Foreword

This standard is a revision of the Philippine National Standard (PNS) 1135:1993 - Lever-Operated Manual Knapsack Sprayer – Methods of Test". The revision was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project entitled "Enhancing the Implementation of AFMA Through Improved Agricultural Engineering Standards" which was funded by the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA).

This revised standard was reviewed by the Technical Committee for Study 1- Development of Standards for Agricultural Production Machinery and was circulated to various private and government agencies/organizations concerned for their comments and reactions. This standard was presented to the Philippine Society of Agricultural Engineers (PSAE) and subjected to a public hearing organized by the National Agriculture and Fisheries Council (NAFC). The comments and reactions received during the presentation and public hearing were taken into consideration in the finalization of this standard.

This standard has been technically revised in accordance with PNS 01:Part 4:1998 - Rules for the Structure and Drafting of Philippine National Standards. The main changes are listed below:

- title of the standard has been modified in conformity to the format of International Standard;
- the scope was delineated thereby indicating the aspects covered and the limits of applicability; and
- items to be included in the test report were enumerated based on the actual test report prepared by AMTEC.

In the preparation of this standard, the following documents/publications were considered:

Workshop on Small Sprayer Standards, Safety and Future Directions held in Bombay, India

Procedures for the Comparative Evaluation of Knapsack Sprayer by J.A. Sutherland

Agricultural Machinery – Lever-Operated Knapsack Sprayer – Methods of Test

1 Scope

This standard specifies the methods of test for lever-operated knapsack sprayer. The verification and test of knapsack sprayers shall consist of the following:

1.1 Verification of the Specifications

1.2 Laboratory Tests

1.2.1 Volumetric Efficiency

1.2.2 Leak

1.2.3 Tilt and Inversion

1.2.4 Nozzle Performance

1.2.5 Cut-off Valve

1.2.6 Pressure Chamber Fatigue

1.2.7 Continuous Running

1.2.8 Strap

1.2.9 Drop

1.3 Actual Field Test

1.3.1 Rate of Work

1.3.2 Ease of Operation

1.3.3 Operator's Safety

2 Reference

The following normative document contains provisions, which, through reference in this text, constitute provisions of this Standard:

PAES 112 : 2000, Lever-Operated Knapsack Sprayers – Specifications.

3 Tests and Inspection

3.1 Verification of Manufacturer's Technical Data and Information

3.1.1 This is carried out to verify that the mechanism, main dimensions, weight, materials, and accessories of the knapsack sprayer conform to the list of technical data and information submitted by the manufacturer.

3.1.2 A plain and level surface shall be used as reference plane for verification of dimensions.

3.1.3 The items to be inspected and verified shall be recorded in Annex A.

3.2 Laboratory Performance Test

3.2.1 Volumetric Efficiency

3.2.1.1 This is carried out to determine the ratio of the actual volume of fluid discharge to that of the piston or plunger displacement in one stroke.

3.2.1.2 The sprayer shall be filled with clean water to its tank capacity.

3.2.1.3 A pressure gauge shall be fitted as close to the nozzle as possible to monitor the normal working pressure specified by the manufacturer. If the manufacturer does not indicate the normal working pressure for use, a range from 270 kPa to 410 kPa shall be used.

3.2.1.4 Actual Volume Discharge per Stroke Determination

With the set-up as in sub-clause 3.2.1.3, the sprayer shall be operated at normal working pressure specified by the manufacturer. Upon the stabilization of pressure, the discharge in 20 successive strokes sustaining the normal working pressure shall be collected and measured using a graduated cylinder.

