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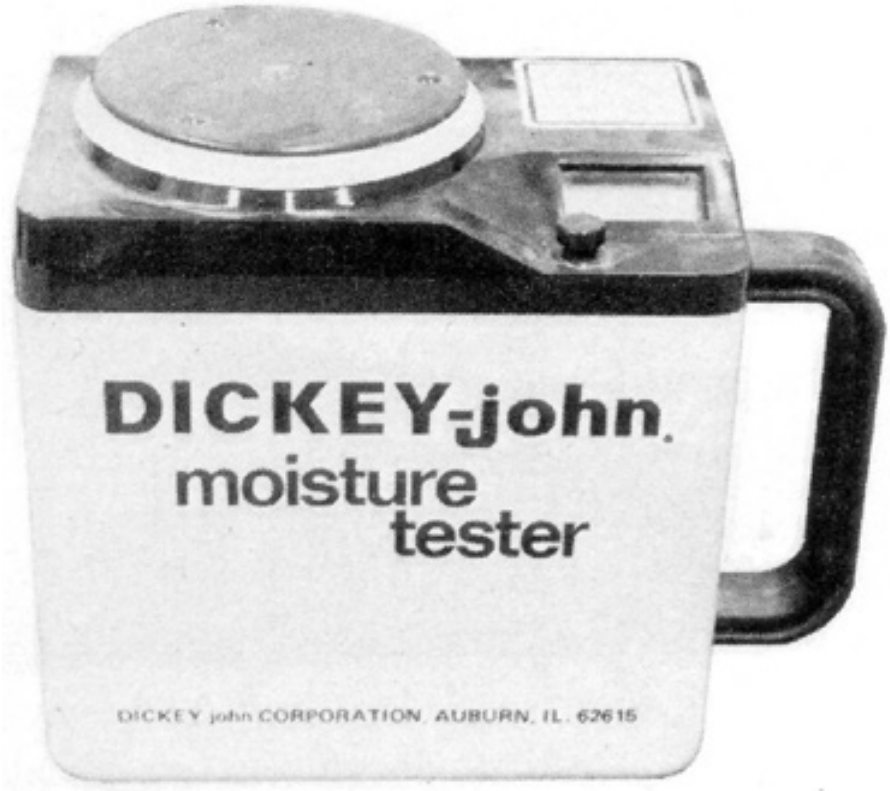
Evaluation Report 9



Dickey-John Farm Grain Moisture Tester

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

Dickey-john Farm Grain Moisture Tester

Manufacturer:

Dickey-john Corporation
P.O. Box 10
Auburn, Illinois 62615
U.S.A.

Distributor:

Dickey-john of Canada Ltd.
133A Milvan Drive
Weston, Ontario
M9L 1Z8

Retail Price: (January, 1977, f.o.b. Weston, Ontario)

