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Evaluation Report 1

Agtek - 35 Moisture Meter

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

Agtek-35 Moisture Meter

(Also known as the Wile-35 and the Farmi-35)

Manufacturer:

OT-tehdas Oy
Helsinki, Finland

Distributor:

OT Industries
Box 1707
Station M
Calgary, Alberta T2P 2L7

Retail Price:

$149.50 (January 1977, f.o.b. Lethbridge, Alberta)

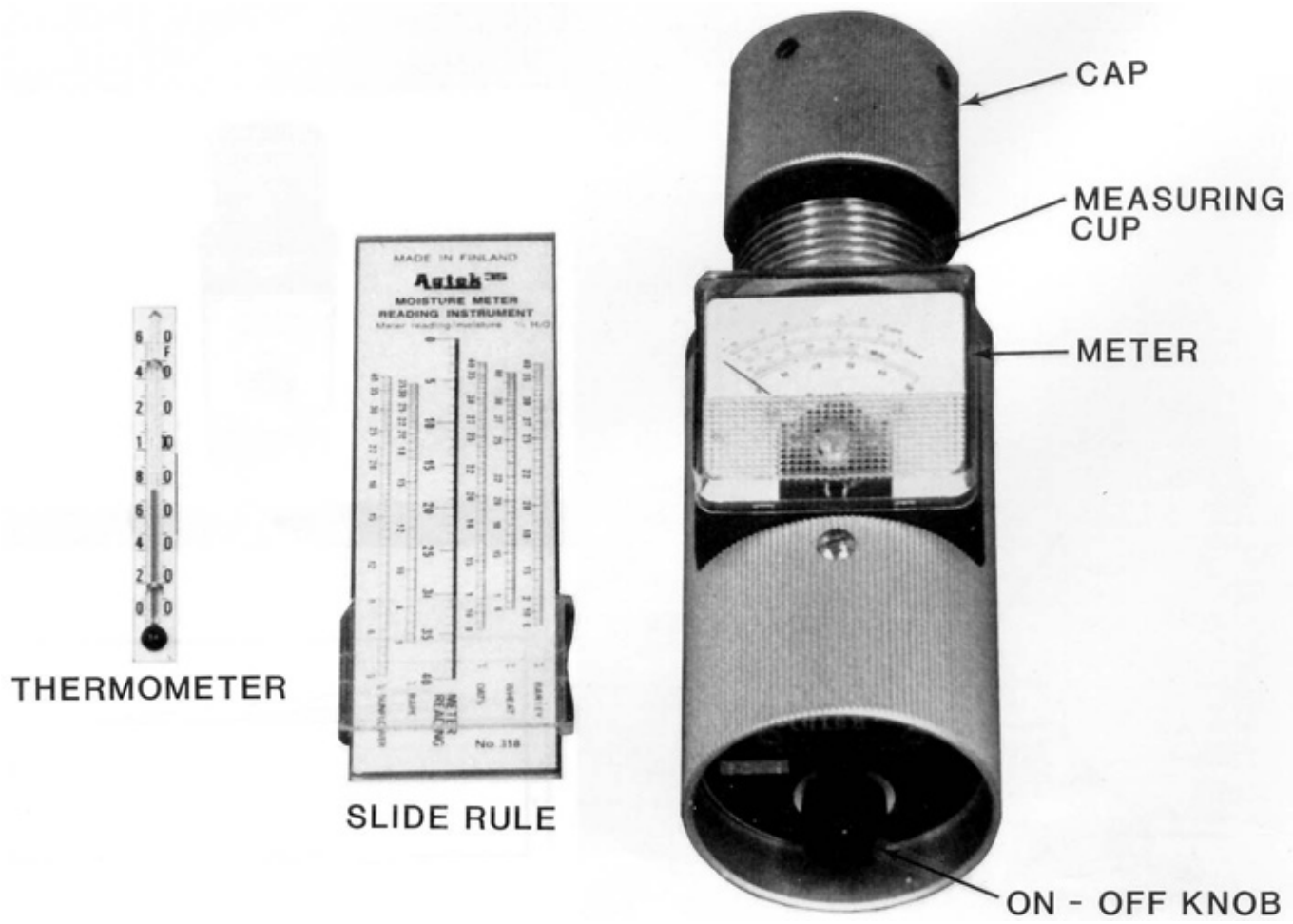

Figure 1. Detailed View of Agtek-35 Grain Moisture Meter.

