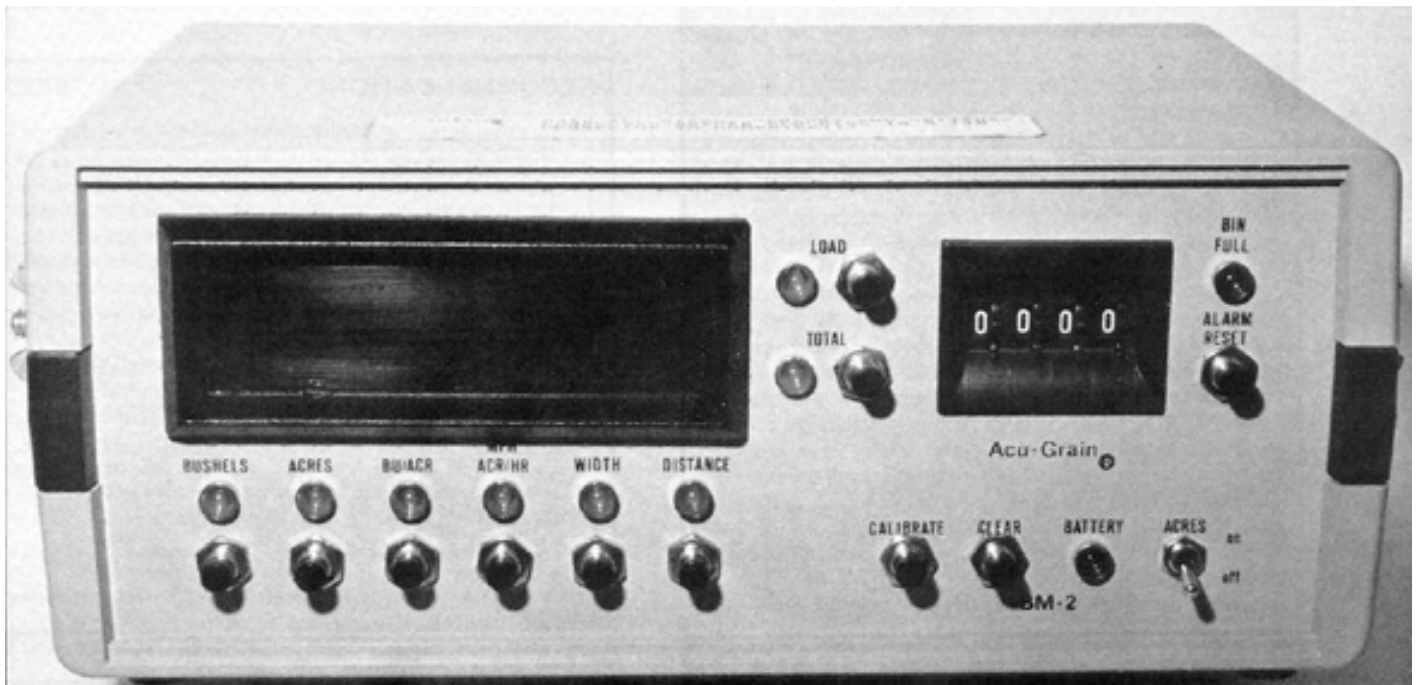


EVALUATION REPORT 362



ACU-GRAIN BM-2 HARVEST MEASURING SYSTEM

A Co-operative Program Between



ALBERTA
FARM
MACHINERY
RESEARCH
CENTRE



PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

ACU-GRAIN BM-2 HARVEST MEASURING SYSTEM

MANUFACTURER:

Acu-Grain
P.O. Box 2453
Great Falls, Montana 59403
U.S.A.

DISTRIBUTOR:

Anderson Sales
P.O. Box 12
Frontier, Saskatchewan
S0N 0W0

RETAIL PRICE:

\$1,995.00 (April, 1984, f.o.b. Humboldt, Saskatchewan).

SUMMARY AND CONCLUSIONS

Quality of Work: The Acu-Grain BM-2 Harvest Measuring System was very useful in providing the operator with crop yield information.

Accuracy of the grain flow measurement was *very good* in dry wheat, corn, barley, and *good* in rapeseed. Careful grain flow sensor adjustment and monitor calibration were important for obtaining accurate measurements. Monitor error varied from 0.1% high in wheat to 2.2% low in rapeseed. Errors greater than 4% occurred when unloading at auger speeds less than the speed at which the monitor was calibrated.