-- Dj1S corn model: $230.00
-- Dj1S wheat model: $259.00

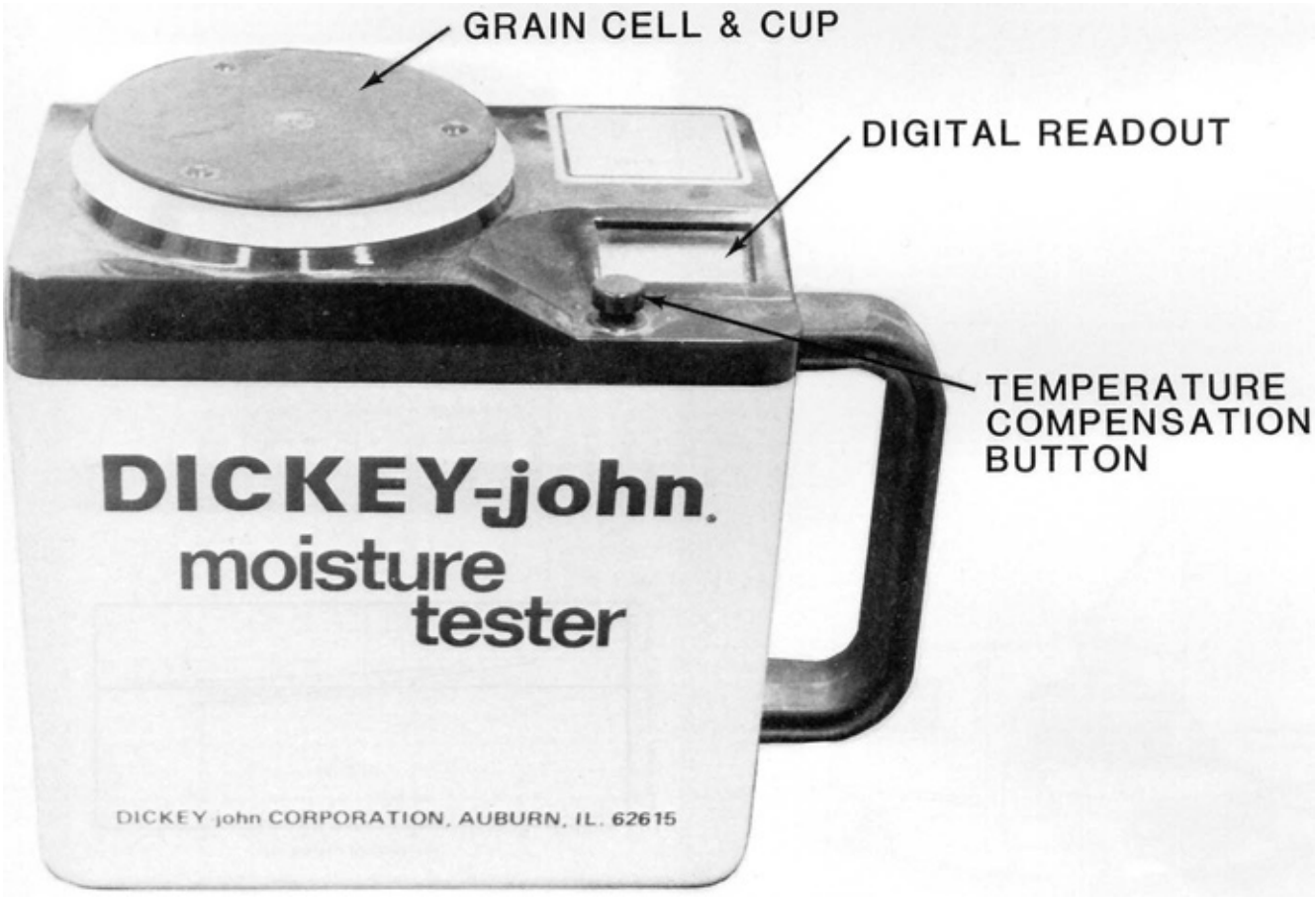


Figure 1. Detailed View of Dickey-John Farm Grain Moisture Meter.

Summary and Conclusions

Accuracy of thc Dickey-john farm grain moisture tester was *very good* in wheat and oats and *fair* in barley.

Meter repeatability was *good* in wheat and barley and *very good* in oats.

Meter readings varied from 0.8 to 0.1% high in wheat, 0.7 to 3.0% high in barley, 1.1% high to 0.2% low in oats over the range of moisture contents from 12 to 20%.

No moisture charts were provided for rapeseed, but test results indicated that the Dickey-john could be used for rapeseed.

The meter was simple to operate and a moisture measurement could be made in less than 30 seconds. Temperature compensation, if required, was done internally and was obtained by pushing the temperature compensation button.

Meter readings were dependent upon grain variety, geographic location in which the 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 operating instructions and moisture charts for grains other than wheat were on loose leaf paper. An instruction manual with more detailed instructions and including moisture content charts for other grains should be provided.

Recommendations

It is recommended that the manufacturer consider:

1. Providing for more uniform sample loading to result in an even flow and density of packing.
2. Modifying charts to provide for a temperature compensated reading in grains other than wheat.
3. Providing an instruction manual.
4. Providing moisture content charts for rapeseed.

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. Various arrangements have been tried -- funnels, spouts, etc. To date, none have proved as successful as pouring slowly. Work will continue on finding a suitable device.
2. It is not feasible to have direct temperature compensated readings for other than wheat as charts are not linear with respect to temperature compensation.
3. We have not elected to write a detailed manual as we feel the tester is very simple to operate and a detailed manual may only confuse the user. A one page instruction sheet is now included with all meters.
4. Preliminary rapeseed charts have been constructed and if need warrants, further charts will be obtained.

