Alberta Farm Machinery Research Centre

Printed: January, 1992
Tested at: Lethbridge
ISSN 0383-3445
Group 8 (B)

Evaluation Report 669

Harmon Model 833 Auto-Fold Field Sprayer

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

HARMON MODEL 833 AUTO-FOLD FIELD SPRAYER

MANUFACTURER AND DISTRIBUTOR:

Harmon International Industries Inc.
P.O. Box 1444
2401 Millar Avenue
Saskatoon, Saskatchewan
S7K 3P7
Phone: (306) 931-1161

RETAIL PRICE: $14,446.50 (DECEMBER, 1991, f.o.b. Lethbridge, Alberta)

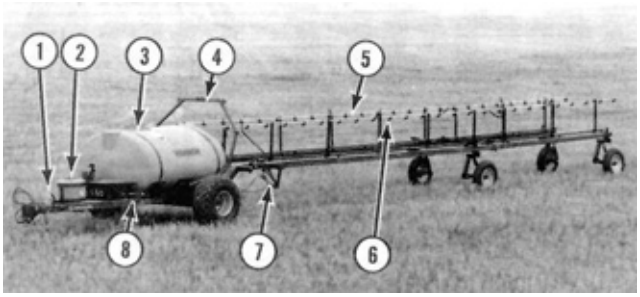

FIGURE 1. Harmon Model 833 Auto-Fold Field Sprayer: (1) Hydraulic Motor and Pump, (2) Easy-Fill Chemical Tank, (3) Spray Tank, (4) Auto-fold Overhead Bar, (5) Spray Boom, (6) Nozzle Body Assembly, (7) Nozzle Height Adjustment Ram and (8) Reload, Agitation Solenoid Valves.

SUMMARY AND CONCLUSIONS

RATE OF WORK:

Operating at speeds between 5.5 and 9.2 mph (8.9 and 14.8 km/h) resulted in instantaneous work rates between 56 and 93 ac/h (23 and 38 ha/h), At an application rate of 10 gal/ac (112 L/ha), about 83 ac (34 ha) could be sprayed with a full tank.

QUALITY OF WORK:

Application rate accuracy was good when tractor speed and pressure were calibrated for and kept constant. Application rate depended on tractor speed, nozzle size and pressure. The application rate using XR110015VS and XR11003VS stainless steel nozzles was 5 and 10 gal/ac (56 and 112 L/ha), respectivety, at a forward speed of 7.5 mph (12 km/h) and nozzle pressure of 40 psi (276 kPa).

Measured nozzle delivery rate was very good. The new Tee-Jet XR110015VS and XR11003VS nozzle deliveries were similar to that specified by the nozzle manufacturer. Nozzle wear was rated as good. Delivery of the used XR110015VS and XR11003VS nozzles increased 2 percent after 53 hours of use, indicating nozzle wear. Variability among individual nozzle deliveries was very good when new and used. The coefficient of variation (CV) for the new XR110015VS and XR11003VS nozzles was 2.1 and 0.8. respectively.

Nozzle spray distribution patterns for Spraying Systems XR110015VS and XR11003VS extended range nozzles were very good at a nozzle operating height of 15 in (381 mm). Spray patterns were acceptable at all pressures and very uniform above 22 psi (150 kPa) using the XR11003VS nozzles. Spray patterns were acceptable above 15 psi (100 kPa) and very uniform above 24 psi (165 kPa) using the XR110015VS nozzles. Both nozzles produced acceptable spray patterns above nozzle heights of 10 in (254 mm).

Alberta Farm Machinery Research Centre (AFMRC) conducted limited tests to evaluated spray drift. Spray drift frac. tion was 6 per cent of the emitted spray using the XR110015VS nozzles in 19 mph (30 km/h) winds. The extended range Tee, Jet XR11003VS nozzle tips at a nozzle pressure of 20 psi (138 kPa) and at a nozzle height of 10 in (254 mm) minimized spray drift during windy conditions.

System pressure losses were rated as good. The pressure loss from the remote control pressure tap tothe nozzles was insignificant using XR110015VS and XR11003VS nozzle tips. The remote control pressure gauge indicated 3 psi (21 kPa) high and rated as fair.

The strainers were good in preventing nozzle plugging. The small XR110015VS nozzle tips plugged frequently when using lake and dugout water.

Boom stability was good. The 4 in (102 mm) square tubing, front boom truss system and suspension system on the castor wheels reduced boom bounce. The outer wet booms were not as stable and bounced up to 4 in (102 mm).

Crop damage was minimal. Trailer and inner castor wheel soil contact pressure was 38 and 23 psi (262 and 159 kPa), respectively.

EASE OF OPERATION AND ADJUSTMENT:

Ease of adjusting application rate was good. The desired application rate had to be calculated using nozzle formulas and charts. The Swivel-Jet dual nozzle body assemblies made nozzle changing quick and easy.

Ease of operating the controls was very good. Spraying Systems remote control made it easy to adjust and monitor nozzle pressure and flow from the tractor seat. The agitator, chemical easy fill tank and reloading valves were accessible and easy to adjust.

Ease of adjusting the middle castor wheels was very good. The adjustments were a trial and error procedure and took an hour before the booms trailed or unfolded satisfactory.

Sprayer maneuverability was very good in both transport and field position. Turning into narrow farm yard approaches was easy since the booms followed the sprayer closely. Backing the sprayer in transport position resulted in the booms gradually unfolding to field position.

Ease of boom positioning was good. The operator could place the booms into transport position in about 30 s. The procedure required the operator to stop and back up the sprayer to lock the middle castor wheels. Placing the booms into field position took about two minutes and required the operator to back the sprayer until the booms completely unfolded. It took about 100 to 150 ft (30 to 46 m) for the booms to completely unfold. The procedure got easier with experience.

Ease of adjusting nozzles was fair. The hydraulic cylinder rod stop collar was difficult to move requiring the use of a tool to tap the collar in the desired position. Nozzle angle was adjusted manually by loosening four U-bolts on the boom parallel linkage. Nozzle height was adjusted with the hydraulic ram stop from about 12 to 36 in (305 to 914 mm). The Swivel-Jet dual nozzle assemblies made nozzle changing fast.

Ease of filling the spray tank was very good utilizing the sprayer pump. tt took about 20 minutes to fill the 835 gal (3796 L) spray tank. A 2 in (51 mm) valve was added to the reload hose to prevent chemical solution from the spray tank entering the water supply source.

Ease of adding chemical to the spray tank was good using the easy-fill chemical tank. tt took about 1.5 minutes to induct the chemical from a full easy-fill tank. Inducting chemical during reloading water allowed immediate chemical agitation.

Ease of hitching was good. The hitch jack was safe and the hitch clevis adjustable for levelling the sprayer trailer to the tractor hitch. The four hydraulic lines and two electronic couplers were easy to hook-up.

Ease of cleaning was good. Removing the nozzle caps for nozzle and strainer cleaning was quick, however, the strainers were difficult to remove. Chemical drained on the operator's hand when removing the main line strainer.

Ease of draining was fair. The sprayer had no drain hose. The suction hose had to be unclamped to completely drain the tank. The spray tank sump allowed for complete draining. The Swivel.Jet diaphragm nozzle assemblies were difficult to drain.