3.2.1.5 Piston Displacement Determination

The inside diameter of the cylinder and the actual length of stroke shall be measured. Piston displacement shall be computed using the formula:

$$D_p = \frac{Al}{1000}$$

where:

$$A = \frac{\pi d^2}{4}$$

where : D_p is the Piston Displacement, L
A is the cross-sectional area of the cylinder, cm^2
d is the diameter of the cylinder, cm
l is the length of actual piston travel, cm

3.2.1.6 Volumetric efficiency shall be calculated using the formula:

$$V_{eff} = \frac{V_a}{D_p}$$

where: V_{eff} is the volumetric efficiency, %
V_a is the actual volume discharge, L
D_p is the piston displacement, L

3.2.2 Leak

3.2.2.1 This is carried out to check the effectiveness of the one-way valve, seals, and cut-off valve connections.

3.2.2.2 Nozzle shall be removed and replaced with a pressure gauge.

3.2.2.3 The sprayer shall be pressurized to 1.75 times the normal working pressure after which, pumping action shall be stopped and the change in pressure after a period of one hour shall be noted and reported.

3.2.2.4 Three trials shall be made with three different operators to assemble the lance assembly without the use of tools.

3.2.3 Tilt and Inversion

3.2.3.1 These are carried out to check for any leak on the sprayer when tilted and inverted.

3.2.3.2 The sprayer shall be filled with water and shall be tilted at an angle of 90^o for five minutes on each side.

3.2.3.3 The sprayer shall then be inverted for five minutes.

3.2.3.4 No leak from any part of the sprayer shall occur.

3.2.4 Nozzle Performance

3.2.4.1 This is carried out to evaluate the performance of the nozzle such as the discharge and spray distribution pattern.

3.2.4.2 Discharge Test

3.2.4.2.1 Discharge in liters shall be measured using the graduated cylinder at the maximum and minimum pressure stated by the manufacturer and two other intermediate pressures for a duration of one minute. In case the manufacturer does not indicate the maximum and minimum pressures to be used, pressure rating of the nozzle shall be used.

3.2.4.2.2 Measurement at every pressure rating shall commence as soon as the pressure has stabilized, and the average of five data for each shall be taken and recorded.

3.2.4.3 Spray Distribution Test
3.2.4.3.1 The test shall be carried out using the patternator as shown in Figure 1.

3.2.4.3.2 The maximum and minimum pressures stated by the manufacturer shall be used in this test. In case the manufacturer does not indicate the maximum and minimum pressures for use, the pressure rating of the nozzle on test shall be used.

3.2.4.3.3 The nozzle shall be positioned either of two ways; fixed above the ridge of the patternator and in its normal working height to direct its spray onto the corrugated trough, or using an operator to normally swing the lance above the ridge of the patternator at the specified height settings.

3.2.4.3.4 The height setting of the nozzle shall be measured between the edge of the ridge and the orifice of the nozzle. The optimum height (H) setting as specified by the manufacturer plus two others, H $\pm$ 150 mm shall be used in the tests. If the manufacturer does not indicate any specified height, the test should be carried out at the following heights: 300 mm, 400 mm and 500 mm.

3.2.4.3.5 Fan spray nozzle for test shall be positioned so that the largest dimension of the spray pattern is at a right angle to the grooves.

3.2.4.3.6 Cone spray nozzle shall be tested in two or three positions as shown in Figure 2.

3.2.4.3.7 Tests shall be conducted for three trials with 1-minute duration per trial. However, if the liquid collected in one of the tubes has reached 90% of its capacity, test trial shall be stopped and the quantities collected in each tube shall be recorded.

3.2.5 Cut-off Valve

3.2.5.1 This is carried out to evaluate the strength and durability of the cut-off valve.

3.2.5.2 Leak Test

3.2.5.2.1 The inlet of the cut-off device shall be attached to the delivery hose and shall be coupled to a hydraulic pump.

3.2.5.2.2 The outlet of the cut-off device shall be in closed position.

3.2.5.2.3 A minimum pressure of 750 kPa , which is 2.75 times the normal working pressure, shall be applied at the inlet of the device for a period of five minutes.