Summary and Conclusions

Accuracy of the Agtek-35 moisture meter was *good* in wheat, and *very good* in barley, oats and rapeseed. Meter accuracy could be further improved by modification of the calibration charts in barley.

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

Meter readings varied from 1.2 to 0.6% high in wheat, from 1.0 to 0.9% low in barley, from accurate to 0.5% low in oats and from accurate to 0.6% high in rapeseed over a range of moisture contents from 12 to 20% for the cereal grains and 8 to 15% for rapeseed.

The supplied temperature correction chart could cause moisture content errors of up to 1%.

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 required clarification regarding sample loading techniques.

Recommendations

It is recommended that the manufacturer consider:

1. Clarifying the sample loading technique in the instruction manual.
2. Calibrating the dial on the meter to read the moisture contents of common Western Canadian grains directly instead of soya, milo and corn.
3. Modifying the calibration charts for barley to improve meter accuracy.
4. Modifying the instruction manual by inclusion of S.I. units and supplying a metric thermometer to be consistent with the Canadian metric conversion program.
5. Modifying the temperature correction chart to improve meter accuracy.

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. A new instruction manual is being printed for 1977 which will clarify the sample loading technique.
2. New scales on the meter dial now read moisture content of wheat, barley and rapeseed. The slide rule will provide moisture contents for rye, oats, flax, rice and sorghum.
3. A new chart for barley will be published for meters sold in 1977.
4. A metric thermometer is being supplied with meters sold in Canada. This was done with all Farmi-35 meters sold in 1976.
5. A new temperature correction chart will be printed to reflect the findings of this evaluation.

General Description

The Agtek-35 grain moisture meter is manufactured in Finland. The meter used for this evaluation was obtained from Agtek Inc., Onedia, New York. The Agtek-35 meter is no longer available under this name. The meter is now called the "Farmi-35" and is being sold and distributed by OT Industries, Calgary, Alberta, who are the exclusive Canadian distributors. Since it was the Agtek-35 that was evaluated, it will be referred to as such throughout the report. OT Industries have advised that this meter is identical to the Farmi-35.

The Agtek-35 determines moisture content using the capacitance principle. It measures the dielectric constant which changes with the moisture content of the grain.

There are four scales on the face of the meter. The moisture content of corn, milo and soya are read directly from three of these scales. The fourth scale is divided in increments of one, from 0 to 50. Readings from this scale are used to obtain moisture contents for wheat, barley, oats, rapeseed and sunflower using the calibrated slide rule. Moisture charts for 11 other grains are supplied in the instruction manual.

Weighing of the sample is not required. Sample size consists of filling the measuring cup which holds about a handful of grain. A thermometer in °F is supplied for temperature correction if required.

The meter operates on a 9 volt transistor battery.

A vinyl, styrofoam lined carrying case is supplied for transporting.

Complete specifications are found in Appendix I.

Scope of Test

The Agtek-35 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 weight basis.

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 naturally being dried). 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 Agtek-35.

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

Results and Discussion

EASE OF OPERATION

The Agtek-35 was a hand held meter which was simple to operate. The meter was "instant on" so no warmup period was required. No sample weigh_ing was necessary and a moisture determination could be made in less than one minute.

The readability of the scales on the meter was adequate and could be read to the nearest 0.5%. The error due to reading the meter from an angle (parallax) was insignificant.

The dial on the meter face was calibrated to read the moisture contents of soya, milo and corn. Since these crops are not common in Western Canada, a meter face calibrated directly in wheat, barley and oats would have been much more useful.

The on-and-adjust knob could be left on my mistake which would result in premature battery failure. The battery lasted the duration of the test, in which about 500 samples were tested. Battery replacement was easy, requiring only a screwdriver. The battery was readily obtainable.

