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Evaluation Report 4

CAE Moisture Master 101-A

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

CAE Moisture Master 101-A

Manufacturer:
Motomco, Inc.
267 Vreeland Avenue,
Paterson, N.J. 07153
U.S.A.

Distributor:
Labtronies
777 Grain Exchange Building
167 Lumbard Avenue
Winnipeg, Manitoba R3B 0V3

Retail Price:
$350.00 (April, 1977, f.o.b. Winnipeg)

Figure 1. Detailed View of CAE Moisture Master 101-A.

Summary and Conclusions

Accuracy of the CAE Moisture Master 101-A was very good in wheat, oats and rapeseed and good in barley.

Meter repeatability was very good in wheat and oats, good in barley and excellent in rapeseed.

Meter readings varied from 0.1 to 0.6% high in wheat, 0.5 to 0.9% low in barley, 0.6 to 0.4% low in oats and 0.4 to 0.1% low in rapeseed in the range of moisture contents from 12 to 20% for the cereals and 8 to 15% for rapeseed.

The meter was simple to operate and a moisture measurement could be made in about one minute if the meter and sample temperatures were the same. If the meter and sample temperatures were different, an additional two minutes were required for the meter to stabilize.

Meter readings were dependent upon grain variety, geographic location in which grain was grown and many other variables. It is recommended that a user annually check a few samples against the meter used by his local grain elevator to determine a suitable correction factor.

The meter was durable and easily transported in its carrying case for field use. The instruction manual was clear and concise.

Recommendations

It is recommended that the manufacturer consider:
1. Binding the loose-leaf moisture charts into a book.
2. Marking the 20 and 40 gram counter-weights to make them easier to identify.

Chief Engineer: E. O. Nyborg
Senior Engineer: E. H. Wiens
Project Engineer: D. R. Stafford

The Manufacturer States That

With regard to recommendation number:
1. The moisture charts will be bound in book form in the future.
2. The counter-weights will be marked for easier identification.

General Description

The CAE Moisture Master 101-A determines moisture content using the capacitance principle. It measures the dielectric constant, which changes with moisture content of the grain.

The dial is marked from 0 to 100 in increments of one. Moisture content is determined from the dial reading by referring to moisture charts supplied for 16 different grains.

A grain sample is weighed automatically by the built-in scale. Sample size depends on the grain and could be either 60, 80 or 100 g. Temperature correction, if required, is performed automatically.

The meter is built into a metal case, the lid of which is equipped with a carrying handle. The meter operates on a 9 volt transistor battery. Complete specifications are found in Appendix I.

Scope of Test

The CAE 101-A was used to determine moisture contents in wheat, oats, barley and rapeseed. Meter readings were compared to moisture contents obtained using the Canadian Grain Commission Research Laboratory oven method. All moisture contents were expressed on a percent wet basis as used in grain elevators.

For each grain, samples of several different varieties, grown in several locations, were used to determine meter characteristics. The meter was used with artificially tempered grain (dry grain which was moistened in the laboratory and allowed to stabilize before moisture measurement) and naturally tempered grain (originally dry windrows which had been rained upon and were being dried naturally). It was also used 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 500 measurements were made with the CAE 101-A.

The meter was evaluated for ease of operation, accuracy, repeatability, durability and portability.

Results and Discussion

EASE OF OPERATION

The CAE 101-A was simple to operate. The meter was “instant on” so no warm-up period was required. About one minute was required to weight the sample on the built-in electronic spring scale and to make a moisture measurement. For accurate weighing, the meter had to be on a level surface. If sample and meter temperatures were different, an additional two minutes were required for the automatic temperature compensating circuit to react.

The resolution of the dial allowed moisture contents to be obtained to the nearest 0.1%. Error due to reading the dial from an angle (parallax) was insignificant.

The “on” switch was spring loaded and had to be held while taking dial readings. This prevented accidental battery failure as it was impossible to leave the meter turned on. The battery lasted the duration of the test in which over 500 samples were tested. The battery was easy to replace and was readily obtainable.

ACCURACY

Sample Weighing: An electronic spring scale was built into the meter. The scale was easy to use and accurately measured the 100 g samples throughout the evaluation providing the meter was on a level surface. The spring scale could conceivably weaken over time and give incorrect weights. If the scale did not weigh accurately, a simple adjustment could be made to reset the scale using a screwdriver and an accurate 100 g weight.

