frac{\Sigma x_i}{n}$$

$$s = \sqrt{\frac{\Sigma (x_i - \bar{x})^2}{n-1}}$$

xi is the height of liquid in the tube and n is the number of patternator columns

To comply, the 30 values derived from the patternator columns should show a coefficient of variation of not more than 10% when calculated for the region of overlapping spray.

9. TR Test procedure 9 - BOOM SUSPENSION PERFORMANCE

9.1 Operate the sprayer with a vehicle with the wheel track set at 2.0 metres (or nearest setting).

9.2 Select a test area, which is firm and level to allow the sprayer to be driven in a straight line for a distance of 100 metres.

9.3 Position three rigid 0.2 metre-wide blocks alternatively in each wheel track at a spacing of 25 metres down the track, so that the blocks protrude above the surface of the track by 100 mm.

9.4 Drive the sprayer down the length of the track at a speed of 2.5 m per second with the boom set at a height of 0.5 m above the ground level.

To comply, the boom should not contact the ground during the test.

APPENDIX 1

APPROXIMATE COMPOSITION OF THE ABRASIVE SUSPENSION FOR USE IN TEST PROCEDURE 5

SiO2 content	87%
CaO content	0.5%
Fe2O2 content	0.2%
Al2O3 content	0.6%
NaCl content	1.0%
Bulk density	160 kg/m3
Specific gravity	1.95
Average particle size	0.022 m
Colour	white

Refractive index	135-165 Gardner-Sward test units
Surface area	140-160 m2 /g
pH (water suspension)	7.3
Loss at 105o C	5%
Loss at 1200o C	10%

The suspension should contain 20g of the above synthetic silica powder per litre of water and the suspension should remain uniform throughout the test.

APPENDIX 2

COMPOSITION OF THE TEST POWDER CONTAINING COPPER OXYCHLORIDE

Composition

Copper in the form of copper oxychloride trihydrate (3CuO×CuCl2×3H2O):	45%
Lignosulfonate:	5%
Calcium carbonate (CaCO3):	8%
Sodium sulfate decahydrate (Na2SO4×10H2O):	11%

Size of the particles

< 20 mm: 98% minimum
< 10 mm: 90% minimum
< 5 mm: 70% minimum

Impurities in the technically active material (3.5% max.)

Water: 2% maximum
Ash: 1.5% maximum (in addition to the copper)

Solubility

Slowly soluble in water and organic solvents

Soluble in strong mineral acids

Soluble in solutions of ammonia and amines through the formation of complexes.