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Evaluation Report 186

Motomco Model 919 Grain Moisture Meter

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

MOTOMCO MODEL 919 GRAIN MOISTURE METER

MANUFACTURER:
Motomco, Inc.
P.O. Box 300
Paterson, New Jersey 07513

DISTRIBUTORS:
-Saskatchewan Wheat Pool
-Alberta Wheat Pool

RETAIL PRICE:
$705.00 (June, 1981, f.o.b. Lethbridge).

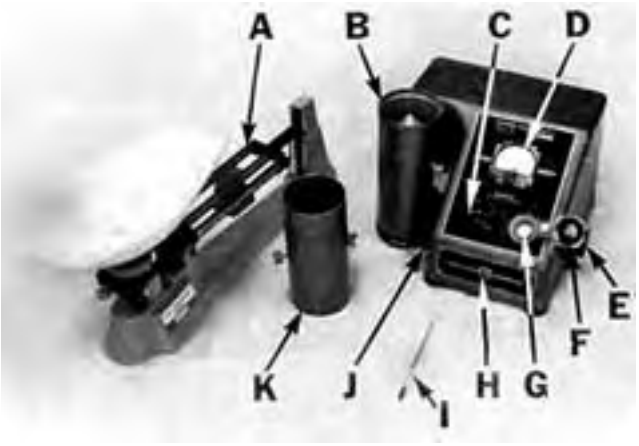

FIGURE 1. Motomco Model 919 Grain Moisture Meter: (A) Triple Beam Balance, (B) Cell, (C) Function Switch, (D) Meter, (E) Dial Knob, (F) Magnifying Glass, (G) Dial Reading, (H) Power Switch, (I) Thermometer, (J) Adjust Knob, (K) Dump Cylinder.

SUMMARY AND CONCLUSIONS

Overall performance of the Motomco model 919 grain moisture meter was excellent in wheat and rapeseed and good in barley and oats. This compares to an overall performance of very good in wheat, barley and oats and excellent in rapeseed for the PAMI reference moisture meter. Both the Motomco and PAMI reference meters are similar to meters commonly used in most prairie grain elevators.

The meter was accurate in wheat. Average meter error varied from accurate to 1.1% low in barley, 0.2 to 0.7% low in oats and from 0.1 to 0.3% low in rapeseed over a range of moisture contents ranging from 12 to 20% for cereal grains and from 8 to 15% for rapeseed. Meter uncertainty varied from excellent in wheat and rapeseed to very good in barley and oats. Meter repeatability varied from excellent in wheat and rapeseed to very good in barley and oats.

The range of moisture contents of greatest concern for cereal grains varies from 12 to 20% and for rapeseed from 8 to 15%. The Motomco was capable of measuring moisture contents throughout these ranges.

The meter was easy to operate and a moisture measurement could be made in about one minute. The meter was durable but was not suitable for transporting for field use.

As with most moisture meters, results depended on grain variety, the geographic location in which the grain was grown and many other variables. It is recommended that the user annually check a few samples against the meter used at his local elevator to determine a suitable correction factor. The instruction manual and moisture charts provided were clear and easy to understand.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Supplying the equipment and conversion charts necessary for convenient sample test weight determination.

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THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Test weight determination equipment and conversion charts are available and can be supplied.

NOTE: This report has been prepared using SI units of measurement. A conversion table is given in APPENDIX IV.

GENERAL DESCRIPTION

The Motomco model 919 grain moisture meter determines moisture content using the capacitance principle. The principle is based on the change in the dielectric properties of grain with changes in moisture content.

The dial reading is marked from 0 to 100 in intervals of one. Readings from the dial, combined with the temperature of the grain sample are used to obtain moisture contents from moisture charts supplied for common grains grown on the prairies.

The Motomco 919 may be purchased with either a 75 or 90 mm (3.0 or 3.5 in) diameter test cell. The meter evaluated was equipped with a 75 mm (3 in) test cell, which is adequate for determining moisture contents of commonly grown grains on the prairies. Sample size depends on the grain type and varies from 125 to 150 g for the 75 mm (3 in) cell.