Ease of lubrication wes very good. All 12 grease fittings were accessible. The four castor wheel pivot arms and spindles required greasing every 10 and 50 hours, respectively.

PUMP PERFORMANCE:

The Hypro 9303C-HM1 pump output was very good. The pump delivered 20.8 gal/min (95 L/min) at a 40 psi (276 kPa) nozzle pressure. This was adequate to apply 25 gal/ac (280 L/ha) at a forward speed of 5 mph (8 km/h), using nozzles rated at 0.42 gal/min (1.9 L/min).

Agitator output exceeded the recommended agitation rates for emulsifiable concentrates.

OPERATOR SAFETY:

The operator's manual emphasized operator safety. The sprayer was safe to operate if normal safety and chemical precautions were taken. The ease-fill chemical tank and Swivel-Jet dual nozzle tips reduced operator contact with chemical.

OPERATOR'S MANUAL:

The operator's manual was very good, providing complete information and illustrations on safety, sprayer operation, maintenance and adjustments.

MECHANICAL HISTORY:

A few mechanical problems occurred during testing. The booms were difficult to keep level with the castor wheel rods. In addition, the wet boom lift bar and U-joints were inadequate and required frequent adjustments to keep the nozzle height the same across the width of the boom.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifying the nozzle pressure line to indicate true nozzle pressure at the remote controi pressure gauge.
2. Modifications to make it easier to adjust nozzle height.
3. Modifying the reloading system to prevent chemical solution from entering the water supply line.
4. Modifying the sprayer boom to keep the booms level.
5. Modifying the boom design to include a boom breakaway system.

Manager: R.P. Atkins

Project Technologist: B. Storozynsky

THE MANUFACTURER STATES THAT:

With regards to recommendation number:

1. Pressure line deficiencies that were measured between remote pressure control gauge and nozzle pressure are not significant in relation to application rates for most dry land crops. A calibration check procedure is outlined in the operator's manual to correct variances in pressure readings as well as land speed readings. We recommend that in cases where precise application rates are required, a sprayer monitoring system be installed. We will conduct further research and testing to improve the differential between nozzle pressure and remote pressure read out.
2. A nozzle height adjustment which will not require tools is being developed.
3. A ball valve will be installed on the water supply line cam lock fitting to prevent chemical from entering the auxiliary water supply.
4. Unevenness of the booms occurs after an initial break-in period where the springs on the boom wheel suspension lose a bit of their spring force requiring the unit to be relevelled. Design changes have been made to increase the rigidity of the wet boom by increasing bearing areas and adding support springs.
5. The present design is not readily adaptable to a full boom breakaway system, however this wilt be addressed in future model changes.

GENERAL DESCRIPTION

The Harmon Model 833 is a trailing, boom-type field sprayer. The trailer is a single axle with floatation turf tires. Two castor wheels with a suspension system support each boom. The booms automatically fold back for transport. The 835 gal (3796 L) plastic tank has two jet agitators, fluid level indicator and a filler opening with strainer.

The Harmon sprayer has 50 Swivel-Jet dual nozzle assemblies with diaphragm check valves spaced at 20 in (508 mm) intervals, giving a spraying width of 83.3 ft (25.4 m). Nozzle height is hydraulically controlled. Nozzle angle is adjustable and remains constant throughout the height range.

The Harmon Model 833 has an easy-fill chemical tank, spray tank access platform, remote control and bottom reload systems. The bottom reload system utilizes the inboard centrifugal pump. The pump is hydraulically driven and operates at speeds between 3500 and 5000 rpm. The Spraying Systems remote control console mounts on the tractor and contains a pressure gauge and control switches to operate the pressure regulating and boom solenoid valves.

FIGURE 1, shows the location of the sprayer's major components while detailed specification are given in APPENDIX I.

SCOPE OF TEST

The Harmon Model 833 sprayer was operated for 122 hours in the conditions shown in TABLES 1 and 2 while spraying about 4168 ac (1687 ha). AFMRC evaluated the sprayer for rate of work, quality of work, ease of operation and adjustment, pump performance, operator safety and suitability of the operator's manual.

Spraying Systems extended range TeeJet flat fan XR110015VS and XR11003VS stainless steel nozzle tips were used during the test. Both nozzle tips were tested in the laboratory at various spraying pressures, heights and forward angles.

TABLE 1. Operating Conditions

CHEMICAL APPLIED	FIELD	HRS	SPEED mph	(km/h)	FIELD AREA ac	(ha)
Rustler	Chemfallow	18	6.4-7.1	(40.3-11.4)	617	(250)
Rustler/2,4-D	Chemfallow	6	7.0-7.4	(11.3-11.91)	278	(113)
Rustler/MCPA	Chemfallow	16	6.3-7.3	(10.1-11.7)	680	(275)
2,4-D	Barley	11	5.5-7.6	(8.9-12.2)	390	(158)
2,4-D/Banvel	Spring Wheat	3	7.1-7.5	(11.4-12.1)	160	(65)
2,4-D/Glean	Duram	2	7.1-7.5	(11.4-12.1)	80	(32)
Buctril M	Spring Wheat	7	7.2	(11.6)	320	(130)
Buctril M/Avenge	Spring Wheat	10	7.0	(11.3)	400	(162)
Hoegrass II	Duram/Barley	23	5.6-9.2	(9.0-14.8)	763	(309)
MCPA/Banvel/ Liquid Fertilizer	Winter Wheat	10	7.1	(11.4)	480	(194)
Transport		16				
TOTAL		**122**			**4168**	**(1688)**

TABLE 2. Topography

TOPOGRAPHY	HOURS	FIELD AREA ac	(ha)
Level	37	1243	(503)
Undulating	37	1588	(643)
Rolling	28	1145	(464)
Hilly	4	192	(78)
Road	16		
TOTAL	**122**	**4168**	**(1688)**

RESULTS AND DISCUSSION

RATE OF WORK

During field testing, the Harmon Model 833 Sprayer was operated between 5.5 and 9.2 mph (8.9 and 14.8 km/h) (TABLE 1) resulting in instantaneous work rates between 56 and 93 ac/h (23 and 38 ha/h). Actual work rates were less depending on operator skill and reloading

time. The quick folding of the boom made tank reloading from a central location convenient. With a full spray tank, about 83 ac (34 ha) could be sprayed at 10 gal/ac (112 L/ha).

QUALITY OF WORK

Application Rate: Application rate accuracy was good when tractor speed and pressure were calibrated and consistant. Application rate depended on tractor speed, nozzle size and pressure. The XR110015VS nozzles supplied with the Harmon sprayer delivered 5 gal/ac (56.2 L/ha) at a forward speed of 7.4 mph (11.9 km/h) and a nozzle pressure of 40 psi (276 kPa). The XR11003VS nozzles supplied with the Harmon sprayer delivered 10 gal/ac (112 L/ha) at a forward speed of 7.5 mph (12.1 km/h) and a nozzle pressure of 40 psi (276 kPa). Changes to forward speed or nozzle pressure resulted in different application rates as shown in FIGURE 2. For example, at a nozzle pressure of 40 psi (276 kPa), reducing speed from 7.5 to 6.5 mph (12.1 to 10.5 km/h) increased application rate from 10 to 11.5 gal/ac (112 to 130 L/ha) using the XR11003VS nozzles. To ensure uniform application rates the desired speed and pressure must be kept constant.

