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Evaluation Report 3

Skuttle Model MT2 Electronic Grain Moisture Tester

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

Skuttle Model MT2 Electronic Grain Moisture Tester

Manufacturer:
Skuttle Manufacturing Company
Electronics Division
Canfield, Ohio 44406

Distributor:
-Smith-Roles Limited
Box 907
Saskatoon, Saskatchewan S7K 3M5

-Frank Flaman Wholesale Ltd.
Southey, Saskatchewan S0G 4P0

Retail Price:
$105.00 (January, 1977, f.o.b. Saskatoon, Sask.)

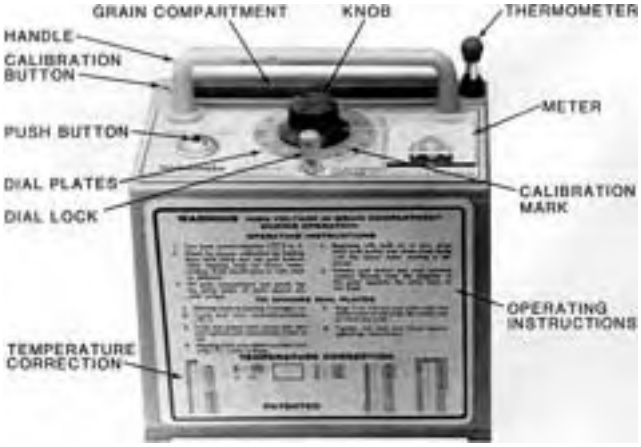

Figure 1. Detailed View of Skuttle MT2 Electronic Portable Grain Moisture Tester.

Summary and Conclusions

Accuracy of the Skuttle Model MT2 electronic grain moisture tester was good in wheat, poor in barley and unsatisfactory in oats and rapeseed.

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

Meter readings varied from 1.6 to 0.3% high in wheat, from 1.5% high to 2.7% low in barley over a range of moisture contents from 12 to 20%. The meter was unsatisfactory in determining the moisture content of oats since it was not capable of measuring below 15.2% where it read 2.6% low, and was 5% low at 20% moisture content. The meter was also unsatisfactory in rapeseed since it was not capable of measuring below 10.7% where it read 0.8% high, and was 2.0% low at 15%.

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 for field use.

The instruction manual was clear and concise.

Recommendations

It is recommended that the manufacturer consider:

1. Modifying the meter and/or moisture charts so the meter could be used to measure moisture content in oats and rapeseed.
2. Placing a calibration mark on all dial plates.
3. Expanding the dial plate scale for wheat in the critical moisture content range from 12 to 15%.
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.

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 difference may be due to geographic differences and different methods of allowing grain to mature (i.e. swathing and standing). Canadian grain is being obtained to make a full check.
2. Placing of a calibration mark on all dials is being considered for next run of dial plates.
3. The electronic circuitry is being looked at to see if signal can be amplified at lower end so scale can be expanded.
4. New thermometers will be ordered with both metric and English units. SI units will be included in new printings of manual.

General Description

The Skuttle Model MT2 electronic grain moisture tester determines moisture content using electrical resistance. The resistance of grain varies with changes in moisture content.

Moisture contents for wheat, oats, barley, corn, soybeans and grain sorghum are read directly on interchangeable dial plates provided with the meter. A dial plate marked from 0 to 100 in intervals of one is also supplied for use with charts in the instruction manual for 10 additional grains.

The grain sample is not weighed. The measuring compartment is simply filled with grain. About 0.6 L (0.5 qt) of grain is needed to fill the measuring compartment. A thermometer is supplied for temperature correction.

The meter operates on a 6 volt lantern battery.

The Skuttle MT2 is encased in plastic and equipped with a carrying handle. Operating instructions and temperature corrections are printed on the case.

Complete specifications are found in Appendix I.

Scope of Test

The Skuttle MT2 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 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 while maturing in the windrow.

The moisture content of each sample was measured five times with the meter. In total, over 500 measurements were made with the Skuttle MT2.

