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Evaluation Report 6

Delmhorst Model G-6B Grain Moisture Meter

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

Delmhorst Model G-6B Grain Moisture Detector

Manufacturer:

Delmhorst Instrument Company
P.O. Box 390607 Cedar Street
Boonton, New Jersey 07005

Distributor:

Smith-Roles Ltd.
Box 907
Saskatoon, Saskatchewan S7K 3M5

Frank Flaman Wholesale Ltd.
Southey, Saskatchewan S0G 4P0

Retail Price:

$240.00 (April, 1977, f.o.b. Saskatoon, Sask.)

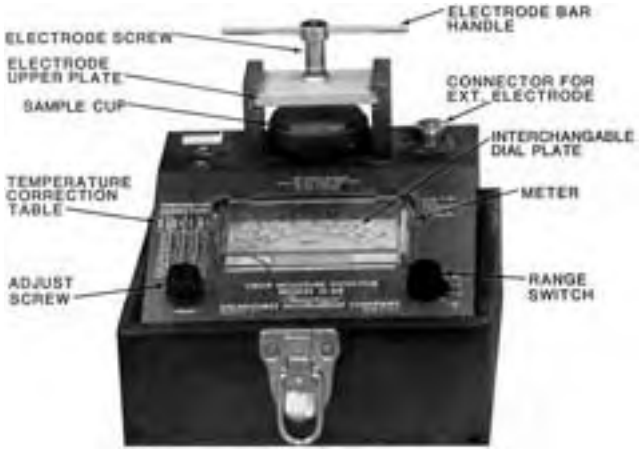

Figure 1. Detailed View of Delmhorst Model G-6B Moisture Detector.

Summary and Conclusions

Accuracy of the Delmhorst Model G-6B moisture detector was good in wheat and oats and fair in barley. Meter repeatability was good in wheat and poor in barley and oats. Meter readings varied from 0.4 to 1.0% low in wheat, 0.7 to 1.9% low in barley, and 0.2% high to 1.2% low in oats over a range of moisture contents from 12 to 20%.

No moisture charts were provided for rapeseed, however, test results indicated that the Delmhorst could be used for rapeseed. Meter readings were dependent upon grain variety, the geographic location in which a grain was grown and many other variables. It is recommended that a user annually check a few samples against the meter used at 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. Lengthening the battery leads to facilitate easier battery installation.
2. Supplying a moisture chart or dial plate for rapeseed.
3. Supplying a thermometer as standard equipment.
4. Modifying the instruction manual by including SI units, to be consistent with the Canadian metric conversion program.

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 battery leads have been lengthened. The meter now uses two 9 volt batteries which are more readily obtainable than the 22.5 volt battery previously used.
2. The meter has now been calibrated for rapeseed. When measuring the moisture content of rapeseed, the sample cup is filled completely, not with just one layer of grain, as with the other grains.
3. Supplying a thermometer calibrated in both Fahrenheit and Celsius, as standard equipment for meters sold in Canada, is being considered.
4. Metric units will be included in the next printing of the owner's manual. A slide rule to apply temperature correction is already available using both Fahrenheit and Celsius scales.

General Description

The Delmhorst determines moisture content using the resistance principle. It measures the electrical resistance of grain, which changes with moisture content.

The meter is supplied with nine interchangeable dial plates, which can be individually placed on the meter face, a temperature compensating slide rule, an instruction manual and a carrying case. The dial plates are calibrated for wheat, barley, oats, rough rice, hay, soybeans, sorghum, rye and corn. In addition, a scale from 0 to 100, divided in increments of two, is located under the dial plate.

Sample size consists of one layer of grain in the sample cup. A chart for temperature correction is located on the outside of the meter. The meter operates on one 22.5 volt transistor battery.

Complete specifications are found in Appendix I.

Scope of Test

The Delmhorst 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 with 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 Delmhorst.

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

Results and Discussion

EASE OF OPERATION

The Delmhorst grain moisture meter was simple to operate. The meter was "instant on" so no warm-up period was required. Sample weighing was not required.

A moisture measurement could be made in less than one minute. Temperature compensation was made by measuring the grain temperature and using the provided slide rule or the charts on the meter face. Although manufacturer's instructions refer to a thermometer, none was supplied. The resolution of the dial plates allowed moisture content to be read to the nearest 0.25%.