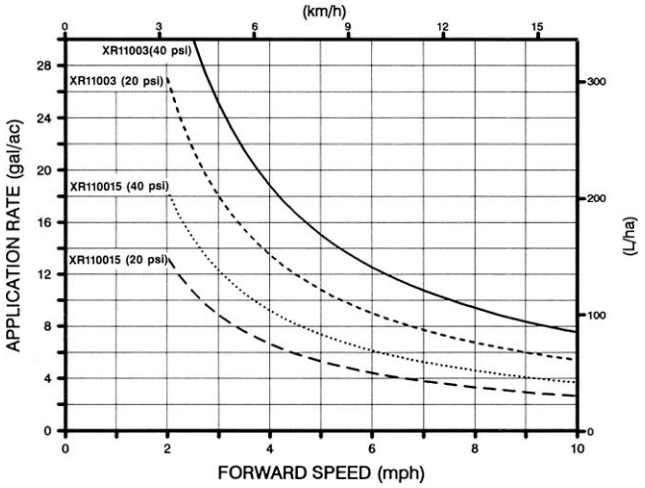

FIGURE 2. Application Rates at Various Forward Speeds and Pressures Using Spraying Systems Extended Range Tee Jet XR110015VS and XR11003VS Nozzles.

Nozzle Calibration: Measured nozzle delivery was very good. FIGURE 3 shows the average delivery of Spraying Systems extended range TeeJet XR110015VS and XR11003VS nozzle tips over a range of nozzle pressures.

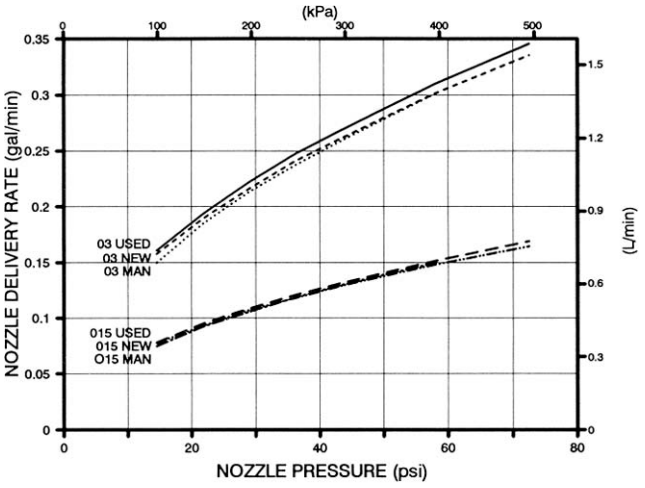

FIGURE 3. Delivery Rates for Spraying Systems Extended Range Tee Jet XR110015VS and XR11003VS Stainless Steel Nozzle Tips.

Measured delivery of the new extended range nozzle tips was similar to Spraying Systems rated output at nozzle pressures above 22 psi (150 kPa). The TeeJet XR110015VS and XR11003VS nozzle tips were used for about 53 hours each. Nozzle wear was rated as good. Both showed a 2 per cent increase in delivery, indicating some nozzle wear. Some researchers indicate that a nozzle needs replacement once delivery has increased by more that 10 per cent. Nozzle wear depends on the type of chemicals sprayed and water cleanliness.

Variability among individual nozzle deliveries for the TeeJet XR110015VS and XR11003VS nozzles was low and rated as very good. A low coefficient of variation (CV) indicates similar delivery rates for all nozzles. A high CV indicates large variations among individual nozzle delivery rates. The CV of nozzle deliveries was 2.1 per cent for the XR110015VS nozzles and 0.8 per cent for the XR11003VS nozzles when new.

Distribution Patterns: Nozzle spray distribution patterns were very good at the recommended nozzle height of 15 in (381 mm) and nozzle forward angle of 30 degrees. FIGURES 4 and 5 show typical spray distribution patterns along the boom with the extended range TeeJet XR110015VS nozzles operated at nozzle pressures of 22 and 44 psi (150 and 300 kPa). The coefficient of variation (CV)[1] at 22 psi (150 kPa) (FIGURE 4) was 10.8 per cent, with application rates along the boom varying from 3.2 to 5.2 gal/ac (36 to 58 L/ha) at 7 mph (11 km/h). At 44 psi (300 kPa) (FIGURE 5) the CV was 6.6 per cent, with application rates along the boom varying from 4.7 to 6.5 gal/ac (53 to 73 L/ha) at 7 mph (11 km/h).

FIGURE 6 shows a typical spray distribution pattern along the boom with the extended range TeeJet XR11003VS nozzle tips operated at a nozzle pressure of 22 psi (150 kPa). The CV was 9.6 per cent, with application rates along the boom varying from 6.7 to 10.2 gal/ac (75 to 114 L/ha) at a 7 mph (11 km/h) forward speed. The CV was similar at 44 psi (300 kPa). As shown, Spraying Systems extended range nozzles could be used at both manufacturer's recommended pressures of 22 and 44 psi (150 and 300 kPa) and produce acceptable spray distribution patterns.

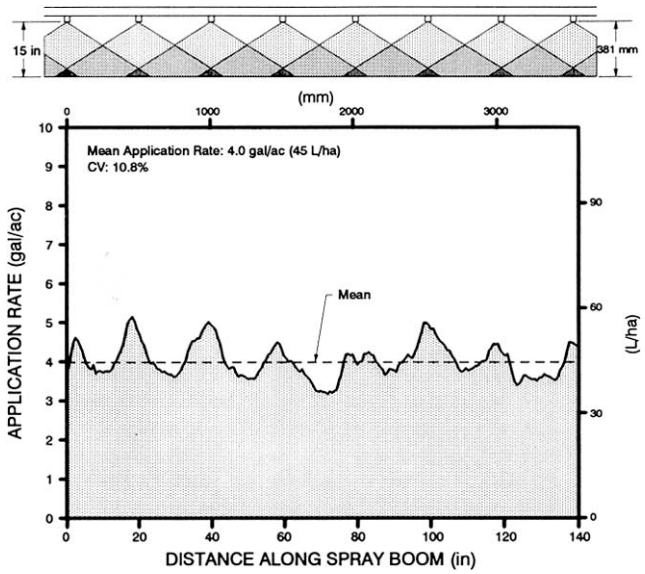

FIGURE 4. Typical Distribution Pattern Along the Boom at 22 psi (150 kPa) with Spraying Systems Extended Range TeeJet XR110015VS Stainless Steel Nozzle Tips, at a 15 in (375 mm) Nozzle Height, 30 Degree Forward Spray Angle and 7 mph (11 km/h).

[1]The coefficient of variation (CV) is the standard deviation of application rates for successive 0.63 in (16 mm) sections along the boom expressed as a per cent of the mean application rate. The lower the CV, the more uniform is the spray coverage. A CV below 10 per cent indicates very uniform coverage while a CV above 15 per cent indicates inadequate uniformity. The CV's above were determined in stationary laboratory tests. In the field, CV's may differ due to boom vibration and wind. Different chemicals vary as to the acceptable range of application rates. For example, 2, 4-D solutions have a fairly wide acceptable range while other chemicals may have a narrow range.

