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Evaluation Report 35

Riteway RS-400 Field Sprayer

A Co-operative Program Between
ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

Riteway RS-400 Field Sprayer

Manufacturer:

Riteway Manufacturing Company Limited
1421 - 7th Avenue
Regina, Saskatchewan
S4R 1B7

Distributors:

Alberta - Renn Sales Ltd., Edmonton and Calgary.
Saskatchewan and Manitoba - Riteway Mfg. Co. Ltd., Regina

Retail Price:

$1,998.00 (April, 1977, f.o.b. Regina).

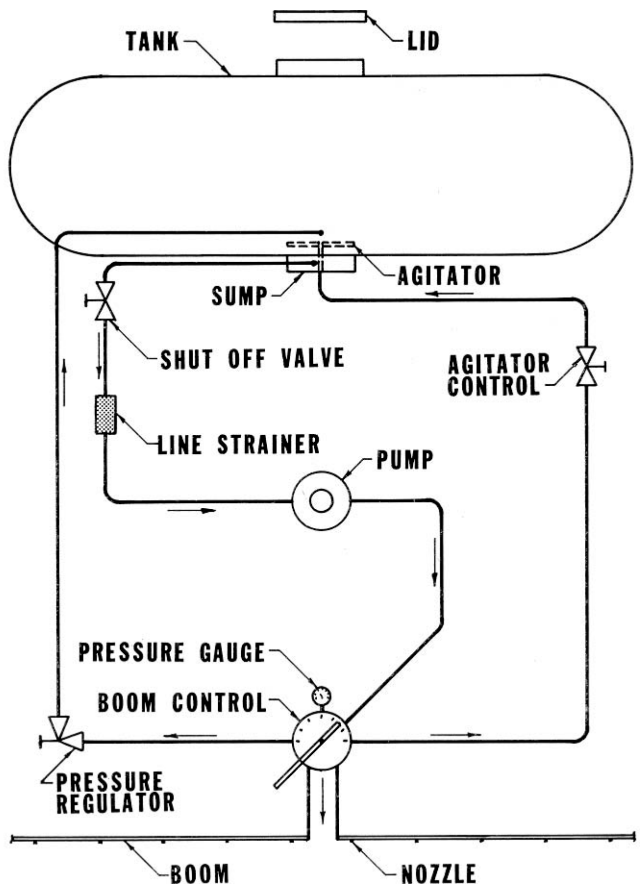

Figure 1. Flow Diagram for Riteway RS-400.

Summary and Conclusions

Functional performance of the Riteway RS-400 field sprayer was fair. Functional performance was reduced by the poor spray pattern at the centre of the spray boom. An extended durability test was not conducted. Durability of the RS-400 during functional evaluation was good.

The RS-400 performed satisfactorily at speeds up to 10 km/h (6 mph) resulting in a field capacity of 18 ha/h (44 ac/h). Severe castor wheel shimmy occurred at higher speeds.

Nozzle distribution patterns were unacceptable at pressures below 310 kPa (45 psi) with the low volume 65° brass nozzle tips supplied as standard equipment. Distribution patterns improved at higher pressures but resulted in excessive spray drift. Although very uniform distribution patterns were possible if the sprayer had been equipped with 80° nozzles, the spray pattern directly behind the trailer was poor due to the boom configuration.

Nozzle tip wear increased output by 8°/0 in 61 hours of use. Nozzle check valves occasionally stuck open allowing some nozzles to drip when the boom control valve was closed.

Pump capacity was adequate to agitate and apply most commonly used chemicals. Pressure losses through the plumbing system were minimal.

Filtering was adequate except for occasional plugging of the 100 mesh nozzle screens.

Spraying pressure was easily controlled from the tractor seat but the agitator control could not be reached. Boom height adjustment was inconvenient and boom angle adjustment was very inconvenient. Folding into transport, hitching to a tractor and servicing were convenient. Transport maneuverability was adequate. There was no tank drain plug. No operator's manual was available.

Several minor mechanical problems occurred during the test: the holes in the radius braces wore, the boom carrier screws loosened frequently and poor routing and fastening of the boom hoses caused hose damage.

Recommendations

It is recommended that the manufacturer consider:

1. Modifying the boom configuration at the centre of the sprayer to improve the spray pattern and to permit the use of a wider variety of nozzle tips.
2. Supplying 80° nozzle tips as standard equipment.
3. Modifications to eliminate loosening of the boom carrier bolts during operation.
4. Modifications to eliminate castor wheel shimmy.
5. Modifying the castor lock pin to prevent chain failure.
6. Modifying the boom hose inlets to prevent buckling of the boom hose.
7. Providing boom hose tie downs and re-routing the hoses to eliminate hose damage.
8. Supplying a high capacity 100 mesh strainer at the tank filler opening.
9. Relocating the tank filler opening and providing a platform to facilitate safe and convenient addition of chemicals to the tank.
10. Providing a tank drain plug.
11. Relocating the agitator control valve so that it can be adjusted from the tractor seat.
12. Modifying the front radius arm brackets so they are more accessible.
13. Modifying the radius braces to prevent premature failure at the pin holes.
14. Supplying a slow moving vehicle sign.
15. Supplying an operator's manual.
16. Supplying a metric or dual calibrated pressure gauge or suitable conversion charts to facilitate sprayer operation after conversion to the S.I. System.

Chief Engineer - E.0. Nyborg
Senior Engineer - E.H. Wiens
Project Engineer - K.W. Drever

The Manufacturer States That:

With regard to recommendation number:

1. The boom configuration has been changed to achieve a standard nozzle spacing of 508 mm (20 in) at the centre of the sprayer. The centre nozzles are no longer angled inward.
2. 80° nozzles are being supplied as standard equipment on our 1977 production.
3. Lock washers are being supplied to eliminate loosening of the boom carrier bolts during operation.
4. A totally new castor system has been developed and implemented for 1977.
5. The castor lockpin has been modified by welding a "T" to the top of the pin.

6&7. The boom is now being fed from the end and the hoses have been rerouted.

8. We have not developed a high capacity strainer at the tank filler opening but plan to do so in the future.
9. We are considering changing the tank filler opening.
10. A tank drain plug will be provided for 1978 production.
11. The agitator control valve has been moved up to the selector valve.
12. We are considering this recommendation for the future.
13. The radius braces have been modified and strengthened for 1977 production.
14. The sign has been left for the operator to provide in 1977. It will be featured as standard equipment on the 1978 production.
15. An operator's manual is being composed.
16. We are sure that pressure gauges will be metric or dual calibrated for 1978 production before conversion to the SI system and will be featured as standard equipment.

General Description

The Riteway RS-400 is a trailing boom type sprayer. The trailer is mounted on tandem axles and each boom is supported by a castor wheel. The low profile, 1818 L (400 gal) galvanized steel tank is equipped with hydraulic agitation and a fluid level indicator. The RS-400 has 36 nozzles spaced at 508 mm (20 in) resulting in a spraying width of 18,288 mm (60 ft). Nozzles are equipped with check valves to prevent spray drip when the booms are shut off. Boom height and spray angle are adjustable. The booms fold back for transport. Controls are mounted on a pedestal at the front of the trailer. The 540 rpm teflon roller pump is driven from the tractor power take-off.

