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Evaluation Report 8

Protimeter Grain Master Model TW73 Moisture Meter

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

Protimeter Grainmaster Model TW73 Moisture Meter

Manufacturer:
Protimeter Ltd., P.O. Box 120
Fieldhouse Lane, Marlow
Bucks SL7 1LK England

Distributor:
R. C. Robson Agencies Ltd.
P.O. Box 188, Station C
Winnipeg, Manitoba. R3M 3S7

Retail Price:
$321.00 (April, 1977, f.o.b. Winnipeg)

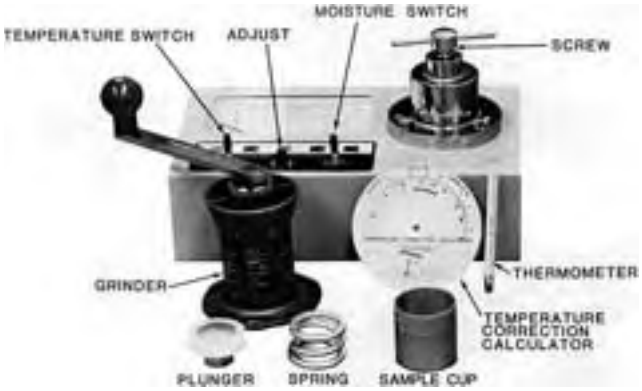

Figure 1. Detailed View of Protimeter Grainmaster.

Summary and Conclusions

Accuracy of the Protimeter Grainmaster Model TW73 moisture meter was very good in wheat, fair in barley and oats, and poor in rapeseed.

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

The meter was capable of measuring moisture contents of whole grain as well as ground grain. More accurate moisture contents of cereal grains were obtained with ground samples. The moisture contents of rapeseed were obtained using whole grain.

Meter readings varied from 0.2 to 0.3% high in wheat, 0.7 to 1.8% low in barley, 0.4 to 2.1% low in oats and0.5 to 5.2% 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. A sample could be ground and its moisture content obtained in about one minute.

Meter readings were dependent upon grain variety, 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 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. Modifying the instructions regarding temperature correction so that the written instructions agree with the illustrations shown in the instruction manual.

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 instructions are being modified so that the illustrations and written instructions in the instruction manual agree.

Additional Comments:

1. If the calibration charts for Canadian barley (supplied with every instrument) had been used, the results in barley would have been closer to true moisture content.
2. The 1977 meter (model number G176M/C) is provided with a scale for Canadian wheat.

General Description

The Protimeter Grainmaster Model TW73 moisture meter determines moisture content using electrical resistance. It measures the electrical resistance, which changes with the moisture content of grain.

The meter is capable of measuring moisture contents of whole grain as well as ground grain. A grinder is supplied for sample grinding to obtain more accurate moisture measurements.

There are six scales on the face of the meter. The moisture content of corn, maize, wheat, rye, barley, oats and paddy rice are read directly from four of these scales. These scales are for ground samples only. The moisture content of unground samples requires the use of charts. The fifth scale is divided in increments of five, from 0 to 100. Readings from this scale are used to obtain moisture contents from charts supplied for a variety of additional grains, seeds and produce. The sixth scale is for use with an optional temperature probe.

Sample weighing is not required. Sample size is the handful of grain needed to fill the grinder or sample cup. The grinder places the sample directly into the sample cup. A thermometer in °C is supplied for temperature correction, if required.

The meter operates on two 9 volt transistor batteries. A leatherette carrying case is supplied for transporting the meter and grinder. Complete specifications are found in Appendix I.

Scope of Test

The Protimeter 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. All meter moisture contents for cereal grains were obtained using ground samples. Rapeseed moisture contents were obtained using whole seed.

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 with naturally tempered grain (originally dry windrows which had been rained upon and were drying 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 300 measurements were made with the Protimeter.

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

Results and Discussion

EASE OF OPERATION

The Protimeter was simple to operate and a moisture measurement could be made in about one minute. The meter was “instant on” requiring no warm-up period. No sample weighing was needed but for optimum accuracy the sample had to be ground.

Temperature correction was accomplished by measuring the temperature of the grain and using the calculator provided to get the corrected moisture content. Contradicting instructions were given for temperature correction. The supplied illustrations inferred that either room temperature or the difference between grain temperature and room temperature were to be used with the calculator. The written instructions correctly stated that grain temperature was to be used. A clarification is required to avoid confusion.

The scales on the meter for corn, maize, wheat and rye were easily read to the nearest 0.1% moisture content in the critical range

of moisture contents from 12 to 20%. Above this range and for barley, oats and paddy rice, moisture contents could be easily read to the nearest 0.25%.