Accuracy of the distance and ground speed measurement was *very good* over the normal range of operating speeds.

Accuracy of the area, grain yield, and workrate calculations was *very good* if the monitor was properly calibrated.

Ease of Installation: Ease of installation was *very good*. It took one man about five hours to install the Acu-Grain BM-2. The monitor, ground speed and grain flow sensors, and unloading auger switch were easily installed on the test combine. Installing the acre meter switch was easy but inadequate instructions made installation confusing. Pull-apart connectors made connecting the wiring harness to the various components convenient and easy.

The monitor was not weather tight and had to be sheltered from the rain.

Ease of Operation and Adjustment: Ease of operating the Acu-Grain BM-2 was *good*, after some operator experience had been gained.

Readability of the LED display and identification of the functions was *fair*. The LED display was easy to read unless it was facing directly into the sunlight. The function lights could not be identified at night unless the combine interior light was on. The monitor readout was in Imperial units only.

Ease of calibrating the monitor was *fair*. Adjusting the grain flow sensor was inconvenient. However, once set for the desired unloading auger speed, it required no further adjustment. Calibrating the grain flow sensor for each grain type and condition was also inconvenient. The distance and ground speed calibration was time-consuming and had to be repeated each time there was a memory loss. The width calibration was easily performed.

Electrical Power Requirements: No excessive electrical demands were made on a normal 12 V battery and charging system. A small 9 volt backup battery was required to prevent memory loss if the main battery voltage dropped below 7 volts.

Operator Manual: The operator manual provided information on installation, operation, adjustment, calibration and troubleshooting.

Mechanical History: No mechanical failures occurred during the test.

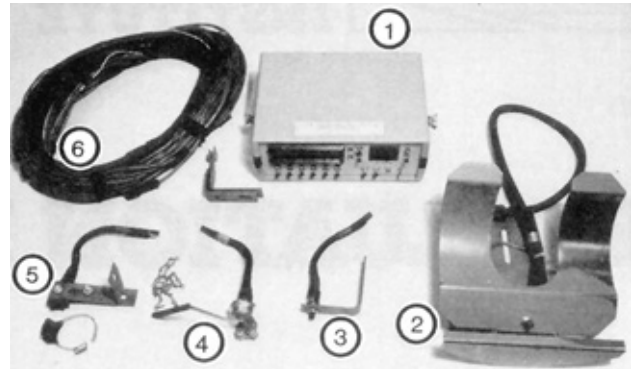


FIGURE 1. Acu-Grain BM-2 Harvest Measuring System: (1) Monitor, (2) Grain Flow Sensor, (3) Unloading Auger Switch, (4) Acre Meter Switch, (5) Ground Speed Sensor, (6) Wiring Harness.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifications to improve the ease of identifying the functions during nighttime operation.
2. Modifications to improve the ease of recalibrating the "Distance" function after memory loss.
3. Supplying a caution in the operator manual and a warning decal for the unloading auger to warn the operator of potential danger when checking the grain flow sensor baffle while unloading grain.
4. Revising the operator manual to clarify installation of the acre meter switch.
5. Revising the operator manual to indicate that distance is displayed in feet in both the "Load" and "Total" mode.
6. Explaining in the operator manual the discrepancy between the "Bu/Ac" value displayed and that obtained by dividing the values displayed in the "Bu" and "Acres" functions.

Senior Engineer: G.E. Frehlich

Project Technologist: R.M. Bartel

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. The figures being displayed should be self-explanatory. However we are looking into alternatives to improve identification of the functions for nighttime operation.
2. A procedure for quickly and easily recalibrating the "Distance" function after memory loss has been included in the new operator manuals.
3. Decals are being provided for the unloading auger and cautions are being included in the operator manual.
- 4 & 5. PAMI had received an older manual which did not include these corrections.
6. This discrepancy is now explained in the operator manual. The numbers appearing in the display for "Acres" and "Bu" are rounded off. The "Bu/Ac" value is accurate since it is calculated from the "Bu" and "Ac" values before they are rounded off.

MANUFACTURER'S ADDITIONAL COMMENTS

If better accuracy is desired in barley, rapeseed or any other crop, the baffle should be readjusted for that crop. This will reduce the error to less than 1%.

