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OPERATIONAL NOTE

A CONSTANT FLOW VALVE FOR HAND-COMPRESSION HYDRAULIC SPRAYERS[1]

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ABSTRACT. A commercial inline constant flow valve for hand-compression hydraulic sprayers was tested to evaluate its capability to maintain constant pressure to the nozzle down to a preset cut-out pressure. The flow-control valve provided consistent flow rates when used with the H.D. Hudson X-Pert 9.5-liter hand-compression sprayers. This flow valve may have potential for use in vector control operations.

KEY WORDS Constant flow valve, hand compression sprayer

The economy, durability, and simplicity of manually operated equipment make them a primary tool of vector control programs in many mosquito-plagued areas of the globe (Anon. 1985, Brown et al. 1993, 1997). One type of application method employed by vector control programs requires the application of residual pesticides to the walls and ceilings throughout a dwelling, targeting resting mosquitoes (WHO 1990). However, in large dwellings, varying application rates can occur during the course of treatment because of the large area and the time required for treatment. When pesticides are applied with conventional hand-compression sprayers, a wide range of application rates can result from a single pressurization of the tank. This variability is caused by the decrease in pressure supplied to the nozzle as the liquid volume decreases and the headspace increases. The rate of pressure loss is related to the volume of headspace at the time of pressurization. This lack of pressure regulation and subsequent erratic flow directly impacts the quality and cost effectiveness of pesticide applications. Inconsistent pressure generated during an application also results in inconsistent droplet emission spectra (Brown et al. 1997). With conventional hand-compression sprayers, the application rate will vary unless the applicator stops and repressurizes the hand compression at frequent intervals (usually 2–3 min). Regardless, the use of lever-operated knapsack sprayers for applying pesticides remains widespread in many countries. A spray valve providing constant flow is a potential solution to pressure variability associated with manually operated equipment.

Several devices have been produced to help maintain constant pressure and improve droplet emission spectra uniformity for manually operated spray equipment (e.g., the spray management valve [Brown et al. 1997]). Another such device is the CFValve™ (constant flow valve; Global Agricultural Technology and Engineering [GATE], Lighthouse Point, FL). The body of the CFValve is constructed of Delrin® plastic and houses a stainless steel throttle pin and spring and a diaphragm of ethylene propylene diene methylene, a terpolymer rubber. It weighs 19.9 g and measures 5 × 3.3 cm. The diaphragm and spring within the valve body sense the inlet pressure from the pump and, together with the backpressure created by the nozzle, continuously modulate the size of the inlet orifice by changing the position of the throttle pin in the orifice. The result is a constant flow rate from the nozzle regardless of changing input pressure at or above the preset operating pressure of the CFValve. The CFValve can be obtained at preset operating pressures of 1, 1.5, 2, and 3 bars (McAuliffe 1999b). This valve was designed initially to work with lever-operated knapsack sprayers and hand-compression sprayers.

Over the past 5 years, this device has been used successfully to spray pesticides on a number of agricultural crops and to reduce the variability of droplet size of the spray while reducing the amount of spray needed for treatment. This in turn contributed to the reduction of pesticide exposure to workers (Choudhury 1998, Eng 1999, McAuliffe 1999a, Shaw et al. 1999).

The purpose of the tests reported here was to evaluate claims of performance made by the manufacturer as a preliminary basis for determining the effectiveness of the CFValve for use in mosquito control operations.

The GATE CFValve at 1, 1.5, 2, and 3 bars were evaluated for performance retrofitted to an HD Hudson X-Pert™ 9.5-liter hand-compression sprayer (Hudson, Chicago, IL) and using a Spraying Systems Co. TeeJet™ 8003 nozzle (Wheaton, IL). Tests were conducted in an enclosed main-

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[1] The opinions and assertions contained herein are the private ones of the writers and are not construed as official or reflecting the views of the Navy Department or Naval Service.

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Table 1. Time to constant flow valve shut-off, H.D. Hudson X-Pert™ 2½-gallon hand compression sprayer with 8003 TeeJet™ nozzles (n = 2).

CFValve bar setting	CFValve shut-off preset pressure (kg/cm²)	Initial sprayer pressure (kg/cm²)	Final sprayer pressure (kg/cm²)	Time to shut off or turn off (min, sec ± SE)	Total water sprayed (ml)
1	0.77	3.87	0.91 ± 0	8′53″ ± 5″	5,940 ± 28.3
1.5	1.19	3.87	1.27 ± 0	5′23″ ± 1″	4,375 ± 7.1
2	1.76	3.87	1.86 ± 0	2′46″ ± 9″	2,595 ± 120.2
3	2.67	3.87	2.80 ± 0	48″ ± 1″	910 ± 14.1
Without valve		3.87	0.67 ± 0	8′32″ ± 14″	7,200 ± 0

tenance shop. Temperatures averaged 22°C and relative humidity averaged 55% over the test period. The hand-compression sprayer and lance were mounted to a work bench. Spraying was conducted off the end of the bench into an 18.9-liter barrel. An air chuck was welded into the Hudson X-Pert sprayer through which air was supplied, and pressures were measured by a standard shop pressure gauge. Two replications were conducted with and without the CFValve and included the following.

(1) Test 1: Time to CFValve shut-off. The sprayer was operated with each of the CFValves in turn. Spray was initiated and timed until automatic shut-off. The spray material, shut-off time, and final pressure (kg/cm²) were measured and are reported in Table 1.

(2) Test 2: Effect of the CFValve on flow rate. In this test, the flow rate (ml) was measured every minute from 0 to 10 min. The test was conducted with and without the CFValve and with and without repressurization between each flow rate measurement. The results are reported in Tables 2 and 3.