ACCURACY

Sample Loading: Proper loading of the measuring cup with grain was essential for accurate moisture content measurements. Errors in moisture content up to 1.5% could result if the bottom two layers of grain in the cup were not properly compacted around the electrode (Figure 2). Proper loading involved shaking the meter with one or two layers of grain before filling to the top.

Instructions regarding proper sample loading were contained both in the instruction manual and on the back of the calibrated slide rule. The instructions in the manual cautioned that the bottom two layers be carefully loaded but did not add that, subsequently, the measuring cup must be filled to the top with grain. Consequently, the inference from these instructions was that a sample was made up of only the bottom two layers of grain. Additions should be made to the instructions in the manual to clarify the sample loading procedure.

Figure 2. Proper Loading of Bottom Layers of Grain was Essential.

Moisture Content: The slide rule provided with the Agtek-35 indicated that it was capable of measuring moisture contents varying from 8 to 40% in wheat, oats and barley and from 5 to 35% in rapeseed. The Agtek-35 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 about 12 to 20% and for rapeseed from 8 to 15%. These ranges include dry, tough and damp grain.

Figure 3 presents results for the Agtek-35 in wheat. It shows the deviations (errors) of meter readings from true moisture content over a range of moisture contents. The best-fit line gives the average results for 24 samples of certified Neepawa wheat which had been artificially tempered (moisture added and samples stabilized in the laboratory together with 20 samples of naturally tempered Neepawa 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 were maturing in

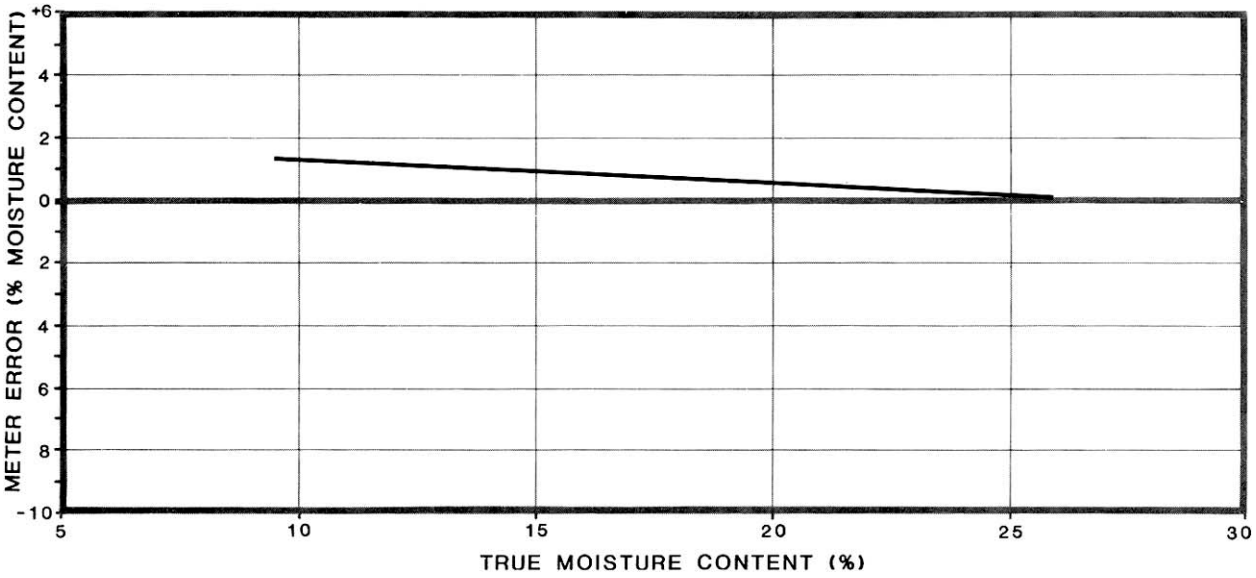

Figure 3. Deviations of Meter Readings for Agtek-35 in Wheat.