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

Results and Discussion

EASE OF OPERATION

The Skuttle MT2 was a hand held meter and was simple to operate. The meter was “instant on”, so no warm-up time was required. No sample weighing was necessary and a moisture measurement could be made in less than one minute.

The scales on the meter dial plates could be read to the nearest 0.5% except for moisture contents less than 13% for wheat and barley and less than 12% for oats. Scales in these ranges were compressed.

The moisture meter remained in calibration throughout the test. The calibration mark to check meter calibration was marked only on the moisture dial plate for corn. Since corn is not a commonly grown grain in Western Canada, the corn plate had to be installed each time to check calibration. A calibration mark on all dial plates would be more convenient.

The meter was turned on by a spring loaded push button switch. This prevented premature battery failure, as it was impossible to

leave the meter turned on. The battery, a 6 volt lantern battery, lasted the duration of the test in which over 500 samples were checked. The battery was easy to replace with a screwdriver and was readily obtainable.

ACCURACY

Sample Loading: The sample was easily loaded by filling the grain compartment, tapping 10 times and refilling the compartment. Differences in grain compaction by tapping and not tapping the meter resulted in errors in moisture content of 0.5%.

Moisture Content: The charts and dial plates provided indicated the meter was capable of measuring moisture contents varying from 13 to 22% in wheat and barley, 12 to 21% in oats and 10 to 25% in rapeseed. The Skuttle MT2 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 2 presents the results for the Skuttle MT2 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 result of 19 samples of certified Neepawa wheat which had been artificially tempered (moisture added and samples stabilized in laboratory) together with 17 samples of naturally tempered wheat from a field at Humboldt, Saskatchewan (originally dry windrows which had been rained upon) and eight samples of several varieties of spring wheat from fields at Lethbridge, Alberta which had received no rain while maturing in the windrow. Although an attempt was made to use the meter for measuring samples with moisture contents varying from 9.5 to 25.9%, it was only capable of measuring moisture contents in the 10.8 to 22.4% range. Below a moisture content of 10.8% the knob (Figure 1) could not be turned counter-clockwise far enough to adjust the meter to the required minimum position. Above 22.4% the knob could be turned clockwise far enough but the dial plate was not calibrated beyond this point. Meter readings varied from 1.6 to 0.3% high over the range of moisture content from 12 to 20%. Data showing statistical significance of the best-fit line are found in Appendix II.

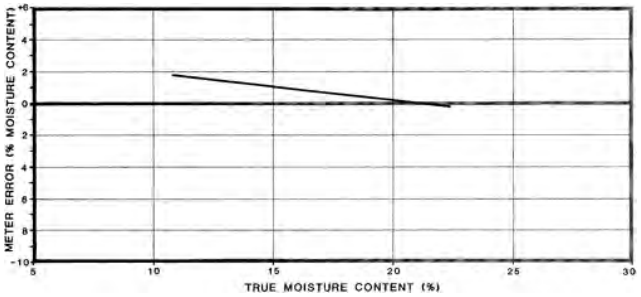

Figure 2. Deviations of Meter Readings for Skuttle MT2 in Wheat.

Figure 3 presents the best-fit line for barley. It gives the average results for 10 samples of tempered Betzes barley and six samples from different barley fields at Lethbridge, Alberta, which received no rain while maturing in the windrow. Although an attempt was made to use the meter for measuring samples with moisture contents varying from 10.0 to 30.5% it was only capable of measuring moisture contents in the 10.0 to 23.5% range. Above a moisture content of 23.5% the knob (Figure 1) could be turned clockwise far enough but the dial plate was not calibrated beyond this point. Meter readings varied from 1.5% high to 2.7% low over a moisture content range from 12 to 20%. Data showing statistical significance of the best-fit line are given in Appendix II.

