Printed: February 1984
Tested at: Lethbridge
ISSN 0383-3445
Group 3c

EVALUATION REPORT 348

VALLEY UNIVERSAL RAINGER MODEL 9880 LINEAR MOVE IRRIGATION SYSTEM

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

VALLEY UNIVERSAL RAINGER MODEL 9880 LINEAR MOVE IRRIGATION SYSTEM

MANUFACTURER:
Valmont Industries Inc.
Valley, Nebraska 68064
U.S.A.

DISTRIBUTOR:
Oliver Irrigation
236 - 36 Street North
Lethbridge, Alberta
T1J 4B2

RETAIL PRICE:
$105,000.00 1984, f.o.b. Lethbridge (1950 ft (595 m) system equipped as shown in APPENDIX I).

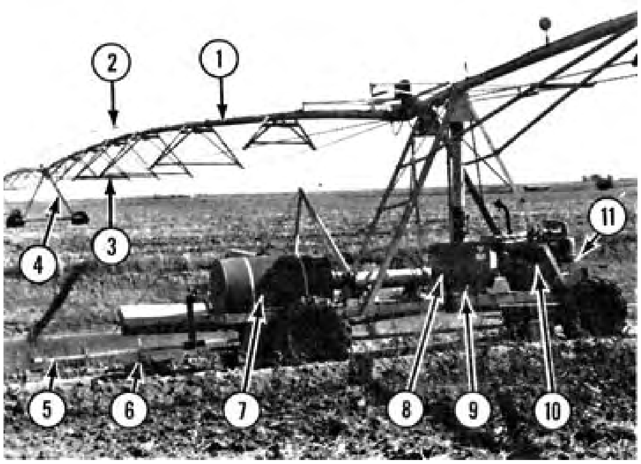

FIGURE 1. Valley Universal Rainger Model 9880 Linear Move Irrigation System: (1) Lateral Pipe, (2) Nozzles, (3) Truss Supports, (4) Support Tower, (5) Steering Arms, (6) Guide Posts, (7) Fuel Tank, (8) Control Panel, (9) Pump, (10) Diesel Engine, (11) Generator.

SUMMARY AND CONCLUSIONS

Overall Performance: Overall functional performance of the Valley Universal Rainger Model 9880 linear move irrigation system was fair. Performance was reduced by guidance and alignment problems and high application rates.

Nozzle Distribution Patterns: Individual distribution patterns of the Delavan Raindrop spray nozzles were circular and ring shaped. Very high applications occurred in one region of the pattern perimeter. Increasing nozzle pressure increased the wetted area and increased the average application rate. Increasing nozzle discharge height increased the wetted area and decreased the average application rate.

System Distribution Uniformity: The coefficient of uniformity (CU)[1] under light wind conditions was 75 per cent when operated with the optional end gun and 76 per cent when the end gun was shut off. The maximum coefficient of uniformity under ideal conditions was 82 per cent. High applications occurred below each nozzle and near each support tower.

Extension Booms: Nozzle extension booms increased the area over which water was applied. Average application rate was 2.2 in/h (56 mm/h). Maximum application rate was 13.7 in/h (348mm/h). Local ponding occurred at various positions along the lateral when operated at low timer settings.

Nozzle Calibration: Nozzle delivery varied less than one per cent after 820 hours of field use. The Senninger pressure regulators were effective in reducing nozzle pressure variations resulting from lateral pressure changes.

Pressure Losses: Pressure losses when operating in hilly fields were occasionally large enough to cause a reduction in the nozzle delivery rate. The system pressure gauge read 6 psi (40 kPa) high in the normal operating range.

Crop Damage: About 1.5 per cent of the total irrigated area was required for the cart road allowance and supply ditch. Tower wheels travel over less than 0.5 per cent of the total irrigated area.

Pump Delivery: Output from the Cornell pump was adequate for most field conditions. Priming the pump was difficult due to an improper seal at the exhaust valve.

Rate of Work: Maximum travel speed was 75 in/min (1900) mm/min). Application depth decreased with increased travel speed.

Ease of Operation: Operation of the steering and alignment system was erratic, causing numerous system shutdowns. All controls were accessible. The system pressure gauge was not readily visible from the control panel location. Servicing and cleaning was easy. Span drains occasionally plugged with silt.

Operator's Manual: The operator's manual was clearly written and contained information on operating, servicing, adjustments and safety.

Mechanical Problems: Several mechanical problems occurred during the 960 hours of operation. The fuel gauge leaked, the booster pump contact and generator malfunctioned. A support tower drive motor burned out and the tread on the cart tires began to separate.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifications to the nozzle patterns or spacing arrangements to provide uniform distribution and to reduce the areas of high application rates.
2. Supplying an accurate system pressure gauge.
3. Modifications to the exhaust priming valve to permit easy pump priming.
4. Relocating the system pressure gauge location to provide convenient visibility from the control panel location.
5. Modifications to the steering and alignment control systems to reduce system down time.

Senior Engineer: E. H. Wiens

Project Engineer: M. V. Eliason

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Valmont has developed a 360 degree spray nozzle which according to our coefficient of uniformity test indicates a uniformity range of 89 to 93 percent. This improved 360 degree spray nozzle with an operating pressure of 20 psi has a wetted area of 35 to 48 feet versus 20 to 25 feet for Raindrop nozzles. Therefore, the wetted area for the 360 degree is t75 percent greater than the Raindrop. Our spray pattern on the 360 degree spray nozzle is evenly distributed across the entire wetted area instead of concentrated in circular rings. The droplet size and angle of trajectory can be adjusted by changing the distribution pad to match customer needs, such as high wind or heavy soil conditions. The nozzle spacing has also been adjusted to a standard 8.5 feet spacing for increased overlap and uniformity.
2. Our pressure gauge today is a liquid-filled unit, which is more reliable and has greater accuracy.
3. The exhaust primer has been redesigned from an exhaust can type to a slide plate that is inserted into the exhaust stack. The slide plate unit has had good field acceptance and is functioning quite well. We also offer an electric primer for our electric-powered pumps that is also an option for our diesel-powered pumps.
4. We now have an optional pressure gauge that is much larger and is easily read from the ground for our linear system.
5. We have modified our steering and alignment controls and have updated all systems in the field to the new style. The steering controls were modified from a post and rail guidance unit to a cable mounted to a post next to the ditch and steering rails were mounted on the cart. The steering point is now