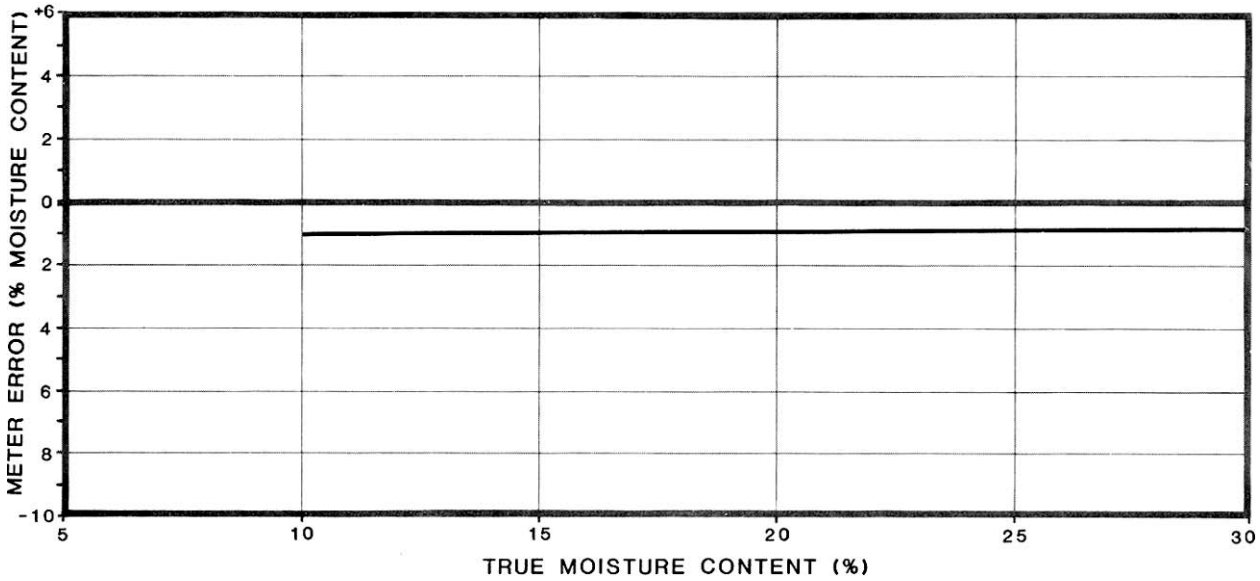

Figure 4. Deviations of Meler Readings for Aglek-35 in Barley.