Since corn, maize and paddy rice are not common crops in Western Canada, these scales would have been more useful if they were calibrated to directly read the moisture contents of rapeseed, flax or durum wheat.

The meter was turned on by a spring loaded switch which had to be held during readings. This prevented accidental battery failure since it was impossible to leave the meter turned on. Only one set of batteries was used throughout the test in which over 300 samples were tested. The battery was easily replaced and was readily obtainable.

ACCURACY

Sample Size: The sample size consisted of filling the sample cup, which required less than a handful. Although the moisture content could be taken without grinding the sample, grinding resulted in improved accuracy. Errors from slight underfilling or overfilling of the sample cup were insignificant.

Moisture Content: The meter scales indicated the meter was capable of measuring moisture contents in wheat, oats and barley from 10 to 35% and in rapeseed from 6 to 18%.

The Protimeter was evaluated with samples ranging in moisture content 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 about 12 to 20%, and for rapeseed from 8 to 15%. These ranges include dry, tough and damp grain.

Figure 2 presents results for the Protimeter 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 of 18 samples of naturally tempered wheat from a field at 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. Meter readings varied from 0.2 to 0.3% high over the range of moisture contents from 12 to 20%. Data showing statistical significance of the best-fit line are presented in Appendix II.

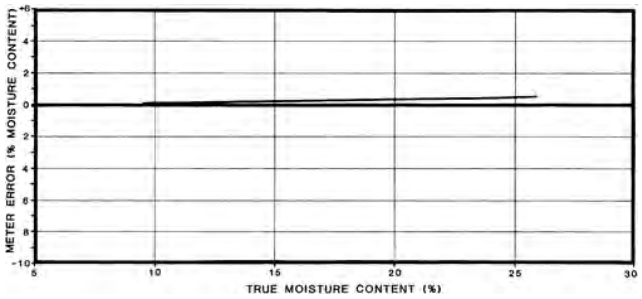

Figure 2. Deviations of Meter Readings for Protimeter in Wheat.

Figure 3 presents the best-fit line for the Protimeter in barley. It gives the average results for six 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 0.7 to 1.8% low over the range of moisture contents from 12 to 20%. Data showing statistical significance of the best-fit line are given in Appendix II.

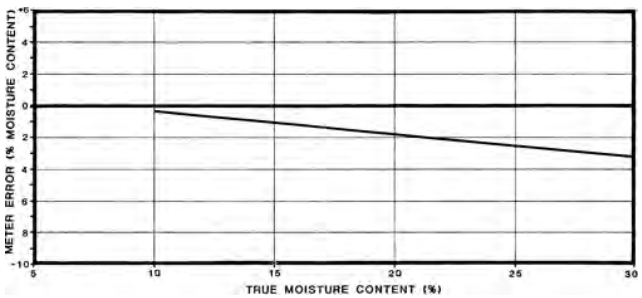

Figure 3. Deviations of Meter Readings for Protimeter in Barley.

The best-fit line for the Protimeter in oats is given in Figure 4. This figure gives the average results for six samples of oats from three fields in Lethbridge, Alberta, which had received no rain while maturing in the windrow. Meter readings varied from 0.4 to 2.1% low over the range of moisture contents from 12 to 20%. The statistical significance of the best-fit line is shown in Appendix II.

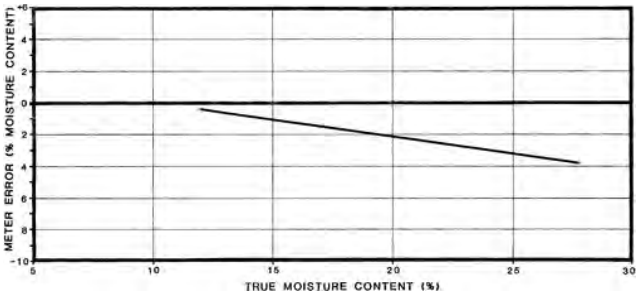

Figure 4. Deviations of Meter Readings for Protimeter in Oats.

The best-fit line for the Protimeter in rapeseed is shown in Figure 5. The line shows the average results for 10 samples from various fields at Lethbridge, Alberta, which received no rain while maturing in the windrow. The meter readings varied from 0.5 to 5.2% low in the range of moisture content from 8 to 15%. Data showing statistical significance of the best-fit line are given in Appendix II. Since heating of moist rapeseed is a problem, accurate readings are desirable in the region around 10%, which represents the borderline between dry and tough rapeseed.