Figure 1 shows the flow diagram for the RS-400 while complete specifications are contained in Appendix I.

Scope of Test

The Riteway RS-400 was operated for 61 hours in the conditions shown in Table 1 while spraying about 1086 ha (2684 ac). It was evaluated for quality of work, distribution patterns, nozzle wear, pump capacity, ease of operation, operator safety and suitability of the operator's manual.

Table 1. Operating Conditions

Chemical Applied	Hours	Speed km/h	Speed (mph)	Spraying Rate ha/h	Spraying Rate (ac/h)	Field Area ha	Field Area (ac)
2, 4-D	51	10	(6.0)	18	(44)	908	(2244)
Banvel	10	10	(6.0)	18	(44)	178	(440)
TOTAL	61					1086	(2684)

Results and Discussion

QUALITY OF WORK

Distribution Patterns: Figure 2 illustrates the positioning of the nozzles at the centre of the RS-400. This design eliminates the need for a third boom behind the sprayer tank and simplifies boom height and angle adjustment. To obtain pattern overlap the two inside nozzles are angled inward, using the same 65° nozzles (TeeJet 6501) as used on the rest of the booms. As a result of this design, the spray pattern directly behind the tank was unacceptable. High spray application occurred at the centre of the sprayer, where the patterns from the two inside nozzles met, with reduced coverage on either side of this peak. A typical spray pattern for the centre boom section is shown in Figure 3. The application rate at 8 km/h (5 mph) varied from 25 to 98 L/ha (2.2 to 8.7 gal/ac) over the 1000 mm (40 in) length of boom covered by the two angled nozzles. This distribution pattern had a coefficient of variation (CV)* of over 27%.

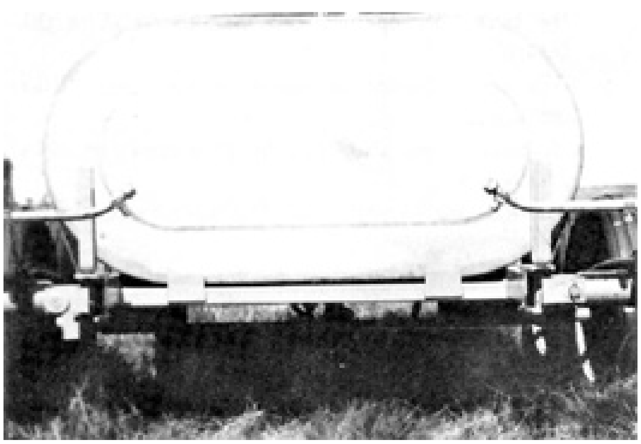

Figure 2. Boom Design at the Centre of the RS-400.

The distribution pattern for a straight section of boom, operating at the same pressure, is shown in Figure 4. This figure shows an improved distribution pattern with a CV of 16%. For this boom section, the application rates at 8 km/h (5 mph) varied from 35 to 67 L/ha (3.1 to 6.0 gal/ac).

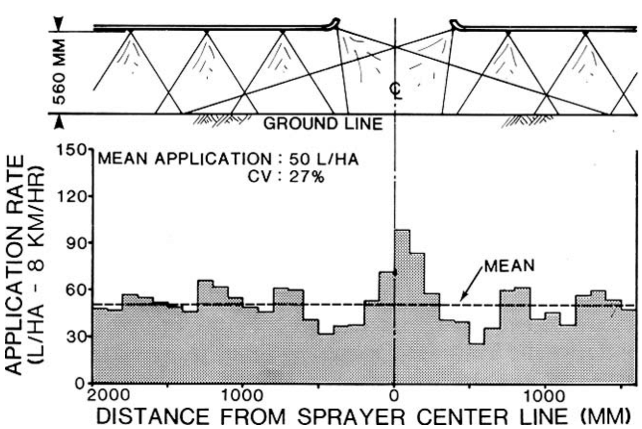

Figure 3. Distribution Pattern at the Centre of the Spray Boom at 275 kPa (40 psi) Pressure with TeeJet 6501 (65°) Nozzles, 560 mm (22 in) above the Ground.

Unacceptable distribution patterns at the centre of the sprayer were evident at all operating pressures. The boom design requires modification to improve the spray pattern and prevent high chemical concentrations at the centre of the sprayer.

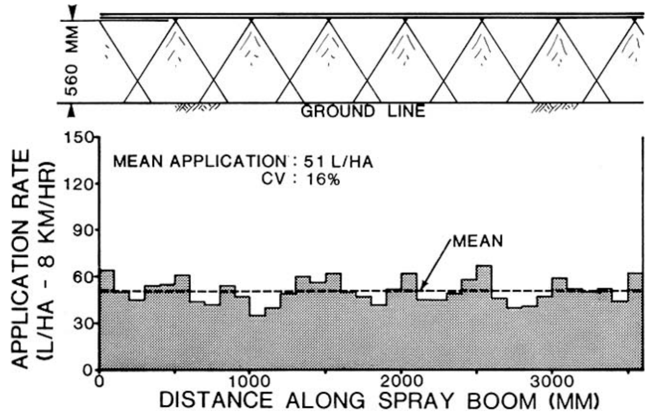

Figure 4. Distribution Pattern for a Straight Section of Spray Boom at 275 kPa (40 psi) Pressure with Tee Jet 6501 (65°) Nozzles, 560 mm (22 in) above the Ground.

Figure 5 shows the distribution pattern at the centre of the sprayer when using 65° nozzles at a pressure of 140 kPa (20 psi). In this case, the CV was 54% with application rates along the boom varying from 3 to 73 L/ha (0.3 to 6.5 gal/ac) at a forward speed of 8 km/h (5 mph). At low pressures, high concentrations occur directly below each nozzle with inadequate coverage between the nozzles. Higher pressures improve the distribution pattern but result in more spray drift.

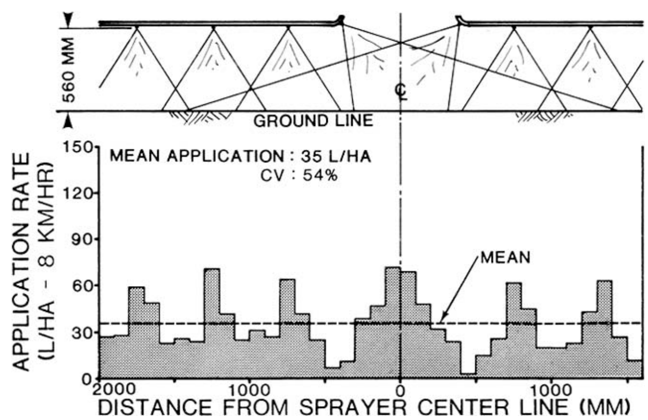

Figure 5. Distribution Pattern at the Centre of the Spray Boom at 140 kPa (20 psi) Pressure with TeeJee 6501 (65°) Nozzles, 560 mm (22 in) above the Ground.