GENERAL DESCRIPTION

The Acu-Grain BM-2 Harvest Measuring System consists of a monitor, a grain flow sensor, ground speed sensor, an unloading auger switch, and an acre meter switch (FIGURE 1). The monitor displays ground speed, bushels harvested, acres covered, distance travelled, bushels harvested per acre, and acres harvested per hour.

The monitor mounts at the operator's station. The grain flow sensor mounts in the discharge end of the unloading auger and measures the amount of grain unloaded. The unloading auger switch and a switch in the grain flow sensor activate the monitor to measure grain flow only when the unloading auger lever is engaged and there is grain flowing. A speed sensor mounts on the combine drive axle and measures ground speed. The acre meter switch mounts on the feeder housing. It activates the monitor to measure the area harvested when the feeder housing is lowered.

The Acu-Grain BM-2 is powered by a 12 V DC electrical system and will operate on either a positive or negative ground.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Acu-Grain BM-2 Harvest Measuring System was operated on a New Holland TR85 self-propelled combine for 52 hours while harvesting about 405 ac (165 ha) in the conditions shown in TABLE 1. It was evaluated for quality of work, ease of installation, ease of operation and adjustment, operator safety, and suitability of the operator manual. In addition, it was tested in the laboratory to determine its accuracy in wheat, barley, rapeseed, and corn.

TABLE 1. Operating Conditions.

CROP	VARIETY	AMOUNT UNLOADED		HOURS	FIELD AREA	
		bu	(t)		ac	(ha)
Wheat	Neepawa	5,295	(144)	25.5	173.0	(70)
Barley	Bonanza	5,395	(118)	13.0	123.5	(50)
Rapeseed	Andor	1,240	(28)	7.0	58.0	(24)
	Regent	935	(21)	6.5	50.5	(21)
TOTAL		12,865	(311)	52.0	405.0	(165)

RESULTS AND DISCUSSION

QUALITY OF WORK

Grain Flow Measurement: When calibrated and operated according to the manufacturer's recommendations, the accuracy of the Acu-Grain BM-2 grain flow sensor was very good. Monitor readings varied from 0.1% high in wheat to 2.2% low in rapeseed. TABLE 2 shows the average accuracy results.

For best accuracy, the baffle in the grain flow sensor had to be adjusted as close as possible to being fully open at maximum grain flow. For example, when properly calibrated, the monitor error in wheat was only 0.1% with the baffle adjusted 95% open at maximum flow. However, this increased to 1.9% with the baffle adjusted to 80% open at maximum flow, even though the monitor had been calibrated for the new baffle position.

TABLE 2. Average Accuracy Results.

GRAIN CONDITIONS				RESULTS				
GRAIN	DENSITY		MOISTURE CONTENT (%)	DOCKAGE (%)	UNLOADING AUGER SPEED (% of maximum)	APPROXIMATE BAFFLE OPENING (% of maximum)	ACTUAL GRAIN QUANTITY bu (t)	MONITOR ERROR (%)
	lb/bu	(kg/hl)						
Wheat	60.5	(75)	14.5	2.0	100	95	152 (4.1)	+0.1
Barley	50.0	(62)	14.3	1.0	100	80	140 (3.1)	-1.6
Rapeseed	51.0	(63)	8.6	3.0	100	66	154 (3.5)	-2.2
Corn	56.0	(69)	14.8	3.0	100	90	125 (3.1)	-0.4

Effect of Grain Type and Moisture Content: The baffle opening at maximum flow varied for each grain type and moisture content. Therefore, to obtain best accuracy, the baffle position should be adjusted and the monitor calibrated for each grain. However, since it was not practical to frequently adjust the baffle during harvest, it was set in the optimum position for dry wheat throughout the tests.

With the baffle set for dry wheat, a maximum error of -2.2% occurred in rapeseed. Also, monitor error increased as the moisture content of the grain increased. For example, the monitor error increased from 0.1% to 2.9% as wheat moisture content increased from 14.5% to 24%.

Effect of Unloading Auger Speed: Reducing unloading auger speed decreased the baffle opening and caused accuracy variations in all crops as shown in FIGURE 2 for wheat. Errors of 4% or greater usually occurred at unloading auger speeds less than 60% of the speed at which the baffle had been set and the monitor calibrated. Therefore, considerable error could be expected if the combine was throttled back when topping off a load. Good accuracy could be obtained for unloading at lower auger speeds by setting the baffle opening and calibrating the monitor.

