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EVALUATION REPORT 349

Senstek DCM-2 Depth Control System

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

SENSTEK DCM-2 DEPTH CONTROL SYSTEM

MANUFACTURER AND DISTRIBUTOR:

Senstek Ltd.
P.O. Box 340
Saskatoon, Saskatchewan
S7K 3L3

RETAIL PRICE:

$3,380.00 (March 1984, f.o.b. Lethbridge, Alberta.)

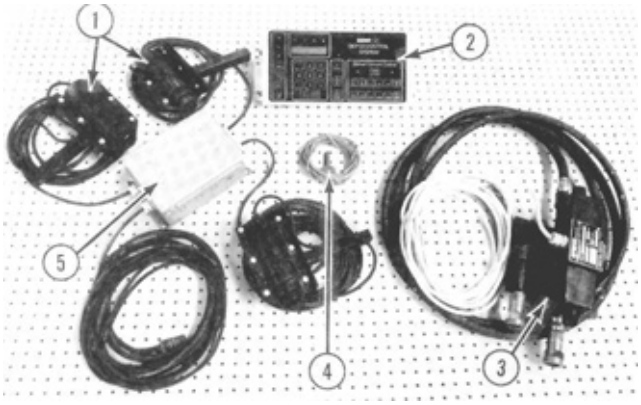

FIGURE 1. Senstek DCM-2 Depth Control System: (1) Sensor, (2) Control Console, (3) Electro-hydraulic Solenoid Valve, (4) Temperature Sensor, (5) Implement Module.

SUMMARY AND CONCLUSIONS

Overall Performance: Functional performance of the Senstek DCM-2 depth control system was good. Performance was reduced by inadequate system response in very soft, lumpy or heavy trash field conditions.

Installation: The Senstek DCM-2 was easily installed by one man in about three hours. No modifications to the tractor or implement were required.

Seed Placement Accuracy: Seed placement accuracy depended on soil conditions. A more uniform depth of seed placement resulted when using the depth control system in varying soil conditions. No difference in seed placement was obtained with and without the depth control in firm soil conditions.

Response: The depth control system response was adequate for most field conditions. In very soft, lumpy or heavy trash field conditions the system would over compensate and result in erratic depth control.

Field Variables: Some error in average depth could result when travelling along field ridges. Depth control system performance was improved when travelling at an angle to field ridges. Similar error in average depths occurred when one cultivator section (one depth sensor) encountered an extended hard area in the field that it could not properly penetrate. Due to cultivator frame geometry, the depth control system could not effectively maintain a uniform depth of tillage through gullies and over sharp hill crests.

Ease of Operation and Adjustment: Control system operation and adjustment were easily performed. An experienced operator could adjust the depth control system to suit most field conditions in less than five minutes. Implement depth adjustments were easily made from the tractor cab. Approximate depth of tillage could be read from the digital display.

Operator Safety: The Senstek DCM-2 was safe for field and transport use. Implement safety lock-ups should be used to ensure safe transport.

Operator's Manual: The operator's manual was well written and contained useful installation, operation, set-up, maintenance and trouble shooting information.

Durability: One failure occurred during the evaluation. Two control console integrated circuits required replacement.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Extending the range of the "set gain" key control to improve system response in very soft, lumpy or heavy trash field conditions.
2. Modifications to improve depth control when travelling parallel to surface ridges.

Senior Engineer: E. H. Wiens

Project Engineer: M. V. Eliason

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. A sensitivity adjustment had been added to the Senstek Depth Control System. Response time can be adjusted as fast as 114 second if desired by the operator or as slow as 2 seconds in very rough conditions.
   This program change has been made on all 1984 production units and is being supplied free of charge to previous purchasers, which is Company policy for changes of this nature.
2. Although we recommend that for more accurate depth control the operator travel at some angle with respect to the direction of the previous pass, there are methods of improving performance when travelling in the same direction as the previous pass. Staggering the sensor spacing position by 1t3 the cultivator spacing will ensure that all sensors will not line up with tops or bottoms of ridges at the same time. Moving the centre sensor to the back of the cultivator eliminates the ridge problem for that sensor with the added benefit of maintaining accurate depth readings when travelling over gullies and over sharp hill crests.