* The coefficient of variation (CV) is a measure of distribution pattern uniformity. The lower the CV, the more uniform is the spray coverage. Some researchers claim that a CV below 10% indicates very uniform coverage while a cv above 15% indicates inadequate uniformity of coverage for chemicals having a narrow range of application rates. The CV's shown in this report were determined in stationary laboratory trials. Field trials have shown that the CV in actual field conditions may be up to 10% higher than that obtained in stationary tests due to boom vibration and wind effects. Manufacturer recommendations for different chemicals vary as to the acceptable range of application rates. For example, 2, 4-D solutions have a fairly wide range of acceptable rates (±14%) while chemicals such as Buctril M have a very narrow acceptable range.

Figure 6 compares spray pattern uniformity at various boom pressures, for the RS-400 boom with angled centre nozzles (Figure 2), for a straight boom without angled centre nozzles, both using 65° nozzles (TeeJet 6501), and for a straight boom using nozzles of the same capacity but with a spray angle of 80° (TeeJet 8001).

Spray distribution was unacceptable on the centre boom section at pressures below 310 kPa (45 psi). Using the same 65° nozzles on a straight boom section, spray distribution was unacceptable at pressures below 283 kPa (41 psi). Neither of these boom configurations produced very uniform distribution (CV less than 10%) in the accepted operating range below 310 kPa (45 psi). However, the straight boom section with 80° nozzles produced acceptable spray distribution at pressures above 200 kPa (29 psi) and in the range from 225 to 340 kPa (33 to 50 psi) the distribution was very uniform. It is evident that 80° nozzles would greatly improve spray distribution and allow spraying at lower presures to reduce drift.

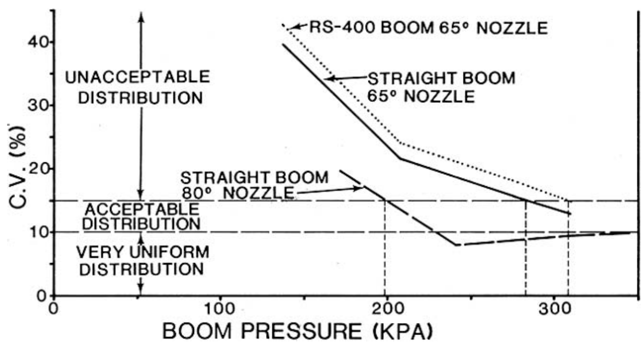

Figure 6. Spray Pattern Uniformity at Various Boom Pressures with 65° and 80° Nozzles.

Spray Drift: To obtain an acceptable spray distribution, the RS-400 had to be operated at boom pressures above 310 kPa (45 psi). Acceptable distribution was achieved at pressures above 283 kPa (41 psi) on straight boom sections with 65° nozzles (TeeJet 6501) or above 200 kPa (29 psi) with 80° nozles (TeeJet 8001). Work by the Saskatchewan Research Council* indicates that drift at the edge of the spray pattern is about 3% of the sprayer output when spraying 56 L/ha (5 gal/ac) at 170 kPa (25 psi). Increasing the pressure to 275 kPa (40 psi) nearly doubles the drift. Using 80° nozzles results in less drift since lower pressure is required to obtain suitable distribution. In addition, 80° nozzles are operated at a lower boom height. It is recommended that the manufacturer supply 80° nozzles as standard equipment to reduce spray drift and to improve spray distribution.

Nozzle Calibration and Wear: Figure 7 compares the delivery rates of the TeeJet 6501 brass nozzles when new and after 61 hours of operation. Nozzle wear during field operation caused the output of the nozzles to increase by 8% . Some researchers indicate that a nozzle needs replacement once delivery has increased by more than 10%. Nozzle wear depends on the type of chemicals sprayed and water cleanliness.

* Maybank, J. and Yoshida, K., "Droplet Deposition and Drift from Herbicide Sprays", Saskatchewan Research Council Report No. P73-16, December, 1973, page 65.

Figure 7 also shows the variability among individual nozzles. The shaded areas represent the range over which the deliveries from 10 nozzles varied when new and after field tests. A narrow range indicates that nozzle discharges are very similar while a wider range indicates more variability among individual nozzle deliveries. Variability among individual nozzle deliveries on the RS-400 was low. The coefficient of variation of the nozzle deliveries was 2.3% when new and increased to 3.6% after the field tests.

The delivery of the new nozzles was 8% lower than the manufacturer's rated capacity. This was due to the nozzle check valves which caused a 35 kPa (5 psi) pressure drop from the boom to the nozzles.

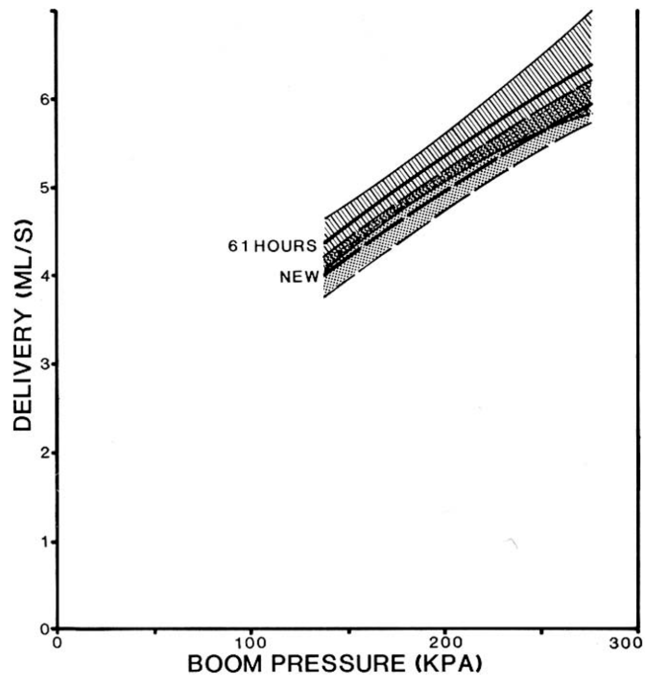

Figure 7. Delivery Rates of TeeJet 6501 Nozzles - New and Used 61 Hours.

Use of Optional Nozzles: The RS-400 was equipped with standard TeeJet nozzle body assemblies (Figure 8), so a wide range of nozzle sizes could be used. Flooding or cone type nozzles, which require a nozzle angle other than vertical, would not function normally due to the boom configuration at the centre of the sprayer.

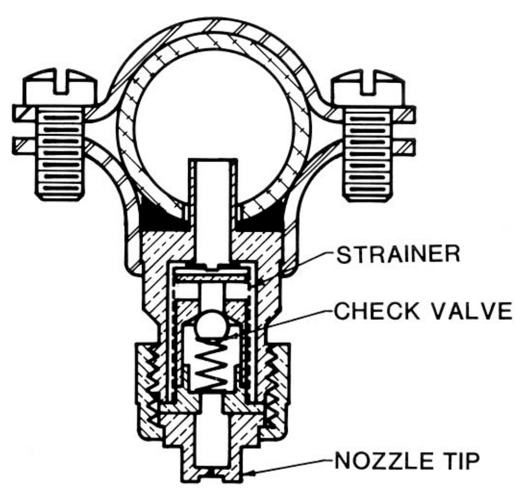

Figure 8. Cross Section of Nozzle.