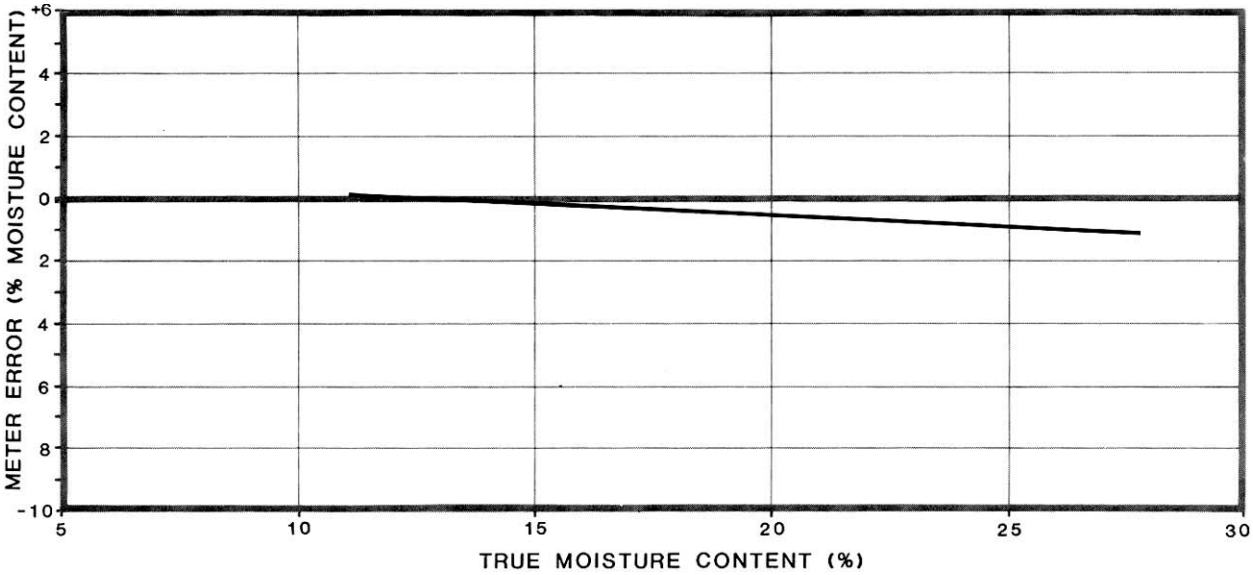

Figure 5. Deviations of Meter Readings for Agtek-35 in Oats.

the windrow and had received no rain. As can be seen, the meter readings varied from 1.2 to 0.6% high over the range of moisture content from 12 to 20%. Data showing statistical significance of the best-fit line are presented in Appendix II.

Figure 4 presents the best-fit line for the Agtek-35 in barley. It gives the average results for 13 samples of tempered Betzes barley and 10 samples from four barley fields at Lethbridge, Alberta which were maturing in the windrow and had received no rain. Meter readings varied from 1.0 to 0.9% low over the range of moisture contents from 12 to 20%. Data showing the statistical significance of the best-fit line are given in Appendix II. Results could be significantly improved by preparation of a new moisture content scale for barley. For example, adding 1.0% to the meter reading makes it accurate over the entire range.

The best-fit line for the Agtek-35 in oats is given in Figure 5. This figure gives the average for six samples of tempered Sioux oats and 12 samples of oats from three fields at Lethbridge which were maturing in the windrow and had received no rain. Meter readings varied from accurate at 12% to 0.5% low at 20% moisture content. The statistical significance of the best-fit line is given in Appendix II.

The best-fit line for the Agtek-35 in rapeseed is given in Figure 6. The line shows the average results for samples of several varieties from 10 fields, which had received no rain after windrowing. The meter readings ranged from accurate at 8% to 0.6% high at 15% moisture content. Statistical data are presented in Appendix II.

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

1. The measuring cup must be kept clean and dry. A wet measuring cup could result in very large errors.
2. Prior to placing grain in the measuring cup, the meter had to be adjusted to full scale reading of 50. Failure to do this