General Description

The Dickey-john farm grain moisture tester determines grain moisture content using the capacitance principle. It measures the dielectric constant which changes with the moisture content of the grain.

The moisture content for wheat is obtained directly from the digital readout on the meter. Moisture charts for corn, oats, milo, rye, barley and durum are printed on the body of the meter.

A grain sample of 200 g (7.05 oz) is weighed automatically by the built-in scale.

Temperature compensation is made automatically.

The meter operates on a 9 volt transistor battery.

The meter is self-contained in a metal case, complete with carrying handle.

Complete specifications are found in Appendix I.

Scope of Test

The Dickey-john 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 all 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 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 Dickey-john.

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

Results and Discussion

EASE OF OPERATION

The Dickey-john was a hand held meter which was easy to operate. It was "instant-on", requiring no warm-up. No sample weighing was required and a moisture measurement could be made in less than 30 seconds.

The digital readout displayed moisture content to the nearest 0.1%. This type of readout has no errors of judgement as does a dial readout.

The meter was turned on automatically when pouring grain into the grain cell and automatically turned off when grain was poured out. If grain was not emptied, the meter automatically shut off after two minutes. This feature prevented accidental battery failure. The same battery was used throughout the test for over 500 moisture measurements. The battery was easily replaced and readily obtainable.

ACCURACY

Sample Weight: A spring scale was built into the meter for automatic weighing. This scale was found to be very accurate throughout the test. Since this scale operates on a spring, over an extended period it may deform and require replacement.

Pouring rate affected the scale accuracy. The meter was automatically turned on when sample weight reached 200 g. At this instant, the moisture measurement was made. Pouring too slow resulted in the scale bouncing and the moisture measurement being made before sample weight had reached 200 g. Pouring too quickly resulted in too large a sample before the scale could react. A device to give a constant rate of flow would give better weighing and moisture content accuracy.

Moisture Content: The digital readout on the Dickey-john indicated it was capable of measuring moisture contents from 0 to 40% for wheat. Charts provided indicated the meter was capable of measuring moisture contents in barley from 8.6 to 23.3% and in oats from 9.0 to 23.9%. No charts were provided for rapeseed. The Dickey-john was evaluated with samples with moisture contents 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 12 to 20%, and for rapeseed from 8 to 15%. These ranges include dry, tough and damp grains.

Figure 2 presents results for the Dickey-john in wheat. It shows the deviation (error) of meter readings from true moisture content over a range of moisture contents. The best-fit line gives the average results for 22 samples of certified Neepawa wheat which had been artificially tempered (moisture added and samples stabilized in 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 10 samples of several varieties of spring wheat from fields at Lethbridge, Alberta which, while maturing in the windrow, had received no rain. Meter readings varied from 0.8 to 0.1% 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 3 presents the best-fit line for the Dickey-john in barley. It gives the average results for 12 samples of tempered Betzes barley and 7 samples from barley fields at Lethbridge which received no rain while maturing in the windrow. Meter readings varied from 0.7 to 3.0% high 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.

The maximum moisture content measureable in barley was 20.1%. Although meter readings were obtained at higher moisture contents, there were no chart readings for these higher meter readings.

The best-fit line for the Dickey-john in oats is given in Figure 4. This figure gives the average results for six samples of tempered Sioux oats and 10 samples of oats from fields at Lethbridge which had received no rain while maturing in the windrow. Meter readings varied from 1.1% high to 0.2% low over the range of moisture content from 12 to 20%. The statistical significance of the best-fit line is given in Appendix II.

No moisture content charts were supplied for rapeseed. However, the meter was capable of measuring moisture contents in rapeseed from 6.5 to 15.5%.

