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# Evaluation Report 183

## Protimeter Grainmini III Moisture Meter

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

## PROTIMETER GRAIN MOISTURE METER

**MANUFACTURER:**

Protimeter Limited
Meter House, Fieldhouse Lane
Marlow, Bucks, SL7 1LX
England

**DISTRIBUTOR:**

R. C. Robson Agencies Limited
P.O. Box 188, Station CWinnipeg, Manitoba
R3M 3S7

**RETAIL PRICE:**

$375.00 (January, 1981, f.o.b. Lethbridge).


**FIGURE 1.** Profimeter Grainmini III Moisture Meter: (A) Grinder, (B) Compressor, (C) Switch, (D) Calibration Knob, (E) Meter Dial, (F) Calibrate Light, (G) Meter Scale, (H) Read Light, (I)Reader Rings, (J) Grain Cell.

## SUMMARY AND CONCLUSIONS

Overall performance of the Protimeter Grainmini III moisture meter using ground samples was fair in wheat and barley and good in oats. Using whole grain, the overall performance was poor in wheat and oats, fair in barley and good in rapeseed. This compares to an overall performance of very good in wheat, barley and oats and excellent in rapeseed for the PAMI reference moisture meter, which is similar to meters commonly used in most prairie grain elevators.

Using ground samples, average meter error varied from 1.7 to 0.9% high in wheat, 1.6 to 2.5% high in barley and 0.2% low to 0.5% high in oats over a range of moisture contents from 12 to 20%. With whole grain samples, average meter error varied from 2.1 to 0.5% high in wheat, 1.6 to 1.0% high in barley, 1.9 to 3.4% high in oats and 0.9 to 0.3% high in rapeseed over a range of moisture contents from 12 to 20% for cereal grains and 8 to 15% in rapeseed.

Meter uncertainty with ground samples varied from very good in wheat and barley to excellent in oats. With whole grain, meter uncertainty varied from fair in wheat, barley and rapeseed to good in oats.

Meter repeatability with ground samples varied from excellent in wheat to very good in barley and good in oats. With whole grain, meter repeatability was good in wheat and barley, very good in oats and excellent in rapeseed.

The upper limit for preparing ground samples in cereal grains, without experiencing grinder plugging, was about 18%. The range of moisture contents of greatest concern for cereal grains varies from 12 to 20% and for rapeseed from 8 to 15%. In whole grain, the Protimeter was capable of measuring moisture contents throughout these ranges.

The meter was easy to operate and a moisture measurement could be made in less than two minutes for ground samples and less than one minute for whole samples. The meter was durable and easily transported in its carrying case for field use.

As with most moisture meters, results depended on grain variety, the 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 at his local elevator to determine a Suitable correction factor. The instruction booklet and moisture charts provided were clear and easy to understand.

## RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifying the hand grinder to reduce the time required for grinding damp cereal grains and lighter grains such as oats.
2. Calibrating moisture charts and reader rings using the American Association of Cereal Chemists oven method for cereal grains.

*Chief Engineer: E. O. Nyborg*
*Senior Engineer: E. H. Wiens*
*Project Engineer: R. K. Allam*

## THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. We have not found the grinder excessively slow provided the rotating burr is adjusted to 2.5 to 3.0 mm as instructed on the label. It is not desirable to grind the grain finely; all that is required is to break the majority of the kernels. Passing dry grain through the grinder, between damp samples, helps to dislodge any damp grain caught in the flutes.
2. We feel that the poor meter accuracy is due to the calibration method used in preparation of the reader rings supplied with the meter. These were based on European grains and on the use of the International Standards Organization rather than the American Association of Cereal Chemists reference method. We have realized that they are unsuitable for the North American market and have prepared new rings for wheat, barley and oats (whole and ground) and for whole rapeseed which will almost completely eliminate the calibration errors found. These new rings will be available to customers in Canada who have already bought the Grainmini.