GENERAL DESCRIPTION

The Senstek DCM-2 automatic depth control system is an electronically controlled, hydraulic system intended for maintaining constant implement depth in varying field conditions.

The depth control system consists of an electronic control console mounted in the tractor cab, an electro-hydraulic solenoid valve mounted between a tractor hydraulic remote valve and the implement, a temperature sensor mounted outside the cab, and an implement module and three ultrasonic depth sensors mounted on the implement.

The electronic control console contains function keys which include "set gain", "auto gain", "auto zero", "set depth", "set depth up", "set depth down", and "display depth". An "on-off" control key is provided for either automatic or manual control of the electro-hydraulic solenoid valve. Manual control keys include "all up", "all down", "full up", and "full down". "Up" and "down" keys provide individual manual control for up to four electro-hydraulic solenoid valves. A digital display is provided for depth monitoring and system information. A numeric key pad is used for system programming.

The electro-hydraulic solenoid valve is pilot operated and electrically controlled. The two inlet ports are connected to the tractor hydraulic remote lines while the two outlet ports are connected to the implement depth cylinders. The Senstek DCM-2 can be used on tractors equipped with either open or closed centre hydraulic systems. An optional dumping valve is required for use in open centre systems. Optional multiple electro-hydraulic solenoid valves are available for independent control of individual implement sections.

The Senstek DCM-2 depth sensors are mounted vertically to a front implement frame member with self drilling and tapping screws. The depth sensors use an ultrasonic signal to determine the distance between the ground and the implement frame.

Sensors are connected to the implement module which processes the depth sensor signals and sends the information to the control console. The Senstek DCM-2 is powered by the tractor electrical system and a 9 V battery.

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

SCOPE OF TEST

The Senstek DCM-2 was operated in the field conditions shown in TABLE 1 for about 42 hours. The Senstek DCM-2 was mounted on a Case 4690 four-wheel drive tractor and a John Deere 4630 four-wheel drive tractor. Implements used included a John Deere 665 air seeder and a Concord AS1002 air seeder. The Senstek DCM-2 was evaluated for ease of installation, adjustment, operation, safety and reliability. Measurements were taken to determine the effectiveness of the depth control system in maintaining uniform implement depth in typical prairie conditions.

TABLE 1. Operating Conditions

CROP	FIELD TILLAGE CONDITIONS	FIELD AREA (ac)	FIELD AREA (ha)	HOURS
Summerfallow	Stubble - Secondary	90	36	4
Fertilizer banding	Stubble - Secondary	120	49	6
Spring Wheat	Stubble - Secondary	320	130	15
Spring Wheat	Summerfallow - Secondary	210	85	8
Winter Wheat	Summerfallow - Secondary	240	97	9
TOTAL		980	397	42

RESULTS AND DISCUSSION

EASE OF INSTALLATION

The Senstek DCM-2 depth control system was easily installed. FIGURE 2 shows installation of the control console in the cab of a Case 4690 tractor. Two holes had to be drilled in the tractor cab to mount the console.

A bracket was fabricated to mount the electro-hydraulic solenoid valve on the rear frame member of the model Case 4690 tractor (FIGURE 3). The valve could also have been mounted on the implement hitch. Hydraulic fittings, hoses and quick couplers were purchased to connect the electro-hydraulic valve to the tractor hydraulics.

The Senstek DCM-2 depth sensors were easily mounted on the front frame member of both cultivators used during the test (FIGURE 4). A sensor was mounted on each section of the three-section cultivator. Electrical cables were strapped to the implement frame and hitch using plastic cable ties.