Effect of Quantity of Grain Unloaded: Monitor error increased slightly as the amount of grain unloaded from the hopper decreased. For example, in wheat, with the monitor calibrated for 150 bu (4.0 t) loads, the error increased to 2.1% when the amount unloaded was reduced to 50 bu (1.3 t) (FIGURE 3). Accuracy for smaller batches would be improved if the monitor was calibrated for smaller batches.

In addition, when unloading batches less than 50 bu (1.3 t), the monitor readings varied considerably when measuring the same batch several times. With batches larger than 50 bu (1.3 t), monitor readings were very consistent.

Stopping and starting the grain flow, as when topping off loads, did not appreciably affect accuracy when unloading at the auger speed for which the monitor was calibrated.

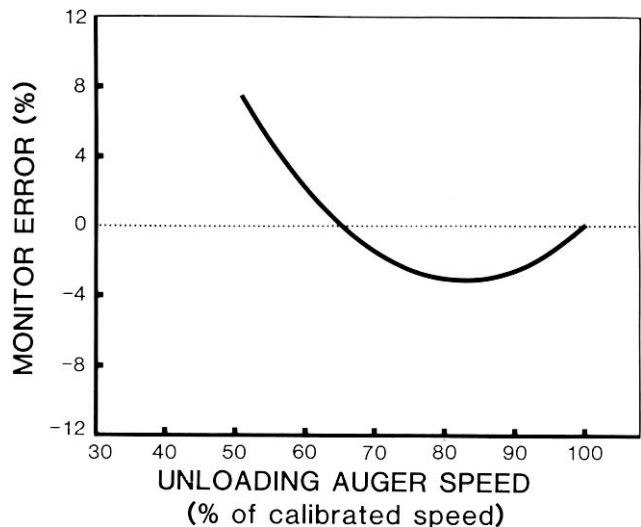


FIGURE 2. Monitor Error when Unloading Wheat at Different Auger Speeds.

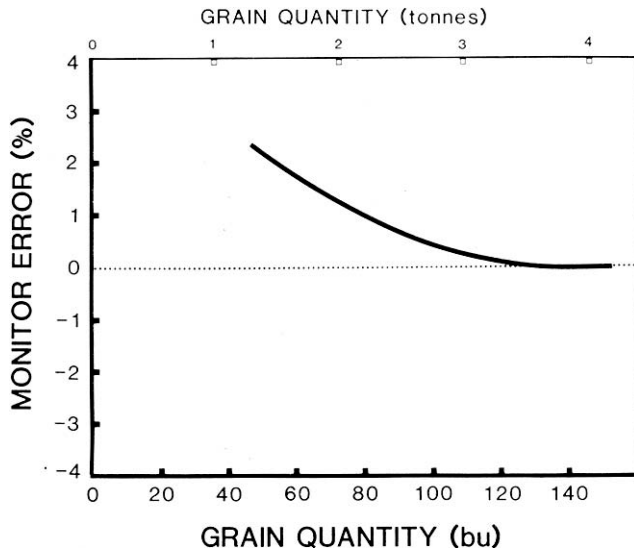


FIGURE 3. Effect of Quantity of Wheat Unloaded on Monitor Error.

Ground Speed Measurement: The ground speed sensor was accurate when properly calibrated. Speed readings did not fluctuate when the sensor was set up according to the manufacturer's recommendations.

Area, Grain Yield, and Workrate Calculations: The monitor calculated the area covered, grain yield, and workrate from the bushels and distance measured and the width calibration. These calculations were accurate if the ground speed, grain flow, and width calibrations were accurately made.

The yield function, "Bu/Ac", did not always correspond to the value obtained by dividing the "Bushels" by the "Acres" displayed. This occurred because the values used to calculate the "Bu/Ac" were not rounded off as much as the values displayed in the "Bushels" and "Acres" functions.

EASE OF INSTALLATION

Installation Time: It took one man about five hours to install the Acu-Grain BM-2 Harvest Measuring System on the self-propelled test combine. Most of the installation instructions were clear and adequate.