3.2.5.2.4 Failure, such as leak and breakage shall be observed within the specified observation period of five minutes.

3.2.5.2.5 Test shall be conducted for three trials.

3.2.5.3 Durability Test

3.2.5.3.1 Cut-off device shall be mounted on the test rig as shown in Figure 3.

3.2.5.3.2 A nozzle, which is the standard accessory of the sprayer on test, shall be used.

3.2.5.3.3 The nozzle shall be attached to the outlet of the device and a pressure equal to that of the normal working pressure shall be applied for duration of 50,000 cycles.

3.2.5.3.4 Valve mechanism shall be arranged to be actuated at a rate of not more than 15 times per minute.

3.2.5.3.5 Major and minor damage and other malfunctions of the valve mechanism shall be observed and reported.

3.2.6 Pressure Chamber Fatigue

3.2.6.1 This is carried out to evaluate the strength and durability of the pressure chamber.

3.2.6.2 The pressure chamber shall be subjected to a simulated cycle of stress-free and stress condition using a specially designed rig as shown in Figure 3.

3.2.6.3 The cylinder shall be alternately compressed and decompressed at pressures of 450 kPa and zero pressure respectively.

3.2.6.4 A 12,000 cycles shall be applied to the pressure chamber.

3.2.6.5 Any sign of failure in the form of dent or leaking weld or crack on any parts of the cylinder shall be observed and reported.

3.2.7 Continuous Running

3.2.7.1 This is carried out to detect any abnormality or trouble resulting from continuous operation.

3.2.7.2 The sprayer shall be mounted to a specially designed test rig as shown in Figure 4.

3.2.7.3 An operating pressure equal to that of the normal working pressure shall be set and it shall be the operating pressure throughout the test.

3.2.7.4 A suitable timer for determining total time of operation and a flow meter for measuring the total volume of spray shall be used.

3.2.7.5 The sprayer shall be run continuously for 200 hours and spray a minimum of 14,000 liters of water.

3.2.8 Strap

3.2.8.1 This is carried out to assess the durability of the straps.

3.2.8.2 The sprayer shall be filled with water to its rated capacity and shall be suspended to its straps in a specially designed test rig as shown in Figure 5.

3.2.8.3 The sprayer shall be lifted 300 mm from its original position and allowed to drop and hang solely by the strap for 25 times.

3.2.8.4 Failure or any damage of a part of the straps, strap hangers, or strap clips, leakage in the tank resulting from the test shall be observed and reported.

3.2.9 Drop

3.2.9.1 This is carried out to assess the durability of the sprayer tank to withstand accidental dropping.

3.2.9.2 The empty sprayer without hose and lance shall be dropped from a height of 750 mm using a specially designed test rig. It shall be dropped six times for each four positions as shown in Figure 6.

3.2.9.3 The sprayer filled with water shall be dropped further four times on its base on the same height.

3.2.9.4 Any form of failure or damage of any part of the sprayer shall be noted.

3.2.10 The items to be measured, inspected and evaluated under the laboratory test shall be recorded in Annex B.

3.3 Field Performance Test

3.3.1 Rate of Work

3.3.1.1 This is carried out to establish the field capacity of the sprayer.

3.3.1.2 A field with a minimum area of 1,000 square meters shall be used for each test trial.

3.3.1.3 Three trials shall be made.

3.3.1.4 During the operation, the sprayer tank shall be filled with water. The lance can be swayed or held fixed as long as equal distribution pattern is achieved. The speed, operating time, total area covered and actual width of spray shall be determined.

3.3.2 Ease of Operation

3.3.2.1 This is carried out to evaluate the ease of using the sprayer.

3.3.2.2 Two operators shall operate and evaluate the sprayer.

3.3.2.3 The sprayer shall be evaluated according to the following:

3.3.2.3.1 Adaptation to back of the operator.

3.3.2.3.2 Accessibility and ease of actuating pump handle.

3.3.2.3.3 Ease of actuating the cut-off device.

3.3.2.3.4 Ease of dismantling, assembly and maintenance of the sprayer.

3.3.2.3.5 Ease of filling and cleaning the tank.

3.3.2.3.6 Convenience in fixing the straps and provisions for adjusting strap length.

3.3.2.4 Physical workload/energy expenditures in operating the sprayer shall be assessed by taking the pulse rate/blood pressure of the operator before and after each operation.