The temperature sensor was mounted behind the cab using plastic cable ties. The temperature sensor had to be mounted in the shade and as far away from the engine and transmission heat as possible.

Installation of the control console, electro-hydraulic valve, temperature sensor and three depth sensors took one man approximately three hours.

FIGURE 2. Senstek DCM-2 Control Console Mounted in Tractor Cab.

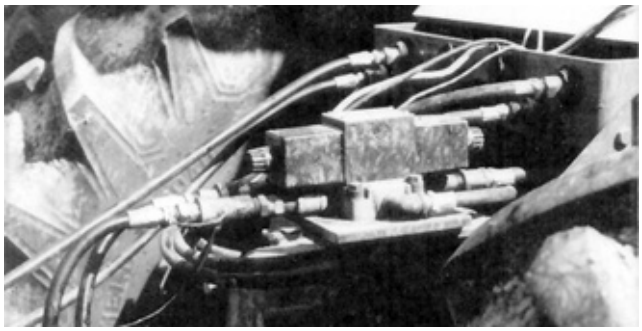

FIGURE 3. Electro-hydraulic Solenoid Valve Mounted at Rear of Tractor.

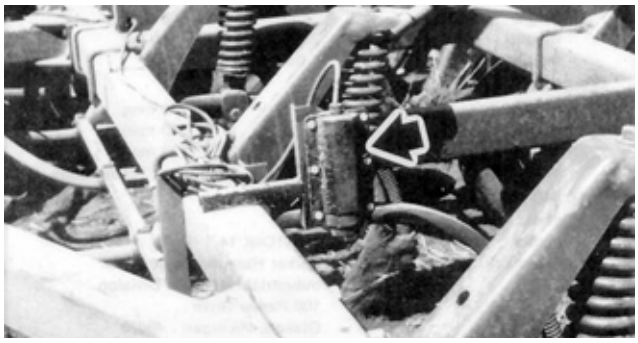

FIGURE 4. Senstek DCM-2 Depth Sensor Mounted on Cultivator Frame.

QUALITY OF WORK

Seed Placement Accuracy: The Senstek DCM-2 depth control system was used predominantly for controlling cultivator depth during normal air seeder operations. These operations included spring seeding, fall seeding and fertilizer banding.

In addition to using the Senstek DCM-2 in normal air seeding operation, a special field plot was prepared for the purpose of determining controller effectiveness. The test plot preparation work consisted of preworking a number of strips across a summerfallow field with a cultivator to a depth of about 5 in (125 mm). This resulted in a variation in field firmness when seeding along the field. Seed depth desired for both test plot and field work was 2 to 2.4 in (50 to 60 mm).

Depth control system effectiveness was determined both by observing its performance during normal field operation and by comparing seed depth placement in adjacent strips seeded with and without the controller. Seed depth placement was determined by uprooting plants after they emerged and measuring the distance from the seed, to where the plant emerged from the ground. Seed depth measurements were taken across the width of the machine as well as along the seed rows, both in the plots and in various fields.

Seed placement measurements in firm conditions showed little difference between average seed depth placement when seeding with and without the depth control system. When soil conditions varied from soft to very firm the depth control system was effective in maintaining a more uniform seed placement depth. For example, without the depth control system, average seeding depth increases ranging from 0.7 to 1.9 in (18 to 47 mm) were experienced due to the cultivator penetrating deeper in soft field conditions. When using the depth control system, little change in average seeding depth was observed.

Response: Response of the Senstek DCM-2 depth control system could be adjusted with the "set gain" key control. In most fields, the depth control system response could be adjusted to suit the particular conditions. Occasionally, however, the response was inadequate. In fields with heavy or lumpy trash

cover, the depth control system would sense the lumps and over compensate. Large variations in depth sensor readings caused the depth control system to alternately raise and lower the implement beyond acceptable limits.