Figure 5 shows the best-fit calibration curve for rapeseed, obtained using 10 samples of several varieties of rapeseed which had received no rain while maturing in the windrow. The readings obtained all fell close to the best-fit line indicating reliable charts for rapeseed could be easily obtained. Data showing the statistical significance of the calibration curve are given

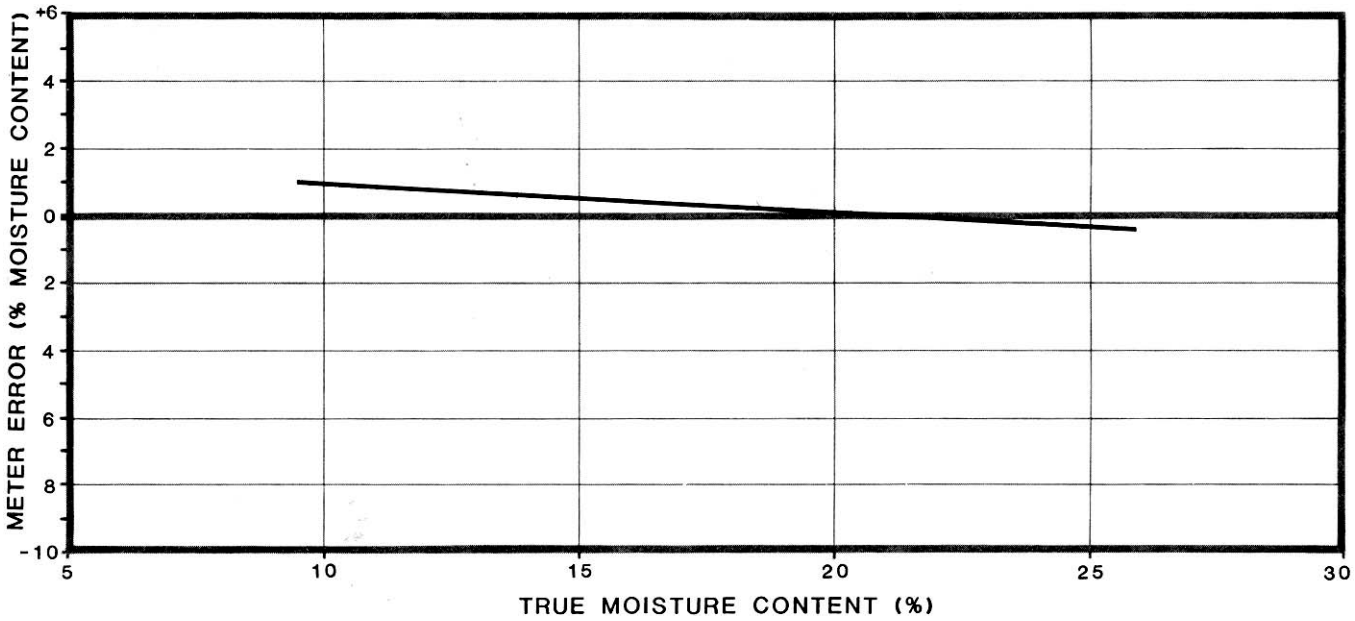


Figure 2. Deviations of Meter Readings for Dickey-john in Wheat.