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[1] Christiansen's coefficient of uniformity (CU) is commonly used as a measure of distribution uniformity. A CU above 85% indicates very uniform coverage while a CU below 70% indicates inadequate uniformity.

continuous and has been moved forward, which has solved the steering problem. This in turn has helped our alignment controls by keeping the system controlled properly to avoid compression in the spans, which can effect the alignment. The alignment controls have also been modified to make them lighter to support and more sensitive,

GENERAL DESCRIPTION

The Valley Universal Rainger model 9880 is a diesel powered, electrically driven, linear move irrigation system designed to irrigate rectangular field areas. Water distribution is through a series of nozzles spaced along an overhead lateral pipe. The lateral pipe is supported by a bowstring truss system and is mounted on support towers. Each support tower is mounted on two wheels and supports one span of lateral pipe. Spans are connected by flexible pipe and ball and socket couplers. Water is supplied to the system from a ditch constructed along the length of the irrigated area.

For the test machine, the supply ditch was located near the centre of the irrigated area with five spans on each side of the ditch. The supply ditch could also be located along the edge of the irrigated area. A cart mounted on two axles and four wheels supports a diesel engine, electric generator, centrifugal pump and fuel supply. The cart is connected to the end of a span and travels beside the supply ditch. Traction drive, powered by electric motors, is through reduction gearboxes and drive shafts. Each support tower is powered by one electric motor while the cart is powered by two electric motors.

An electrical control panel mounted on the cart controls travel direction and speed. Application depth is determined by system speed, with greater depths applied at slower speeds. Guidance and alignment are controlled through four steering arms contacting a series of guide posts placed at 20 ft (6.1 m) intervals along the supply ditch. Small alignment deviations are automatically corrected while electrical safety switches provide system shutdown in the event of excessive alignment deviation or mechanical failure.

The test machine was equipped with 224 nylon Delavan Raindrop hollow cone spray nozzles and 20 psi (140 kPa) Senninger pressure regulators. System pressure at the pump was 35 psi (240 kPa). Nozzles and regulators were mounted on 60 in (1525 mm) booms extending perpendicular to and on alternate sides of the lateral. Nozzle spacing was about 100 in (2540 mm) giving an irrigated width of 1970 ft (600 m).

The test machine was equipped with a 135 hp (100 kW) turbo charged diesel engine, a 25 KVA electrical generator, a centrifugal pump, a Nelson end gun and other equipment listed in APPENDIX I.

FIGURE 1 shows the location of major components while detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Valley Universal Rainger was operated for 960 hours while irrigating a 380 ac (152 ha) field of barley. It was evaluated for quality of work, rate of work, ease of operation and adjustment, operator safety and suitability of the operator's manual.

RESULTS AND DISCUSSION

QUALITY OF WORK

General: The test machine was equipped with six sizes of 3.4 in (19 mm), 140 degree spray angle, nylon Delavan Raindrop spray nozzles. Sizes included RA-85, RA-90, RA-95, RA-100, RA-110 and RA-130. The selection and arrangement of various nozzle sizes is usually unique to a particular system installation. Nozzle selection and arrangement are usually designed for the particular soil, topographic, climatic and crop conditions of each system installation. Application rates and distribution patterns of similar systems can vary significantly and may not be directly comparable.

Nozzle Distribution Patterns: Delavan Raindrop nozzles (FIGURE 2) delivered spray downward in a hollow conical fashion resulting in a circular ring-shaped distribution pattern. FIGURE 3 shows a typical distribution pattern of a single stationary RA-95 Raindrop nozzle when operating at 20 psi (140 kPa) and a 167 in (4250 mm) discharge height. Higher applications occurred at the perimeter of the pattern than the interior. Very high applications occurred in one region of the perimeter. This region was characteristic of all nozzles tested and occurred in a similar relative position. TABLE 2 shows the average[2] and maximum application rates of various sizes of Delavan Raindrop nozzles while operating at a 167 in (4250 mm) discharge height and 20 psi (140 kPa). High application rates can cause local ponding and run-off on certain soils. Care has to be exercised during system design to ensure application rates do not exceed soil infiltration capacity.

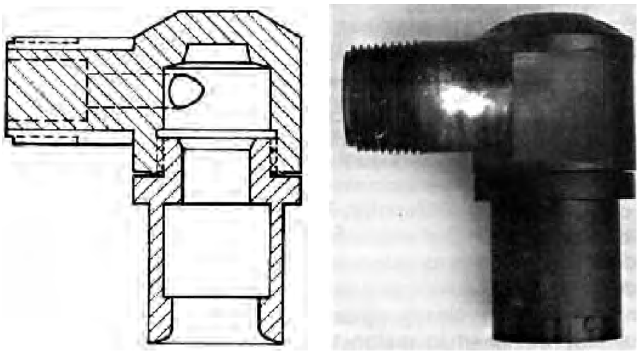

FIGURE 2. Delavan RA Raindrop Spray Nozzle, mm) while discharge heights varied from 154 to 185 in (3900 to 4700 mm).

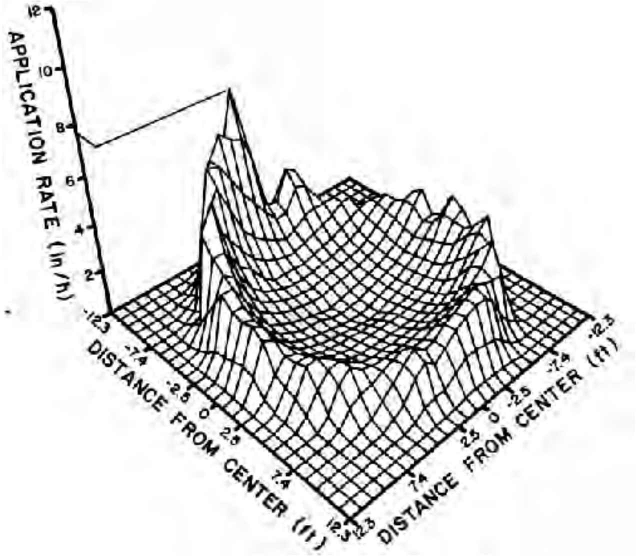

FIGURE 3. Distribution Pattern of a Delavan RA-95 Raindrop Spray Nozzle at a 167 in (4250 mm) Discharge Height and a Pressure of 20 psi (140 kPa).