**PAMI NOTE:** Readings with the new rings supplied were compared to the readings obtained on the 0 to 100 meter scale. Calibration accuracy improvements were noted. For example, meter readings in ground wheat varied from 0.3 to 0.8% high in the range of moisture contents from 12 to 18.8%, respectively. In ground barley, meter readings varied from 0.2 to 0.5% high in the range of moisture contents from 12 to 17.9%, respectively. This compared to meter readings varying, from 1.7 to 0.9% high with ground wheat and 1.6 to 2.3% high for ground barley when using the old reader rings over the same range of moisture contents. Grain at higher moisture contents could not be ground due to grinder plugging.

In whole rapeseed, calibration accuracy with the new rings was reduced at high moisture contents. For example, meter readings varied from 0.4% high to 2.8% low over a range of moisture contents from 8 to 15%, respectively. With the old rings, over the same range of moisture contents, the meter readings varied from 0.9 to 0.3% high.

**NOTE:** This report has been prepared using SI units of measurement. A conversion table is given in APPENDIX IV.

## GENERAL DESCRIPTION

The Protimeter Grainmini III moisture meter determines grain moisture content using the resistance principle. This principle is based on the change in electrical resistance of grain with changes in moisture content.

The meter measures moisture contents of both whole and ground grain. A hand grinder is supplied for grinding grain samples.

The meter scale is marked from 0 to 100 in increments of one. Moisture content is determined from the dial reading by referring to charts supplied for more than 27 grains. Reader rings for 8 common grains are also supplied which allow direct moisture content readings. These rings fit around the meter dial and cover the 0 to 100 meter scale.

Sample weighing is not required. Sample size for whole grain

consists of filling the grain cell to within 6 mm (0.25 in) from the top while for ground grain the cell is filled to within 3 mm (0.125 in) of the top. Only a small handful of grain is required. Temperature correction is performed automatically.

Predetermined sample compaction is obtained by placing the compressor over the sample in the grain cell and turning it until the ratchet slips.

The calibration-moisture content switch is spring loaded to avoid premature battery failure. A plastic carrying case with a built-in handle and carrying cord are supplied.

The meter operates on a 9 V transistor battery.

Detailed specifications are given in APPENDIX I while FIGURE 1 shows major components.

## SCOPE OF TEST

The Protimeter was evaluated in wheat, barley, oats and rapeseed. Meter readings were compared to moisture contents obtained using the American Association of Cereal Chemists oven method. This method is the one used by the Canadian Grain Commission Research Laboratory. In addition, performance was compared to that of the PAMI reference moisture meter[1].

Samples of several different varieties of each grain, grown in several locations, were used to determine meter performance. The Protimeter was used with artificially tempered grain, naturally tempered grain and 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. The meter was evaluated using both whole and ground grain samples. In total, over 950 measurements were made with the Protimeter. All results in this report are expressed on a percent wet-weight basis, consistent with common grain practice. The Protimeter was evaluated for ease of operation, quality of work and suitability of the operator's manual.

## RESULTS AND DISCUSSION

### EASE OF OPERATION

**Moisture Measurement:** The Protimeter Grainmini III was simple to operate. The circuitry was fully transistorized, requiring no warm-up period. No sample weighing was needed but for best repeatability and accuracy the sample should be ground. Automatic temperature compensation was provided. In total, it took about two minutes to complete a moisture measurement with ground grain and about one minute with whole grain.

Sample grinding was quick and easy for grain moisture contents below 18%, providing the meter could be placed on a solid surface when grinding. Grain above 18% moisture content and light grains such as oats were difficult to grind due to plugging of the hand grinder. It is recommended grinder modification be considered to reduce the time required for grinding damp cereal grains and lighter grains such as oats.

The scales on the reader rings for wheat, oats and barley could be easily read to the nearest 0.25% moisture content in the range of 10 to 20% moisture content and to the nearest 0.5% above 20%. The reader ring for rapeseed could be easily read to the nearest 0.25%.