The grain samples are weighed on a triple beam balance scale supplied with the meter.

Also supplied are a thermometer (°C), rapeseed counter, grain dump cylinder, magnifying class dial readout, and a complete set of moisture charts.

The meter operates on a 115 V AC outlet. A DC battery powered model is also available.

Detailed specifications are found in APPENDIX I while FIGURE 1 shows major components.

SCOPE OF TEST

The Motomco 919 was evaluated in wheat, barley, oats and rapeseed. Meter readings were compared to moisture contents obtained using the American Association of Cereal Chemists oven method. This is the method used by the Canadian Grain Commission Research Laboratory. In addition, performance was compared to that of the PAMI reference moisture meter[1].

Samples of several different varieties of each grain grown in several locations, were used to determine performance. The Motomco was used with artificially tempered grain, naturally tempered grain and with field samples of several grain varieties at various stages of maturity, which had not been subjected to rain after windrowing.

The moisture content of each grain sample was measured five times with the meter. In total, over 550 measurements were made with the Motomco 919. All results in this report are expressd on a per cent wet-weight basis, consistent with common grain practice.

The Motomco was evaluated for ease of operation, quality of work and suitability of the operator's manual.

RESULTS AND DISCUSSION

EASE OF OPERATION

Moisture Measurement: The Motomco 919 was easy to operate. The meter circuit was fully transistorized and no warm-up period was required. It was necessary to accurately weigh the sample before determining its moisture content. Both the meter and scale required a level surface for best accuracy. Temperature compensation was made by measuring sample temperature (°C) and using the charts provided. In total, it took aobut one minute to complete a moisture measurement.

Moisture conversion charts indicated both the sample Weight and grain test weight for each grain. Test weight ("bushel weight") was obtained by filling a pint measure, weighing its contents and converting to either grams per half litre or kilograms per hectolitre. No apparatus or conversion charts were supplied for determination of

[1]*The PAMI reference moisture meter is a Labtronics model 919, similar to the moisture meters used in most prairie grain elevators. Detailed results for the reference moisture meter are presented in Evaluation Report E2379H.*

sample test weight. It is recommended that the manufacturer include the equipment and charts for convenient test weight determination.

The meter was easily calibrated by turning the function switch to the calibrate position, setting the dial reading to “Cal” and turning the adjust knob to obtain a minimum (null) meter reading. Calibration was necessary when first turning the meter on and about every hour thereafter if the meter was used continuously.

The dial could be easily read to the nearest 0.5 division which resulted in moisture contents to the nearest 0.1%. The meter was supplied with a magnifying glass, which could be positioned over the dial reading window for easier readings. The dial reading window was also provided with a double hairline to prevent errors due to reading the scale from an angle (parallax).

Field Use: The Motomco 919 was not provided with a carrying case. A flat surface, protected from the wind was required for accurate sample weighing. The Motomco was not transportable for field use and should be considered primarily for use indoors.

QUALITY OF WORK

Weighing Accuracy: The triple beam balance supplied, was accurate to 0.1 g and was easy to use. Sample size was dependent on the grain type tested and varied from 125 to 150 g when using the 75 mm (3 in) cell. Careful weighing with the triple beam balance resulted in the required sample weight accuracy to obtain accurate moisture content measurements. However, pouring the sample until the balance tipped, could result in errors in sample weight up to 5 g and a resulting 1% error in moisture content. Accurate sample weights are necessary to obtain accurate moisture content measurements.

Temperature Compensation: Temperature compensation with the Motomco was accomplished by obtaining the grain sample temperature with the thermometer provided and referring to temperature compensation charts. Both the thermometer and temperature compensation charts were accurate.

Measurement Range: The range of moisture contents of greatest concern for cereal grains varies from about 12 to 20% and for rapeseed from 8 to 15%. These ranges include dry, tough and damp stages. The Motomco was capable of moisture measurement throughout these ranges.