The meter turned on automatically when the grain sample was compressed by turning the electrode screw (Figure 1). It turned off automatically when grain was emptied so battery failure due to accidentally leaving the meter on was remote. The battery lasted the duration of the test, in which 500 samples were tested. Battery replacement was difficult because the wires leading to the battery terminals were too short, causing problems in removing the cover plate for battery insertion. The battery was not readily obtainable at retail outlets.

ACCURACY

Sample Size: The instructions specify a single layer of grain or seed in the sample cup. It was difficult to get the sample exactly one

layer deep. Differences in moisture content of up to 1% could result if the sample size differed from one layer deep.

Moisture Content: The dial plates indicated that the Delmhorst was capable of measuring moisture content from 9 to 30% in Wheat, barley and oats. Dial plates were not provided for rapeseed. The Delmhorst 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 is from 12 to 20% and for rapeseed from 8 to 15%. These ranges include grains in the dry, tough and damp stages.

Figure 2 presents results for the Delmhorst 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 25 samples of certified Neepawa wheat which had been artificially tempered (moisture added and samples stabilized in laboratory) together with 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 received no rain while maturing in the windrow. Meter readings varied from 0.4 to 1.0% low over the range of moisture content from 12 to 20%. Data showing statistical significance of the best-fit line are presented in Appendix II.

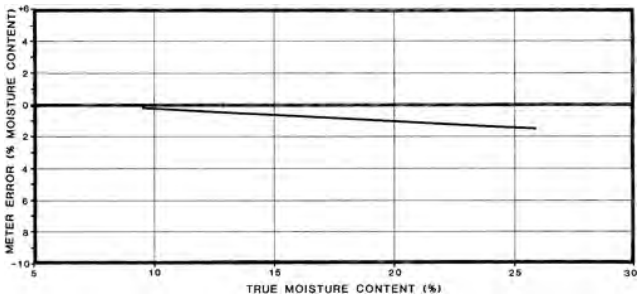

Figure 2. Deviations of Meter Readings for the Delmhorst G-6B in Wheat.

Figure 3 presents the best-fit line for the Delmhorst in barley. It gives the average results for six samples of tempered Betzes barley and 10 samples from four fields at Lethbridge, Alberta, which received no rain while maturing in the windrow. Meter readings varied from 0.7 to 1.9% 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.

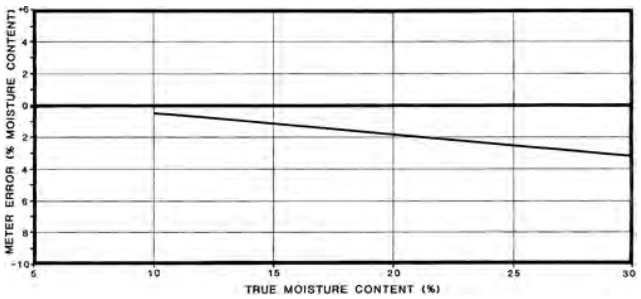

Figure 3. Deviations of Meter Readings for the Delmhorst G-6B in Barley.

The best-fit line for the Delmhorst in oats is given in Figure 4. This figure gives the average results from six samples of tempered Sioux oats and 12 samples from three fields at Lethbridge, Alberta, which received no rain while maturing in the windrow. Meter readings varied from 0.2% high to 1.2% low over the range of moisture contents from 12 to 20%. Meter readings corresponded with true moisture content at 13.1%. Statistical data for the best-fit line are given in Appendix II.

No dial plate was supplied for rapeseed. The meter, however, was capable of measuring moisture contents in rapeseed from 6.5 to 15.5%.

Figure 5 shows the best-fit calibration curve for rapeseed as obtained using 10 samples of several varieties of rapeseed which had received no rain while maturing in the windrow. The scale from 0 to 100, located under the dial plate, was used for calibration. Readings all fell close to the best-fit line indicating that reliable charts for rapeseed could be easily prepared. Data showing the statistical significance of the calibration curve are given in Appendix II. Moisture charts for rapeseed and other oilseed crops should be supplied with the meter.

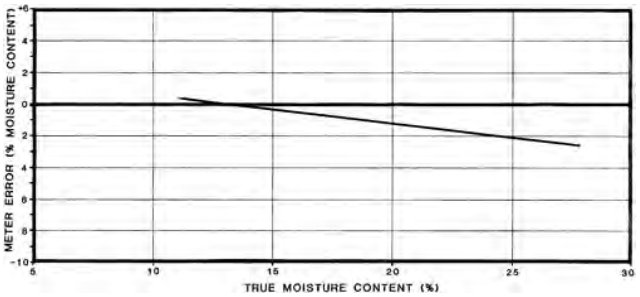

Figure 4. Deviations of Meter Readings for the Delmhorst G-6B in Oats.