TABLE 2. Average and Maximum Instantaneous Application Rates of Various Delavan Raindrop Nozzles

Delavan Nozzle Size	Average Application Rate		Maximum Application Rate	
	in/h	mm/h	in/h	mm/h
RA-85	1.18	30	6.1	155
RA-90	1.24	32	7.9	201
RA-95	1.28	33	7.4	188
RA-100	1.32	34	6.9	175
RA-110	1.50	38	7.9	201

Single nozzle distribution patterns were not seriously affected by small pressure variations. Large pressure variations, however, altered both the wetted area and the average application rate. FIGURE 4 shows the average application rates for various nozzles while operating over a range of pressures and a 138 in (3500 mm) discharge height. Increasing nozzle pressure increased the wetted area and increased the average application rate. For example, increasing the nozzle pressure for nozzle RA-85 from 15 psi (100 kPa) to 50 psi (345 kPa) increased the average application from 1.35 to 1.65 in/h (34 to 42 mm/h).

FIGURE 5 shows the effect of nozzle discharge height on the average application rate for various sizes of Raindrop nozzles. Increasing nozzle discharge height increased the wetted area and decreased the average application rate. For example, increasing the operating height of nozzle RA-100 from 148 to 187 in (3750 to 4750 mm) decreased the average application rate from 1.45 to 1.24 in/h (37 to 31 mm/h).

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[2] *Average application rate is the delivery rate of the nozzles over the wetted area.*

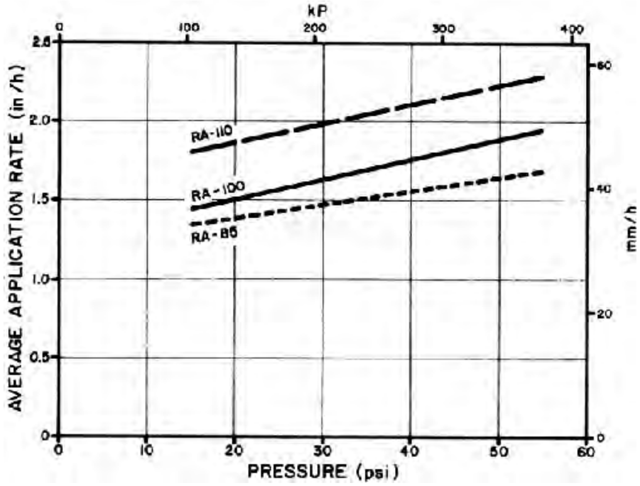

FIGURE 4. Average Application Rate of Various Delavan Raindrop Nozzles While Operating at Various Pressures and a 138 in (3500 mm) Discharge Height.

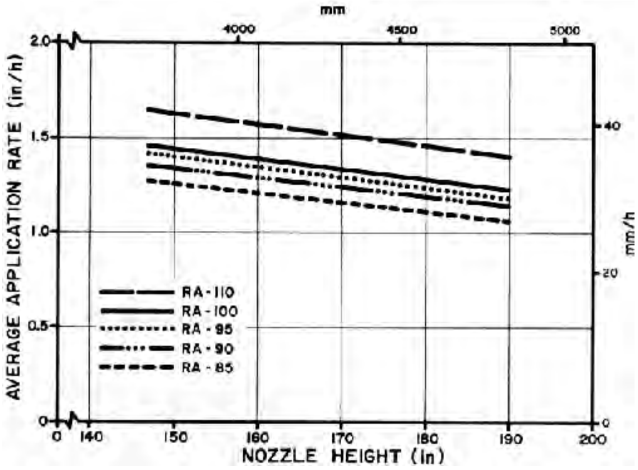

FIGURE 5. Average Application Rates of Various Delavan Raindrop Nozzles Operating at Various Discharge Heights and a Pressure of 20 psi (140 kPa).

Distribution Uniformity: To obtain a more uniform water application than that obtained from individual nozzles, nozzle distribution patterns are overlapped. The amount of overlap depends on the nozzle size, lateral pressure, nozzle height and nozzle spacing. Nozzle sizes and spacing arrangements are usually designed to match the application requirements of individual system installations. For the test machine, nozzle spacings along the lateral varied from 83 to 228 in (2110 to 5800 mm) while discharge heights varied from 154 to 185 in (3900 to 4700 mm).

FIGURE 6 shows a typical distribution along one section of the Valley Rainger lateral. Inadequate overlap due to excessive nozzle spacing occurred at two locations. At distances of 676 and 840 ft (206 and 256 m) from the system centre, excessive nozzle spacings resulted in inadequate application and reduced crop growth. It is recommended that the manufacturer modify the nozzle spacing at these locations to provide adequate coverage.

The coefficient of uniformity (CU) can be used as a measure of system distribution uniformity. The average coefficient of uniformity for the test machine was 75 per cent when operated with the optional end gun and 76 per cent when the end gun was shut off. These values represent average values based on eight field distribution can tests[3] obtained under light wind conditions. Distribution uniformity will vary depending on climatic conditions.

With the aid of a computer, individual nozzle distribution patterns can be overlapped to determine the theoretical spray distribution along the lateral. FIGURE 7 shows the theoretical spray distribution along one section of the test machine when operated with the end gun shut off. The theoretical CU for the test machine was 82.0 per cent. High spray concentrations occurred below each nozzle. The very high application regions on the perimeter of the nozzle distribution patterns (FIGURE 3) tended to overlap and superimpose on one another. High applications also occurred nearer the support towers than those near the centre of the lateral spans. The low nozzle discharge heights at the tower locations tended to decrease the wetted area and increase the average application.

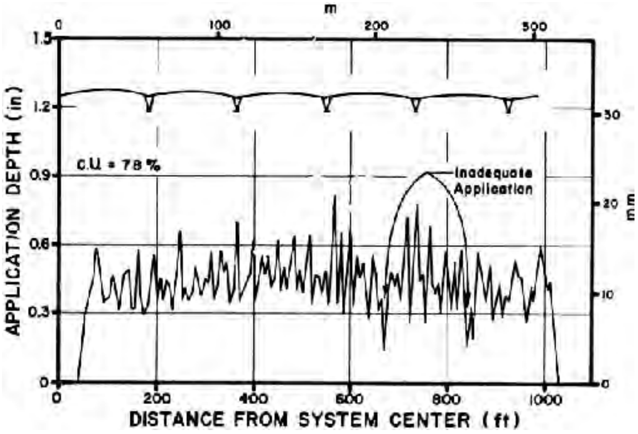

FIGURE 6. Typical Distribution Along One Side of the Valley Rainger Lateral with Delavan Raindrop Spray Nozzles and Senninger Pressure Regulators.