Some grains required only a 60 or 80 g sample for moisture measurement. These sample weights were obtained by placing a 40 or 20 g counterweight over the centre post of the grain cup. Since they were similar in size, it was difficult to know which weight to use. Marking the counterweights for easier identification is recommended.

Moisture Content: Charts indicated that the meter was capable of measuring moisture contents varying from 11.1 to 19.7% in wheat, 10.5 to 19.1% in barley, 10.9 to 19.5% in oats and 6.8 to 14.9% in rapeseed. The charts were linear so it was possible to extrapolate and extend these ranges. The CAE 101-A was evaluated with samples ranging from 9.5 to 25.9% in wheat, 10.0 to 30.5% in barley, 11.1 to 27.8% in oats and 6.5 to 15.5% in rapeseed.

The range of moisture contents of greatest concern for cereal grains varies from approximately 12 to 20% and for rapeseed from 8 to 15%. These ranges include grains in the dry, tough and damp stages.

Figure 2 presents the results for the CAE 101-A in wheat. It shows the deviation (error) of the meter readings from true moisture content over a range of moisture contents. The best-fit line gives the average results for 21 samples of certified Neepawa wheat which had been artificially tempered (moisture added and samples stabilized in laboratory) together with 19 samples of naturally tempered wheat from Humboldt, Saskatchewan (originally dry windrows which had been rained upon) and 13 samples of several varieties of spring wheat from fields at Lethbridge, Alberta which had received no rain while maturing in the windrow. As can be seen, meter readings varied from 0.1 to 0.6% high in the range of moisture contents from 12 to 20%. Data showing statistical significance of the best-fit line are presented in Appendix II.

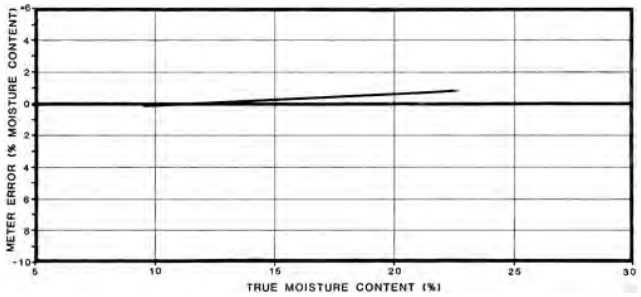

Figure 2. Deviations of Meter Readings for CAE 101-A in Wheat.

Figure 3 presents the best-fit line for the CAE 101-A in barley. It gives the average results for 11 samples of tempered Betzes barley and 10 samples from four barley fields at Lethbridge, Alberta, which received no rain while maturing in the windrow. Meter readings varied from 0.5 to 0.9% low in the range of moisture contents from 12 to 20%. The statistical significance of the best-fit line is shown in Appendix II.

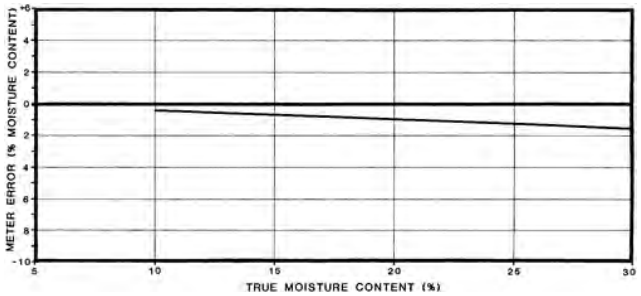

Figure 3. Deviations of Meter Readings for CAE 101-A in Barley.

The best-fit line for the CAE 101-A in oats is given in Figure 4. This figure gives the average results for four samples of tempered Sioux oats and 12 samples of oats from three fields at Lethbridge, Alberta, which had received no rain while maturing in the windrow. Meter readings varied from 0.6 to 0.4% low over the range of moisture contents from 12 to 20%. The statistical significance of the best-fit line is given in Appendix II.

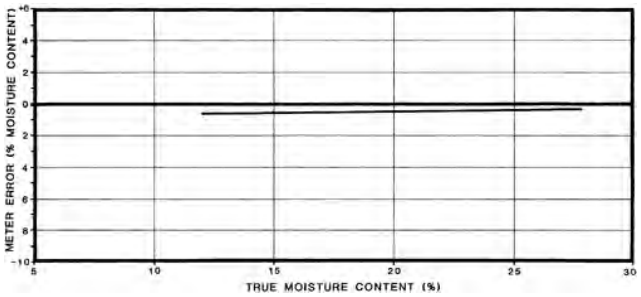

Figure 4. Deviations of Meter Readings for CAE 101-A in Oats.