Charts supplied with the Motomco 919 indicated that it was capable of measuring moisture contents ranging from 7.7 to 25.9% in wheat, 10.4 to 26.5% in barley, 10.4 to 23.2% in oats and from 6.8 to 14.8% in rapeseed.

The Motomco 919 was evaluated with samples ranging from 9.4 to 30.1% in wheat, 10.2 to 30.4% in barley, 11.0 to 22.5% in oats and 6.9 to 16.7% in rapeseed.

Accuracy: FIGURE 2 presents accuracy results for the Motomco in wheat. It shows the error (difference between indicated moisture content and oven moisture content) over the meter measurement range. The best-fit line gives the average results for 13 samples of Neepawa wheat which had been artificially tempered (moisture added and samples stabilized in the laboratory), together with 12 samples of naturally tempered Neepawa wheat from Lethbridge (originally dry windrows which had been rained upon) and 10 samples of Neepawa wheat from Lethbridge which had received no rain while maturing in the windrow. Meter readings were accurate over the entire range of moisture contents from 12 to 20%. At 14.5%, the upper limit for dry wheat, the PAMI reference meter read 0.5% high for the same samples.

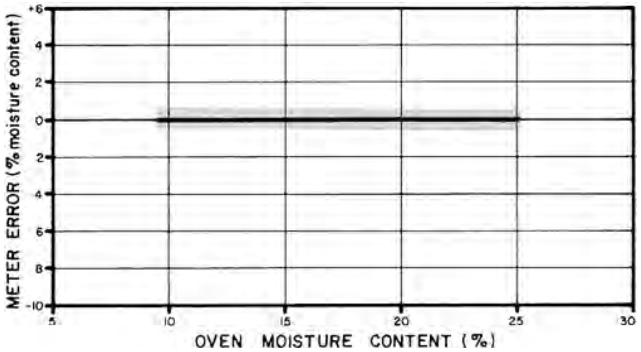

FIGURE 2. Accuracy of the Motomco in Wheat.

FIGURE 3 presents accuracy results for the Motomco in barley. The best-fit line gives the average results for 17 samples of tempered Betzes barley, seven samples of naturally tempered Gait barley and eight samples of Gait barley which had received no rain while maturing in the windrow. Meter readings varied from accurate to 1.1% low in the range of moisture contents from 12 to 20%, respectively. At 14.8%, the upper limit for dry barley, the Motomco read 0.4% low. This compares to a reading of 0.1% high for the PAMI reference meter at 14.8% in the same grain.

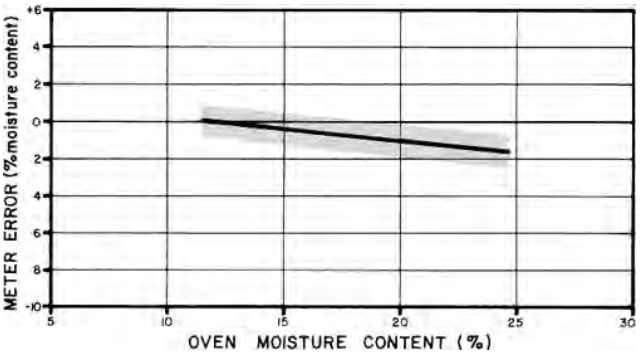

FIGURE 3. Accuracy of the Motomco in Barley.

Accuracy results for the Motomco in oats are given in FIGURE 4. The best-fit line gives the average results for 16 samples of artificially tempered Sioux oats and three samples of naturally tempered oats. Meter readings varied from 0.2 to 0.7% low over the range of moisture contents from 12 to 20%, respectively. At 14.0%, the upper limit for dry oats, the Motomco read 0.3% low while the PAMI reference moisture meter for the same grain samples read 0.1% low.