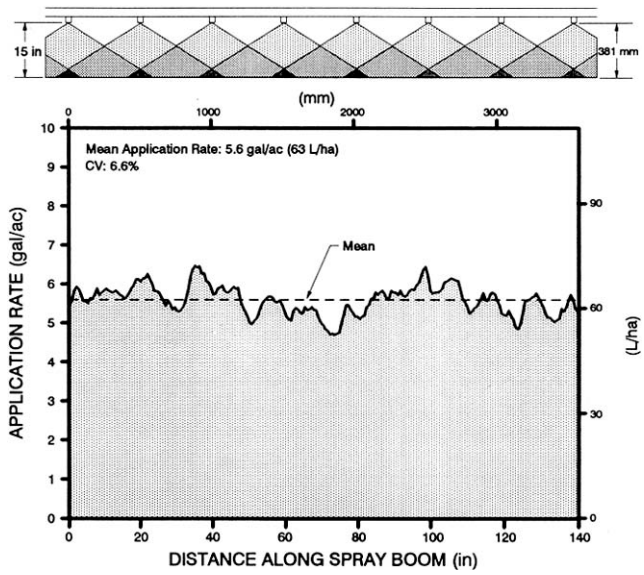

FIGURE 5. Typical Distribution Pattern Along the Boom at 44 psi (300 kPa) with Spraying Systems Extended Range TeeJet XR110015VS Stainless Steel Nozzle Tips, at 15 in (375 mm) Nozzle Height, 30 Degree Forward Spray Angle and 7 mph (11 km/h).

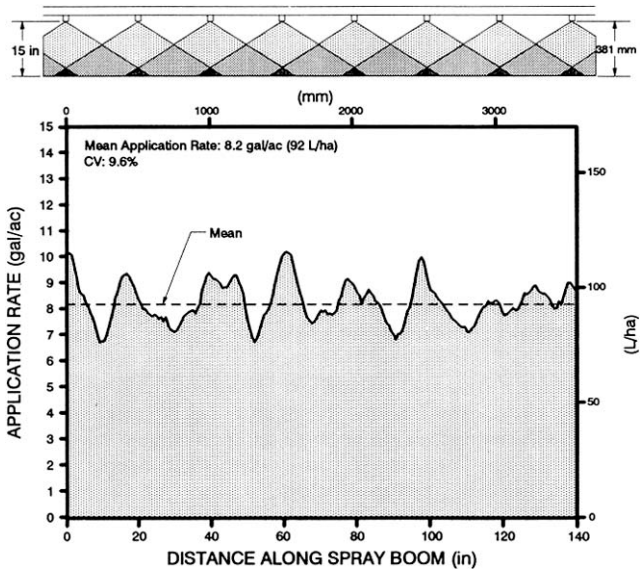

FIGURE 6. Typical Distribution Pattern Along the Boom at 22 psi (150 kPa) with Spraying Systems Extended Range TeeJet XR11003VS Stainless Steel Nozzle Tips, at a 15 in (375 mm) Nozzle Height, 30 Degree Forward Spray Angle and 7 mph (11 km/h).

Spraying Systems extended range nozzles were designed to spray at pressures between 15 and 60 psi (100 and 415 kPa). FIGURE 7 shows how nozzle pressure affected spray pattern uniformity for the extended range TeeJet XR110015VS and XR11003VS nozzles. The larger XR11003VS nozzles produced acceptable patterns at all pressures tested and very uniform patterns above 22 psi (150 kPa). The XR110015VS nozzles produced acceptable spray distribution patterns above 15 psi (100 kPa) and very uniform patterns above 24 psi (165 kPa). The spray distribution patterns changed very little after the nozzles were used in the field for 53 hours. Forward angle of the nozzle had very little effect on spray distribution patterns.

FIGURE 8 shows how nozzle heights affected spray pattern uniformity for the extended range TeeJet XR110015VS and XR11003VS nozzles. Both nozzles produced acceptable spray patterns above and nozzle heights of 10 in (254 mm) at 22 and 44 psi (150 and 300 kPa).

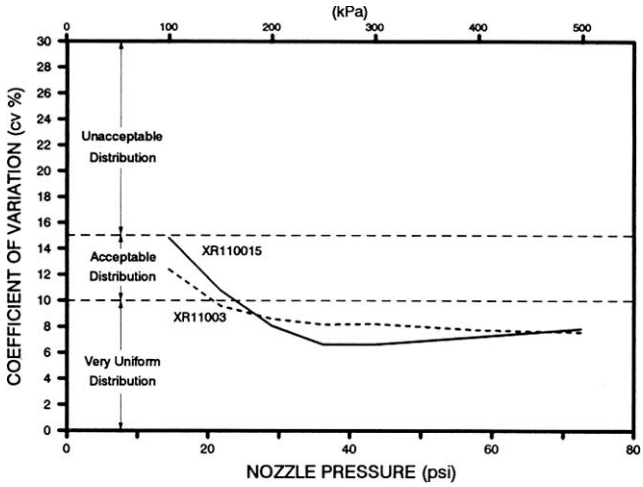

FIGURE 7. Spray Pattern Uniformity for Spraying Systems Extended Range TeeJet XR110015VS and XR11003VS Stainless Steel Nozzles Operated at a 15 in (381 mm) Nozzle Height and 30 Degree Forward Spray Angle.

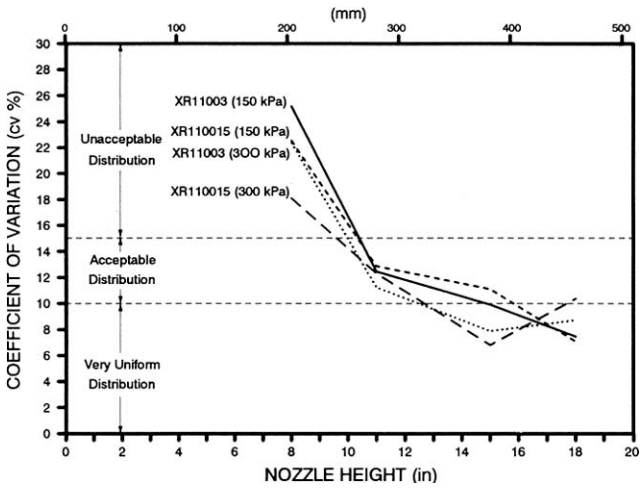

FIGURE 8. Spray Pattern Uniformity for TeeJet XR110015VS and XR11003VS Stainless Steel Nozzles Operated at Nozzle Pressures of 22 and 44 psi (150 and 300 kPa) and a Nozzle Forward Angle of 30 Degrees.