The best-fit line for Skuttle MT2 in oats is given in Figure 4. This figure gives the average results for three samples of tempered Sioux oats and seven samples of oats from three fields at Lethbridge, Alberta, which received no rain while maturing in the windrow. Although an attempt was made to use the meter for measuring oat samples with moisture contents varying from 11.1 to 27.8%, it was not capable of measuring moisture contents below 15.2%. Below this moisture content the knob (Figure 1) could not be turned counter-clockwise far enough to adjust the meter to the required minimum position. The Skuttle MT2 was unsatisfactory for measuring moisture contents in oats. At 15.2% moisture content it read 2.6% low. At 20% moisture content it read 5.0% low. Statistical significance of the best-fit line is given in Appendix II.

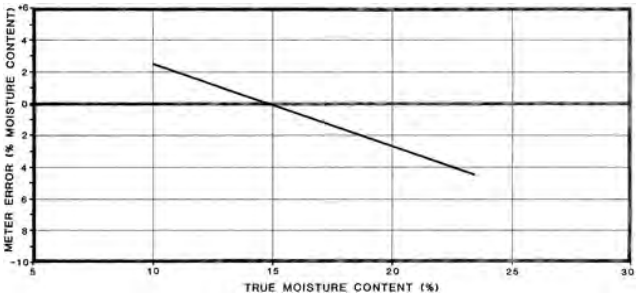

Figure 3. Deviations of Meter Readings for Skuttle MT2 in Barley.

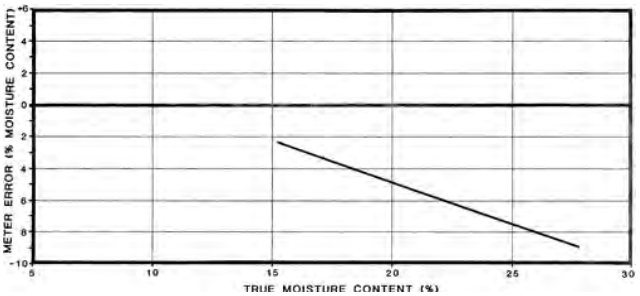

Figure 4. Deviations of Meter Readings for Skuttle MT2 in Oats.

Figure 5 shows the best-fit line for the Skuttle MT2 in rapeseed. This line is the average of five samples from several fields at Lethbridge, which received no rain while maturing in the windrow. Although an attempt was made to use the meter for measuring samples of rapeseed with moisture contents varying from 6.5 to 15.5%, it was not capable of measuring moisture contents below 10.7%. Below this moisture content, the knob (Figure 1) could not be turned counter-clockwise far enough to adjust the meter to the required minimum position. At a moisture content of 10.7% the meter read 0.8% high, while at 15% it read 2% low. The Skuttle MT2 was unsatisfactory for measuring the moisture content in rapeseed since it would not determine moisture contents below 10.7%. Because heating of rapeseed is a problem, accurate readings are desirable in the region around 10%, which represents the borderline between dry and tough rapeseed. Data presenting the statistical significance of the best-fit line are given in Appendix II.

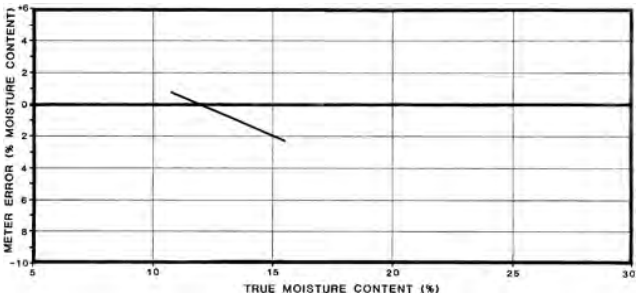

Figure 5. Deviations of Meter Readings for Skuttle MT2 in Rapeseed.

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

1. The grain compartment must be kept dry and clean.
2. The battery must be in good condition.
3. The dial plate zero and knob zero must be properly aligned when changing dial plates.
4. The scale on the wheat dial was compressed in the 13 to 15% range. Only a small movement of the knob was required to span this range, thus making accurate readings difficult. Since this range contains the dividing point between dry and tough wheat, it is necessary to read accurately in this range. The span on the dial plate in this range should be expanded.