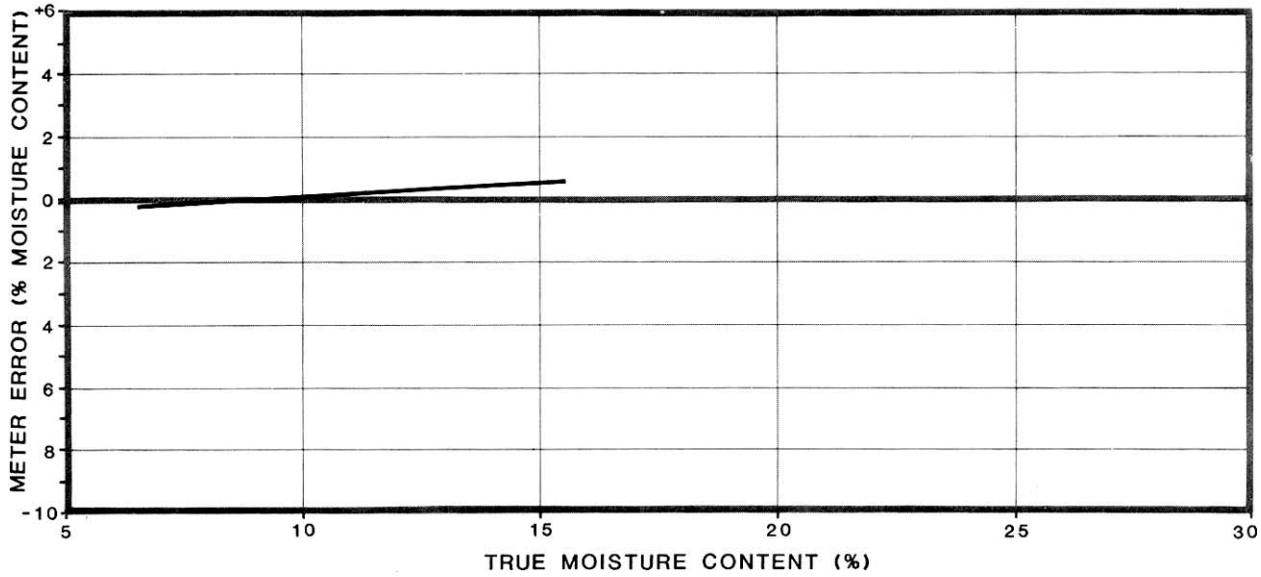

Figure 6. Deviations of Meter Readings for Agtek-35 in Rapeseed.

accurately could result in errors in moisture content up to 1.5%. Failure to remove the cap from the measuring cup prior to making full scale adjustment could result in moisture content error of 1%.

3. A weak battery could also cause errors in measuring moisture content.

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 upon 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 difficult to try to 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 3 shows good results for the Agtek-35 in wheat. Figure 3 is the average best-fit line for three different types of spring wheat. Figure 7 presents the 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 wheat dried in the field, very similar to what a farmer would do under the same situation. Meter readings varied from 2.2 to 0.2% 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 varied from 0.8% high to 0.1% low. 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 1.4 to 0.1% high over the range. Data showing statistical significance of these best-fit lines are presented in Appendix II.

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 by his local grain elevator agent. Comparing only a few samples should give enough information to decide how much to add to or subtract from the meter reading.

Only one Agtek-35 moisture meter was evaluated. This does not guarantee that the results from all Agtek-35 meters will be the same as presented in this report.

Temperature Compensation: Temperature compensation was necessary only if the meter and grain temperatures were different. Figure 8 shows the difference in temperature compensation from the tables supplied and that actually obtained with a sample of wheat at varying grain temperatures. This indicates that using the tables could result in a larger moisture content correction being added than is actually necessary. For example, if the meter was at 74°F and the grain sample was at 50°F, according to the tables given, 1.6% should be added to the moisture content obtained from the meter reading. Actually it is only necessary to add 0.8%. Figure 7 presents results for only one meter temperature. Different results would occur at other meter temperatures.

The thermometer and temperature compensation tables used English units (°F) to express temperature. This is inconsistent with the Canadian metric conversion program.

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.

Table 1 gives the coefficients of variation for the Agtek-35 in wheat, barley, oats and rapeseed. These results show that the repeatability of the Agtek-35 was good in wheat and oats, poor in barley and excellent in rapeseed. The greater variation in barley was due to barley beards resulting in slightly different cell loading for each sample.