Spray Drift: AFMRC conducted limited tests to evaluate spray drift. Off-swath drift from the XR110015VS TeeJet nozzle operated at 40 psi (276 kPa) and at a 17 in (432 mm) height was about 6 per cent of the emitted material in 19 mph (30 km/h) winds. This was excessive and could result in damage to nearby shelter belts, gardens and other susceptible crops. Previous work by AFMRC and the Saskatchewan Research Council indicates that off-swath drift from large nozzles operated at low pressures and heights is less than small nozzles operated at standard nozzle pressures and heights. The Harmon sprayer effectively reduced spray drift with the large XR11003VS nozzles operated at low nozzle pressures and heights. As shown in FIGURES 7 and 8, the XR11003VS nozzles produced acceptable spray patterns at low nozzle pressures and heights.

Studies have shown that 110 degree nozzles produce smaller droplets that are more susceptible to drift than 80 degree nozzles of the same size. However, operating the 110 degree nozzles at heights lower than the standard 18 in (457 mm) minimized the smaller droplets susceptibility to drift.

Pressure Losses: Pressures in the plumbing system were measured at the pump, controls, booms and varying sized nozzles. The remote control pressure gauge did not indicate true nozzle pressure. The pressure gauge indicated the pressure at the boom inlet hoses. The pressure difference at the boom inlet hoses and nozzles was negligible when using nozzles that delivered less than

0.3 gal/min (1.4 L/min). The difference was greater than 4 psi (28 kPa) when using nozzles that delivered more than 0.3 gal/min (1.4 L/min). It is recommended that the manufacturer consider modifying the nozzle pressure line to indicate true nozzle pressure at the remote control pressure gauge. Small pressure losses occurred across the nozzle body assemblies and solenoid valves.

The remote control console pressure gauge was rated as fair. The gauge indicated about 3 psi (21 kPa) high throughout the test.

Use of Optional Nozzles: The Swivel-Jet dual nozzle body assembly (FIGURE 9) accepted a wide range of standard nozzle tips. Nozzle height and angle were adjustable permitting the use of flat, flood or cone nozzle tips.

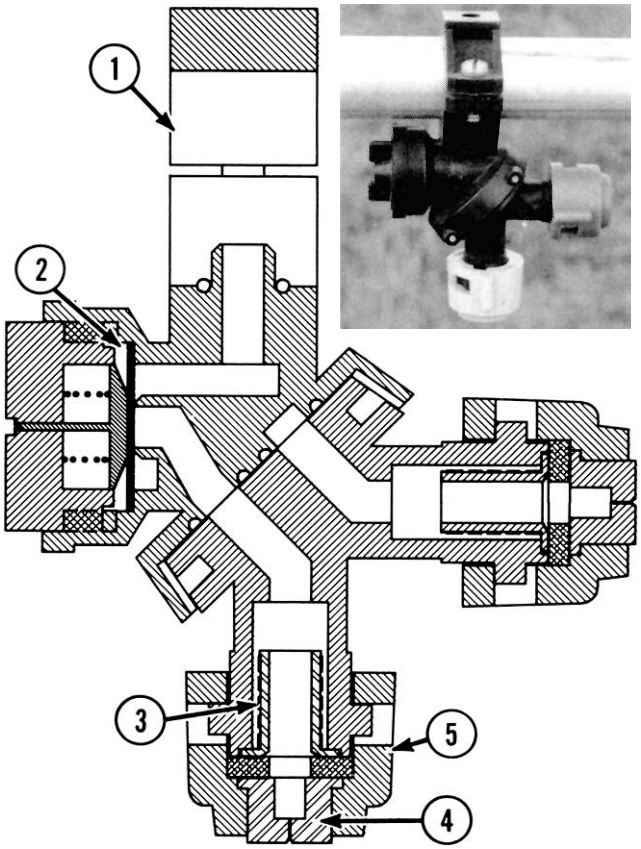

FIGURE 9. Swivel-Jet Diaphragm Dual Nozzle Body Assembly: (1) Split-Eyelet Clamp, (2) Diaphragm Check Valve, (3) Strainer, (4) Nozzle Tips, and (5) Quick-Disconnect and Self-Aligning Nozzle Cap.

System Strainers: The Harmon sprayer system strainers were good. The tank filler opening and pump inlet hose were equiped with 16 and 50 mesh strainers, respectively. Both strainers effectively removed large foreign material. The 50 mesh nozzle strainers effectively prevented the TeeJet XR11003VS nozzles from plugging. The 100 mesh strainers plugged frequently when using lake or dugout water.

Boom Stability: The Harmon sprayer boom stability was good. Field observations indicated that the booms remained stable in the field conditions encountered (TABLE 2). The 4 in (102 mm) square tubing used for boom rail construction and suspension system on the castor wheels reduced boom bounce on rough fields. In addition, the front truss reduced horizontal boom end movement. The outer wet booms were not as stable. The pivot system was loose which caused the wet booms to bounce in most field conditions. Boom operation across gullies was also very good since the boom pivoted near the middle.

Soil Compaction and Crop Damage: Soil contact pressure beneath the castor wheels was less than that of an unloaded one-half ton truck. The soil contact pressure beneath the sprayer trailer wheels was about 38 psi (262 kPa). The average soil contact pressures under the sprayer wheels with a full tank are given in TABLE 3.

Crop damage was minimal. The trailer and castor wheels travelled over about 2.3 and 1.3 per cent of the total field area sprayed, respectively. Less crop damage was observed in the sprayer wheel tracks when spraying in young crops less than 7 in (178 mm) tall. AFMRC studies show that sprayer wheels should be run in tractor tracks since the combined percentages of crop damage due to sprayer wheels and tractor wheels is greater than the damage if sprayer wheels are run in tractor tracks. The Harmon sprayer trailer wheels ran outside most tractor tracks since the trailer wheel tread width could not be adjusted.

TABLE 3. Soil Contact Pressure by Sprayer Wheels

	TIRE TRACK WIDTH		AVERAGE SOIL CONTACT PRESSURE*	
	in	(mm)	psi	(kPa)
Trailer Wheels	11.4	(290)	38	(262)
Boom Wheels—Inner	3.8	(97)	23	(159)
—Outer	2.5	(64)	23	(159)

*For comparative purposes, an unloaded on-half ton truck has a soil contact pressure of about 30 psi (207 kPa).

EASE OF OPERATION AND ADJUSTMENT

Application Rate: Ease of adjusting application rate was good. The dual nozzle body assemblies made changing application rates quick and very easy. Adjusting application rate within a 20 per cent range with the same nozzles was done by using formulas and nozzle charts to calculate the ground speed and nozzle pressure.

The Swivel-Jet diaphragm dual nozzle body assembly housed two nozzle tips. This was convenient when the desired application rate had to be adjusted more than 20 per cent.

Controls: Ease of operating the remote control console was very good. The Harmon sprayer was equipped with Spraying Systems remote control console (FIGURE 10) to operate sprayer controls from the tractor seat.

The remote control console included a pressure gauge to indicate nozzle pressure, boom solenoid valve switches to control flow to the booms and a pressure regulating switch to adjust nozzle pressure. Depending on the butterfly valve position, small adjustments of the pressure switch resulted in small or large pressure changes. With experience, nozzle pressure became easier to adjust by jogging the switch.

The agitator valve was mounted on the sprayer hitch frame and could not be operated from the tractor seat. The agitator valve was fully open during spraying and only had to be opened once.

The tank liquid level indicator gave only a rough indication of liquid level. The tank liquid level indicator was only reliable when the sprayer was stopped on level ground.