Booms: The RS-400 was driven over a series of standard obstacles to determine boom stability. The obstacles were semi-circular in cross section with lifts of 40, 65 and 105 mm (1.6, 2.6 and 4.1 in). The boom castor wheels were driven over the obstacles at speeds of 6, 9 and 12 km/h (3.7, 5.6 and 7.5 mph). Both the horizontal boom movement in the direction of travel and the vertical boom movement were measured at the boom end and midway between the castor wheels and trailer.

Figure 9 shows vertical boom movement (bounce) when the castor wheel was driven over the obstacles at 9 km/h (5.6 mph). The maximum movement at the end of the boom was a lift of 130 mm (5.1 in) and a drop of 80 mm (3.1 in). This resulted in a variation in boom height above the ground from 480 mm (18.9 in)to 690 mm (27.2 in), compared to the correct boom height of 560 mm (22 in). Figure 10 compares the nozzle overlap at these three boom heights.

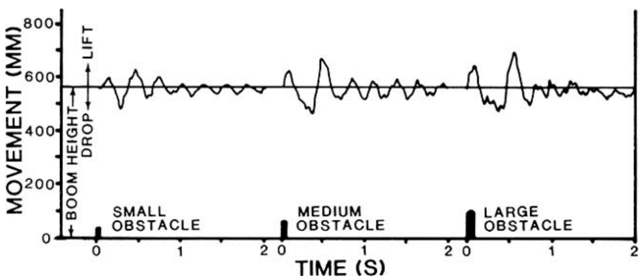

Figure 9. Vertical Boom Movement at Boom End (lift and drop) when the Boom Castor Wheel is Driven over Different Obstacles at a Forward Speed of 9 km/h (5.6 mph).

Figure 11 shows the forward speed of the boom end relative to the ground when the boom wheel was driven over the standard obstacles. Boom forward speed is important since application rate is inversely proportional to speed (doubling the forward speed cuts the application rate in half). Assuming that the nozzle spray follows boom movement, Figure 11 illustrates the resultant variation in application rates. High application rates occur at low speeds while low application rates occur at high speeds. Extremely high variations in application rates can result for short periods of time due to horizontal boom movement. For example, at a forward speed of 9 km/h (5.6 mph) driving over the 65 mm (2.6 in) obstacle caused boom speed to vary from 3 to 14 km/h (1.9 to 8.7 mph). Respective application rates would vary from 133 to 29 L/ha (11.8 to 2.6 gal/ac). This variation occurred in only 0.14 second during which time the sprayer travelled 350 mm (14 in). Speed changes due to horizontal boom movement were very similar on the RS-400 at operating speeds of 6 and 9 km/h (3.7 and 5.6 mph). At 12 km/h (7.5 mph), speed changes were much larger. In addition, when passing over the largest obstacle at 12 km/h (7.5 mph) the castor wheel made a complete rotation about the castor pivot as it was going over the obstacle. This caused extreme bouncing of the boom and the boom took about twice as long to stabilize after passing over the obstacle.

The data presented in Figure 11 are based on the assumption that the nozzle spray output follows boom movement over very short periods of time (0.1 second). The extreme variations in application rate that are suggested due to boom movement indicate that more research is required on boom stability and its effect on nozzle discharge and spray distribution.

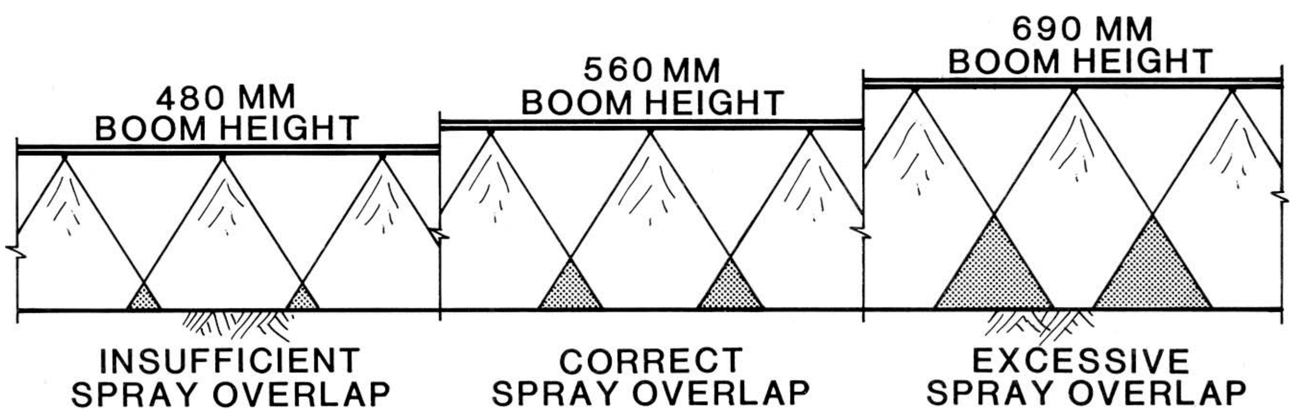

Figure 10. The Effect of Boom Lift and Drop on Spray Overlap.

The lift and drop at the centre of the boom was about half that at the boom end.

Operations at 6 km/h (3.7 mph) caused vertical boom bounce about half as great as that at 9 km/h (5.6 mph). Driving over the obstacles at 12 km/h (7.5 mph) caused vertical boom bounce about 1.5 times greater than that at 9 km/h (5.6 mph).

Driving over an obstacle with the boom wheels also caused the forward speed of the boom to vary in relation to the tractor speed since the boom initially deflects rearward and then springs forward.

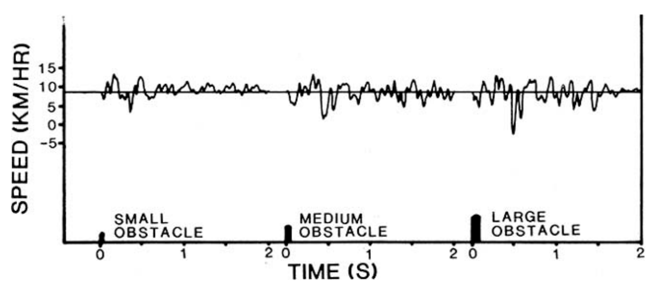

Figure 11. Variation in Boom End Speed when the Boom Castor Wheel is Driven over Different Obstacles at an Average Forward Speed of 9 km/h (5.6 mph).

Measurements of boom stability and field observations indicated that the rigid boom carrier design used in the RS-400 aided in reducing boom movement. The booms operated satisfactorily on rolling terrain and across gullies.

Castor Wheels: The castor wheels on the RS-400 shimmied excessively at field speeds greater than 10 km/h (6 mph) and sometimes made complete turns, especially on corners. Modifications to eliminate castor wheel shimmy are required.