The theoretical coefficient of uniformity represents the spray distribution obtained for a continuously moving system under ideal environmental conditions. Actual uniformity will vary depending on environmental conditions and system speed.

Although the theoretical and field distribution uniformities of the test machine represent adequate coverage, it is recommended that the manufacturer modify the nozzle patterns and spacing arrangements to provide more uniform coverage.

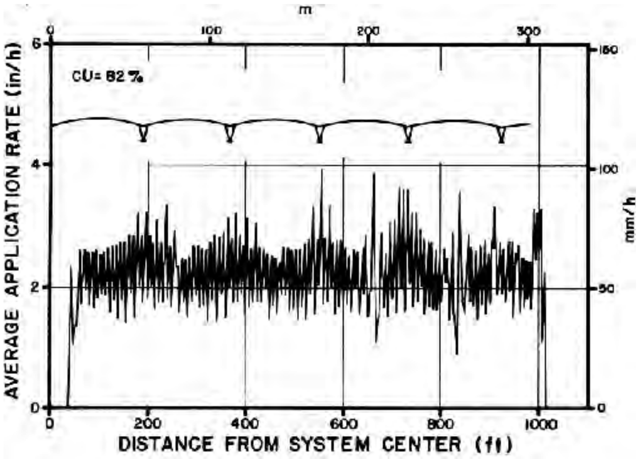

FIGURE 7. Theoretical Application Distribution Along One Side of the Valley Rainger Lateral.

End Gun: The optional end gun extended the irrigated width by about 105 ft (32 m) and permitted irrigation of irregular field areas. The average coefficient of uniformity for the end gun was 70 per cent. This compares to an average system uniformity of 75 per cent when the end gun was operating and 76 per cent with the end gun shut off.

Extension Booms: Nozzle extension booms increased the area over which water was applied. FIGURE 8 shows the theoretical average application rates of the test machine for various positions about the lateral when equipped with 60 in (1525 mm) extension booms. High applications occur below the lateral and up to 150 in (3810 mm) on either side of the lateral due to distribution patterns from adjacent nozzles overlapping and superimposing below the lateral.

The average theoretical application rate for the test machine was 2.2 in/h (56 mm/h). Maximum application rate for the test machine was 13.7 in/h (348 mm/h). High application rates can cause local ponding and runoff on certain soils. Few soils can accept such high instantaneous applications for more than a few minutes. For the test machine, local ponding occurred at various positions along

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[3] *PAMI Detailed Test Procedures for Irrigation Systems.*

the lateral when operated at slow speeds. As already recommended, modifications to eliminate high applications are required.

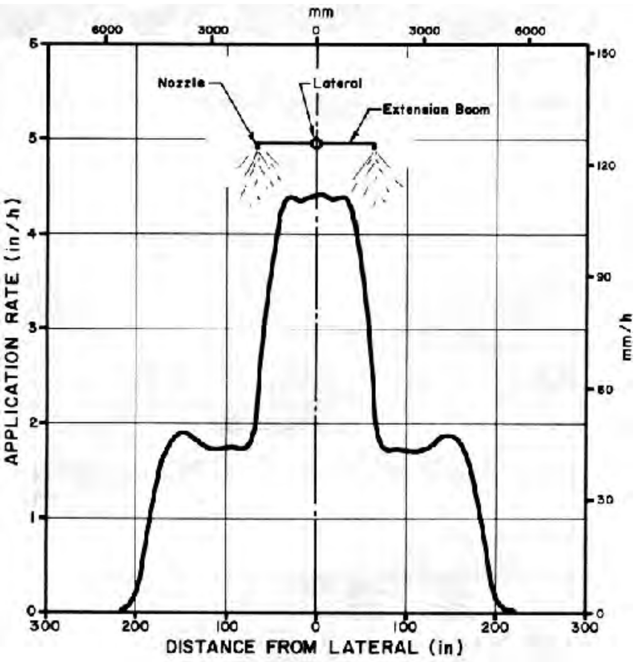

FIGURE 8. Theoretical Average Application Rates for Various Positions About the Lateral.

Spray Drift: The Delavan nozzles produced a concentrated application pattern, with relatively large droplets, which resulted in little susceptibility to wind drift. Water was directed downward from the nozzle outlet, which reduced exposure to wind. Excessive losses can, however, occur when wind velocities are high.

Nozzle Calibration: FIGURE 9 shows the average delivery of various sizes of Delavan Raindrop nozzles over a range of operating pressures. Delivery rate increased less than 1.0% about 820 hours of field use. Nozzle wear would depend on water cleanliness and type, if any, of chemicals used.

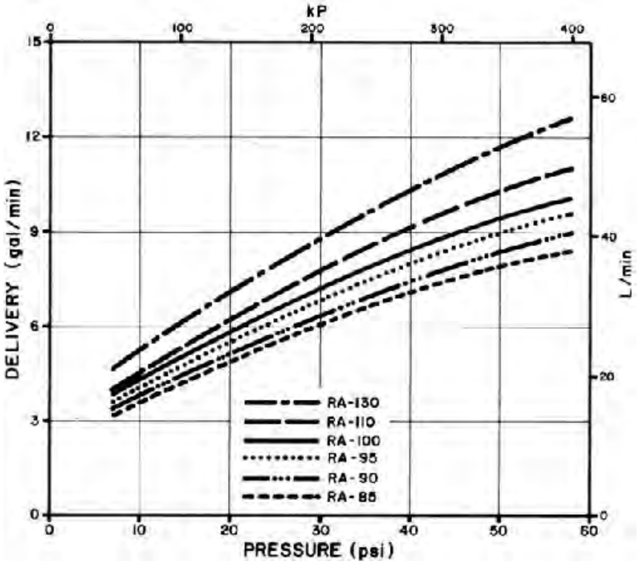

FIGURE 9. Delivery Rates for Various Sizes of Delavan Raindrop Spray Nozzles over a Range of Pressures.