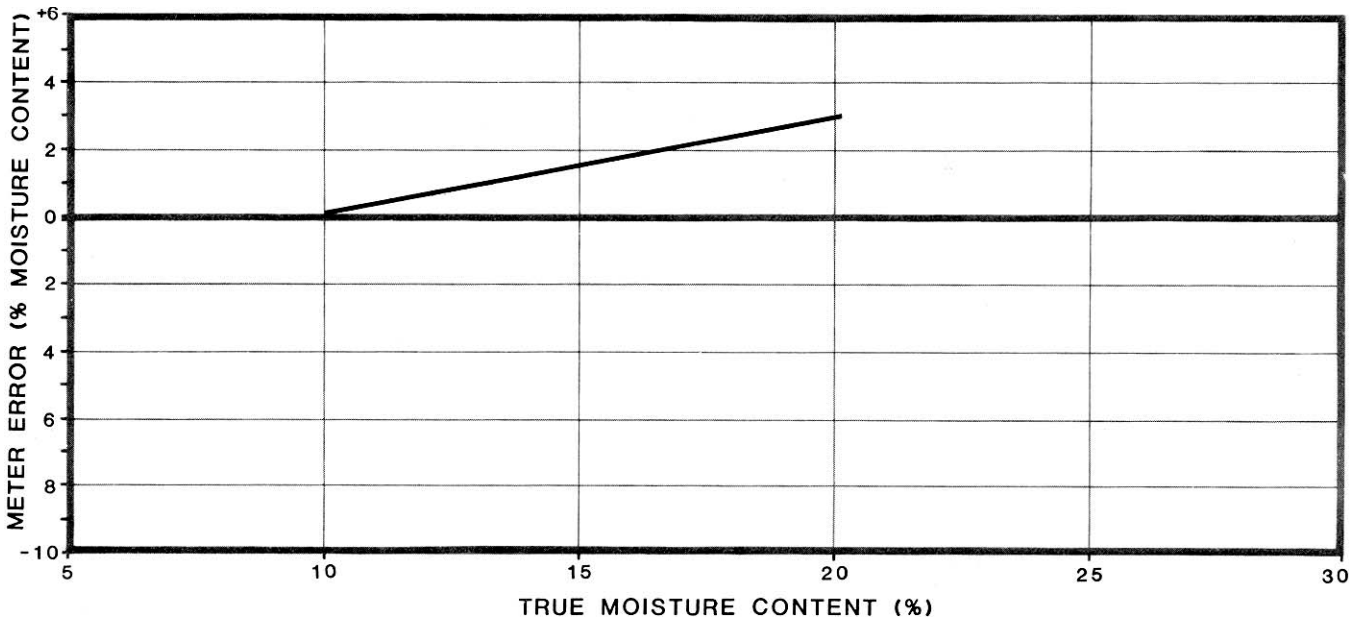


Figure 3. Deviations of Meter Readings for Dickey-john in Barley.

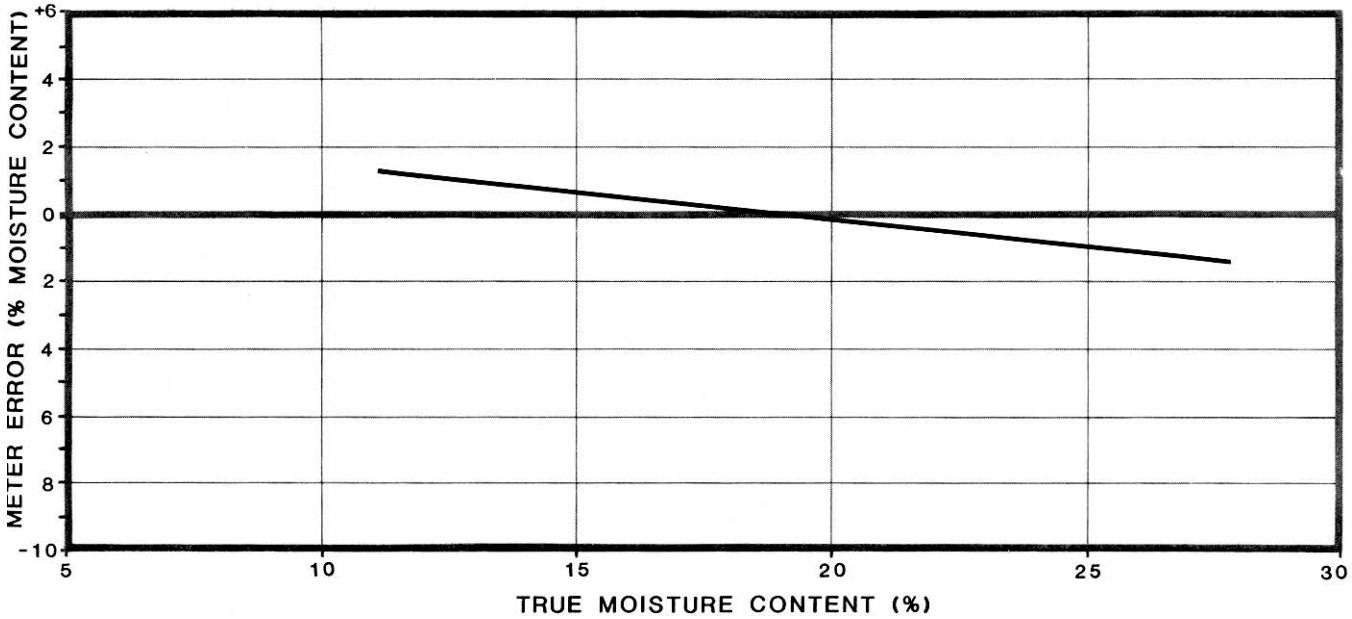


Figure 4. Deviations of Meter Readings for Dickey-john in Oats.

in Appendix II. Moisture charts for rapeseed should be supplied with the meter.