Monitor: Mounting hardware and cable were provided for mounting the monitor at the operator's station and connecting it to the combine electrical system. The unit was not weather tight and had to be sheltered from rain.

Ground Speed Sensor: The magnet for the ground speed sensor was easily fastened to the combine drive axle with a hose clamp (FIGURE 4). The ground speed sensor pickup was equipped with adequate brackets for mounting. It was easily positioned within 0.25 to 0.5 in (6 to 12 mm) of the magnet as recommended.

Grain Flow Sensor: The grain flow sensor was easily mounted in the unloading auger discharge of the test combine (FIGURE 5). It had to be carefully installed so the baffle was free to travel through its full range. On some combines the baffle and/or unloading auger may have to be modified to obtain optimum performance.

Unloading Auger Switch: The unloading auger switch activated the monitor to measure grain flow when the unloading auger was engaged. It was easily installed near the unloading auger clutch lever. The sensor was equipped with adequate brackets to secure and position the switch.

Acres Meter Switch: The acres meter switch activated the monitor to measure the acres harvested when the combine header was lowered. It was easily mounted under the cab of the test combine and adjusted for correct operation. However, unclear instructions made installation confusing.

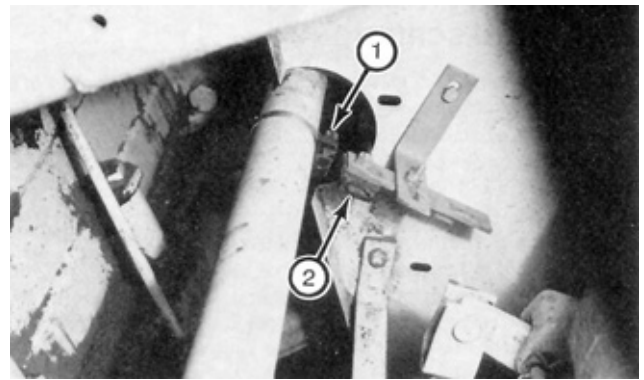


FIGURE 4. Ground Speed Sensor (1) Magnet, (2) Pickup.

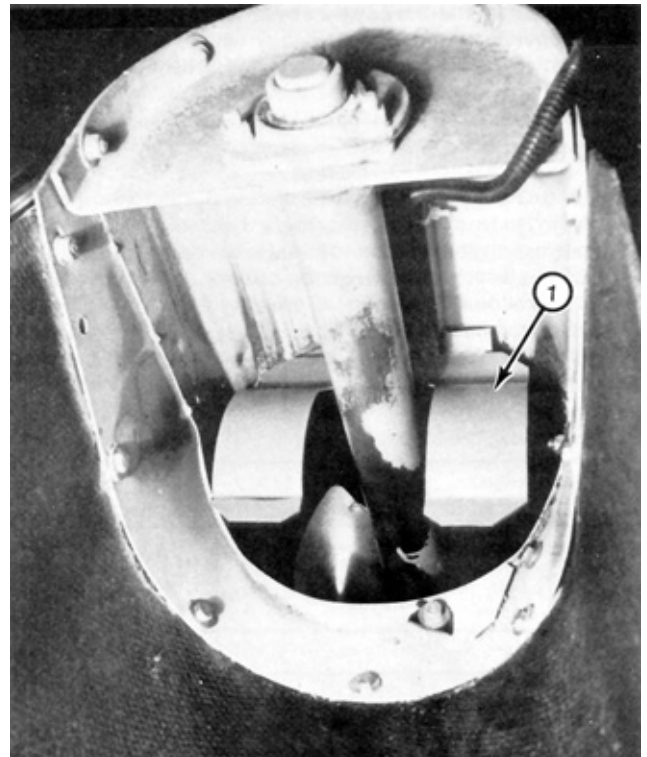


FIGURE 5. Grain Flow Sensor (1) Baffle.

Wiring Harness: The wiring harness included ties for securing cables away from pinch points and components that may cause electrical interference. Pull-apart connectors between the monitor and the various components were included to permit easier installation.

EASE OF OPERATION AND ADJUSTMENT

Monitor Operation: The Acu-Grain BM-2 monitor was easy to operate after some operator experience had been gained. It was very versatile and could be used to obtain many important measurements while harvesting.