The Protimeter Grainmini III was easily calibrated by setting the meter dial to the "R" position, holding the power switch in the "R" position and adjusting the calibrate knob until the calibrate light was illuminated.

The power switch was spring loaded and had to be manually depressed during calibration or moisture determination. This prevented accidental battery failure since it was impossible to leave the meter turned on. The meter battery lasted throughout the evaluation period. The battery was readily obtainable and easy to replace.

**Field Use:** The Protimeter Grainmini III was provided with a plastic carrying case for the meter and its accessories. It was light and convenient to transport. Moisture measurements could be made in the field providing a solid surface on which to place the meter while grinding grain samples was available.

*[1]The PAMI reference moisture meter is a Labtronics model 919, similar to the moisture meters used in most prairie grain elevators. Detailed results for the reference moisture meter are presented in Evaluation Report E2379H.*

### QUALITY OF WORK

**Sample Size:** Sample weighing was not required. Sample size for ground grain consisted of filling the grain cell to within 3 mm (0.125 in) from the top while for whole grain the cell was filled to within 6 mm (0.25 in) from the top. This required only a small handful of grain. Errors from slight under filling or overfilling of the grain cell were insignificant.

**Temperature Compensation:** The Grainmini III was equipped with automatic temperature compensation: Both grain and meter temperatures must be similar for the automatic temperature compensation to be accurate. For example, with 15% Neepawa wheat and the meter temperature maintained at 20°C, reducing the sample temperature from 20 to 10°C resulted in a 0.9% decrease in moisture content reading.

**Measurement Range:** 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 stages. The Protimeter was capable of moisture measurements beyond these ranges with whole grain. Grinder plugging restricted the upper limit of ground samples for cereal grains to about 18%. Only whole grain samples of rapeseed were tested since, due to its oil bearing characteristics, it is not conducive to grinding.

The reader rings supplied with the Protimeter indicated the meter was capable of measuring moisture contents in ground grain from 11.0 to 34.0% in wheat, 11.0 to 30.0% in barley and 10.0 to 30.0%in oats. Reader rings and moisture charts indicated in whole grain the Protimeter could measure moisture contents from 12.6 to 31.0% in wheat, 12.0 to 34.0% in barley and oats and 6.9 to 21.5% in rapeseed.

The Protimeter was evaluated with ground grain samples ranging from 9.4 to 18.8% in wheat, 10.2 to 17.9% in barley and 11.0 to 18.2% in oats. The meter was evaluated with whole grain samples ranging from 9.4 to 30.1% in wheat, 10.2 to 30.4% in barley, 11.0 to 22.5% in oats and 6.9 to 16.7% in rapeseed.

**Accuracy:** Moisture contents could be taken with either ground or whole grain. Grinding usually resulted in improved accuracy.

FIGURE 2 presents accuracy results for the Protimeter in ground wheat. It shows the error (difference between indicated moisture content and oven moisture content) over the meter measurement range. The best-fit line gives the average results from eight samples of certified Neepawa wheat which had been artificially tempered (moisture added and samples stabilized in laboratory), together with nine samples of naturally tempered wheat from Lethbridge, Alberta (originally dry windrows which had been raised upon) and eight samples of Neepawa wheat from Lethbridge which had received no rain while maturing in the windrow. Meter readings varied from 1.7 to 0.9% high in the range of moisture contents from 12 to 18.8%, respectively. Grinding wheat above this moisture content was not possible due to plugging of the hand grinder. At 14.5%, the upper limit for dry wheat, the Protimeter read 1.4% high. This compares to a reading of 0.5% high for the PAMI reference moisture meter at 14.5% in the same grain.