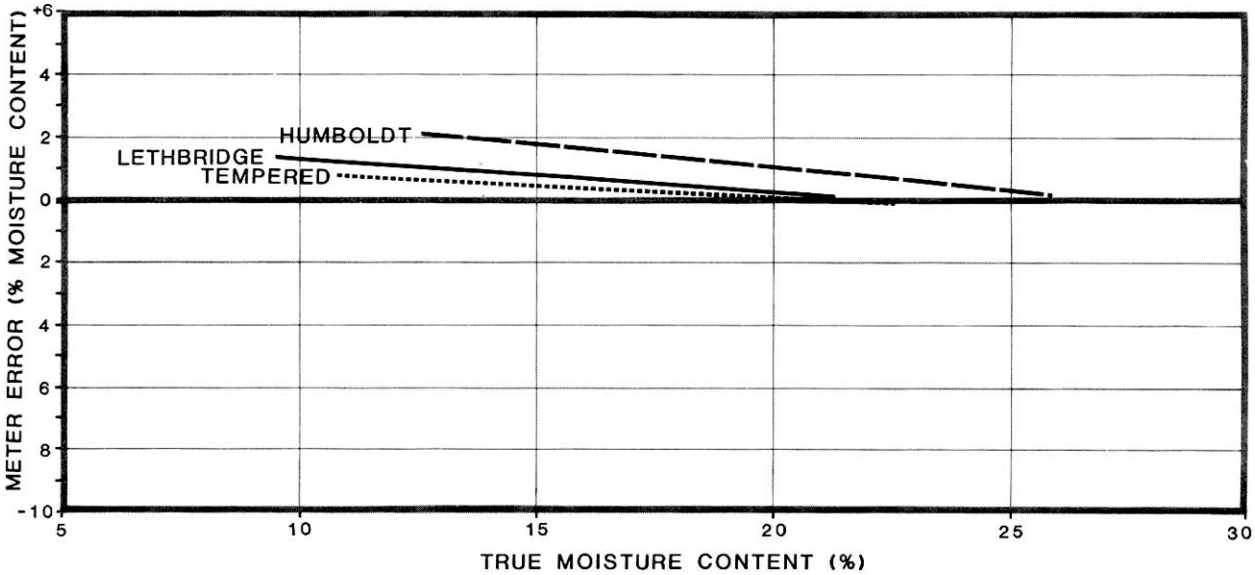

Figure 7. Deviations of Meter Readings for Agtek-35 in Three Different Types of Spring Wheat.

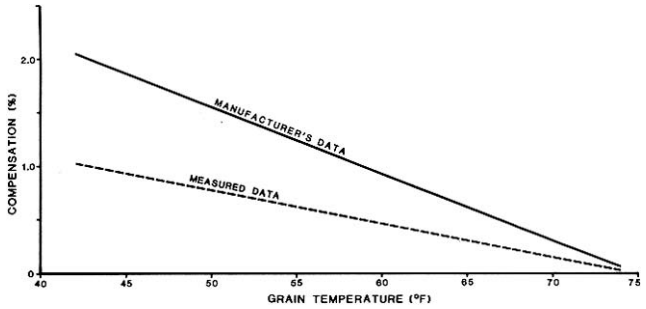

Figure 8. Errors in Temperature Compensation at Varying Grain Temperatures with the Agtek Meter at 23°C (74°F).

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

Table 1. Coefficients of Variation for the Agtek-35

Wheat	Barley	Oats	Rapeseed
1.29%	2.81%	1.42%	0.65%

DURABILITY AND PORTABILITY

The Agtek-35 was well constructed and durable. It was small enough to be hand held while taking a moisture measurement, making it very adaptable for use in the field. The meter, thermometer, slide rule and instruction manual all fit into a carrying case for transporting.

INSTRUCTION MANUAL

The instruction manual was easy to read and understand. In addition to information on parts identification, operating instructions and maintenance, it contained moisture content charts for 13 different grains.

As was noted previously, the instructions regarding filling of the measuring cup should be clarified.

Temperature compensation tables should be expressed in degrees Celsius to be consistent with the Canadian metric conversion program.

ACKNOWLEDGEMENTS

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

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

APPENDIX I

SPECIFICATIONS

Model Number: -- 35

Serial Number: -- 52195

Electrical Power Requirements: -- 9 V transistor battery

Overall Height: -- 170 mm (6.7 in)

Overall Diameter: -- 77 mm (3.0 in)

Total Weight (in carrying case): -- 1.22 kg (2.7 lb)

Principle of Operation: -- capacitance

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 3 to 7. 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 Agtek-35 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	Fg. No.	Regression Equation	Simple Correlation Coefficient	Standard Error Estimate	Residual Mean Square	Sample Size	Sample Mean
Wheat	3	M = 0.92T+2.16	0.97	0.82	0.67	57	16.73
Barley	4	M = 1.01T - 1.15	0.98	0.97	0.89	23	15.60
Oats	5	M = 0.93T+0.88	0.99	0.58	0.34	18	16.60
Rapeseed	6	M = 1.09T - 0.76	0.97	0.90	0.65	10	11.35
Wheat, Humboldt	7	M = 0.85T+4.10	0.98	0.64	0.41	20	18.92
Wheat, Lethbridge	7	M = 0.87T+2.86	0.97	0.67	0.46	13	14.67
Wheat, Tempered	7	M = 0.92T+1.67	0.99	0.48	0.24	24	16.00

(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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