3.3.3 Operator's Safety

3.3.3.1 This is carried out to assess the safety of the operator in using the sprayer.

3.3.3.2 The sprayer shall be subjected to different safety tests such as the following:

3.3.3.2.1 Liquid Spillage Test

The sprayer filled with water shall be operated in the field. While pumping, observation shall be made if liquid spills out at the cylinder cap. Also, the operator shall be instructed to bend over while carrying the sprayer. Observation shall be made if the liquid spills out at the tank filler cap and cylinder cap.

3.3.3.2.2 Liquid Drifting Test

The sprayer filled with liquid shall be pumped to working pressure recommended by the manufacturer; observation shall be made if liquid is drifting on the cut-off valve, lance and nozzle connections.

3.3.3.2.3 Tank Filler Cap Test

A full capacity sprayer standing on a level surface shall be pushed until it tips over, observation shall be made if the tank filler cap is removed.

3.3.3.3 The different components of the sprayer shall be checked regarding any injury that the operator may encounter while using the sprayer.

3.3.4 Items to be measured shall be recorded in Annex C.

4 Inspection, Investigation, Measurements and Record Sheet

The items for inspection, investigation, measurements and record sheet are given in Annex A.

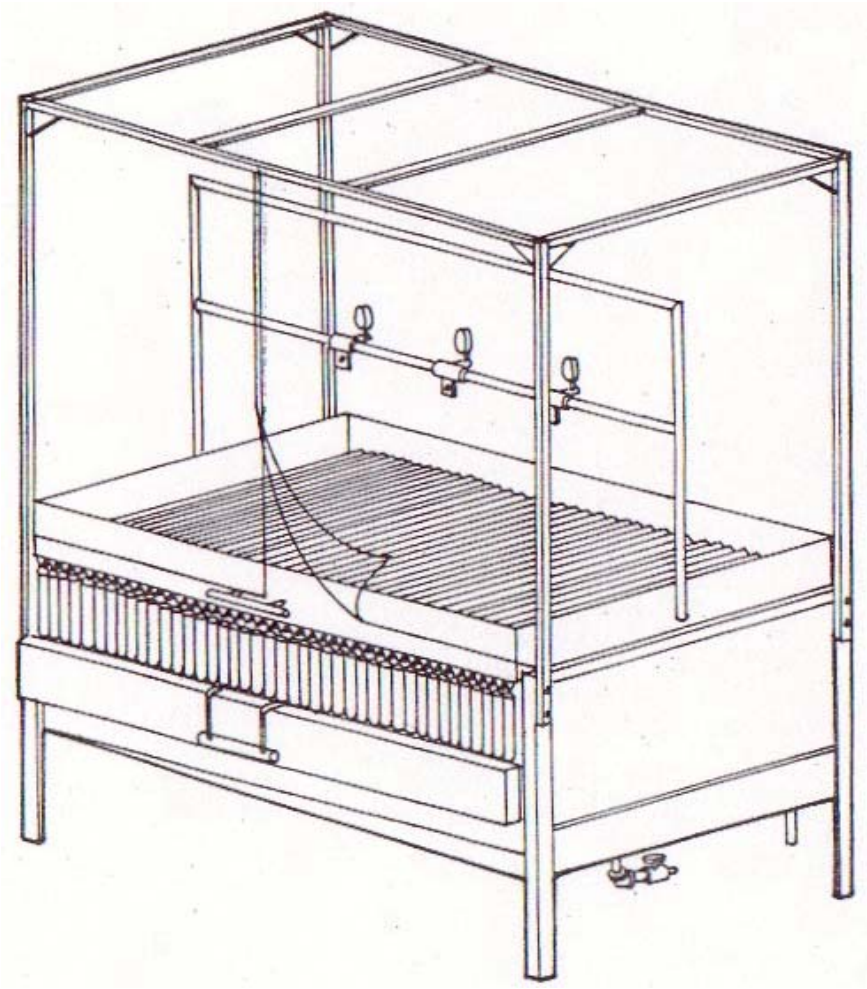

Figure 1 – Patternator

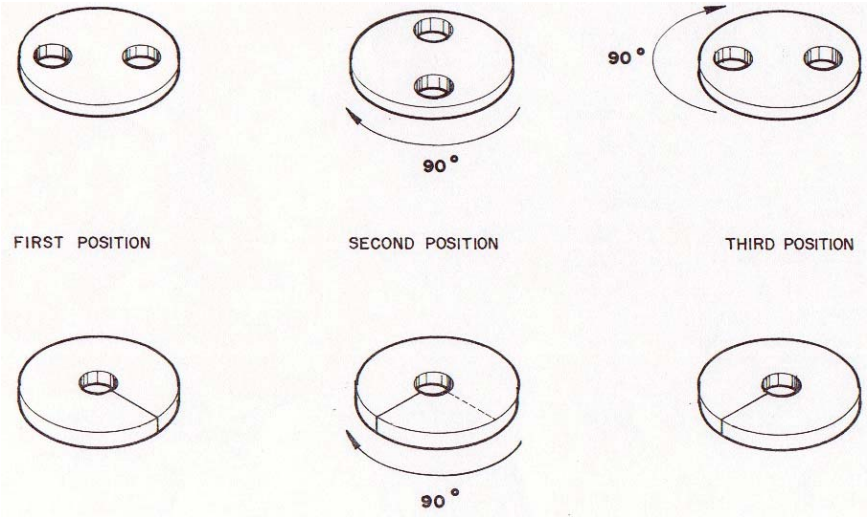

Figure 2 – Test position for cone spray nozzle

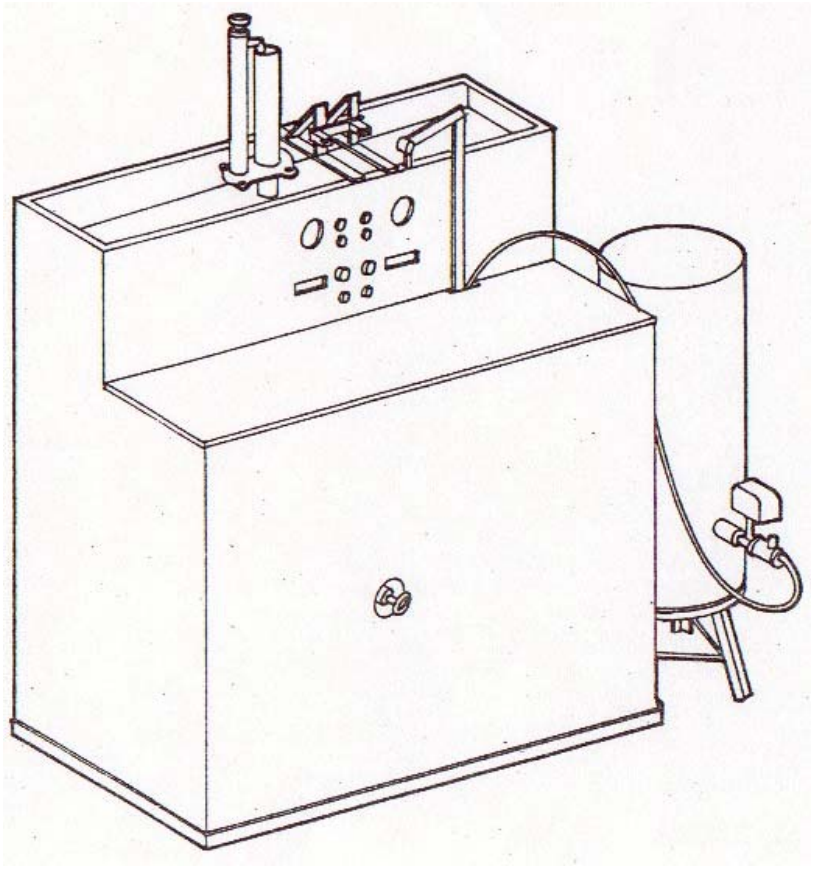

Figure 3 – Pressure chamber/Cut-off device durability test rig

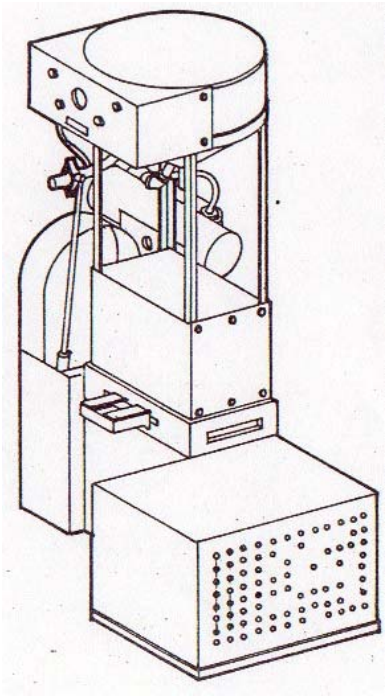

Figure 4 – Continuous-running test rig

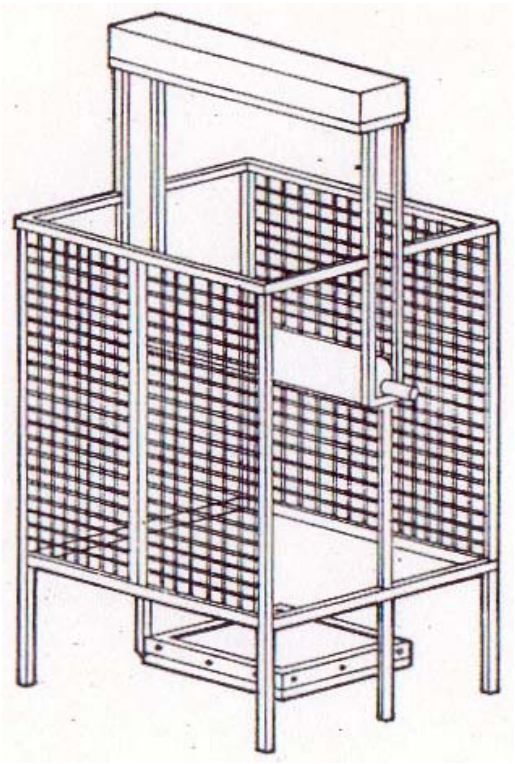