Pressure Losses in Plumbing System: Plumbing system pressures were measured at the pump outlet, boom control, boom inlet and boom end. Pressure drop throughout the system was negligible indicating that hose and fitting sizes were adequate.

The non-drip nozzle check valves (Figure 8) caused a pressure drop of 35 kPa (5 psi) at the entrance to each nozzle. This pressure drop could affect calibration and nozzle spray patterns. Control valve pressure must be set 35 kPa (5 psi) higher than the desired application pressure to compensate for this pressure drop.

Buckling of the boom supply hoses (Figure 12) could possibly cause appreciable pressure drops as the hoses became fatigued. Modifications are required to eliminate this possibility.

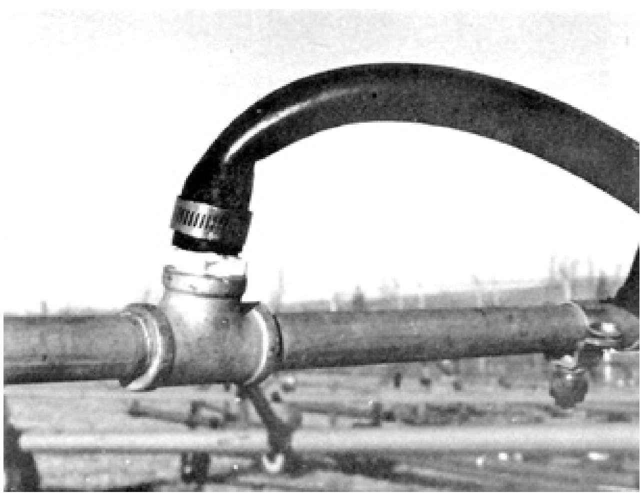

Figure 12. Buckling of Supply Hose at Boom Inlet.

Pressure Gauge: The pressure gauge read 14 kPa (2 psi) low at the beginning of the test and 28 kPa (4 psi) low at the end of the test. This was a significant error since calibration and nozzle spray patterns were affected. The pressure gauge was calibrated only in psi. Due to the changeover to the SI system (metric), a pressure gauge calibrated in both psi and kPa, or suitable conversion tables, should be supplied with the sprayer.

Tank Strainer: No strainer was provided at the tank filler opening. A fine (100 mesh) high capacity strainer would be desireable to strain out foreign particles before they entered the sprayer tank.

Line Strainer: The 50 mesh screen in the line strainer adequately removed most abrasive materials that could damage the pump. Water containing, impurities smaller than 50 mesh, such as sand, could cause pump damage. The plastic strainer bowl was convenient to remove for cleaning without the use of tools. The strainer gasket did not seat properly when the sprayer was new, causing the strainer to leak. After a few hours of operation the gasket expanded and leaking stopped.

Nozzle Strainers: The 100 mesh nozzle strainers prevented nozzle plugging but occasionally the strainer plugged with material that passed through the 50 mesh line strainer.

The check valves located in the nozzle strainers usually stopped boom drip after the boom control valve was shut off. Occasionally, some check valves stuck open and required tapping to properly seat them.

Soil Compaction and Crop Damage: The trailer and boom wheels travelled over about 2% of the total field area sprayed. The wheel tread of the trailer was 1 844 mm (6.0 ft) and matched the wheel tread on most tractors used for spraying. The only crop damage, in addition to that caused by the tractor wheels, was that caused by the castor wheels. This was only 0.6% of the total area sprayed. The soil contact pressure beneath the castor wheels was about 80% that of an unloaded pickup truck and would probably cause some crop damage. The average soil contact pressures under the sprayer wheels, with a full tank, are given in Table 2.

Table 2. Soil Compaction by Sprayer Wheels

	Average Soil Contact Pressure* With Tank Full		Tire Track Width	
	kPa	psi	mm	(in)
Trailer Wheels	234	(34)	130	(5.1)
Castor Wheels	165	(24)	57	(2.2)

* For comparative purposes, an unloaded pickup,truck has an approximate soil pressure of 207 kPa (30 psi).

PUMP CAPACITY

Agitation Capability: The new pump delivered 1.18 L/s (15.6 gal/min) at 276 kPa (40 psi) and 540 rpm (Figure 13). This was adequate to apply 177 L/ha (15.8 gal/ac) of emulsifiable concentrates or 67 L/ha (5.9 gal/ac) of wettable powders at 8 km/h (5 mph) and provide sufficient agitation to keep solution in the tank properly mixed. Normally recommended agitation rates for emulsifiable concentrates such as 2,4-D are 0.03 L/s per 100 L of tank capacity (1.5 gal/min per 100 gal of tank capacity). For wettable powders such as Atrazine and Sevin recommended agitation rates are 0.05L/s per 100 L of tank capacity (3.0 gal/min per 100 gal of tank capacity).

If a 20% pump wear allowance is assumed, a worn pump could apply 130 L/ha (11.6 gal/ac) of emulsifiable concentrates or 18 L/ha (1.7 gal/ac) of wettable powders while keeping the solution in the tank sufficiently agitated. The pump was adequate for most chemicals when new but was not adequate for wettable powders, if worn.

Operation at Reduced Speed: Figure 13 also shows that reducing pump speed from 540 rpm to 400 rpm resulted in a 30% decrease in pump output. Reduction in pump speed could occur when reducing tractor speed to turn a corner or when operating at reduced engine speed to obtain a correct ground speed to suit nozzle calibration.

Pump Wear: Pump capacity decreased by 6% after 61 hours of field operation. Pump wear depends on the type of chemicals sprayed and amount and type of abrasive materials in the water.

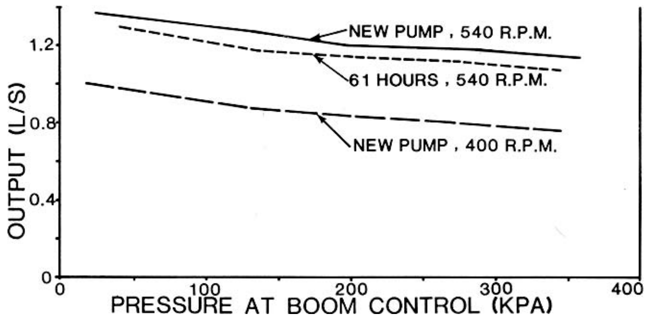

Figure 13. Pump Curves.

EASE OF OPERATION

Controls: Application rate was controlled by adjusting tractor speed and spraying pressure. Pressure was easily regulated by adjusting the pressure regulator (Figure 14). Chemical flow to the booms was conveniently controlled with the selector lever. Most controls were accessible and the pressure gauge was easily read from the seat of most tractors. The agitator control valve (Figure 15), which was located near the bottom of the tank, could not be reached from the tractor seat. It would be desirable to have this valve near the boom control valve so that agitation could be adjusted from the tractor seat.