When seeding in very soft conditions, the depth control system would occasionally raise the implement and leave it at the shallow seeding depth. Manual intervention was then required to return the system to the proper depth. It is recommended that the manufacturer increase the range of the "set gain" key control to improve system response.

Field Variables: Overall best performance with the Senstek DCM-2 was obtained in fields which had not been previously tilled or on previously tilled fields which had been worked in a different direction. When working fields the same direction as the previous operation, implement depth was subject to any surface ridging. For example, when one or more of the sensors travelled along a surface ridge, the depth control system would adjust the implement to reflect the new depth readout. This readout would not be correct for the total width of the implement. Alternatively, when travelling across surface ridges, the averaging characteristics of the implement module compensated for the continuous sensor movements thereby providing improved depth control. It is recommended that the manufacturer consider modifications to improve the depth control when travelling parallel to surface ridges.

In hard field areas such as those caused by extensive field traffic, uneven implement penetration occurred. This was evident in areas where one section of the implement encountered a very hard area while the remaining section(s) did not. Due to poor penetration of the implement section in the hard area, the depth control system would lower the implement, allowing the remaining implement sections, which were on softer ground, to penetrate too deep. When working areas such as these the depth control system had to be used manually to avoid excessively uneven implement section penetration.

Due to cultivator frame geometry, the depth control system was not effective in maintaining a uniform depth of tillage when going through gullies or over sharp hill crests.

EASE OF OPERATION AND ADJUSTMENT

Calibration: An experienced operator could calibrate the control console in less than five minutes. Control console calibration involved setting the "auto zero", "auto gain", "set gain", and "set depth" keys. The calibration procedure required operation of the tractor and implement in an open, level field at normal operating speeds and conditions. The "auto zero" key control established the ground level references and was set with the implement just skimming the soil surface. The "auto gain" key control established the response time of the hydraulic system by automatically raising and lowering the implement.

The "set gain" key control determined depth control system response. Proper adjustment of the "set gain" key control was important to ensure adequate depth adjustment response. The "set gain" key control varied the amount of error and the size of the correction the depth control system would allow in making a depth adjustment. Operator experience was needed to coordinate various responses to various field conditions. The "set gain" key control was preset and did not require initial calibration. Changing the control was easy and involved keying in the appropriate number with the numerical key pad. Pressing the "display depth" key returned the console to normal operation.

The "set depth" key control established the initial desired depth. Pressing the "set depth" key and keying the desired depth with the numerical key pad set the desired depth. Pressing the "display depth" key returned the display to normal operation.

Depth Adjustment: The initial depth setting established by the "set depth" key control could be adjusted by the "set depth up" or "set depth down" keys. Pressing the keys adjusted the desired depth by 0.2 or 0.4 in (5 or 10 mm) for each time the key was pressed.

Manual Override: Depth adjustments could be made manually at any time and were required when turning at the headlands. Pressing the "full up" key switched the console to manual control and fully raised the implement. The "full down" key returned the console to automatic control and lowered the implement to the working depth. The control "on/off" key switched the console to either automatic or manual control. A red indicator light indicated when the console was in manual control. Under manual control, the "all up" and "all down" keys adjusted implement depth for a long as the key was held or until the implement was fully raised or lowered. "Up" and "down" keys permitted individual control of the optional multiple valve system.

Hydraulics: The Senstek DCM-2 depth control system could be used on tractors equipped with either open or closed centre hydraulic systems. A dumping valve was required when used with open centre systems.

Visibility: The automatic depth controller was considered advantageous for use with air seeders where visibility of the cultivator was obstructed by the grain tanks. The depth control system provided the operator with an indication of seeding depth.

OPERATOR SAFETY

The Senstek DCM-2 depth control system was considered safe for field and transport use providing adequate precautions were taken. Caution should be used to avoid working under the implement without a safety lock-up in place. A safety lock-up should also be used to ensure safe transport.