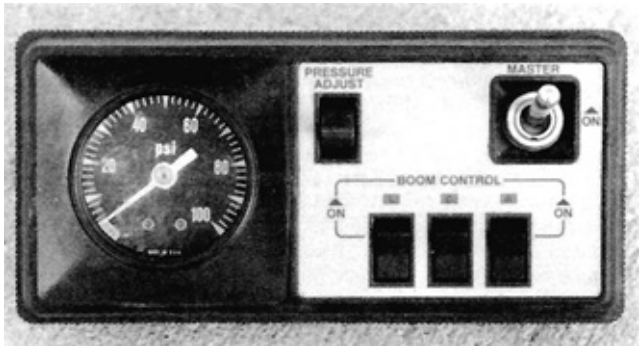

FIGURE 10. Spraying Systems Remote Control Console.

Castor Wheel Adjustments: Ease of adjusting the middle castor wheels was very good. The middle castor wheels had to toe-in slightly for proper boom performance. Two bolts on each castor wheel had to be adjusted. The procedure was by trial and error and took about an one hour before the booms trailed satisfactory and unfolded quickly to field position.

Maneuverability: Sprayer maneuverability was very good. The sprayer towed very well in both field and transport position. The sprayer had a turning radius of about 40 ft (12 m) in transport position. Cornering was easy since the boom wheels followed the trailer closely eliminating the need to swing out turning corners.

Backing up the sprayer in transport position for a short distance was possible, until the booms started unfolding into field position. Backing up long distances was possible by chaining the booms together.

Boom Positioning: Ease of boom positioning was good. Positionlng the booms from the tractor seat allowed getting in and out of fields quickly and conveniently. The sprayer booms were placed into transport position in less than 30 seconds. The procedure required the operator to stop the sprayer, raise the wet booms and then back the sprayer until the castor wheels locked, before travelling forward. The procedure took longer when the time to lock the hydraulic cyclinders with the safety lock bars was included. The lock bars were difficult to secure to the cylinder pins. The cylinder pins had to be turned using a pipe wrench so the holes for the hitch pins were parallel with the lock bar. The hitch pins were difficult to insert or remove because the channel iron lock bars interfered with the operator's hands.

Placing the booms in field position was done by backing up the sprayer until the boom auto-fold overhead bar secured in the sprayer trailer clevis. The procedure took about one to two minutes and a distance of 100 to 150 ft (30 to 46 m) depending on operator experience and reverse speed. The booms had to unfold evenly to avoid damage to the castor wheels. In addition, the operator had to watch the boom auto-fold overhead bar guy wires, in case the wire interfered with the boom nozzle body assembly. The guy wires caught on a nozzle body assembly twice during field testing. No damage occurred since the interference was quickly noticed.

The transport width was 10.3 ft (3.1 m) (FIGURE 11) providing safe road transport.

FIGURE 11. Harmon in Transport Position.

Nozzle Adjustments: Ease of adjusting nozzle height and angle was fair. Nozzle angle was adjusted by loosening 4 clamps on the parallel linkage system and rotating the wet spray booms. Spray interference with the castor wheels resulted when nozzle angle was adjusted more than 36 degrees forward at a nozzle height of 18 in (457 mm). Nozzle angle remained constant at all boom heights.

Nozzle height was controlled hydraulically from the tractor. The hydraulic cylinder rod had a stop collar (FIGURE 12) that was adjustable to set the nozzles at a fixed height during spraying. Adjusting nozzle height was a trial and error procedure that was difficult and time consuming. The collar was difficult to move along the cylinder rod and usually required a tool to tap the sleeve of the collar into position. Several collar adjustments were required before the desired nozzle height was made. It is recommended the manufacturer consider modifying the nozzle height adjustment assembly to make it easier to adjust nozzle height.

Nozzle height could be adjusted from 12 to 36 in (304 to 914 mm). The maximum nozzle height was the same height as the main boom since the castor wheel lock pins were adjusted to lock the castor wheels at that boom height. Operating the nozzles higher than the main boom was possible. Care had to be exercised to prevent the castor wheels from turning parallel to the boom and locking in place. The boom could be raised 60 in (1.6 m) before the boom auto-fold clevis disengaged and released the booms from field position.

The sprayer was delivered with the booms uneven from end to end. The booms were initially levelled by adjusting the suspension adjustment rods on the castor wheels. This was done two more times during the field tests before the booms stayed level. The Swivel-Jet dual nozzle tip assemblies made nozzle changing very easy.

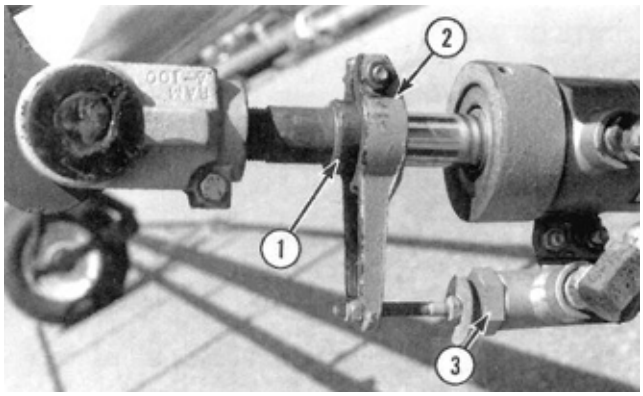

FIGURE 12. Nozzle Height Adjustment System: (1) Stop Collar Sleeve, (2) Stop Collar, and (3) Shut-off Valve.

Tank Filling: Ease of filling the spray tank was very good. The 835 gal (3796 L) spray tank could be filled utilizing the filler opening or reloading system. The reloading system was more convenient and safe, since less foaming and splashing occurred. All reloading valves were easily accessible from the reloading side of the sprayer. The time required to fill the spray tank averaged about 20 minutes. Increasing pump speed did not significantly reduce the time to refill the spray tank, but leaving the agitator valve open did reduce refill time. A 2 in (51 mm) transfer hose was needed to connect the nurse tank to the reloading coupler.

Care had to be exercised to prevent chemical solution from the spray tank entering the water supply source and running the sprayer pump dry during reloading. Therefore, it was important to open and close the valves quickly in the recommended sequence. To make reloading easier and prevent chemical solution from entering the water supply line, AFMRC installed a 2 in (51 mm) valve (FIGURE 13) between the reload line inlet coupler and sprayer suction line. It is recommended the manufacturer modify the reloading system to prevent chemical solution from entering the water supply line.

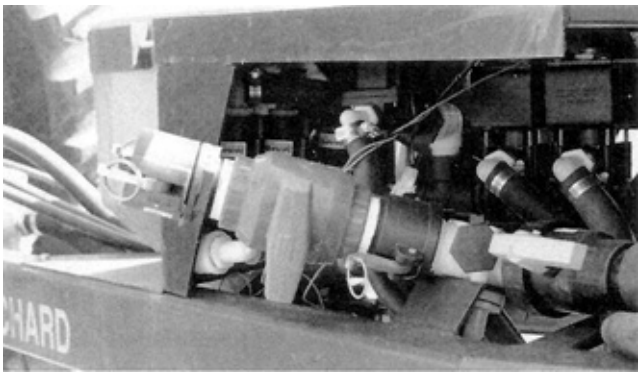

FIGURE 13. Reload Valve

Chemical Inducting: Ease of adding chemical to the spray tank was good. The Harmon sprayer was equipped with an easy-fill chemical tank (FIGURE 1). The easy-fill tank filler opening was 41 in (1 m) above the ground making it easily accessible. Normal caution was still needed to prevent chemical splashing.