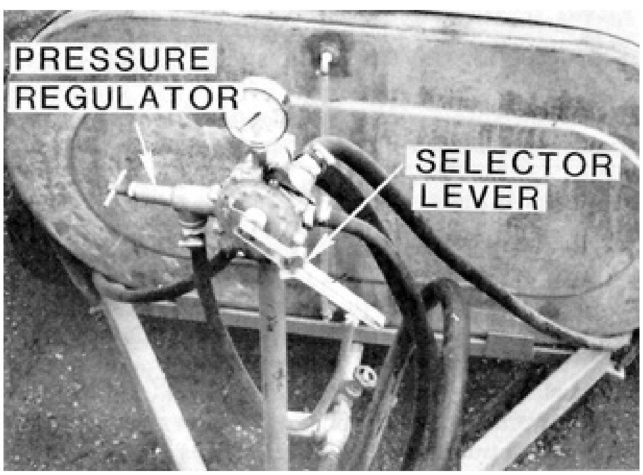

Figure 14. Controls.

The tank liquid level indicator (Figure 15) was easy to read if the solution in the tank was opaque. With clear solutions such as Banvel, the level in the tube was difficult to read. The gauge was only a rough indicator of liquid remaining in the tank because operation on hills and movement of liquid in the tank caused the level in the tube to fluctuate.

Transport: The RS-400 could be folded into transport by one man in 10 minutes without using tools. The pin located at the front of the radius brace (Figure 16) was difficult to install. Aligning the pin holes was difficult since the bracket was located underneath the tank. Lengthening the bracket to locate the pin further from the tank would make it easier to place the sprayer in field position.

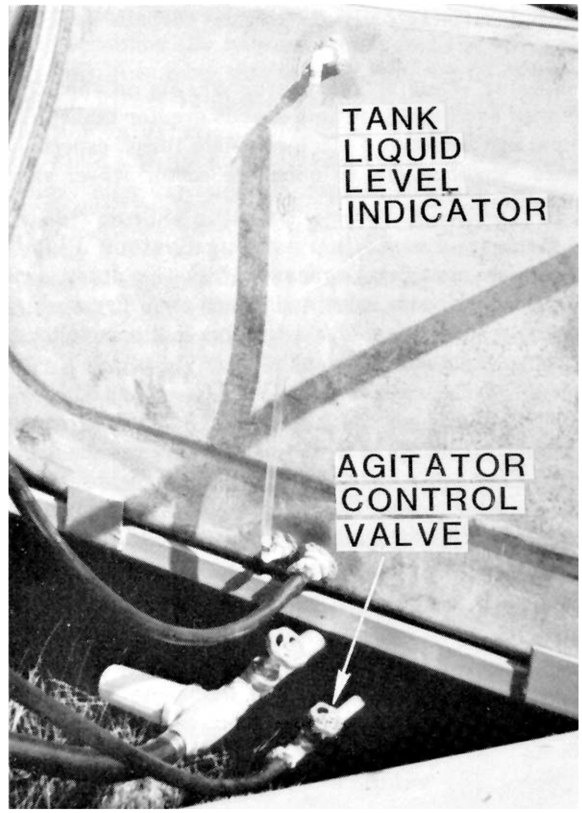

Figure 15. Awkward Location of Agitator Control Valve.

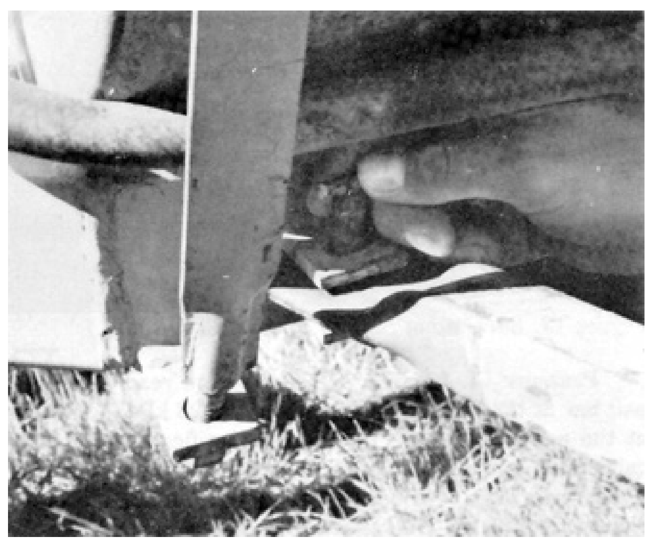

Figure 16. Awkward Location of Radius Brace Pin.

The RS-400 had a turning radius in transport position of 8230 mm (27 ft). This provided reasonable maneuverability. Backing the sprayer in transport position was difficult. The sprayer towed well at speeds up to 40 km/h (25 mph).

The castor wheels had to be cambered excessively in transport to keep the boom rail level in field position (Figure 17).

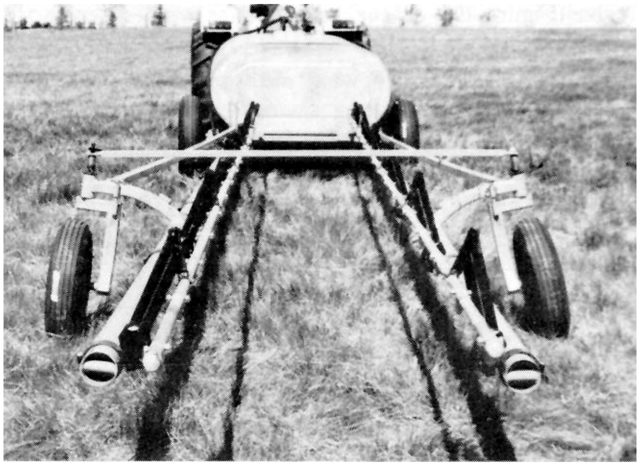

Figure 17. Excessive Camber of Castor Wheels.

Tank Filling: The low profile tank was easily filled by gravity from a nurse tank on a farm truck. The 255 mm (10 in) filler opening was adequate for adding chemicals and water. Tank filling would have been more convenient if the opening was located closer to one edge of the sprayer tank instead of near the centre (Figure 18). There was also no convenient place to stand while lifting and pouring chemicals into the tank. An operator stand or platform should be provided to prevent the possibility of spillage or slipping while handling toxic chemicals.

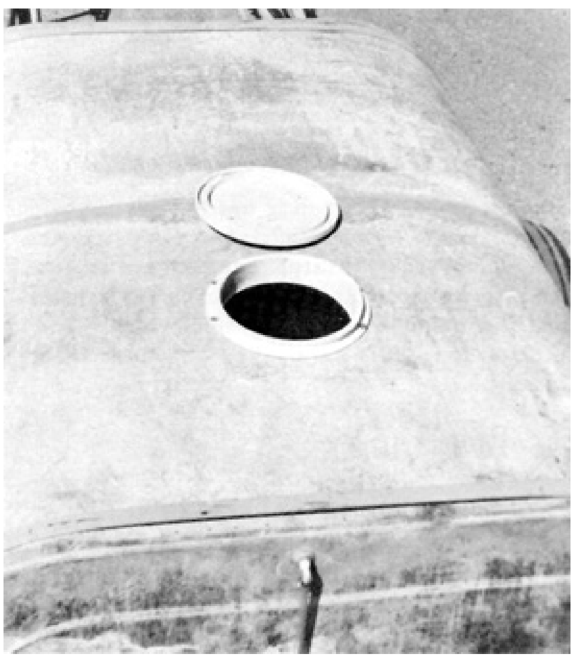

Figure 18. Location of Tank Filler Opening.

