Design Consideration in Developing an Accurate Proportioning Device for the Application of Spray Chemicals

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The problems experienced with conventional spray equipment (e.g., the corrosion problem created in carbon steel tanks by spray chemicals) are discussed. The method used to proportion mechanically and accurately spray material and water while traveling is described.

•THE CALIFORNIA Division of Highways has used and tested chemicals in its roadside vegetation control program for several years; however, mechanical methods were most generally employed. During the testing phase, agricultural-type sprayers were used. Various modifications were made to adapt these units for roadside use, but they were still not efficient for use in a comprehensive roadside spraying program. Further investigation of the methods used indicates that the equipment should have the following features:

1. Mobility—Unit should be self-powered, have a 5 to 8 mph working speed, and be able to travel at usual road speeds when going to and from location.
2. Capacity—Capacity should permit the unit to operate as long as possible without stopping for refill, since sources of water are often many miles apart in some of the arid sections of the state. The use of a "nurse tank" requiring an additional vehicle and driver should be eliminated if possible.
3. Operation—All functions of the machine should be controllable by the driver without leaving cab.
4. Coverage—Unit should have at least a 24-ft coverage from either side of the vehicle.
5. Pressure—Delivery pressure should be adjustable between 30 to 60 psi.

Several units were built fulfilling these requirements. The tank capacities varied from 1,500 to 3,000 gal. A 3-in. single-stage centrifugal pump was mounted behind the tank for spraying and filling. A 24-ft hydraulically actuated spray boom was installed on the front bumper.

Operation of these units was observed on the job during the 1962-63 spraying season. The results achieved and the findings of the operators and supervisors were reviewed periodically. The equipment seemed to be generally satisfactory but there were some problems with excess material, agitation, and tank corrosion and contamination.

The spray materials were tank mixed; i.e., the operator estimated the quantity of water required for a given acreage and added the required amount of chemicals. By this method, often sizable quantities of material were left over, depending on the accuracy of the estimates of the operator. Because this excess material was toxic, it could not be promiscuously dumped. Because of the quantity, storage for further use is undesirable; therefore, long trips to dispose of the excess material were sometimes necessary.

Agitation is necessary to keep the wettable powders in suspension. Both mechanical and pressure jet methods have been used with success; however, the power necessary

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to agitate 2,000 gal of liquid by the mechanical method is approximately 3 hp. The pressure jet system was found to require approximately 10 hp. In large tanks the placement of baffles reduce the effectiveness of the agitating system. The number of such baffles should be held to the minimum necessary to prevent excessive tank surge.

The oxidation in the carbon steel tanks accelerated by the chemical additives caused considerable lost time due to plugged filters and spray jets. To overcome this problem, several types of paints and epoxy liners were applied to the interior of the tanks with only mediocre results. The lining was applied according to the suppliers recommendations which includes sandblasting the interior and grinding all welds. In spite of this, flaking occurred. Rusting beneath the coating created pockets for the deposition of chemicals which could not be removed by washing.

Since these tanks are used for irrigation as well as spraying, contamination resulting from the use of 2, 4-D and similar materials had to be removed necessitating steam cleaning.

FINAL DESIGN

Mixing the material with water outside the tank appeared to be the solution to the problem. Several types of commercially available nozzle mixers were investigated, but none were found to have the flexibility and accuracy required for the particular application. It was determined that equipment capable of performing the mixing function outside the tank would be the most economical and accurate means of securing the desired results; therefore, design of the equipment was undertaken to encompass the following parameters:

1. Chemicals—Chemicals and maximum quantities (per acre) most commonly used are as follows: Simazine, 6 lb; Atrazine, 6 lb; aminotriazole, 4 lb; Simazine and aminotriazole, 6 lb; Hyvar-X, 6 lb; Karmex, 10 lb; Dalapon, 15 lb; IPC, 6 lb; TCA, 20 lb; Diquat, 2 qt; Ansar 160, 2 qt; Ansar 529, 2 qt; and 2, 4-D or 2, 45T, 1 gal. New materials are tested as they become available.
2. Application Rate—To secure adequate foliage and ground coverage, 100 gal/acre is generally adequate. Operators are able to estimate quantities and coverage without making computations or resorting to charts.
3. Application pressure—Because of the variety of chemicals, terrain and wind conditions encountered, a variable pressure system is necessary. A pressure gage and a volume meter is mounted in the cab in view of the operator. Pressure, controlled by varying the speed of the pump engine, is variable from 0 to 100 psi.

The pump chosen is a two-stage centrifugal type, 2-in. inlet, with a maximum pressure of 125 psi. The engine is single cylinder, 12 HP and 1,800 rpm. A compact unit is desirable so that mounting can be made near the cab; thus keeping flow losses in the piping to a minimum.