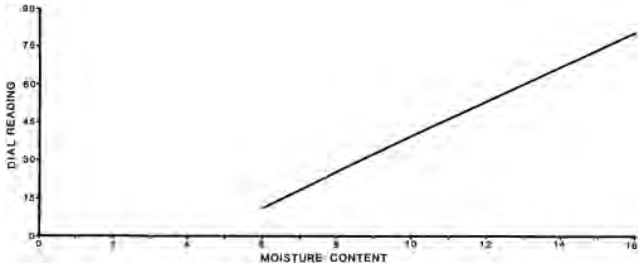

Figure 5. Calibration Curve for the Delmhorst G-6B in Rapeseed.

Sources of Error: Before measuring the moisture content of a sample, the meter must be carefully adjusted to read 100 on the scale located beneath the dial plate. Failure to do so will result in an error in moisture content. Errors in moisture content of up to 1% could result if care was not taken to make the sample size exactly one kernel deep.

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.

This can be illustrated as follows. Figure 2 shows good results for the Delmhorst 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 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 in the same situation. Meter readings varied from 0.1 to 0.8% low 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 0.5% to 1.8% 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 0.3% high to 1.6% low over the range. Data showing statistical significance of these best-fit lines are presented in Appendix II.

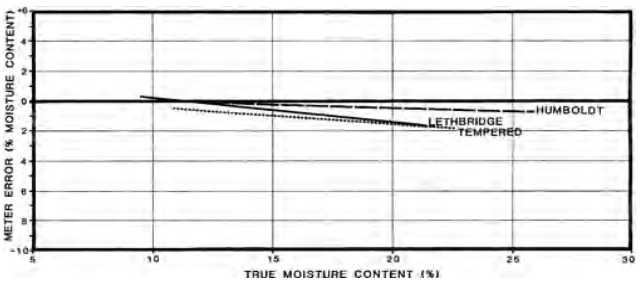

Figure 6. Deviations of Meter Readings for Delmhorst G-6B in Three Different Types of Spring Wheat.

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 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 Delmhorst G-6B moisture meter was evaluated. This does not guarantee that the results from all Delmhorst 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.

Table 1 gives the coefficients of variation for the Delmhorst in wheat, barley and oats. These results show that the repeatability of the Delmhorst was good in wheat and poor in oats and barley.
If repeatability of a meter is poor, several readings of the same sample should be averaged to ensure that the proper moisture content is obtained.

Table 1. Coefficients of Variation for the Delmhorst G-6B

Wheat	Barley	Oats
1.40%	2.66%	2.70%

DURABILITY AND PORTABILITY

The Delmhorst was well constructed, durable and very portable for field use. The meter, dial plates, slide rule and instruction manual all fit into a carrying case for transporting.

INSTRUCTION MANUAL

The instruction manual was easy to read and understand. It contained information on operating and servicing as well as general information on the Delmhorst Model G-6B. The manual also contained general information on grain moisture measurement.

The instruction manual contained only English units of measurement, not 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 are also extended to Lethbridge area farmers and the Agriculture Canada Research Station, Lethbridge for assistance in collecting grain samples.

APPENDIX I
SPECIFICATIONS

Model:	G-6B
Serial Number:	1932
Electrical Power Requirements:	22.5 V transistor battery
Overall Height:	80 mm (3.2 in)
Overall Width:	152 mm (6.0 in)
Overall Length:	178 mm (7.0 in)
Total Weight (in carrying case):	2.6 kg (5.6 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 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 Delmhorst G-6B in percent moisture, wet basis, T = the moisture content of the sample in percent moisture, wet basis, as determined by the Canadian Grain Commission Research Laboratory oven method and R = the dial reading of the Delmhorst G-6B in scale graduations. 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=0.92T+0.57	0.98	0.63	0.39	56	15.18
Barley	3	M=0.86T+0.94	0.99	0.57	0.33	16	14.93
Oats	4	M=0.82T+2.37	0.95	1.32	1.73	18	16.13
Wheat Humboldt	6	M=0.94T+0.70	0.99	0.48	0.23	18	17.56
Wheat Lethbridge	6	M=0.84T+1.84	0.99	0.31	0.10	13	13.21
Wheat Tempered	6	M=0.89T+0.67	0.98	0.60	0.36	25	14.50
Rapeseed Calibration		R=6.85T-28.76	0.86	11.79	138.99	10	47.52

(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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