The functions provided by the monitor are listed in TABLE 3. The function buttons and switches (FIGURES 6 and 7) were very convenient to operate. Calibration numbers were easily dialed into the monitor using the thumbwheel switches.

When obtaining crop yield results for each hopper, it was important for the operator to remember to press the "Clear" button immediately after but not before the hopper was unloaded. This was not necessary when the crop yield results for each hopper were not required.

TABLE 3. Monitor Controls and Functions.

IDENTIFICATION	OPERATION	FUNCTION
Bushels	Push Button/Indicator Light	- displays grain unloaded when in "Load" mode or total of the "Load" mode values when in "Total" mode.
Acres	Push Button/Indicator Light	- displays acres harvested when in "Load" mode or the total of the "Load" mode values when in the "Total" mode.
Bu/Ac	Push Button/Indicator Light	- displays the average bushels per acre harvested when in the "Load" mode or the average of the "Load" mode values when in the "Total" mode.
Mph: Ac/Hr	Push Button/Indicator Light	- displays the actual ground speed in miles per hour in the "Load" mode or the acres harvested at current ground speed in the "Total" mode.
Width	Push Button/Indicator Light	- displays windrow width in feet when in "Load" mode.
Distance	Push Button/Indicator Light	- displays the distance travelled in feet when in either "Load" or "Total" mode.
Load	Push Button/Indicator Light	- places the display functions into "Load" mode.
Total	Push Button/Indicator Light	- places the display functions into "Total" mode.
Calibrate	Push Button	- used to enter calibration numbers dialed on the calibration thumbwheel switches
Clear	Push Button	- used to zero all display functions in the "Load" mode and to transfer "Bushels", "Acres" and "Bu/Ac" values displayed in the "Load" mode to the "Total" mode.
Total Clear	Push Button	- used to zero all display functions in the "Total" mode.
Battery	Indicator Light	- indicates low battery or memory loss.
Acres	On-Off Switch	- overrides acre meter switch.
Alarm Reset	Push Button	- used to reset the optional full bin audio alarm.
Full Bin	Indicator	- indicates full grain bin.
Crop Calibration	On-Off Switch	- used to enter crop calibration numbers.

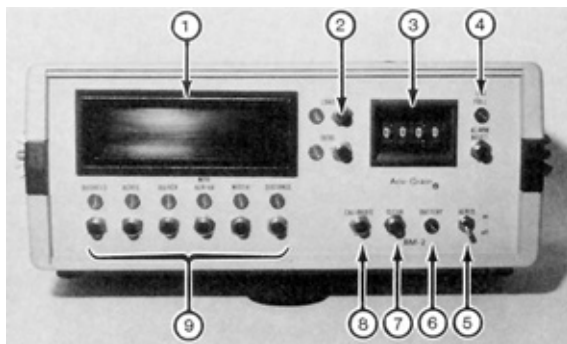


FIGURE 6. Monitor: (1) Display Screen, (2) Mode Buttons, (3) Calibration Thumbwheel Switches, (4) Optional Full Bin Indicator and Alarm Reset, (5) Acre Meter Switch, (6) Low Battery Power Indicator, (7) "Load" Mode Clearing Button, (8) Calibration Button, (9) Monitor Functions.

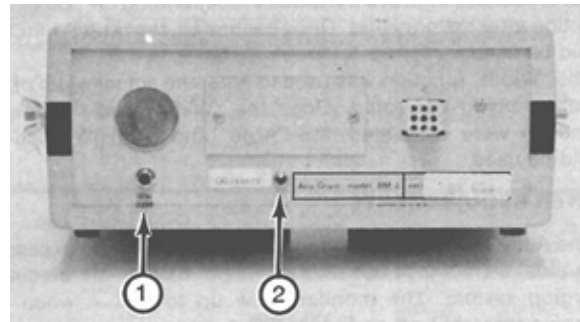


FIGURE 7. Back of Monitor: (1) "Total" Mode Clearing Button, (2) Crop Calibration Switch.

When the "Distance" function was cleared in the "Load" mode, it was also cleared in the "Total" mode. Therefore, the total distance travelled in a field could not be determined if the "Load" mode was cleared after unloading each hopper. However, this total distance was seldom required.

Display Readability: The display screen was easy to read except in direct sunlight. The function buttons could only be identified at night if the combine's interior light was on. It is recommended that the manufacturer consider modifications to improve function identification for nighttime operation.