Figure 5 – Drop/Strap test rig

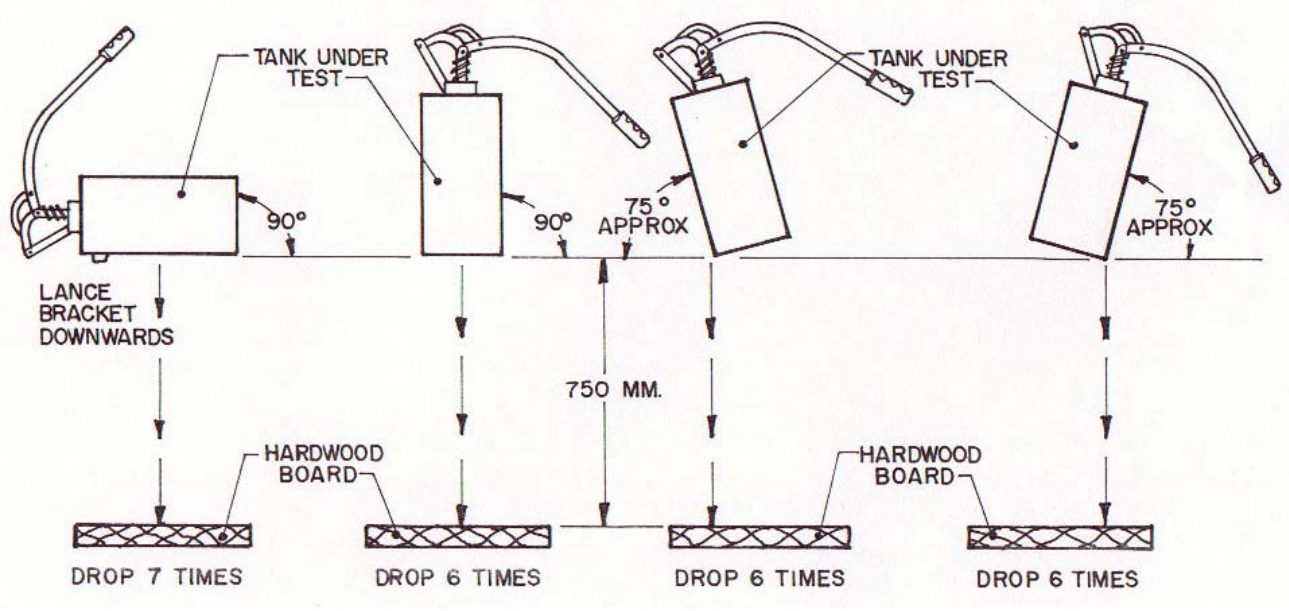

Figure 6 – Drop test

Annex A

Inspection and Verification of Knapsack Sprayer

Name of Applicant : _____
Address : _____
Telephone No. : _____
Name of Distributor : _____
Address : _____
Name of Manufacturer : _____
Factory Address : _____

GENERAL INFORMATION

Make : _____ Model : _____

Serial No. : _____ Classification : _____

Production date of sprayer to be tested : _____

Items to be inspected

ITEMS	Manufacturer's Specifications	Verification by the testing agency
A1 Dimension (in transport position including handle and lance)		
A1.1 Length, mm		
A1.2 Width, mm		
A1.3 Height, mm		
A2 Weight, kg		
A2.1 Without water		
A2.2 With water (tank capacity)		
A3 Working pressure, kg/cm^2		
A3.1 Normal		
A3.2 Maximum		
A4 Tank		
A4.1 Capacity, L		
A4.2 Dimension, mm		