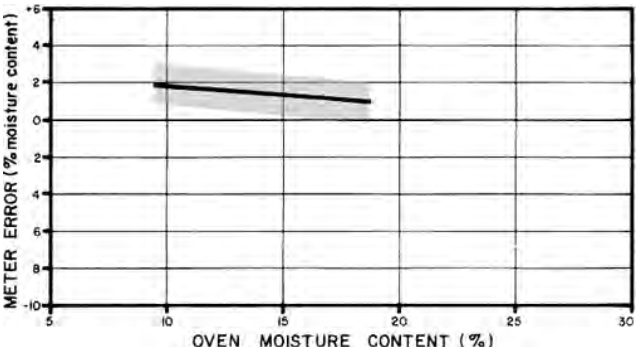


**FIGURE 2.** Accuracy of the Protimeter in Ground Wheat.

FIGURE 3 presents accuracy results for the Protimeter in whole wheat. The best-fit line gives the average results from 13 samples of certified Neepawa wheat which had been artificially tempered, together with 15 samples of naturally tempered wheat from Lethbridge, Alberta and 11 samples of Neepawa wheat from Lethbridge which had received no rain while maturing in the windrow. Meter readings in whole grain varied from 2.1 to 0.5% high

in the range of moisture contents from 12 to 20%, respectively. At 14.5%, the upper limit for dry wheat, the Protimeter read 1.6% high. This compares to a reading of 0.5% for the PAMI reference moisture was accurate while the PAMI reference moisture meter for the same meter at 14.5% in the same grain samples read 0.1% low.

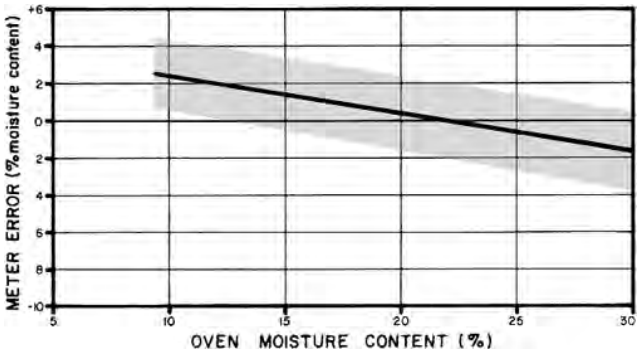


**FIGURE 3.** Accuracy of the Protimeter in Whole Wheat.

FIGURE 4 presents accuracy results for the Protimeter in ground barley. The best-fit line gives the average results for 11 samples of tempered Betzes barley, nine samples of tempered Gait barley and four samples of Gait barley which had received no rain while maturing in the windrow. Meter readings varied from 1.6 to 2.3% high in the range of moisture contents from 12 to 17.9%, respectively. Higher moisture contents resulted in plugging of the hand grinder. At 14.8%, the upper limit for dry barley, the Protimeter read 1.9% high. This compares to a reading of 0.1% high for the PAMI reference moisture meter at 14.8% in the same grain.

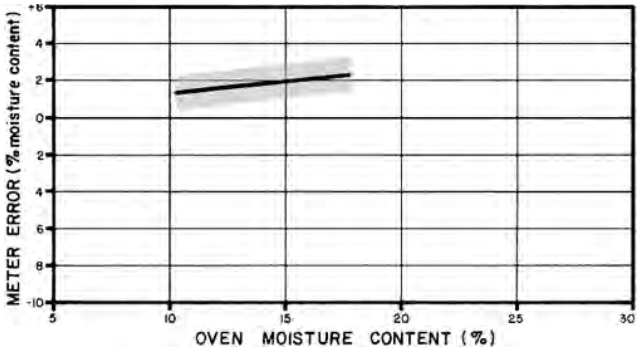


**FIGURE 4.** Accuracy of the Protimeter in Ground Barley.

FIGURE 5 presents the accuracy results for the Protimeter in whole barley. The best-fit line gives the average results for 18 samples of tempered Betzes barley, 11 samples of naturally tempered Gait barley and 10 samples of Gait barley which had received no rain while maturing in the windrow. Meter readings in whole grain varied from 1.6 to 1.0% high over the range of moisture contents from 12 to 20%, respectively. At 14.8%, the upper limit for dry barley, the Protimeter read 1.4% high, compared to the 0.1% high for the PAMI reference moisture meter with the same grain.