The 20 psi (140 kPa) Senninger pressure regulators (FIGURE 10) were effective in reducing nozzle delivery variations resulting from lateral pressure variations. FIGURE 11 shows the average delivery of various Delavan nozzles when equipped with the Senninger pressure regulators. The use of pressure regulators is recommended where lateral pressures are subject to large variations. For example, nozzle delivery from an RA-100 nozzle equipped with a regulator operating at a lateral pressure of 35 psi (240 kPa) decreased only 7 per cent for a 30 per cent decrease in lateral pressure.

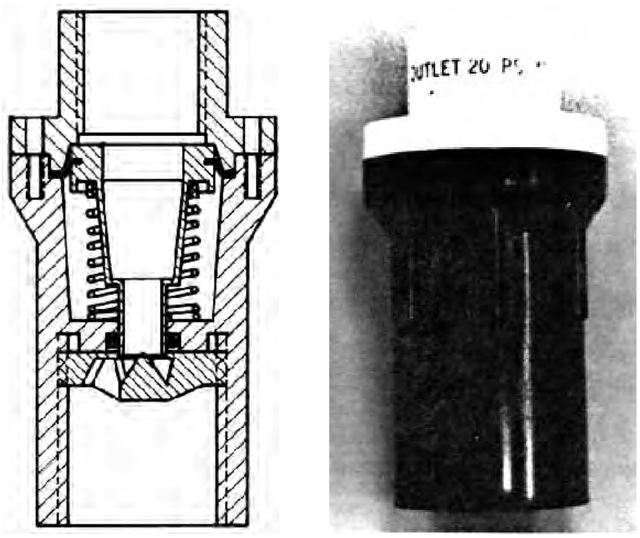

FIGURE 10. Senninger Pressure Regulator.

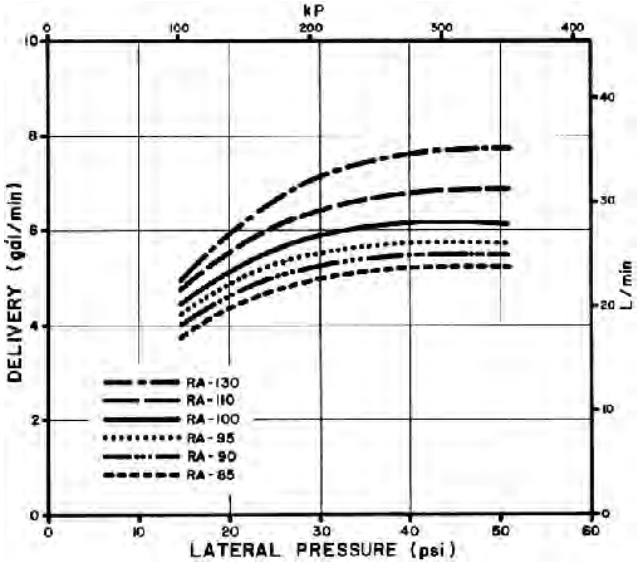

FIGURE 11. Delivery Rates for Various Sizes of Delavan Raindrop Spray Nozzles Equipped with 20 psi (140 kPa) Senninger Pressure Regulators.

Use of Optional Nozzles: A wide range of nozzles and sprinklers are adaptable to the Universal Rainger. However, to ensure even distribution and suitable application rates, various nozzles and sprinklers must suit the particular system, crop, soil and topographic conditions.

Lateral Pressure Losses: Lateral pressures were measured at the pump outlet and various positions along the system. Pressure at the pump was 35 psi (240 kPa). Pressure losses along the lateral were uniform with lowest pressures occurring at the system ends. Pressure at the system ends was 27 psi (190 kPa). Pressure losses when operating on flat fields were minimal and did not seriously affect nozzle output. When operating in hilly fields, however, pressure losses were occasionally large enough to cause a significant reduction in nozzle delivery. Care has to be taken to ensure that sufficient pressure is available to overcome pressure losses due to elevation changes.

Pressure Gauges: Two pressure gauges were supplied with the Valley Universal Rainger. One gauge served as a safety switch for low pressure shutdown while the other was mounted on the lateral pipe. The gauge mounted on the lateral pipe read 6 psi (40 kPa) high in the normal operating range. It is recommended that an accurate system pressure gauge be supplied.

Strainers: A mesh screen (FIGURE 12) was located on the suction intake, which removed most particles that could damage the pump. No line strainers were provided on the system lateral. The nozzles did not plug during testing. However, nozzle plugging would depend on water cleanliness.

FIGURE 12. Intake Pipe Suction Screen.

Crop Damage: The tower wheels travelled over less than 0.5 per cent of the total area irrigated. This area represented a crop loss as repeated irrigations prevented crop growth. In addition, approximately 1.5% of the total area was required for the cart roadway and water supply ditch.

Pump: Pump delivery at 35 psi pressure head (240 kPa) was about 1300 gal/min (5940 L/min) which was adequate to supply the test system when operating on level ground. The Cornell centrifugal pump was coupled directly to the engine. The pump was oil lubricated which enabled system movement without water application.

The pump was primed by activating an engine exhaust valve (FIGURE 13) to supply vacuum to the intake pipe. Priming was difficult as a proper seal at the exhaust valve could not be achieved. It is recommended that the manufacturer modify the valve to provide adequate intake pipe vacuum.

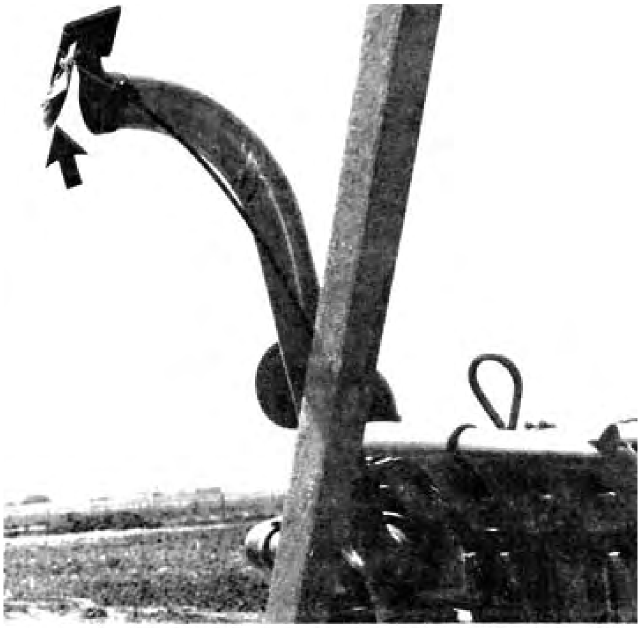

FIGURE 13. Exhaust Priming Valve.