A4.2.1 Length		
A4.2.2 Width		
A4.2.3 Height		
A4.3 Diameter of filler hole, mm		
A4.4 Material		

ITEMS	Manufacturer's Specifications	Verification by the testing agency
A5 Piston Assembly		
A5.1 Length of stroke, mm		
A5.2 Diameter, mm		
A5.2.1 Piston head		
A5.2.2 Cylinder		
A5.3 Material		
A5.3.1 Piston head		
A5.3.2 Cylinder		
A5.3.3 Push rod		
A6 Pressure Chamber		
A6.1 Volume, L		
A6.2 Shape		
A6.3 Location		
A6.4 Material		
A7 Lever		
A7.1 Length, mm		
A7.2 Stroke, mm		
A7.3 Location		
A7.4 Material		
A8 Cut-off Valve		
A8.1 Type		
A8.2 Material		
A9 Delivery Hose		
A9.1 Length, mm		
A9.2 Inside diameter, mm		
A9.3 Thickness, mm		
A9.4 Clamping device		
A9.5 Material		
A10 Lance		
A10.1 Shape		
A10.2 Length, mm		
A10.3 Inside diameter, mm		
A10.4 Material		
A11 Grip (lance)		
A11.1 Shape		
A11.2 Size, Dia. x Length, mm		
A11.3 Material		