Truck Chassis

A 35,000-lb G. V. W. was selected with a power shift transmission and a torque converter drive. Such a drive system keeps starting shocks to a minimum, reduces horizontal stresses in the boom, and eliminates clutch failure in the truck. The operator is able to direct his attention to the spraying operation, permitting greater travel speeds. "Duplex" tires were mounted on the rear to permit operation in sandy and soft ground. The unit is shown in Figure 1.

Spray Boom

A commercially available "contour-matic" boom, hydraulically actuated and powered from the truck engine, is mounted on the front bumper (Figs. 2 and 3). This allows the driver to have full view of the operation without diverting his attention from the normal line of vision.

The boom is mounted 50 in. above ground level to clear standard roadside markers without raising. Except under windy conditions, little spray drift is encountered at

Figure 1. Overall unit as tested, showing main and proportioning pump mounted near cab.

Figure 2. Front veiw with spray boom folded in travel position and unit being used for irrigating roadside ornamentals (water pipe air actuated for quick lifting to clear signs, etc.).

this height. However, the boom may be lowered or raised by the operator to suit the local conditions.

Main Tank

Main tank capacity is 2,000 gal. The tanks are oval in shape, the major diameter being 90 in. and minor diameter 50 in. As a result, the tank is relatively short, permitting the use of a short wheel-base truck and eliminating the need for longitudinal tank supports. This further allows adequate space on the rear for mounting the chemical tanks and engine for agitation of the materials.

Figure 3. Spray boom in operation with irrigation pipe in travel position.

Figure 4. Rear view showing two chemical tanks and agitating engine with drive belts beneath platform and retractable rear step.

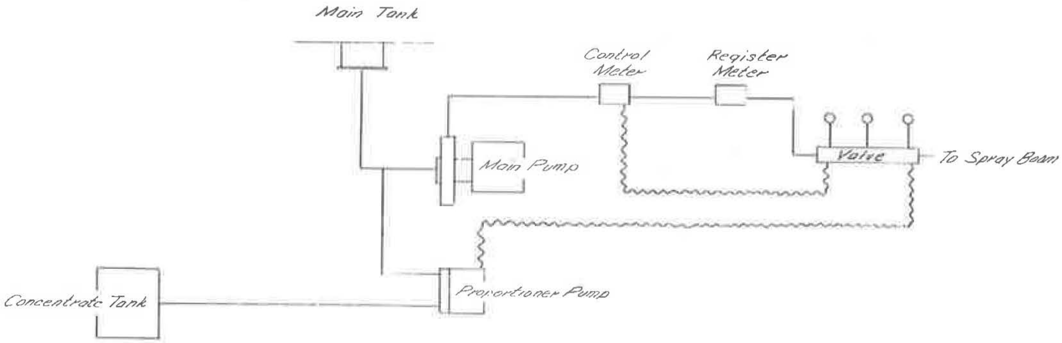

Figure 5. Flow system of proportioner.

TABLE 1

APPLICATION RATE SCHEDULE FOR AMINOTRIAZOLE[a]

Truck Speed (mph)	Pump Pressure (psi)
3.0	14
3.5	18
4.0	23
4.5	28
5.0	33
5.5	39
6.0	45

[a]Applicate rate, 4 lb/acre; 4 lb/gal of water mixed in concentrate tank; proportioner dial set at 40.

Chemical Tanks

Two 60-gal capacity chemical tanks are fabricated from 303 stainless steel and mounted at the rear of the vehicle (Fig. 4). Mechanical agitation is provided by a propeller-type mixer in the bottom of each tank and driven by a 1½-hp vertically mounted gasoline engine. Not all chemicals require constant agitation; therefore, the engine may be used intermittently. The tanks are connected to a common line by valves which permit the use of two different chemical types. A pressure hose is provided at the tanks for flushing and filling.

Proportioning System

The proportioning system is an adjustable pumping unit modulated by volume changes and is not materially affected by pressure changes. Figure 5 is a typical flow diagram of the unit. According to this diagram, when the valve is opened, water is drawn from the main tank by the main pump, pressurized and caused to flow through the control meter, register meter, control valve, and spray boom to the spray jets.

Water flowing through the control meter causes a set of electrical contacts to cycle once for each ⅛ gal of fluid passing through the meter. On closure, a 12-volt electrical relay causes the positive displacement diaphragm pump to inject a predetermined quantity of spray chemical drawn from the concentrate tank into the inlet of the main pump where it is thoroughly mixed with the water drawn from the main tank and ejected through the spray boom as long as the control valve remains open.