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

1. The pouring rate must be constant to obtain proper weight and packing density.
2. The moisture content conversion charts for grains other than wheat required that the original display reading be subtracted from the temperature compensated reading and added to the chart reading to obtain temperature compensated moisture content. If a chart reading could be obtained directly from the temperature compensated meter reading, there would be less chance of error and the procedure would be greatly simplified.

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 re-wetted 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 dielectric 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 good results for the Dickey-john in wheat. Figure 2 is the average best-fit line for three 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 1.4 to 0.4% high over the range of moisture contents tested. One of the lower lines is for Neepawa wheat which was harvested a year earlier at Lethbridge, Alberta and which was artificially tempered in the laboratory. Meter readings for this wheat varied from 0.2% high to 1.2% low. The third 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 1.7% high to

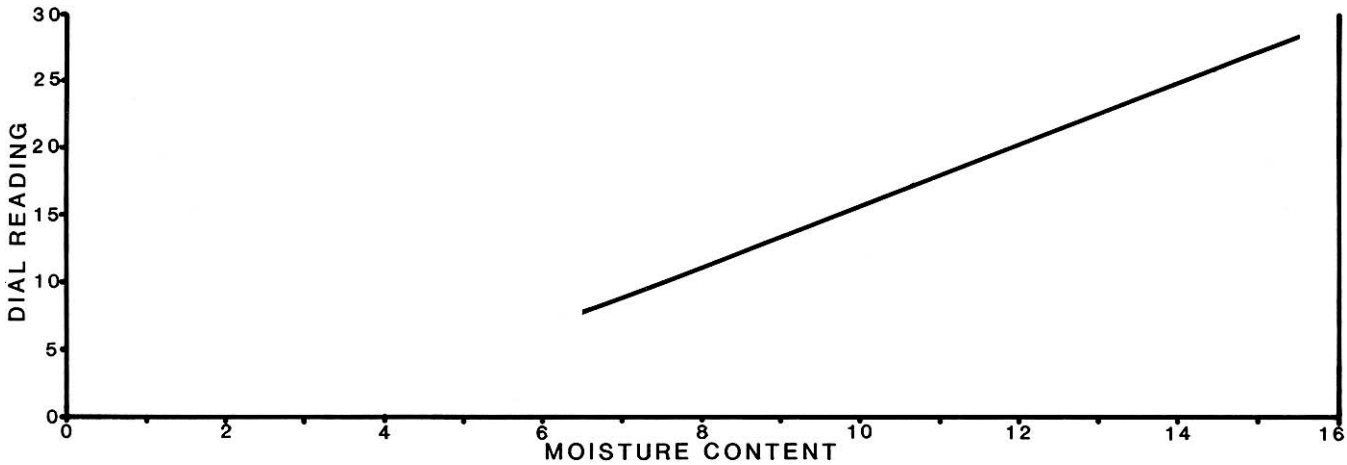


Figure 5. Calibration Curve for Dickey-john in Rapeseed.