Calibration: The monitor readout was in Imperial units only. Calibrations had to be made using corresponding values. Calibration numbers were easily entered by setting the thumbwheel switches to the desired calibration number and then depressing the "Calibrate" button until the number appeared on the display screen.

Calibration numbers for the crop being harvested, distance or speed travelled, and windrow width had to be obtained and stored in the monitor for it to be completely functional for harvesting. These numbers were stored in the monitor under the following functions: "Bushels", "Distance" and "Width".

The "Bushels" function was used to store the crop calibration number. Obtaining an accurate calibration number for the crop harvested was time-consuming. The grain flow sensor had to be adjusted so the baffle opened almost to its full extent at maximum grain flow. This adjustment should be carried out prior to the harvest season since the baffle and/or unloading auger may have to be modified. The manufacturer recommends that for best results, adjustments be made with the grain requiring the most baffle movement. Once properly adjusted, the baffle did not require further adjustment.

To obtain the maximum amount of travel and provide free movement for the baffle, it was necessary to locate the grain flow sensor away from the auger tubing. This created a gap at the leading edge of the grain flow sensor. At full flow a small amount of grain flowed over the top of the baffle (FIGURE 8). However, this did not affect the accuracy.

Once the grain flow sensor was properly adjusted, a quantity of grain was unloaded and the actual bushels determined. This bushel figure was then entered into the monitor. Once calibrated, the crop calibration number could be displayed by pressing the on-off crop calibration switch on the back of the monitor (FIGURE 7). This number was recorded so that subsequent calibrations did not have to be performed in similar crop conditions or in case of memory loss. However, for accurate results, the calibration procedure had to be repeated for changes in grain moisture, test weight or grain type.

The "Distance" function was used to store the distance calibration number. The calibration number was obtained by travelling a measured distance of at least 200 ft (61 m) and entering this distance into the monitor. This calibration was time-consuming and had to be repeated each time there was a memory

loss. It is recommended that the manufacturer consider modifications to improve the ease of recalibrating the "Distance" function after memory loss. Once calibrated, the "MPH" function could be used.

The "Width" function was used to enter the actual width of the windrow being harvested. Once the "Width" and "Distance" functions were calibrated, the "Acre" and "Ac/Hr" functions could be used.

POWER REQUIREMENTS

The Acu-Grain BM-2 required a 12 V DC supply. No excessive demands were made on the combine battery or electrical charging system. The monitor drew up to 0.01 A when the combine was shut off and up to 0.7 A when the combine was operating.

The monitor functioned well with a supply voltage between 7 and 16 volts. Supply voltage exceeding 16 volts could damage the circuitry. When supply voltage dropped below 7 volts, the numbers stored in memory were lost and the monitor had to be recalibrated. Memory loss could be prevented by installing a 9 (or 12) volt backup battery in the slot provided in the monitor.

OPERATOR SAFETY

Most adjustments could be made safely if normal precautions were followed when working near the combine. Extreme caution was required when checking the position of the grain flow sensor while unloading grain. No warning was provided. It is recommended that the manufacturer consider supplying a caution in the operator manual and a warning decal for the unloading auger to warn the operator of potential danger when checking the grain flow sensor while unloading grain.

OPERATOR MANUAL

Most of the operator manual was clearly written and well illustrated. It contained useful information on installation, operation, adjustment, calibration, and troubleshooting.

Instructions for installing the acre meter switch were not clear and it is recommended that the manufacturer consider revising the operator manual to clarify installation of the acre meter switch.

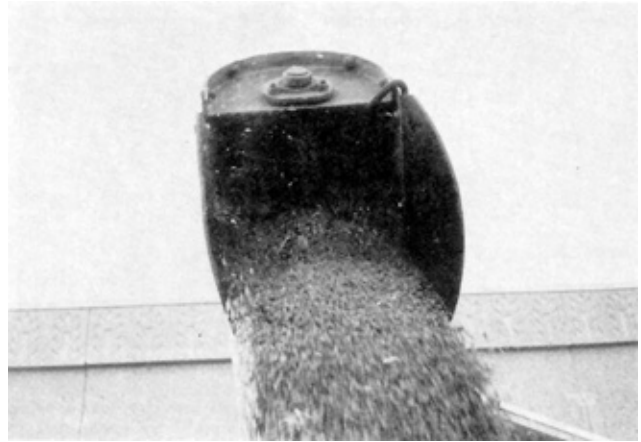


FIGURE 8. Grain Flow Over Top of Grain Flow Sensor Baffle.