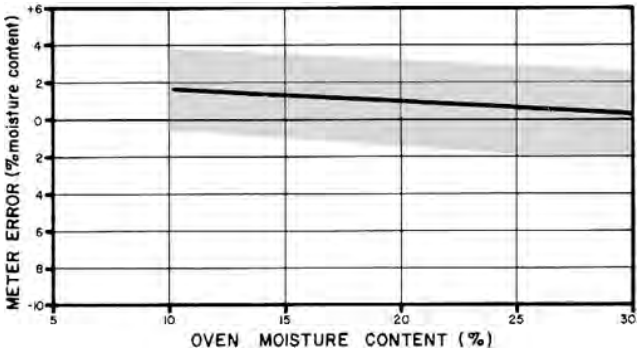


**FIGURE 5.** Accuracy of the Protimeter in Whole Barley.

Accuracy results for the Protimeter in ground oats is given in FIGURE 6. The best-fit line gives the average results for 12 samples of artificially tempered Sioux oats and three samples of naturally tempered oats. Meter readings varied from 0.2% low to 0.4% high in the range of moisture contents from 12 to 18.2%, respectively. Grinding oats above this moisture content resulted in plugging of the hand grinder. At 14.0%, the upper limit for dry oats, the Protimeter

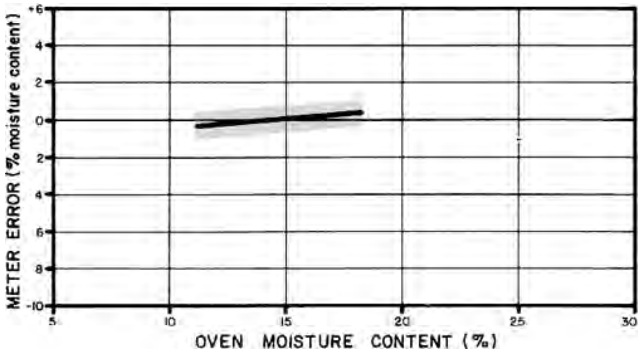


**FIGURE 6.** Accuracy of the Protimeter in Ground Oats.

Accuracy results for the Protimeter in whole oats is given in FIGURE 7. This figure gives the average results for 14 samples of artificially tempered Sioux oats and three samples of naturally tempered oats. Meter readings in whole grain varied from 1.9 to 3.4% high over the range of moisture contents from 12 to 20%, respectively. At 14%, the upper limit for dry oats, the Protimeter read 2.2% high while the PAMI reference moisture meter for the same oat samples read 0.1% low.

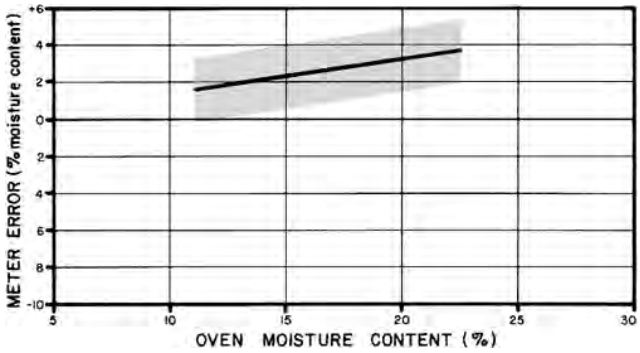


**FIGURE 7.** Accuracy of the Protimeter in Whole Oats.

The best-fit line for the Protimeter in whole rapeseed is given in FIGURE 8. This figure gives the average results for 17 samples of artificially tempered Argentine rapeseed and four samples of naturally tempered rapeseed. Meter readings varied from 0.9 to 0.3% high in the range of moisture content from 8 to 15%, respectively. At 10.5%, the upper limit for dry rapeseed, the Protimeter read 0.7% high while the PAMI reference moisture meter, with the same rapeseed samples, was accurate.