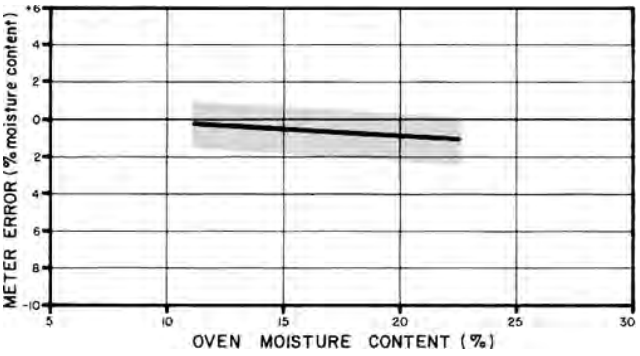

FIGURE 4. Accuracy of the Motomco in Oats.

The best-fit line for the Motomco in rapeseed is given in FIGURE 5. This figure gives the average results for 11 samples of artificially tempered Argentine rapeseed and three samples of naturally tempered rapeseed. Meter readings varied from 0.1 to 0.3% low over the range of moisture contents from 8 to 15%, respectively. At 10.5%, the upper limit for dry rapeseed, the Motomco read 0.2% low while the PAMI reference moisture meter for the same rapeseed samples was accurate.

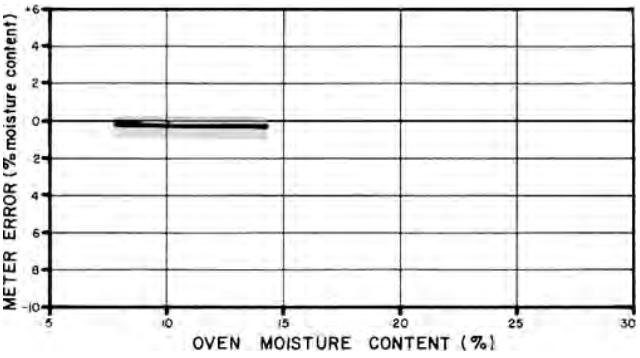

FIGURE 5. Accuracy of the Motomco in Rapeseed.

Uncertainty: The shaded belts on FIGURES 2 to 5 are the 95% confidence belts. These belts can be used as a measure of meter

uncertainty since they represent the region in which 95% of the test results can be expected to occur. A wide belt indicates a wide scatter and measurement uncertainty, where as a narrow belt shows good meter certainty. Uncertainty of the Motomco was excellent in wheat and rapeseed and very good in barley and oats. This compares to an uncertainty of very good in wheat, barley and oats and excellent in rapeseed for the PAMI reference meter.

Data showing further statistical interpretation are presented in APPENDIX II.

Repeatability: Repeatability is a measure of how consistently a meter gives the same reading when the same grain sample is tested several times. If operator error or instrument error result in different readings with repeated measurements of the same sample, then the repeatability is poor.

Repeatability of the Motomco was excellent in wheat and rapeseed and very good in barley and oats. This compares to a repeatability of excellent in wheat and rapeseed and very good in barley and oats for the PAMI reference moisture meter.

Errors from Crop Variables: The dielectric properties of grain vary with grain variety, kernel size, geographic location, maturity, weathering, artificial or natural drying, tempering (whether or not a dry windrow was re-wetted with rain) and other factors depending on the year the grain was harvested. The manufacturer's moisture charts are an attempt to accurately represent the average properties for one grain variety. It is difficult to accurately predict the dielectric properties of all varieties of grains grown in the prairies and to prepare an appropriate calibration chart.

To illustrate this point, FIGURE 6 and APPENDIX II show the average best-fit lines for three separate groups of spring wheat samples tested with the PAMI reference moisture meter. The upper line is for 20 samples from a field of Neepawa wheat at Humboldt, Saskatchewan in 1976. The windrows had received rain and samples were taken as the wheat dried in the field. Meter readings varied from 0.9 to 1.0% high over a range of moisture contents from 12 to 20%.

The middle line is for 34 samples of Neepawa wheat from Lethbridge, Alberta in 1979, 12 of which were naturally tempered, nine of which had received no rain while maturing in the windrow and 13 of which had been artificially tempered. Meter readings for these samples were 0.5% high over a range of moisture contents from 12 to 20%.