The proportioning pump is an adaption of a device used in municipal water systems to add chlorine or other chemicals to the water. A positive displacement unit, it is designed for a constant running speed of 1,800 rpm. The pumping stroke is brought about by an electrically pulsed clutch which causes only one revolution of the piston assembly. Unless additional signals are present, the clutch disconnects after one complete cycle and is again in position to receive the next signal.

The power for the proportioning pump is taken from the shaft of the main pump through a V-belt. The speed of the proportioning pump is not critical. However, since it is driven by the main pump, the speed of the two units is always relative and an additional power source is unnecessary.

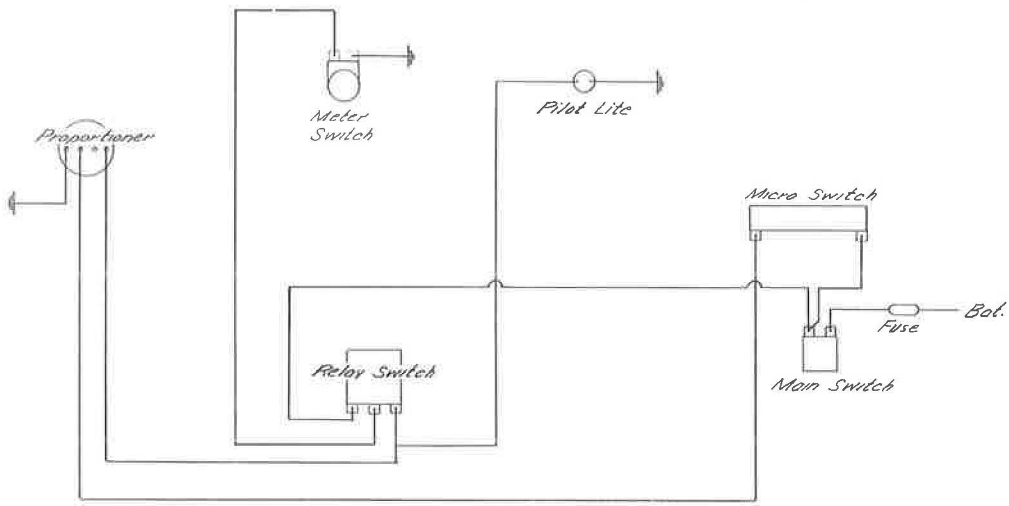

Figure 6. Wiring diagram for proportioner.

TABLE 2

AVERAGE RESULTS OBTAINED FOR FIVE-MINUTE TEST

Metering Pump Setting (%)	Gage Pressure (psig)	Avg. Water Delivery (gal)	Avg. Concentrate Delivery (gal)	Metering Pump (rpm)
100	35	124.9	4.32	1,500
	55	160.3	5.16	1,925
	80	194.4	6.25	2,250
75	35	124.9	3.09	1,500
	55	160.3	3.59	1,925
	80	194.4	4.44	2,250
50	35	124.9	1.64	1,500
	55	160.3	2.03	1,925
	80	194.4	2.29	2,250
25	35	124.9	0.89	1,500
	55	160.3	1.14	1,925
	80	194.4	1.52	2,250

The quantity of material delivered per stroke of the pump is adjustable by rotating a calibrated dial which is marked in percent of total ouput per stroke. A typical material application rate schedule is given in Table 1.

Electrical

The power to operate the clutch is supplied by the vehicle battery. Timing is accomplished by the meter switch (Fig. 6) which is a integral part of the control meter (Fig. 5).

The control meter is an adaption of a remote reading water meter. The magnetic reed contacts in the factory unit failed after a few hours of operation. A four-lobe cam activating a roller-type microswitch was installed and operation has been reliable and positive since this alteration.

As shown in Figure 6, the control meter switch operates a relay which has sufficient current-carrying capacity to supply the 6 amperes required to close the magnetic clutch in the proportioning pump.

A microswitch, mounted on the spray control console, is operated by the handle of the control valve. The function of this switch is to disconnect the system in the event the pulse meter switch remains in the closed position when the unit is not in operation. Without this feature, the proportioning pump would continue to inject chemical into the system although there was no flow from the main pump.

Static tests were run at several pressure and rate settings. The accuracy was found to be well within the limits of good spraying practice (Table 2).

Although considerable controversy has developed over the use of herbicides and pesticides, reports indicate that these materials are being utilized in ever-increasing quantities. Because of the more toxic varieties and higher concentrations now available, more accurate control of the application rate appears desirable. From the standpoint of public relations, operating economy, and equipment maintenance, further efforts in the field of equipment development are justified.