Test 1 showed that the HD Hudson X-Pert without the CFValve operated for about 8½ min until the spray pattern became irregular and output decreased. The final pressure in the spray tank was 0.67 kg/cm² (Table 1). Spray solution output and the time from the start of spraying until the appearance of an irregular pattern was a function of the nozzle tip used, the starting pressure, and the initial headspace in the tank. For the CFValves with preset pressures of 1, 1.5, 2, and 3 bars, the sprayer ran for 8.88, 5.38, 2.77, and 0.80 min, respectively, before cutting off. The time from the start of spraying until spraying stops was a function of the nozzle tip used, the preset operating pressure of the CFValve, and the preset pressure at which the valve closed. Over the spray intervals, the water output was 5,940, 4,375, 2,595, and 910 ml, respectively. In all cases, output with the CFValve was less than that produced by sprayers without the valve (7,200 ml).

Table 2. Measured flow compared with expected flow rate for Spraying Systems Co. TeeJet™ 8003 nozzle with and without the GATE Constant Flow Valve™.

CFValve preset pressure (kg/cm²)	Average flow rate (ml/min)	Expected flow rate (ml/min)
1.02	669	683
1.48	813	822
2.04	938	967
3.06	1,138	1,184
Without valve	844	—

The CFValve is designed to regulate pressure at a preset level and to shut off completely once pressure drops below a closing pressure. This closing pressure is 0.21–0.35 kg/cm² below the operating pressure. As measured by the final sprayer pressure, all CFValves closed as expected. Table 2 shows the average measured flow rate for each CFValve tested and the expected flow rate based on a nozzle (TeeJet 8003) with a flow specification of 1,136 ml/min at 2.81 kg/cm² and operating at the prescribed preset valve pressure. In all cases, the measured flow rate was within 96–99% of the expected flow rate. Some flow rate reduction is expected because of the decline in flow with the slight pressure drop prior to valve turn off. Without the CFValve in place, the measured flow rate was 844 ml/min; however, in this situation, pressure and output from the nozzle changed continually from the 3.87 kg/cm² initial tank pressure to 0.67 kg/cm² final pressure. Average pressure was approximately 1.55 kg/cm² based on the measured flow rate for the nozzle in use.

The effect on flow rate from the nozzle with and without the CFValve is shown in Table 3. These data show a constant output of flow at each measurement when the CFValves are used up to the final measurement. Prior to the end of the last minute for which a measurement was made, each CFValve shut off, thus reducing the measured flow rate for the last minute of spray output. The flow rate without a CFValve showed a continuous decline over the course of the test. Consistent output was possible only if the tank was recharged after each minute of operation. These data confirmed that the CFValve improved constant flow from the nozzle.

The average flow rate for the Hudson sprayer without a CFValve was approximately 844 ml/min (Table 2) for the time between initial pressurization and loss of pattern. If the tank were again charged

Table 3. Effect of the CFValve™ on flow rate from the H.D. Husdson™ 9.5-liter hand-compression sprayer and Spraying Systems TeeJet™ 8003 nozzle (n = 2).

Valve and pressure	Bar	Kg/cm^2 (±SE)	Color code	Flow rate (ml) per minute (±SE)[1] 1	2	3	4	5	6	7	8	9
With CFValve	1.0	1.04 ± 0.02	Yellow	680 ± 0	680 ± 0	680 ± 0	690 ± 0	690 ± 0	690 ± 0	685 ± 7	488 ± 345	Shut off
Without repressurization	1.5	1.51 ± 0.05	Red	840 ± 0	840 ± 0	835 ± 7	823 ± 3.5	537 ± 380	276 ± 195	Shut off	0	0
	2.0	1.97 ± 0.09	Blue	955 ± 7	953 ± 9.6	523 ± 480	Shut off	0	0	0	0	0
	3.0	2.97 ± 0.13	Green	950 ± 0	Shut off	0	0	0	0	0	0	0
Without the CFValve and without repressurization between each measurement				1,170 ± 14	1,055 ± 78	895 ± 7	895 ± 7	750 ± 0	695 ± 7	650 ± 0	603 ± 3.5	560 ± 0
Without the CFValve and with repressurization between each measurement				1,165 ± 7	1,190 ± 0	1,205 ± 7	1,205 ± 7	1,240 ± 0	1,240 ± 0	118 ± 11	Shut off	0

to 3.87 kg/cm^2, the remaining water in the tank, 2,263 ml, would be discharged in approximately 2 min (Table 3, flow rate measurements without CFValve). Therefore, the total time to drain a full tank is approximately 10.5 min. This compares with the output from the sprayer fitted with a 0.98 kg/cm^2 and 1.48 kg/cm^2 CFValve as follows. Remaining water would be discharged in about 5.2 and 6.2 min, respectively. The total time to drain a full tank would be approximately 14.1 and 11.6 min, respectively. These times represent an increase in spraying time of 10% for the 1.48 kg/cm^2 CFValve and 34% for the 1.02 kg/cm^2 CFValve. A decrease in spray time means a reduction in water and chemical use per area sprayed. For the 2.04 kg/cm^2 and 3.06 kg/cm^2 CFValves, the flow rate would be higher than that without a CFValve and the time to drain a tank reduced. However, the time and delivery of spray solution is known and consistent.

These tests demonstrated that use of the GATE CFValve can achieve reduced chemical usage, more precise application, and water conservation. Ease of operation and worker safety should also result from the use of these valves. These attributes should be beneficial for disease vector management involving the use of hand compression, knapsack, or other manually operated equipment.

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