Nozzle Adjustment: Nozzle height adjustment required removing and replacing 10 thumb screw and wing nut assemblies (Figure 19). This took about 10 minutes if no problems were encountered. The thumb screws and wing nuts were easily lost in the field and it was difficult to tighten the wing nuts sufficiently without tools so that they would not loosen during operation.

Nozzle angle adjustment was time consuming and awkward. A screw driver was required to loosen 10 split clamp assemblies (Figure 19) before the booms could be rotated. The machine screws were awkward to loosen since they turned in from the bottom of the split clamp assembly. These screws also loosened in the field due to vibration.

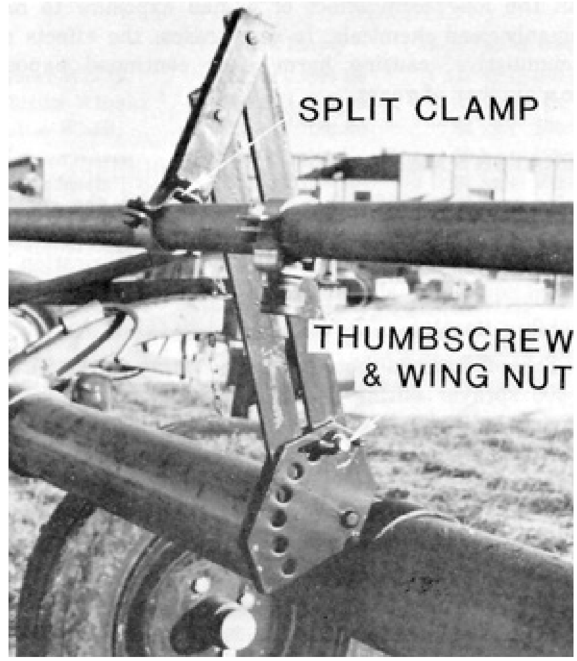

Figure 19. Boom Adjustment.

Nozzle Cleaning: The nozzles were conveniently removed for cleaning with a wrench.

Hitching: The sprayer could be hitched without the use of a jack when the tank was empty. With the tank full a jack was required. The quick disconnect coupling used to attach the sprayer pump to the power take-off shaft was convenient.

Servicing and Cleaning: The RS-400 was easy to service. All grease fittings were accessible except the tandem axle pivot fittings which were located underneath the sprayer.

No drain plug was provided on the tank. The only way to drain the tank was to remove the line strainer bowl. This was not satisfactory because the pump was located at the centre of the fiat bottomed tank making removal of all liquid difficult. A drain plug located at one end of the tank would make tank draining and flushing easier.

OPERATOR SAFETY

Hitching: The sprayer was balanced so that there was no weight on the hitch point when the tank was empty. This created a hazard, especially ff the tank was partially full. If the tank was tipped back when partially full, the water ran to the rear of the tank causing the hitch to rise. An operator not expecting this to happen could get injured.

Slow Moving Vehicle Sign: No slow moving vehicle sign was provided with the sprayer. This item should be standard equipment to comply with safety regulations.

Caution: Operators of all spraying equipment are cautioned to wear suitable eye protection, respirators and protective clothing to minimize operator contact with the chemical. Although many commonly used agricultural chemicals appear to be relatively harmless to humans, they may be quite deadly. In addition, little is known about the long term effect of human exposure to many commonly used chemicals. In some cases, the effects may be cumulative, causing harm after continued exposure over a number of years.

OPERATOR'S MANUAL

No operator's manual, was supplied with the sprayer. Only a parts list was supplied. An operator's manual outlining calibration, operation, servicing, lubrication and optional equipment should be included with the sprayer.

Durability Results

Table 3 outlines the mechanical history of the Riteway RS-400 sprayer during 61 hours of field operation while spraying 1086 ha (2684 ac). The intent of the test was evaluation of functional performance. The following failures represent only those which occurred during the functional testing. An extended durability evaluation was not conducted. Consider each failure separately since some are not as serious as others.

Table 3. Mechanical History

Item	Hours	Hectares	(Acres)
BOOM AND CASTOR ASSEMBLY:			
-the chain on the left castor lock pin failed and was repaired at	Beginning of test		
-the chain on the right castor lock pin failed at	45	810	(2002)
-the right castor support rotated on the boom rail. The bolts on the castor support clamps were tightened to prevent this from reoccurring at	10	180	(445)
-the wing nuts on the boom carrier loosened and had to be retightened. Many of the nut and bolt assemblies were lost and replaced with capscrews, lockwashers and nuts	throughout the test		
-the screws on the split boom clamps loosened and had to be retightened. Several screws were eventually lost and replaced	throughout the test		
-the holes in the radius brace were worn almost to failure and repaired at	34	612	(1513)
PLUMBING ASSEMBLY			
-the left boom hose was damaged at	beginning of test		
-it was damaged at another location again at	6	108	(267)
-the tank lid cracked at	8	144	(356)
MAIN FRAME			
-the inside of the trailer frame was cracked and bent at	end of test	1086	(2684)

Discussion of Mechanical Problems

BOOM AND CASTOR ASSEMBLY

Castor Lock Pins: The chains on the castor lock pins broke where they were welded to the pin. The chain did not have sufficient strength to restrain movement of the lock pin. When the chain broke, the pin fell through the holder (Figure 20). A length of rod was welded across the top of the lock pin to eliminate this problem.

Boom Carriers: The wing nuts on the boom carrier loosened continually during operation, even when they were tightened with a wrench. Operation with loose bolts resulted in premature bolt failure (Figure 21). Many of the wing nut assemblies were replaced with capscrews

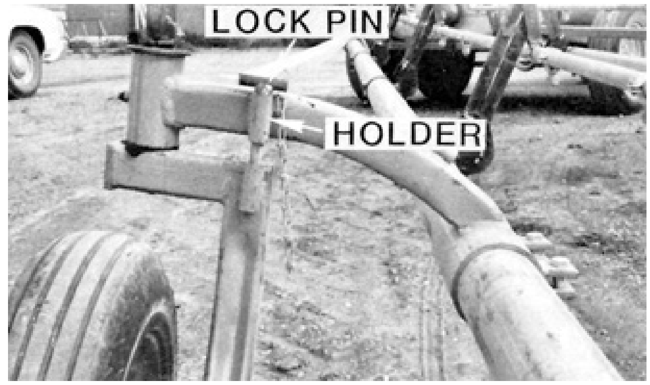

Figure 20. Castor Assembly.

equipped with lockwashers. These did not loosen; however, a wrench was then required to adjust boom height. The screws on the boom split clamps also loosened during operation.

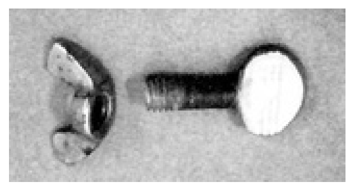

Figure 21. Typical Wear on Boom Carrier Bolts.