RATE OF WORK

Field Speeds: Most electric irrigation machines travel in an on-off fashion. Travel speed during the on cycle is constant and depends on tire size, electric motor speed and the gear reduction ratios of the traction drives. Average travel speed is adjusted by the duration of the on portion of the travel cycle. Speed was controlled by adjusting the per cent timer, which determines the duration of the current signal supplied to the electric motors. The Valley Universal Rainger could be operated at speeds varying from 0 to 75 in/min (0 to 1900 mm/min) when equipped with 11 x 24.5 tires.

FIGURE 14 shows the average depth applied for various timer settings for the test machine. Average application depth decreased with an increase in overall travel speed. Average application depths for similar machines will vary depending on nozzle sizes and pump delivery.

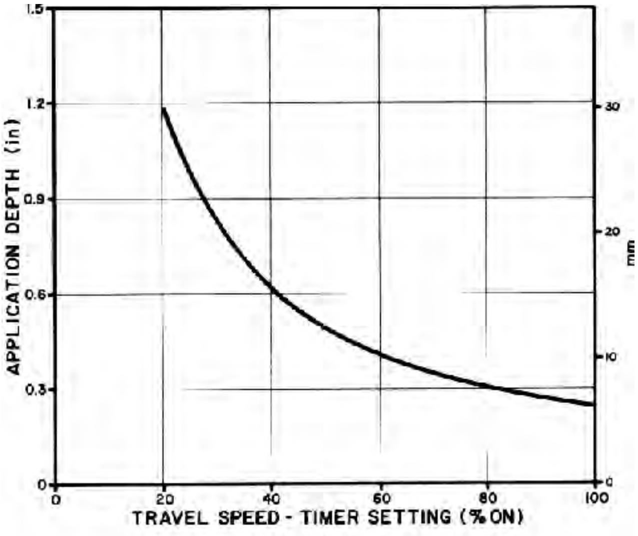

FIGURE 14. Average Application Depth for Various Time Settings for the Test System.

EASE OF OPERATION AND ADJUSTMENTS

Controls and Gauges: The main control panel (FIGURE 15) was conveniently located for easy access to system controls. The control panel included gauges for system voltage, the per cent timer, a main disconnect switch, and a forward and reverse selector switch. Indicator lights were provided to indicate forward or reverse steering, type of system shutdown, and when the system and per cent timer were on.

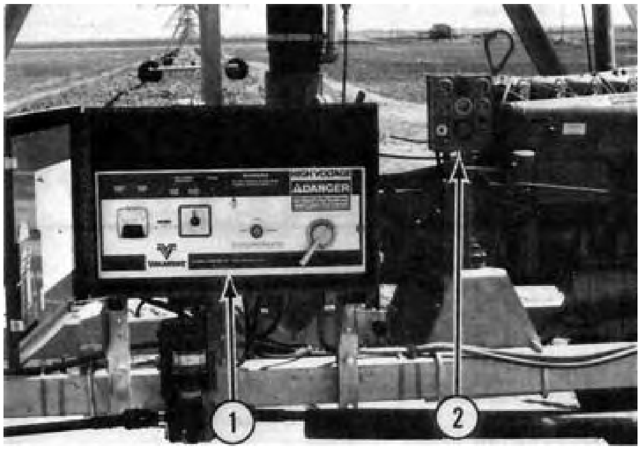

FIGURE 15. Rainger Control Panel: (1) Main Control Panel, (2) Engine Control Panel.

An engine control panel included gauges for engine oil pressure, engine temperature, engine hours, engine vacuum, battery voltage and system water pressure. Safety switches mounted on the engine temperature, engine oil pressure, engine vacuum, and system water pressure gauges permitted system shutdown if normal operating levels were exceeded. Bypass switches were provided to override safety switches for system start-up.

An engine oil level gauge and safety switch were conveniently located to monitor engine oil levels.

System pressure and generator voltage were controlled by engine speed. The engine throttle was conveniently located.

The system pressure gauge (FIGURE 16) was not readily visible from the control panel location. It is recommended that the manufacturer relocate the system pressure gauge location to provide convenient visibility from the control panel location.

The intake float level was easily adjusted by a winch (FIGURE 17) located near the control panel.

The 258 gal (1135 L) fuel tank was easily filled. A fuel level gauge was conveniently located on the tank.

Towers: The support towers (FIGURE 18) provided convenient access to the tower electrical control boxes. The electrical control boxes were suitably protected from precipitation. Adjustment of the tower alignment linkages was easy but required tools.

Steering and Alignment: Steering and alignment of the Valley

Universal Rainger were automatically sensed by steering arms which followed a series of guide posts placed at intervals along the supply ditch (FIGURE 19). Electrical micro-switches controlled the system steering. Small angular deviations were automatically corrected while severe deviations resulted in system shutdown. Tower alignment was controlled through mechanical linkages and electrical micro-switches.

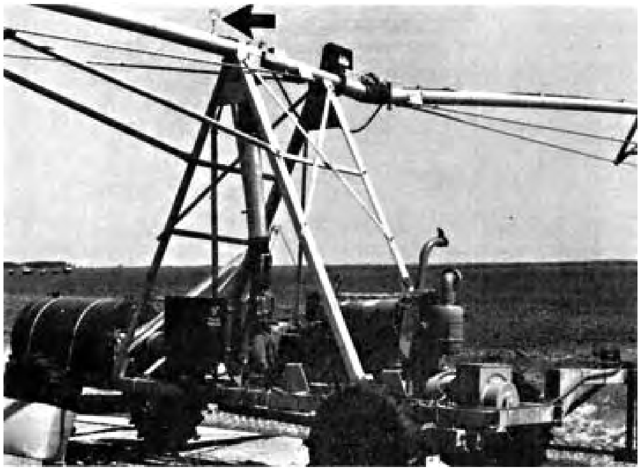

FIGURE 16. System Pressure Gauge Location.