Effect of Variables: The resistance 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 difficult to try to accurately predict the resistance 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 the results for the Skuttle MT2 in wheat. Figure 2 is the average best-fit line for three different types of spring wheat. Figure 6 represents 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 the wheat dried in the field, very similar to what a farmer would do under a similar situation. Moisture readings varied from 1.3 to 1.4% high over the range of moisture contents tested. One of the other lines is for Neepawa wheat harvested a year earlier at Lethbridge, Alberta, which was tempered artificially in the laboratory. Meter readings for this wheat varied from 1.8% high to 0.9% low. The third best-fit line is for a variety of spring wheat harvested at Lethbridge, Alberta in 1976. These samples had received no rain while maturing in the windrow. In this case, meter results varied from 1.9% high to 1.0% low. Data showing statistical significance of these best-fit lines are presented in Appendix II.

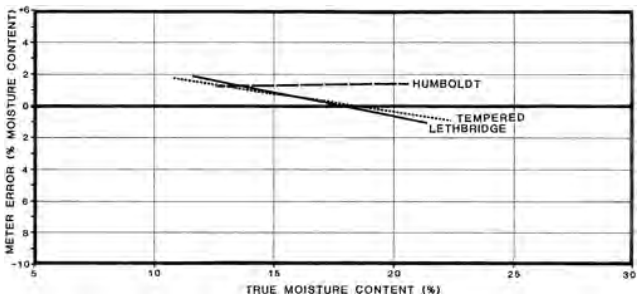

Figure 6. Deviations of Meter Readings for Skuttle MT2 in Three Different Types of Spring Wheat.

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 elevator agent. Comparing only a few samples should give enough information to determine how much to add to or subtract from the meter reading.

Only one Skuttle MT2 electronic moisture tester was evaluated. This does not guarantee all Skuttle MT2 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 human error or instrument error is high, then the repeatability will be poor. Conversely, if chances of human or instrument error are low, repeatability will be good. The coefficient of variation (explained in Appendix II) is a measure of 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 Skuttle MT2 in wheat, barley, oats and rapeseed. These results show that the repeatability of the Skuttle MT2 was excellent in wheat and barley and very good in oats and rapeseed.

Table 1. Coefficients of Variation for the Skuttle MT2

Wheat	Barley	Oats	Rapeseed
0.69%	0.823%	1.08%	1.08%

DURABILITY AND PORTABILITY

The Skuttle MT2 was well constructed and durable. The dial plates and thermometer were attached to the meter for easy transporting. The meter could be hand held while taking a moisture measurement making it very adaptable for measuring moisture contents in the field.

INSTRUCTION MANUAL

The instruction manual was easy to read and understand. In addition to information on operating instruction, maintenance, temperature correction charts and specifications, it contained general information on grain moisture testing and moisture content charts for 10 grains.

SAFETY

An electrical shock hazard occurred if the metal plates of the grain compartment were touched when energized. The instructions in the manual and on the side of the meter both warned of this hazard.

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:	Skuttle MT2
Serial Number:	none
Electrical Power Requirements:	6 V lantern battery
Overall Height:	203 mm (8 in)
Overall Width:	127 mm (5 in)
Overall Length:	190 mm (7.5 in)
Weight:	2.2 kg (4.75 lb)
Principle of Operation:	resistance

APPENDIX II
STATISTICAL INFORMATION

(a) Statistical Significance of Meter Results

The following data are presented to illustrate the statistical significance of 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 Skuttle MT2 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. 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=0.83T+3.65	0.94	0.97	0.94	44	16.78
Barley	3	M=0.48T+7.70	0.95	0.69	0.47	16	15.23
Oats	4	M=0.49T+5.20	0.91	0.98	0.95	10	14.86
Rapeseed	5	M=0.37T+7.49	0.84	0.57	0.32	5	12.46
Wheat Humboldt	6	M=0.93T+2.54	0.98	0.62	0.38	17	17.79
Wheat Lethbridge	6	M=0.71T+5.23	0.89	1.36	1.84	8	15.63
Wheat Tempered	6	M=0.77T+4.26	0.95	0.81	0.66	19	16.37

(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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