The lower line is for 14 samples of spring wheat from Lethbridge, Alberta in 1976. These samples had received no rain while maturing in the windrow. Meter results varied from 0.3 to 0.2% high over a range of moisture contents from 12 to20 %.

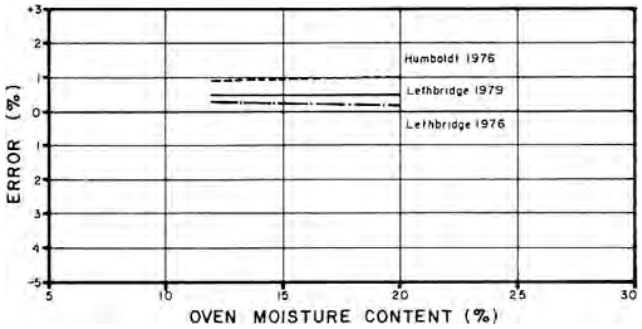

FIGURE 6. Deviations of Meter Readings for the PAMI Reference Moisture Meter in Three Different Groups of Wheat.

It can be seen from the above results that though the PAMI reference moisture meter is a relatively accurate instrument, it is very difficult for a manufacturer to prepare a calibration chart with suitable correction factors to suit all the possible combinations for one type of grain. The measurements involved would be time consuming and would defeat the purpose of a portable grain moisture meter.

The Motomco moisture meter was similarly affected by these same variables. It is, therefore, recommended that the owner annually check the results of his moisture meter against the moisture meter used at his local elevator. Comparing only a few samples should give enough information to correct meter readings.

OPERATOR'S MANUAL

The Motomco 919 operator's manual included operating and service instructions, grain sampling instructions and moisture charts for various grain types. Grain test weight information was not included. This information was necessary for the selection of appropriate wheat and barley conversion charts and should be supplied.

ACKNOWLEDGEMENT

Thanks are extended to Lethbridge area farmers for assistance in collecting grain samples and the Agriculture Canada Research Station, Lethbridge, for the use of their stationary thresher.

APPENDIX I
SPECIFICATIONS

Model No.:	Motomco 919
Serial Number:	F-902
Electrical Power Requirements:	115 V AC Outlet
Overall Height:	210 mm with cell
Overall Width:	280 mm with cell
Overall Length:	210 mm
Total Weight (complete with beam balance):	8.2 kg
Principle of Operation:	Capacitance
Sample Weight:	Wheat 150 g Barley 125 g Oats 125 g Rapeseed 150 g

APPENDIX II
Statistical Significance of Moisture Meter Results

The following data are presented tc illustrate the statistical significance of the moisture meter results shown in FIGURES 2 to 6. This information is intended for use by those who may wish to check results in greater detail.

In the following table, M = the reading of the Motomco 919 in per cent moisture, wet basis, while T = the moisture content of the sample in per cent moisture, wet basis, as determined by the American Association of Cereal Chemists oven method. Sample size refers to the number of grain samples used. Each meter sample represents the average of five meter readings on that sample.

Grain Type	Fig. No.	Regression	Correlation Coefficient	Standard Error	Sample Size	Sample Mean
MOTOMCOM						
Wheat	2	M = 0.99T + 0.15	1.00	0.26	35	16.86
Barley	3	M = 0.87T + 1.54	0.99	0.38	32	16.32
Oats	4	M = 0.93T + 0.66	0.99	0.53	19	15.15
Rapeseed	5	M = 0.98T + 0.05	0.99	0.22	14	10.34
PAMI REFERENCE METER						
Wheat, Humboldt (1976)	6	M = 1.01T + 0.81	1.00	0.38	20	18.26
Wheat, Lethbridge (1979)	6	M = 1.01T + 0.42	0.38	0.38	34	17.32
Wheat, Lethbridge (1976)	6	M = 0.98T + 0.58	0.99	0.32	14	13.87

APPENDIX III
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

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

APPENDIX IV
CONVERSION TABLE

1 millimetre (mm)	= 0.04 inches (in)
1 gram (g)	= 0.04 ounces (oz)
1 kilogram (kg)	= 2.2 pounds (lb)

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