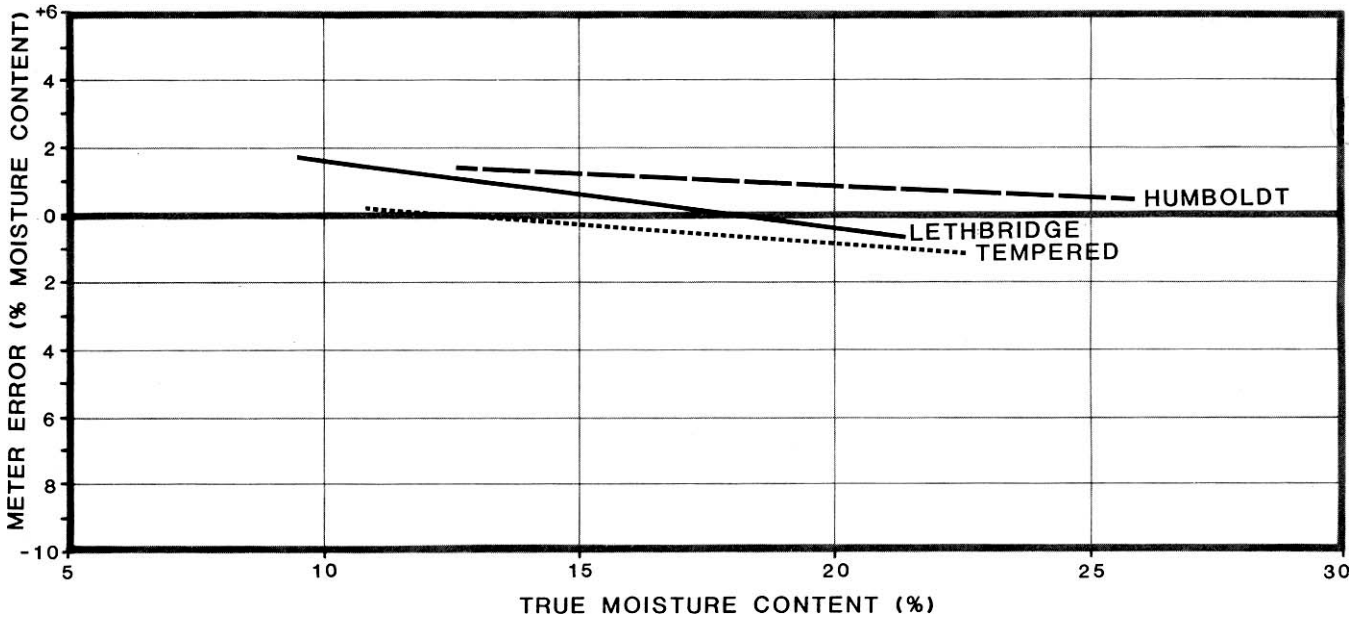


Figure 6. Deviations of Meter Readings for Dickey-john in Three different Types of Spring Wheat.

0.7% low over the range. Data showing statistical significance of these best-fit lines are presented in Appendix II.

The above results show that it is nearly impossible 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 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 agent. Comparing only a few samples should give enough information to decide how much to add to or subtract from the meter reading.

It should be noted that only one Dickey-john tester was evaluated. This does not guarantee that results from all Dickey-john testers 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 would be poor. Conversely, if chances of human error or instrument error are low, repeatability would 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 Dickey-john in wheat, barley and oats. These results show that the repeatability of the Dickey-john was good in wheat and barley and very good in oats.

The repeatability of the meter could be improved by providing for more uniform sample loading to result in a more uniform flow and packing density.

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 Dickey-john

Wheat	Barley	Oats
1.28%	1.54%	1.02%

DURABILITY AND PORTABILITY

The Dickey-john was well constructed and durable. It was small enough to be hand held while taking a moisture measurement making it adaptable for use in the field.

INSTRUCTION MANUAL

No instruction manual was supplied with the meter. Operating instructions consisted of those on a promotional brochure and on the side of the meter. Moisture charts were supplied on single loose pages and also on a decal pasted to the meter body. It is recommended that an instruction manual be supplied containing information on parts identification, operating and maintenance instructions and moisture content charts.

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:	-- Dj1S
Serial Number:	-- 44766-1S
Electrical Power Requirements:	-- 9 V transistor battery (NEDA type 1604)
Overall Height:	-- 178 mm (7 in)
Overall Length:	-- 203 mm (8 in)
Overall Width:	-- 102 mm (4 in)
Total Weight (in carrying case):	-- 1.1 kg (2.4 lb)
Principle of Operation:	-- capacitance
Weight of Grain Sample:	-- 200 g (7.05 oz)

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 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 Dickey-john 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 = Dickey-john dial reading 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	Fg. No.	Regression Equation	Simple Correlation Coefficient	Standard Error of Estimate	Residual Mean Square	Sample Size	Sample Mean
Wheat	2	M = 0.91T + 1.89	0.97	0.89	0.78	52	17.63
Barley	3	M = 1.29T - 2.82	0.98	0.96	0.93	19	16.27
Oats	4	M = 0.84T + 3.04	0.95	1.29	1.67	16	17.14
Wheat, Humboldt	6	M = 0.92T + 2.46	0.99	0.62	0.38	20	19.56
Wheat, Lethbridge	6	M = 0.80T + 3.60	0.98	0.58	0.34	10	15.77
Wheat, Tempered	6	M = 0.88T + 1.51	0.99	0.48	0.23	22	16.71
Rapeseed Calibration	5	R = 2.29 - 7.25	0.99	1.05	1.10	10	17.07

(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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