The best-fit line for the CAE 101-A in rapeseed is given in Figure 5. This figure gives the average results for 10 samples of rapeseed from fields at Lethbridge, Alberta, which had received no rain while maturing in the windrow. Meter readings varied from 0.4 to 0.1% low in the range of moisture contents from 8 to 15%. Appendix II shows the statistical significance of the best-fit line.

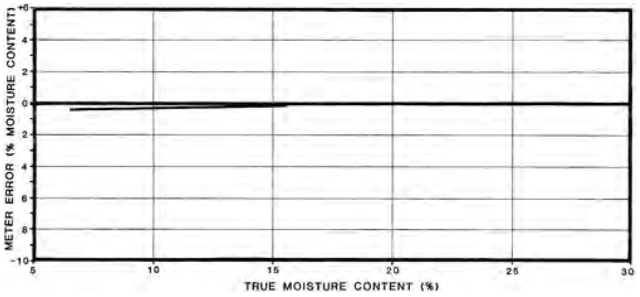

Figure 5. Deviations of Meter Readings for CAE 101-A in Rapeseed.

Sources of Error: The following precautions must be taken to ensure accurate moisture content readings:

1. Touching the grain cup or holding the hand near the grain cup while taking a reading could result in errors in moisture content of up to 1%.
2. Failure to set the dial at 50 before weighing could result in an incorrect sample weight and an incorrect moisture content.
3. Failure to switch back and forth between “read” and “calibrate”, as instructed, could result in errors of up to 0.5% in moisture content.
4. Failure to remove the grain cup before taking a reading could result in an error in moisture content of up to 0.1%.
5. Not allowing time for the temperature compensation circuit to stabilize could result in an incorrect moisture content.

Effect of Variables: The dielectric properties of grain with respect to moisture content can vary due to grain variety, kernel size, geographic location, maturity, weathering, artificial or natural drying, tempering (whether or not a dry windrow was rewetted with rain) and other factors depending upon the year the grain was harvested. The manufacturer’s charts and tables are an attempt to accurately represent the average properties for one sample of one variety. It is difficult to predict the dielectric properties of all varieties of spring wheat grown in North America and to prepare an appropriate calibration chart.

This can be illustrated as follows: Figure 2 shows very good results for the CAE 101-A in wheat. Figure 2 is the average best-fit line for three different types of spring wheat. Figure 6 presents the best-fit lines for each of these types of wheat. The upper line is for samples from a field of Neepawa wheat at Humboldt, Saskatchewan in 1976. The windrows received rain during combining (naturally tempered) and samples were taken as wheat dried in the field, very similar to what a farmer would do in the same situation. Meter readings were 1.0% high over the range of moisture contents tested. One of the lower lines is for Neepawa wheat harvested a year earlier at Lethbridge, Alberta and which was artificially tempered in the laboratory. Meter readings for this wheat were 0.5% low over the entire range tested. The third best-fit line is for samples of several varieties of spring wheat from Lethbridge in 1976. These samples were maturing in the windrow and had received no rain. In this case, meter results varied from 0.2 to 1.0% high over the range. Data showing statistical significance of these best-fit lines are presented in Appendix II.

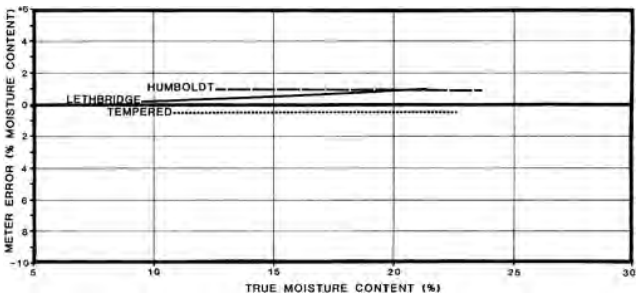

Figure 6. Deviations of Meter Readings for CAE 101-A in Three Types of Spring Wheat.