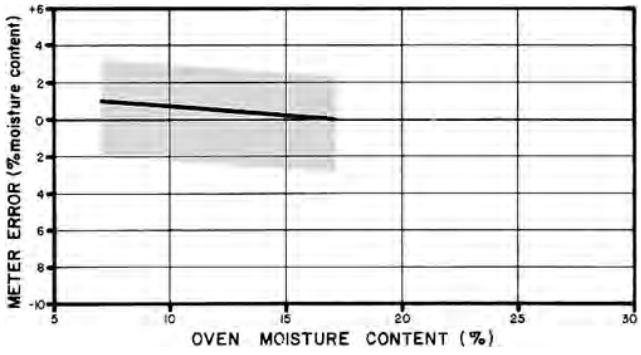


**FIGURE 8.** Accuracy of the Protimeter in Rapeseed.

**Uncertainty:** The shaded belts on FIGURES 2 to 8 are the 95% confidence belts. These belts can be used as a measure of meter uncertainty since they represent the region in which 95% of the test results can be expected to occur. A wide belt indicates wide scatter and measurement uncertainty, whereas a narrow belt shows good meter certainty. Uncertainty of the Protimeter in ground grain was very good in wheat and barley and excellent in oats. In whole

grain, uncertainty was fair in wheat, barley and rapeseed and good in oats. This compares to an uncertainty of very good in wheat, barley and oats and excellent in rapeseed for the PAMI reference moisture meter.

Data showing further statistical interpretation are presented in APPENDIX II.

**Repeatability:** Repeatability is a measure of how consistently a meter gives the same reading when the same grain sample is tested several times. If operator error or instrument error result in different readings with repeated measurements of the same sample, then the repeatability is poor.

Repeatability of the Protimeter in ground grain was excellent in wheat, very good in barley and good in oats. In whole grain, repeatability was good in wheat and barley, very good in oats and excellent in rapeseed. This compares to a repeatability of excellent in wheat and rapeseed and very good in oats and barley for the PAMI reference moisture meter.

**Errors from Crop Variables:** The dielectric properties of grain vary with 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 moisture charts are an attempt to accurately represent the average properties for one grain variety. It is difficult to accurately predict the dielectric properties of all varieties of grain grown in the prairies and to prepare an appropriate calibration chart.

To illustrate this point, FIGURE 9 and APPENDIX II show the average best-fit lines for three separate groups of spring wheat samples tested with the PAMI reference moisture meter. The upper line is for 20 samples from a field of Neepawa wheat at Humboldt, Saskatchewan in 1976. The windrows had received rain and samples were taken as the wheat dried in the field. Meter readings varied from 0.9 to 1.0% high over a range of moisture contents from 12 to 20%.

The middle line is for 34 samples of Neepawa wheat from Lethbridge, Alberta in 1979, 12 of which were naturally tempered, nine of which had received no rain while maturing in the windrow and 13 of which had been artificially tempered. Meter readings for these samples were 0.5% high over a range of moisture contents from 12 to 20%.

The lower line is for 14 samples of spring wheat from Lethbridge, Alberta in 1976. These samples had received no rain while maturing in the windrow. Meter results varied from 0.3 to 0.2% high over a range of moisture contents from 12 to 20%.

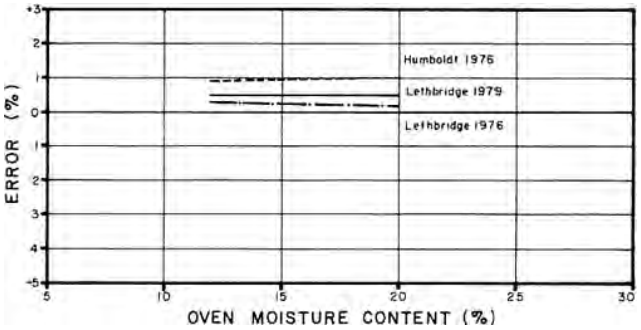


**FIGURE 9.** Deviations of Meter Readings for the PAMI Reference Moisture Meter in Three Different Groups of Wheat.

It can be seen from the above results that though the PAMI reference moisture meter is a relatively accurate instrument, it is very difficult 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 time consuming and would defeat the purpose of a portable grain moisture meter.