FIGURE 17. Winch for Rainger Intake Float Level Adjustment.

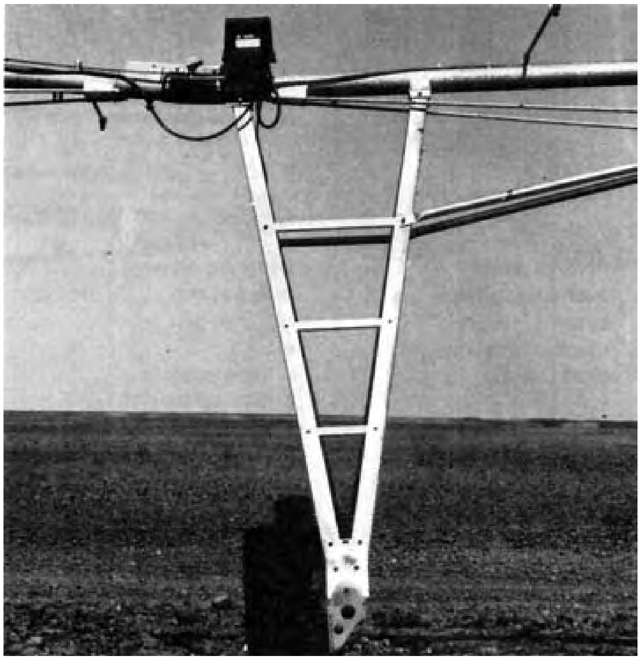

FIGURE 18. Valley Universal Rainger Support Tower.

Operation of the steering and alignment system was erratic. Tower misalignment and system over steering resulted in numerous system shut-downs. It is recommended that the manufacturer modify the steering and alignment systems to improve system guidance and alignment.

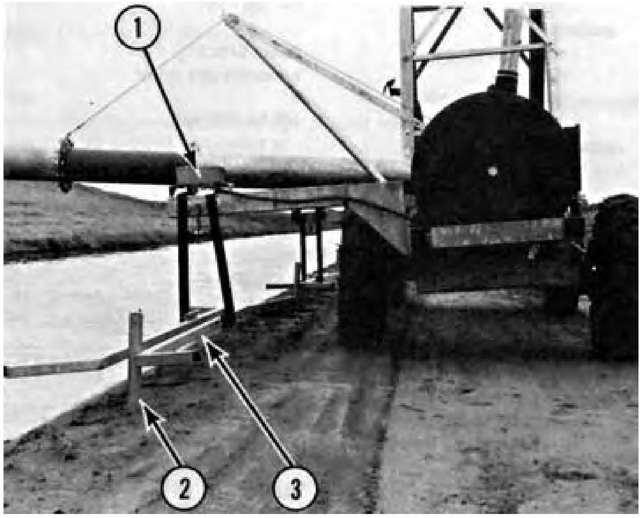

FIGURE 19. Rainger Steering Mechanism: (1) Electrical Micro-switches, (2) Guide Post, (3) Steering Arms.

Safety Devices: The Valley Universal Rainger was equipped with automatic safety devices to provide system shut-off in the event of mechanical or electrical failures. Safety switches on the engine control panel monitored engine oil level, engine temperature, engine vacuum, engine oil pressure and system water pressure. The control panel included safety devices to monitor system electrical power levels. Safety switches located on the steering arms prevented over-watering and excessive path variations while safety switches located at each support tower prevented excessive tower alignment deviation.

The Valley Universal Rainger automatically shut off when the end of the field was reached. The standard steering arm “end of field shut-off” (FIGURE 20) ensured system shut-off at the field ends. An optional end tower “end of field shut-off” was available to provide system shut-down if the end towers reached the fields ends before the steering arm shut-off was activated. This was especially important in installations where obstacles were present at the field ends.

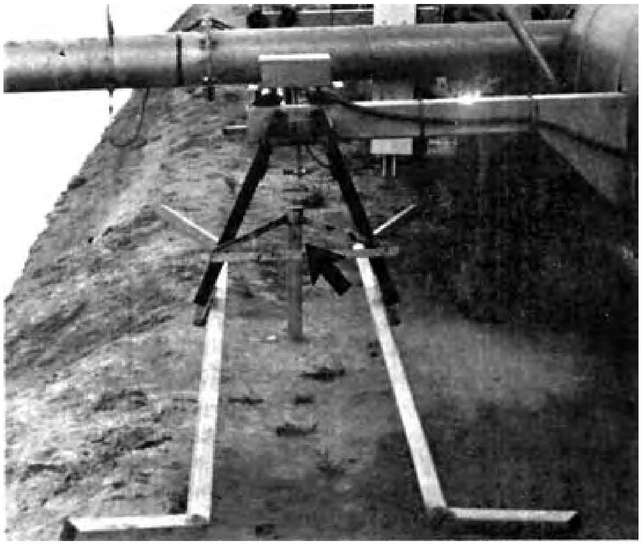

FIGURE 20. Steering Arm End of Field Shut-off.

End Gun and Booster Pump: The optional end gun and booster pump were mounted on the system end and end tower respectively (FIGURE 21). Operation of the end gun and booster pump extended the irrigated width by about 105 ft (32 m) and permitted irrigation of irregular-shaped field areas. A manually operated switch located on the end tower activated the pump and end gun.

Running Light: An optional running light mounted on the end tower provided a convenient means of monitoring system operation.

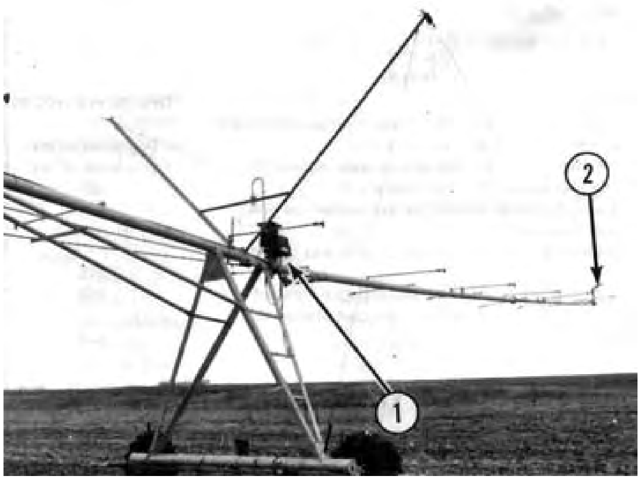

FIGURE 21. Booster Pump (1) and End Gun (2).