It can be seen from the above results that it is nearly impossible for the manufacturer to prepare a calibration chart with suitable correction factors to suit all the possible combinations for any one

type of grain. The measurements involved would be time consuming and would really defeat the purpose of a portable grain moisture meter. It is, therefore, recommended that the owner annually check the results of his moisture meter against the moisture meter used at his local grain elevator. Comparing only a few samples should give enough information to decide how much to add to or subtract from the meter reading.

It should also be noted that only one CAE 101-A moisture meter was evaluated. This does not guarantee that the results from all CAE 101-A meters will be the same as presented in this report.

REPEATABILITY

Repeatability is a measure of how consistently a meter gives the same reading when the same sample of grain is tested several times. If a meter is designed so that chances of human error or instrument error are high, the repeatability will be poor. Conversely, if chances of human error or instrument error are low, repeatability will be good. The coefficient of variation (defined in Appendix II) is a measure of meter repeatability. A low coefficient of variation indicates good meter repeatability while a high coefficient of variation indicates poor repeatability.

T able 1 gives the coefficients of variation for the CAE 101-A in wheat, barley, oats and rapeseed. These results show that the repeatability of the CAE 101-A was very good in wheat and oats, good in barley and excellent in rapeseed.

If repeatability of a meter is poor, several moisture content readings of the sample should be averaged to ensure that the proper moisture content is obtained.

Table 1. Coefficients of Variation for the CAE 101-A

Wheat	Barley	Oats	Rapeseed
0.80%	1.33%	1.07%	0.17%

DURABILITY AND PORTABILITY

The CAE Moisture Master 101-A was well constructed and durable. The meter was self-contained in a sturdy metal carrying case. Moisture measurements could be readily made in the field providing a relatively fiat surface was available on which to set the meter.

INSTRUCTION MANUAL

The instruction manual was easy to read and understand. It contained information on operating instructions and maintenance. The grain moisture charts were supplied on individual, loose pages for each grain. To prevent loss of charts it would be desirable to have them bound into book form.

ACKNOWLEDGEMENTS

The assistance of the Canadian Grain Commission Research Laboratory, Winnipeg, in developing test procedures and laboratory techniques is gratefully acknowledged.

Appreciation and thanks are also extended to Lethbridge area farmers and the Agriculture Canada Research Station, Lethbridge for assistance in collecting grain samples.

APPENDIX I
SPECIFICATIONS

Model Number:	Moisture Master 101-A
Serial Number:	02583
Electrical Power Requirements:	9 V transistor battery
Overall Height:	150 mm (5.9 in)
Overall Width:	175 mm (6.9 in)
Overall Length:	292 mm (11.5 in)
Total Weight (in carrying case):	3.36 kg (7.4 lb)
Principle of Operation:	capacitance
Sample Size:	100 g (wheat and rapeseed) 80 g (barley and oats)

APPENDIX II
STATISTICAL INFORMATION

(a) Statistical Significance of Moisture Meter Results

The following data are presented to 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. Sufficient information is presented to permit calculation of confidence belts. In the following table, M = the reading of the CAE 101A in percent moisture, wet basis, while T = the moisture content of the sample in percent moisture, wet basis, as determined by the Canadian Grain Commission Research Laboratory oven method. Sample size refers to the number of grain samples used. Each meter sample represents the mean of five replicates (five meter readings) on that sample.

Grain Type	Fig. No.	Regression Equation	Simple Correlation Coefficient	Standard Error of Estimate	Residual Mean Square	Sample Size	Sample Mean
Wheat	2	M=1.07T-0.75	0.98	0.67	0.44	33	16.07
Barley	3	M=0.95T+0.06	0.99	0.57	0.33	21	15.44
Oats	4	M=1.02T-0.85	0.96	1.30	1.68	16	16.44
Rapeseed	5	M=1.04T-0.70	0.99	0.43	0.18	10	10.85
Wheat Humboldt	6	M=1.00T+0.98	1.00	0.30	0.09	19	17.82
Wheat Lethbridge	6	M=1.04T-0.52	0.99	0.53	0.28	13	13.58
Wheat Tempered	6	M=1.08T-1.34	0.98	0.66	0.44	21	16.03

(b) Meter Repeatability

Moisture meter repeatability (Table 1) was determined using the coefficient of variation. The coefficient of variation was determined by expressing the standard deviation as a percent of the mean for each of the five replicates taken on each sample. The values presented in Table 1 are the average coefficients of variation for all samples.

APPENDIX III
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

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

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