The easy-fill chemical tank was near the reloading valves, making chemical inducting and reloading water one operation. This allowed immediate chemical agitation. Chemical could also be inducted

during agitation with the spray tank nearly full, thus reducing solution foaming. Both were convenient and preference depended on operator skill, time and amount the chemical foamed.

Normally, it took about 1.5 minutes to induct the chemical from a full easy-fill tank. The pump had to be operated slowly, about 3500 rpm, to prevent cavitation.

Hitching: Ease of hitching was good. The hitch jack provided was safe. In transport position with the spray tank empty, the hitch jack had to be placed at the rear of the sprayer trailer, to prevent the trailer from tipping rearwards. The hitch clevis was adjustable to level the spray tank trailer. Hitching included the hook-up of four hydraulic lines for the pump orbit motor and height adjustment of the spray booms, plus two electronic couplers for the remote control and monitor systems.

Cleaning: Ease of cleaning was good. Removing nozzle caps from the Swivel-Jet nozzle assemblies for cleaning was quick. The nozzle orifices should be unplugged using a soft bristle toothbrush to prevent orifice damage.

Removing the strainers from the Swivel-Jet nozzle assemblies was difficult at times. The top of the nozzle assemblies had to be tapped or the strainer pried with a screwdriver, causing chemical solution to splatter on the operator.

The pump inlet strainer was accessible from under the hitch frame for removal. Because the strainer bowl was pointed towards the center of the trailer, during strainer bowl removal, the chemical solution drained on the operators hands.

Draining: Ease of draining the spray tank was fair. The spray tank was partially drained through the reload line. The pump suction hose at the suction line had to be removed to completely drain the tank.

The pump cavity was easily drained by opening the cock at the bottom of the pump. Draining the hoses was done by loosening the ring clamps and removing the hose ends. The spray booms were drained by removing the end plugs. The Swivel-Jet diaphragm nozzle body assemblies were difficult and inconvenient to drain since the diaphragm had to be removed to completely drain the body assembly.

Lubrication: Ease of lubricating the sprayer was very good. The Harmon sprayer had only 12 pressure grease fittings. The four grease fittings located in the castor wheel pivot arms required greasing every 10 hours. The two boom pivot and four castor wheel spindle grease fittings required greasing every 50 hours. All grease fittings were easily accessible. Frequency of greasing the two grease fittings on the overhead bar pivot was not indicated.

PUMP PERFORMANCE

Output: The Hypro 9303C-HM1 centrifugal pump output was very good. The pump was operated between 3500 and 5000 rpm at hydraulic flows between 6.6 and 9.8 gal/min (30 and 45 L/min), respectively. At 4500 rpm the pump delivered 20.8 gal/min (95 L/min) to the Harmon sprayer booms at a 40 psi (276 kPa) nozzle pressure. This was adequate to apply 25 gal/ac (280 L/ha) at a forward speed of 5 mph (8 km/h), using nozzles rated at 0.42 gal/min (1.9 L/min).

Agitation: Agitation output was good. The Harmon sprayer was equipped with two horizontally mounted, hydraulic agitators. TABLE 4 shows agitator outputs during various operating conditions using the 0.19 and 0.25 in (4.8 and 6.4 mm) diameter orifices. Agitation rates varied depending on pump speed and the amount the regulator and agitator valves were opened. Maximum agitation rates occurred with the agitator valve fully opened and the regulator valve closed. The flows shown in TABLE 4 are with the agitator valve opened and the regulator valve adjusted to produce a nozzle pressure of 40 psi (276 kPa) during spraying.

Agitator output was 20 to 26 gal/min (91 to 118 L/min) during field spraying, depending on the nozzle and agitator orifice used. This exceeded the recommended agitation rates for emulsifiable concentrates and just fell short of the recommended agitation rates for wettable powders. Normally recommended agitation rates for emulsifiable concentrates such 2,4-D are 1.5 gal/min per 100 gal (1.4 L/min per 100 L) of tank capacity. For wettable powders such as Atrazine, recommended agitation rates are 3.0 gal/min per 100 gal (3.0 L/min per 100 L) of tank capacity. Operators should use the 0.25 in (6.4 mm) diameter orifices when spraying wettable powders.

TABLE 4. Agitator Outputs

OPERATING CONDITION	PUMP SPEED rpm	AGITATOR OUTPUT	
		3/16 in ORIFICE gal/min (L/min)	1/4 in ORIFICE gal/min (L/min)
Reloading	4500	19 (86)	22 (100)
Field Spraying (110015)	4500	20 (91)	23 (105)
Field Spraying (11003)	4500	22 (100)	26 (118)

OPERATOR SAFETY

The operator's manual emphasized operator safety throughout. The Harmon sprayer had warning decals to indicate proper operating procedures, ie. wearing rubber gloves. The Swivel-Jet dual nozzle body assemblies reduced operator exposure to chemical during changing nozzle tips. The sprayer was not equipped with a slow moving vehicle sign.

Caution: Operators are cautioned to wear suitable eye protection, respirators and clothing to minimize operator contact with chemicals. Although many commonly used agricultural chemicals may be relatively harmless to humans, they are a hazard if improperly used. In addition, little is known about the long-term effects of human exposure to many commonly used chemicals. In some cases, the effects may be cumulative, causing harm after continued exposure over several years.

OPERATOR'S MANUAL

The operator's manual was very good. It was clearly written and well illustrated. It provided useful information on safety, machine specifications, sprayer operation, maintenance, adjustments, trouble shooting and optional equipment.

MECHANICAL PROBLEMS

TABLE 5 outlines the mechanical history of the Harmon sprayer during 122 hours of operation while spraying about 4168 ac (1687 ha). The intent of the test was evaluation of functional performance. An extended durability evaluation was not conducted.

DISCUSSION OF MECHANICAL PROBLEMS

Booms: The booms were difficult to keep at the same height and forward angle throughout the field test. The castor wheel adjusting rods and secondary lift tube U-joints were adjusted several times to keep the nozzle height the same across the width of the booms. The tension on the castor wheel spring changed and the U-joints moved causing the booms to become uneven. It is recommended the manufacturer modify the sprayer boom to help keep the booms height and forward angle constant. Both boom ends failed a couple of times while spraying near fences and irrigation pipes. It is recommended the manufacturer modify the boom design to include a boom breakaway system.