The Protimeter moisture meter was similarly affected by these same variables. It is, therefore, recommended that the owner annually check the results of his moisture meter against the moisture meter used at his local elevator. Comparing only a few samples should give enough information to correct meter readings.

## DURABILITY

Two failures occurred during the evaluation. After approximately 435 moisture readings, the "Read" light quit working due to electronic circuitry failure. A replacement meter was obtained for the remainder of the evaluation. The compression cell on the replacement meter cracked and was replaced after approximately 310 moisture readings.

## OPERATOR'S MANUAL

The operating instructions were easy to read and understand and contained information on the care and operation of the meter. Moisture charts for 27 grains were supplied on a separate sheet. Operating instructions were also printed on the meter face for convenient field reference.

## ACKNOWLEDGEMENT

Thanks are extended to Lethbridge area farmers for assistance in collecting grain samples and the Agriculture Canada Research Station, Lethbridge, for the use of their stationary thresher.

## APPENDIX I
## SPECIFICATIONS

| | |
|---|---|
| **Model:** | Grainmini III |
| **Serial Number:** | 927706 |
| **Electrical Power Requirements:** | 9 V transistor battery |
| **Overall Height (with grinder):** | 195 mm |
| **Overall Width:** | 195 mm |
| **Overall Length:** | 160 mm |
| **Total Weight (in carrying case):** | 1.2 kg |
| **Principle of Operation:** | Resistance |
| **Size of Grain Sample:** | Fill test cylinder (small handful) |

## APPENDIX II
## 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 9. This information is intended for use by those who may wish to check results in greater detail.

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 American Association of Cereal Chemists oven method. Sample size refers to the number of grain samples used. Each meter sample represents the average of five meter readings on that sample.

| Grain Type | Fig. No. | Regression | Correlation Coefficient | Standard Error | Sample Size | Sample Mean |
|---|---|---|---|---|---|---|
| PROTIMETER | | | | | | |
| Wheat | 2 | M = 0.90T + 2.87 | 0.98 | 0.48 | 17 | 16.15 |
| Barley | 4 | M = 1.12T + 0.11 | 0.99 | 0.41 | 24 | 16.01 |
| Oats | 6 | M = 1.08T - 1.27 | 0.99 | 0.27 | 15 | 14.35 |
| *Ground Grain:* | | | | | | |
| Wheat | 3 | M = 0.80T + 4.52 | 0.97 | 0.94 | 39 | 18.92 |
| Barley | 5 | M = 0.93T + 2.44 | 0.98 | 1.06 | 39 | 21.05 |
| Oats | 7 | M = 1.19T - 0.43 | 0.98 | 0.74 | 17 | 18.32 |
| Rapeseed | 8 | M = 0.91T + 1.66 | 0.95 | 1.00 | 21 | 12.07 |
| PAMI REFERENCE METER | | | | | | |
| Wheat, Humboldt (1976) | 9 | M = 1.01T + 0.81 | 1.00 | 0.38 | 20 | 18.26 |
| Wheat, Lethbridge (1979) | 9 | M = 1.01T + 0.42 | 1.00 | 0.38 | 34 | 17.32 |
| Wheat, Lethbridge (1976) | 9 | M = 0.98T + 0.58 | 0.99 | 0.32 | 14 | 13.87 |

## APPENDIX III
## MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

| | |
|---|---|
| (a) excellent | (d) fair |
| (b) very good | (e) poor |
| (c) good | (f) unsatisfactory |

## APPENDIX IV
## CONVERSION TABLE

| | |
|---|---|
| 1 millimetre (mm) | = 0.04 inches (in) |
| 1 gram (g) | = 0.04 ounces (oz) |
| 1 kilogram (kg) | = 2.2 pounds (lb) |

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