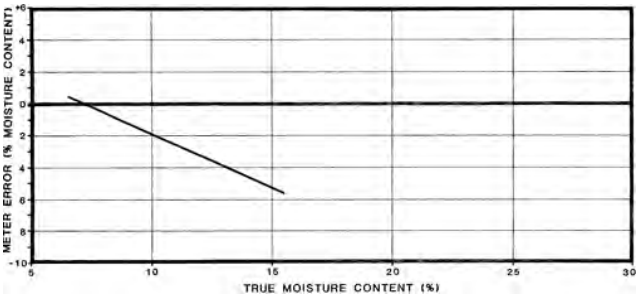

Figure 5. Deviations of Meter Readings for Protimeter in Rapeseed.

Temperature Compensation: The temperature correction calculator gave accurate moisture content corrections.

Sources of Error: To ensure accurate moisture content readings, the screw (Figure 1) should not be tightened more than one-half turn after the meter moves, as described in the instruction manual. Over tightening caused errors in moisture content of less than 0.5%.

Effect of Variables: The electrical 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 on the year the grain was harvested. The manufacturer's charts and tables are an attempt to represent the average properties accurately for one sample of one variety. It is, however, difficult to try to accurately predict the electrical properties of all varieties of spring wheat grown in North America and to prepare an appropriate calibration chart.

To illustrate this point, Figure 2 shows very good results for the Protimeter in wheat. Figure 2 is the average best-fit line for two different types of spring wheat. Figure 6 presents best-fit lines for each of these wheat types. 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 the wheat dried in the field, very similar to what a farmer would do under the same situation. Meter readings varied from 0.7 to 0.3% high over the range of moisture contents tested. The other best-fit line is for samples of several varieties of spring wheat from Lethbridge, Alberta in 1976. These samples were maturing in the windrow and had received no rain. In this case, meter results varied from 0.2% high to 0.8% low over the range. Data showing statistical significance of these best-fit lines are presented in Appendix II.

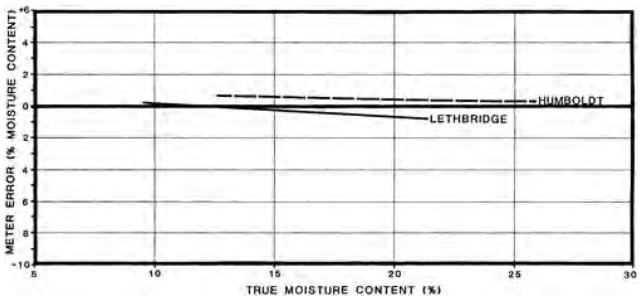

Figure 6. Deviations of Meter Readings for Protimeter in Two Different Types of Spring Wheat.

It can be seen from the above results that it is nearly impossible for a manufacturer to prepare a calibration chart with suitable correction factors to suit all the possible combinations of one type of grain. The measurements involved would be difficult and 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 by 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.

Only one Protimeter meter was evaluated. This does not guarantee that results from all Protimeter 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, then 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.

Table 1 gives the coefficients of variation for the Protimeter in wheat, barley, oats and rapeseed. These results show that the repeatability of the Protimeter was excellent in wheat and rapeseed and very good in barley and oats.

If repeatability of a meter is poor, several moisture content readings of the same sample should be averaged.

Table 1. Coefficient of Variation for the Protimeter

Wheat	Barley	Oats	Rapeseed
0.66%	1.00%	1.04%	0.05%

DURABILITY AND PORTABILITY

The Protimeter was well constructed and durable. It had to be placed on a solid support while grinding the sample. The meter, thermometer and temperature correction calculator all fit into the carrying case while the grinder attached to the carrying strap, making it easy to transport for field use.

INSTRUCTION MANUAL

The instruction manual was clearly and concisely written in five different languages. It required some clarification, as mentioned previously, on temperature compensation procedure.

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:	Grainmaster TW73
Serial Number:	917164
Electrical Power:	two 9 V transistor batteries
Overall Height:	70 mm (2.8 in.)
Overall Width:	125 mm (4.9 in.)
Overall Length:	210 mm (8.3 in.)
Total Weight with Carrying Case:	2.86 kg (6.3 lb.)
Principle of Operation:	resistance

APPENDIX II
STATISTICAL INFORMATION

(a) Statistical Significance of Moisture Meter Results

The following data are presented to illustrate the statistical significance of the 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 Protimeter 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=1.02T-0.06	0.99	0.67	0.45	31	16.38
Barley	3	M=0.86T+0.96	0.98	1.05	1.10	16	15.09
Oats	4	M=0.79T+2.08	0.99	0.62	0.39	6	15.85
Rapeseed	5	M=0.32T+4.95	0.89	0.51	0.26	10	8.50
Wheat Humboldt	6	M=0.97T+1.12	0.99	0.52	0.28	18	18.58
Wheat Lethbridge	6	M=0.92T+0.95	0.98	0.58	0.34	13	13.34

(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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