TABLE 5. Mechanical History

ITEM	OPERATING HRS.	EQUIVALENT FIELD AREA ac (ha)
BOOM:		
--the booms were uneven and levelled at	beginning	of test
--the end booms were too high and adjusted at	14	160 (65)
--the wet booms became	27	1056 (428)
uneven and were	35	1296 (525)
re-adjusted at	58	2071 (838)
--the end booms bent	49	1846 (747)
after striking an object	73	2509 (1016)
and were repaired at	111	3827 (1549)
--the end booms' spray angle	73	2509 (1016)
changed and were	83	2865 (1160)
re-adiusted at		
--the outer left boom parallel link rod was loose and retightened at	111	2827 (1145)
--the inner wet boom supports failed and were repaired at	121	4168 (1687)
--the castor pivot rocker arm assembly was worn at	end of	test
TRAILER:		
--the teft trailer wheel nuts loosened and were replaced at	8	288 (117)
--the tank straps were loose and retightened at	25	1056 (428)
--the auto-fold catch guy wire clamp failed and was repaired at	73	2509 (1016)
--the left auto-fold bar spring coil broke at	111	3827 (1549)

APPENDIX I

SPECIFICATIONS

MAKE:	Harmon
MODEL:	833
SERIAL NUMBER:	A01068
MANUFACTURER:	Harmon International Industries Inc. P.O. Box 1444 2401 Millar Avenue Saskatoon, Saskatchewan STK 3P7 Phone: (306) 931-1161
OVERALL DIMENSIONS:	
-trailer wheel tread	9 ft (2.7 m)
-transport height	6.2 ft (1.9 m)
-length	55.3 ft (16.9 m)
-width	10.3 ft (3.1 m)
-field height	6.2 ft (1.9 m)
-length	19.8 ft (6 m)
-width	82.2 ft (25 m)
-clearance height	14 in (356 mm)
-turning radius	40 ft (12 m)
TIRES:	
-trailer	two, 16.5 L x 16.1, 6 ply
-boom	four, 6.7 L x 15, 4 ply

WEIGHT:	**TRANSPORT POSITION** Empty	Loaded
-left trailer wheels	1360 lb (617 kg)	5420 lb (2459 kg)
-right trailer wheels	1340 lb (608 kg)	5420 lb (2459 kg)
-inner boom wheels-left	500 lb (227 kg)	500 lb (227 kg)
-right	500 lb (227 kg)	500 lb (227 kg)
-outer boom wheels-left	240 lb (109 kg)	240 lb (109 kg)
-right	240 lb (109 kg)	240 lb (109 kg)
-hitch	-10 lb (-5 kg)	640 lb (290 kg)
TOTAL	4170 lb(1892 kg)	12960 lb (5880 kg)

FIELD POSITION Empty	Loaded
1320 lb (599 kg)	5320 lb (2413 kg)
1270 lb (576 kg)	5320 lb (2413 kg)
500 lb (227 kg)	500 lb (227 kg)
500 lb (227 kg)	500 lb (227 kg)
240 lb (109 kg)	240 tb (109 kg)
240 lb (109 kg)	240 lb (109 kg)
100 lb (45 kg)	840 lb (381 kg)
4170 lb (1892 kg)	12960 lb (5879 kg)

SPRAY TANK:	
-material	plastic
-capacity	835 gal (3796 L)
-agitation	hydraulic, 2 jet agitators
FILLER OPENING:	
-shape	round
-size	
-small	4.75 in (121 mm) I.D.
-large	15.75 in (400 mm) I.D.
-location	top, front
-height above ground	72 in (1829 mm)
CHEMICAL INDUCTOR:	
-type	Easy-fill tank
-capacity	15.7 gal (71 L)
-opening	8 in (203 mm) I.D.
-height above ground	41 in (1041 mm)
STRAINERS:	
-pump inlet hose	1, 50 mesh
-nozzle assembly	
-XR110015VS	50, 100 mesh
-XR11003VS	50, 50 mesh
-spray tank	1, 16 mesh
PUMP:	
-make	Hypro
-model	9303C-HM1
-type	centrifugal
-operating speed	4500 rpm at hydraulic flow of 8.3 gal/min (38 L/min)
-type of drive	hydraulic orbit motor
CONTROL CONSOLE:	
-make	Spraying Systems Co.
-model	744
-pressure gauge	dial, 0-100 psi (0-690 kPa)
SOLENOID VALVES:	
-make	Spraying Systems Co.
-model	18605-1
-size	two, 1 in (25.4 mm) NPT, 12 VDC, 30 watt
SPRAY BOOM:	
-material	aluminum
-size	1 in (25.4 mm) Schedule 80
-height adjustment	
-type	hydraulic
-range	12 to 36 in (305 to 914 mm)
-angle adjustment	
-type	manual rotation
-range	36 degrees forward
-nozzle assembly	
-make	Swivel-Jet
-type	split-eyelet diaphragm dual nozzle
-number	5O
spacing	20 in (508 mm)
cap	quick-connect, colour coded, self-aligning
-effective spraying -width	83.3 ft (25.4 m)

SUMMARY CHART
HARMON 833 AUTO-FOLD FIELD SPRAYER

RETAIL PRICE:	$14,446.50 (December 1991, f.o.b. Lethbridge)
RATE OF WORK:	77 ac/hr (31 ha/hr) @ 7.5 mph (12.1 km/h)
QUALITY OF WORK:	
Application Rate	**good;** at constant tractor speed and nozzle pressure
Nozzle Calibration (XR110015VS)	
-delivery	**very good;** similar to manufacturer's rating
-wear	**good;** 2 per cent increase after 53 hours
-CV	**very good;** about 2.1 per cent
Nozzle Calibration (XR11003VS)	
-delivery	**very good;** similar to manufacturer's rating
-wear	**good;** 2 per cent increase after 53 hours
-CV	**very good;** about 0.8 per cent
Spray Distribution	
-XR110015VS	**very good**; uniform above 24 psi (165 kPa)
-XR11003VS	**very good;** uniform above 22 psi (150 kPa)
Spray Drift	**good;** minimized using XR11003VS nozzles at low pressures and heights
Pressure	
-loss	**good;** true nozzle pressure not indicated
-gauge	**fair;** 3 psi (21 kPa) high
Straining	**good;** 100 mesh nozzle strainer ineffective using lake water
Boom Stability	**good;** wet boom lift bar was unstable
Soil Contact Pressure	
-trailer	38 psi (262 kPa)
-castor	23 psi (159 kPa)
Crop Damage	minimal

EASE OF OPERATION AND ADJUSTMENT:	
Application Rate	**good;** easy with dual nozzles
Controls	**very good**
Castor Wheel Adjustments	**very good;** took about 1 hour
Maneuverability	**very good;** towed easy in tight corners
Boom Position	**good;** transport--30 s, field--2 min
Nozzle Adjustments	**fair;** difficult to adjust hydraulic stop collar
Tank Filling	**very good;** 20 minutes
Chemical Inducting	**good;** Easy-fill tank
Hitching	**good;** negative hitch weight in transport position
Cleaning	**good;** strainers difficult to remove and messy
Draining	**Fair;** no drain, had to disconnect suction hose
Lubrication	**good;** 12 grease fittings required greasing 10 and 50 hours
PUMP PERFORMANCE:	**very good;** adequate capacity for 0.42 gal/min (1.9 L/min) nozzles
OPERATOR SAFETY:	improved with remote control and dual nozzles
OPERATOR'S MANUAL:	**very good;** complete information on safety and operation
MECHANICAL HISTORY:	problems with booms staying level and nozzles remaining at the desired forward angle.

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