Radius Brace: The radius brace holes wore due to insufficient bearing surface against the pins (Figure 22). The radius braces vibrated excessively in the field contributing to the wear on the radius brace holes. The ends of the radius braces were reinforced with a steel plate. No significant wear was apparent after this modification.

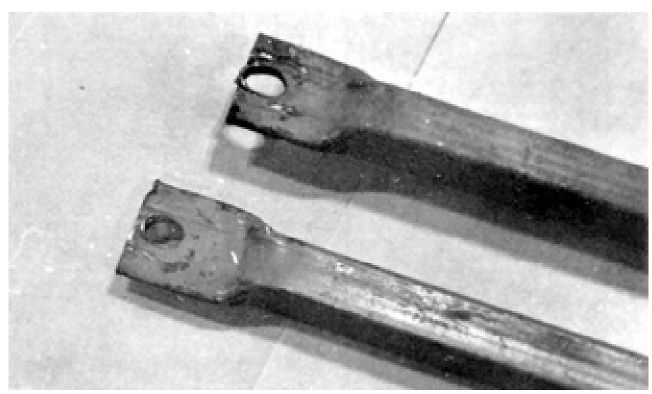

Figure 22. Worn Radius Brace Holes.

PLUMBING ASSEMBLY

Boom Hoses: Damage to the boom hoses occurred at the boom universal joint (Figure 23). The hoses were also not adequately restrained to prevent damage due to rubbing against sharp surfaces. For example, rubbing against the boom carriers caused hose damage.

Tank Lid: The plastic tank lid cracked while an operator was attempting to install the lid in the filler opening.

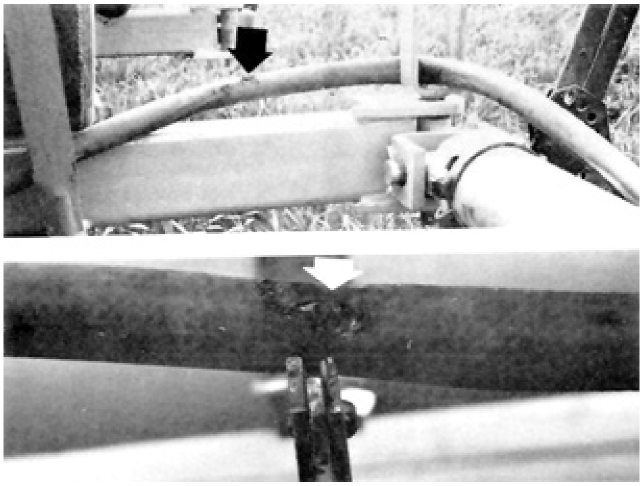

Figure 23. Damaged Hose.

MAIN FRAME

The inside of the trailer frame cracked (Figure 24) as a result of turning too short in transport position. The boom universal joint interferred with the frame, causing the tubing to crack and bend. A more desirable design would eliminate interference between the boom universal joints and the boom main frame during short turns in transport.

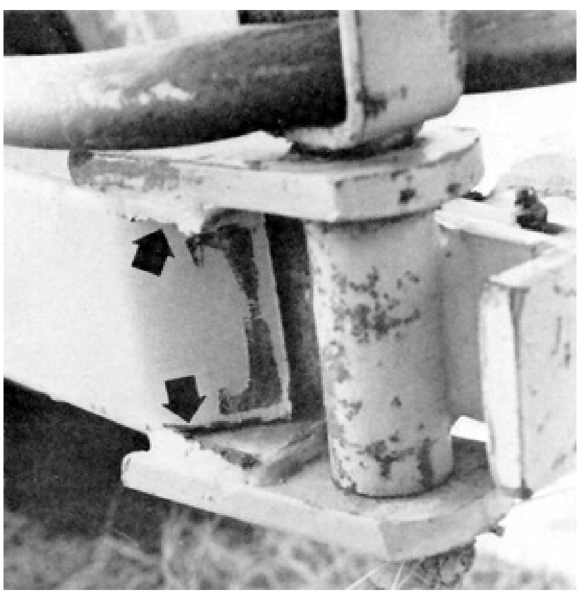

Figure 24. Failure of Trailer Frame.

APPENDIX I
SPECIFICATIONS

Model: Riteway RS-400 Field Crop Sprayer
Serial Number: 76193

	Field Position	Transport Position
Overall Width:	18,000 mm (59.1 ft)	2040 mm (6.7 ft)
Overall Length:	3550 mm (11.7 ft)	11,600 mm (38.1 ft)
Height:	1530 mm (5.0 ft)	1530 mm (5.0 ft)

	Trailer	
Wheel Base:	780 mm (2.6 ft)	
Wheel Tread:	1844 mm (6.0 ft)	11,810 mm (38.7 ft)
Tire Size:	4 - 7.60 x 15 6 ply rib implement	2 - 4.00 x 12 4 ply rib implement

WEIGHTS

	Tank Empty	Tank Full of Water
Left Trailer Wheels:	254 kg (560 lb)	1152 kg (2540 lb)
Right Trailer Wheels:	245 kg (540 lb)	1129 kg (2490 lb)
Left Castor Wheel:	84 kg (186 lb)	84 kg (186 lb)
Right Castor Wheel:	90 kg (199 lb)	90 kg (199 lb)
Hitch (tank level):	0 kg (0 lb)	91 kg (200 lb)
Total	673 kg (1485 lb)	2546 kg (5615 lb)

Tank: material - galvanized steel
capacity - 1818 L (400 gal)

Strainers: line strainer - 50 mesh
nozzle strainers - 100 mesh c/w check valve

Pump (540 rpm, pto driven): Hypro model C1700 teflon roller

Agitation: hydraulic

Pressure Gauge: Missimers (0 to 160 psi)

Boom: 3/4 inch galvanized steel pipe

Nozzles (Tee Jet 6501 brass): number - 36
spacing - 508 mm (20 in)

Spraying Width: 18,288 mm (60 ft)

Boom Adjustment: height - minimum 710 mm (28.0 in)
- minimum 191 mm (7.5 in)
angle - 360°

Hitch Height Adjustment: maximum - 660 mm (26 in)
minimum - 360 mm (14 in)

Lubrication Points:

	tandem pivots	4
	boom universal joints	4
	castor pivots	2
	Total	10

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

(a) excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory.

APPENDIX III
METRIC CONVERSIONS

In keeping with the Canadian metric conversion program this report has been prepared in SI units. For comparative purposes, the following conversions may be used.

1 hectare (ha)	= 2.47 acre (ac)
1 litre per hectare (//ha)	= 0.09 Imperial gallon per acre (gal/ac)
1 kilopascal (kPa)	= 0.15 pound per spuare inch (psi)
1 kilometre per hour (km/h)	= 0.62 mile per hour (mph)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 litre per second (L/s)	= 13.20 Imperial gallons per minute (gal/min)
1 metre (m)	= 1000 millimetre (mm) = 39.37 inches (in)
1 litre (L)	= 0.22 Imperial gallons (gal)

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