ITEMS	Manufacturer's Specifications	Verification by the testing agency
A12 Nozzle		
A12.1 Type		
A12.2 Material		
A13 Strainer/Filter		
A13.1 Filler hole strainer		
A13.1.1 Size of mesh, hole/cm^2		
A13.1.1 Materials		
A13.2 Inlet-strainer (pump)		
A13.2.1 Size of mesh, hole/cm^2		
A13.2.2 Materials		
A13.3 In-line filter (lance)		
A13.3.1 Size of mesh, hole/cm^2		
A13.3.2 Materials		
A13.4 Nozzle filter		
A13.4.1 Size of mesh, hole/cm^2		
A13.4.2 Materials		
A14 Straps		
A14.1 Material		
A14.2 Dimension		
A14.2.1 Length, m		
A14.2.2 Width, m		
A14.2.3 Thickness, m		

Annex B

Laboratory Test Data

B1 Volumetric Efficiency

ITEMS	I	II	III	IV	V	Ave.
Method of operating the lever						
Working pressure, kg/cm^2						
Number of strokes						
Discharge, L						
Volume discharge/stroke, L						
Piston displacement, L						
Volumetric efficiency, %						

B2 Leak Test

TRIALS	Pressure Applied kg/cm^2	Duration min	Final Pressure kg/cm^2	Pressure Drop kg/cm^2
I				
II				
III				
IV				
Ave.				

B3 Tilt and Inversion Tests

Observations:

_____

_____

_____

_____

B4 Nozzle Performance Test

B4.1 Nozzle Discharge Test

Pressure kg/cm^2	Duration min	TRIALS, mL					
		I	II	III	IV	V	Ave.
2.8							
4.2							

B4.2 Nozzle Spray Coverage

Height mm	Spray Coverage at 2.8 kg/cm^2 mm
300	
400	
500	

B5 Cut-off Valve Test

B5.1 Cut-off valve leak test

TRIALS	Pressure Applied kg/cm^2	Duration min	Observations
I			
II			
III			

B5.2 Cut-off Valve Durability Test

Pressure Applied kg/cm^2	Duration pressure cycles	Observations
2.8		
5.6		

B6 Pressure Chamber Fatigue Test

Operating pressure kg/cm^2	Duration pressure cycles	Observation
0 – 4.6		

B7 Continuous-Running Test

Operating pressure kg/cm^2	Total time elapsed h	Observations
2.8		

B8 Strap Test

Height of lift, mm	No. of times dropped	Observations
300		

B9 Drop Test

Position	No. of times dropped	Observations
On the base (upright position)		
On the left side (75° inclination)		
On the back		

Annex C

Field Performance Test Data Sheet

ITEMS TO BE INSPECTED

Particulars	Test Number			
	1	2	3	Ave.
Date of Test				
C1 Test Condition				
C1.1 Field Conditions				
C1.1.1 Location				
C1.1.2 Field type				
C1.1.3 Length, m				
C1.1.4 Width, m				
C1.1.5 Area, m^2				
C1.2 Ambient Conditions				
C1.2.1 Temperature				
Wet bulb, °C				
Dry bulb, °C				
C1.2.2 Wind velocity				
C1.2.3 Weather (sunny, cloudy, rainy, hot, cold, etc)				
C2 Field Performance				
C2.1 Actual operating time, min				
C2.2 Time lost, min				
C2.2.1 Refilling liquid chemical				
C2.2.2 Adjustment				
C2.2.3 Others (give details)				
C2.3 Actual area covered, m^2				
C2.4 Effective field capacity, ha/hr				
C2.5 Effective working width, m				
C2.6 Forward speed, m/min				

Particulars	Test Number			
	1	2	3	Ave.
C3 Labor Requirement				
C3.1 Number of total man-hours of operators				
C3.1.1 Number				
C3.1.2 At test (man/hour)				
C3.1.3 Per ha (man-h/ha)				
C4 Time to fill the tank				
C5 Comment on the following				
C5.1 Conformity to operator's body				
C5.2 Position and shape of lever and fatigue in operation				
C5.3 Ease of manipulating of cut-off device				
C5.4 Ease of dismantling and maintenance				
C5.5 Operator's safety				
C5.6 Other comments (including constructional observations)				