OPERATOR'S MANUAL

The operator's manual for the Senstek DCM-2 depth control system contained useful information on components, installation, set-up, maintenance and trouble shooting. The manual was easy to follow and contained good, step-by-step set-up and operating instructions.

DURABILITY RESULTS

The Senstek DCM-2 depth control system was operated in the field for about 42 hours. The intent of the test was functional performance and an extended durability evaluation was not conducted. TABLE 2 outlines the failures that occurred during functional testing.

TABLE 3. Mechanical History

ITEM	OPERATING HOURS
- To improve system response, a 3/32 in (2.4 mm) orifice flow restrictor was placed in the control valve line at	12
- Two control console integrated circuits failed and were replaced at	24

DISCUSSION OF MECHANICAL PROBLEMS

Two control console integrated circuits were replaced when the control system failed to operate.

APPENDIX I

SPECIFICATIONS

MAKE:	Senstek	
MODEL:	DCM-2	
VERSION:	DC-01	
SERIAL NUMBER:	44003	
MANUFACTURER:	Senstek Ltd. P.O. Box 340 Saskatoon, Saskatchewan S7K 3L3	
CONTROL CONSOLE:		
width	6.75 in	(172 mm)
length	16 in	(406 mm)
height	4.5 in	(114 mm)
weight	4 lb	(1.8 kg)
mounting	4 - 5/16 in (8mm) bolts	
power supply	12 volt negative ground	
IMPLEMENT MODULE:		
- width	8 in	(200 mm)
- length	12 in	(305 mm)
- height	4 in	(100 mm)
- weight	22 lb	(10 kg)
- mounting	4 bolt	
SENSORS:		
- width	3 in	(75 mm)
- length	11 in	(280 mm)
- height	9 in	(230 mm)
- mounting	2 - 3/16 in (5 mm) self taping bolts	
ELECTRO-HYDRAULIC VALVE:		
- make	Parker	
- model	D3WlC4K 14	
- manufacturer	Parker Hannifin Corp. Industrial Hydraulic Division 100 Parker Drive Otsego, Michigan 49078	
width	9 in	(230 mm)
length	16 in	(406 mm)
height	6.5 in	(165 mm)
solenoid	12 VDC 3.0 AMP	
pressure	3000 psi	(20,700 kPa)
weight	50 lb	(23 kg)
mounting	subplate 4 - 7/16 in (11 mm) bolts	
plumbing	3/4 in	(19 mm) NPT

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)
horsepower (hp) x 0.75	= kilowatts (kW)
inches (in) x 25.4	= millimeters (mm)
miles/hour (mph) x 1.61	= kilometres/hour (km/h)
pounds (lb) x 0.45	= kilograms (kg)

SUMMARY CHART
SENSTEK DCM-2 DEPTH CONTROL SYSTEM

RETAIL PRICE:	$3,380.00 (March, 1984, f.o.b. Lethbridge)
QUALITY OF WORK:	
- seed placement accuracy	-effective in maintaining uniform seed placement depth in varying field conditions -did not improve seed placement accuracy within a given field condition
- response	-inadequate in soft, lumpy or heavy trash field conditions
- field variables	-inadequate depth control when travelling parallel to surface ridges -inadequate depth control when implement penetration was uneven - inadequate depth control when travelling through gullies or over sharp hill crests
EASE OF OPERATION AND ADJUSTMENT:	
- calibration	- an experienced operator could calibrate in less than five minutes
- depth adjustment	- through numeric key pad and "set depth up" and "set depth down" keys
- manual override	-through key control with a red indicator light indicating manual control
HYDRAULICS:	- could be used with either open or closed hydraulic systems
VISABILITY:	- provided indication of tillage depth when implement view was obstructed
OPERATOR SAFETY:	- safe - implement safety lock-ups should be used for transport
OPERATOR'S MANUAL:	-easy to follow -contained useful information

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