Servicing and Cleaning: The Valley Universal Rainger required seasonal checks and lubrication of the pump, tower drive shaft universal joints and tower motor, gear motors and gearboxes. Periodic flushing of the system was required to remove accumulated debris or sand. Flushing required removal of the overhang end caps, sand traps and drains. A ladder was required to remove the overhang end caps.

Occasionally, the span water drains (FIGURE 22) plugged with silt. Cleaning was easy but required a pipe wrench.

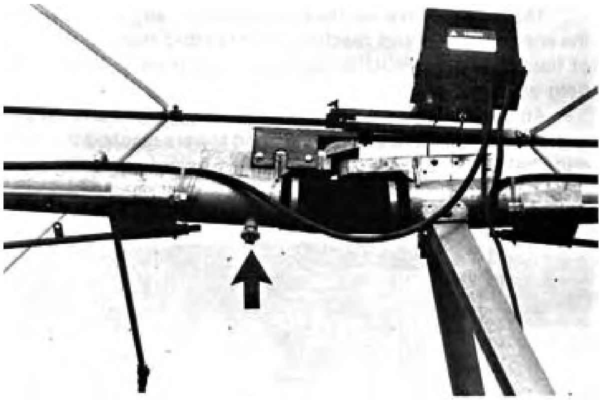

FIGURE 22. Span Water Drain.

OPERATOR SAFETY

The Valley Rainger was safe to operate if manufacturer's recommendations were closely followed. Extreme care must be exercised when handling electric irrigation machines. To reduce the possibility of electrical shock all electrical connections should be inspected by a qualified electrician during system assembly.

OPERATOR'S MANUAL

he operator's manual was clearly written and contained much useful information on operating, servicing, adjustments and safety precautions.

MECHANICAL PROBLEMS

TABLE 2 outlines the mechanical history of the Valley Rainger during 960 hours of operation. The intent of the test was evaluation of functional performance. The following failures represent only those, which occurred during functional testing. An extended durability evaluation was not conducted.

TABLE 3. Mechanical History

Item	Operating Hours
-Interference between the intake pipe support brace and the cart tire was eliminated at	beginning of test
-A small hole in the lateral pipe was repaired at	beginning of test
-The fuel gauge began to leak at	20
A booster pump switch contact burned out and was replaced at	421
-A tower drive motor burned out and was replaced at	576
-The generator malfunctioned and was repaired at	893
-The 11 x 24.5 recap tires on the cart started to separate and were replaced at	895

DISCUSSION OF MECHANICAL PROBLEMS

Brace Supports: Interference between the intake pipe cable support brace and the tire occurred as a result of elevation changes in the cart roadway and an extension of the intake pipe to accommodate a larger ditch design. Shortening the brace supports eliminated tire interference.

Electrical Tower Motors: A tower drive motor burned out when water entered the motor. All motor enclosures should be periodically checked and tightened.

Generator: The generator malfunctioned and caused voltage variations. The generator was repaired and no further problems were encountered.

APPENDIX I
SPECIFICATIONS

MAKE:	Valley Universal Rainger Linear Move Irrigation System
MODEL:	9880
MANUFACTURER:	Valmont Industries Inc. Valley, Nebraska 68064
OVERALL WIDTH:	1950 ft (595,000 mm)
OVERALL LENGTH:	22 ft (6700 mm)
OVERALL HEIGHT:	22 ft (6700 mm)
NUMBER OF SPANS:	10
SPAN LENGTH:	8 - 185 ft (56,000 mm) 2 - 170 ft (52,000 mm)
OVERHANG LENGTHS:	42 and 84 ft (12,800 and 25,600 mm)
NUMBER OF TOWERS:	10
TOWER WHEEL BASE:	13.3 ft (4050 mm)
UNIVERSAL RAINGER CART:	
-- length	14.6 ft (4450 mm)
-- width	5.7 ft (1740 mm)
-- height	120 ft (36,600 mm)
TIRES:	11 x 24.5 recap
CROP CLEARANCE:	8.7 ft (2650 mm)
INTAKE PIPE DIAMETER:	9.8 in (250 mm)
LATERAL PIPE DIAMETER:	6.6 in (167 mm)
LATERAL PIPE FINISH:	Galvanized
LATERAL PRESSURE:	35 psi (240 kPa)
SPRINKLER SPACING:	8.3 ft (nominal) (2500 mm)
NOZZLES:	
-- make	Delavan
-- model	nylon, 3/4 RA Raindrop
-- size	RA-85, RA-90, RA-95, RA-100, RA-110, RA-130
-- number	224
PRESSURE REGULATORS:	
-- make	Senninger
-- size	0.08 - 6.4 gal/min-20 psi (0.4 - 30L/min-140 kPa)
-- number	224
END GUN:	
-- make	Nelson
-- model	PC 100 - 18°
ENGINE:	
-- make and model	Deutz BF6L913
-- type	turbo-charged diesel
-- number of cylinders	6
-- manufacturer's rating	135 hp (100 kW)
GENERATOR:	
-- make	Lima
-- size	25 KVA
-- rating	3 phase - 230/460 V, 60 Hz
-- type of drive	belt
PUMP:	
-- make	Cornell
-- model	6RB64B4-3
-- serial number	29508 11
-- type	centrifugal
-- type of drive	direct
BOOSTER PUMP:	
-- make and model	Berkley - 1/2 TPHS
-- manufacturer's rating	2 hp (1.5 kW) - 460 V, 60 Hz
FUEL TANK:	
-- material	steel
-- capacity	258 gal (1135 L)
OPTIONS:	
-- end tower end of field shutdown	
-- running light	

APPENDIX II
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Very Good
Good	Fair
Poor	Unsatisfactory

APPENDIX III
CONVERSION TABLE

acres (ac) x 0.40	= hectares (ha)
feet (ft) x 0.305	= metres (m)
horsepower (hp) x 0.75	= kilowatts (kW)
Imperial gallon (gal) x 4.55	= litres (L)
inches (in) x 25.4	= millimeters (mm)
pounds force/square inch(psi) x 6.89	= kilopascals (kPa)

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