The operator manual stated that the "Distance" function displayed distance travelled as feet in the "Load" mode and miles in the "Total" mode. In actual operation, distance was displayed as feet in both modes. It is recommended that the manufacturer correctly state this in the operator manual.

Because of round-off errors within the monitor, the "Bu/Ac" value did not always correspond to that calculated using the values displayed in the "Bu" and "Acres" functions. This may cause confusion. It is recommended that the manufacturer explain this discrepancy in the operator manual.

DURABILITY RESULTS

The Acu-Grain BM-2 Harvest Measuring System was operated in the field for 52 hours. The intent of the test was functional performance and an extended durability evaluation was not conducted. No mechanical failures occurred during the tests.

APPENDIX I

SPECIFICATIONS

MAKE: Acu-Grain

MODEL: BM-2

SERIAL NUMBER: 820329

MONITOR:

- size 10 x 4 x 3.1 i n (255 x 103 x 80 mm)
- weight 3 lbs (1.36 kg)
- controls four calibration thumbwheel switches, acre meter and crop calibration switches, a full bin alarm reset, and 11 function buttons
- alarm light and alarm full bin indicators and a low battery power indicator light
- display 6 digit LED display screen
- options full bin indicator light, alarm and reset button

SENSORS:

- speed magnetic switch
- grain flow variable position baffle connected to a potentiometer
- baffle switch push button on-off switch
- unloading auger switch push button on-off switch
- acre meter switch lever-type on-off switch with extension spring and adjusting chain
- options full bin sensor

WIRING HARNESS:

- power 7 ft (2.1 m)
- ground speed sensor 25 ft (7.6 m)
- grain flow sensor 20 ft (6.1 m)
- unloading auger switch 25 ft (7.6 m)
- acre meter switch 15 ft (4.6 m)
- full bin sensor 25 ft (7.6 m)
- options full bin sensor cable

CONNECTORS:

- type pull-apart
- options pull-apart extension cables

ELECTRICAL REQUIREMENTS: 12 V DC, negative or positive ground

APPENDIX II

The following rating scale is used in Machinery Institute Reports:

excellent	fair
very good	poor
good	unsatisfactory

APPENDIX III

CONVERSION TABLE

IMPERIAL UNITS	MULTIPLY BY	SI UNITS
Inches (in)	25.4	Millimetres (mm)
Pounds Mass (lb)	0.454	Kilograms (kg)
Acres (ac)	0.405	Hectares (ha)
Bushels (bu)	0.0272	Tonnes (t) wheat
	0.0218	Tonnes (t) barley
	0.0227	Tonnes (t) rapeseed
	0.0254	Tonnes (t) corn

SUMMARY CHART

ACU-GRAIN BM-2 HARVEST MEASURING SYSTEM

RETAIL PRICE - \$1,995.00 (April, 1984, f.o.b. Humboldt, Saskatchewan).

	RATING	COMMENTS
QUALITY OF WORK		
Grain Flow Measurement Wheat, Corn and Barley Rapeseed	Very Good Good	- proper sensor adjustment and unloading auger speed were important
Ground Speed Measurement Area, Grain Yield, and Workrate Calculations	Very Good Very Good	- accurate with no fluctuations - accuracy depended on calibration
EASE OF INSTALLATION	Very Good	- approximately 5 hours to install on test combine
EASE OF OPERATION AND ADJUSTMENT		
Monitor Operation	Good	- easily operated after some experience had been gained
Display Readability	Fair	- difficult to see in direct sunlight - functions difficult to identify at night
Calibration	Fair	- considerable time required to accurately calibrate grain flow sensor
OPERATOR SAFETY	Good	- caution decals not provided
OPERATOR MANUAL	Good	- some instructions unclear
POWER REQUIREMENTS		- 12 V DC, negative or positive ground
CAUTION:		
<p>This summary chart is not intended to represent the final conclusions of the evaluation report. The relevance of the ratings is secondary to the information provided in the full text of the report. It is not recommended that a purchase decision be based only on the summary chart.</p>		



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