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Evaluation Report 185

RDS Grain Test 2 Moisture Meter

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

RDS GRAIN TEST 2 MOISTURE METER

MANUFACTURER:

RDS (Agricultural) Ltd.
Stroud Road
Nailsworth, Stroud
Glos, GL6 0BE
ENGLAND

DISTRIBUTOR:

Crawfords of Alberta, Ltd.
P.O. Box 1720
Camrose, Alberta
T4V 1X8

RETAIL PRICE:

$580.00 (March, 1981, f.o.b. Lethbridge).

FIGURE 1. RDS Grain Test 2 Moisture Meter: (A) Test Cell, (B) Meter Scale, (C) Power Switch, (D) Meter Indicator, (E) Meter Reading, (F) Temperature Reading, (G) Build-in Temperature Sensor, (H) Sliding Crop Scale, (I) Additional Crop Scales.

SUMMARY AND CONCLUSIONS

Overall performance of the RDS Grain Test 2 moisture meter using ground samples was very good in wheat and good in barley and oats. Using whole grain, the overall performance was good in wheat, barley and oats, and fair 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 prairie grain elevators.

Using ground samples, average meter error was 0.1% high in wheat and varied from 0.1 to 1.0% high in barley and from 0.7 to 0.5% low in oats over the range of moisture contents tested. With whole grain samples, average meter error varied from 0.1% high to 1.3% low in wheat, 0.2 to 1.0% low in barley, 0.3 to 0.7% high in oats and 0.3% high to 3.1% low in rapeseed over a range of moisture contents from 12 to 20% for cereal grains and 8 to 15% for rapeseed.

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

Meter repeatability with ground samples varied from excellent in wheat to very good in barley and oats. With whole grain, meter repeatability was very good in wheat and oats, good in barley 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 RDS was capable of measuring moisture contents throughout these ranges. Moisture measurements with grain samples above 23% were very inaccurate.

The meter was easy to operate and a moisture measurement could be made in less than two minutes for ground samples and leas 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 instructions provided with the meter were clear and easy to understand.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Supplying a grain sample grinder as standard equipment.
2. Providing operating instructions on the meter body for convenient field reference.

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. A grain sample grinder is available as optional equipment. We also find that hand-operated coffee grinders can normally be purchased at local stores at a very low cost and are entirely suitable.
2. Operating instructions are now provided as an inseparable part of the carrying case, which has also been improved to provide storage for calibration slides.

Manufacturer's Additional Comments:

It is certainly true, as indicated in the PAMI report, that there are no absolutes in the measurement of grain moisture. Consequently there is bound be some slight variation between moisture meters used at different elevators. We have consequently now made provision on the scales for setting in a constant error factor so that a farmer can effectively adjust his moisture meter to agree with the results obtained by his merchant. When this small adjustment has been done, by comparing results with those obtained by his merchant as recommended on page 5 of the report, it should be possible to get consistent agreement thereafter.

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

GENERAL DESCRIPTION

The RDS Grain Test 2 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 available as optional equipment.

The meter reading and scale are marked from 0 to 100 in increments of one. The sliding crop scale is positioned on the meter face according to the temperature measured by the built-in temperature sensor. Meter readings are then transferred to the meter scale and the corresponding grain moisture content is read from the sliding crop scale. Sliding crop scales are available for both ground and whole samples of grains commonly grown .on the prairies.

Sample weighing is not required. Sample size for whole or ground grain consists of filling the grain test cell. Only a small handful of grain is required. The meter is equipped with a built-in temperature sensor.

Predetermined sample compaction is obtained by tightening the test cell until the indicator is flush with the top of the cell. The power switch is spring loaded to avoid premature battery failure. A leatherette carrying case complete with carrying strap is supplied. The meter operates on two 9 V transistor batteries.

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

SCOPE OF TEST

The RDS Grain Test 2 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. 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 RDS 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 900 measurements were made with the RDS. All results in this report are expressed on a per cent wet-weight basis, consistent with common grain practices.

The RDS 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 RDS Grain Test 2 was simple to operate. The circuitry was fully transistorized, requiring no warm-up period. Temperature compensation was made by positioning the sliding crop scale on the meter face according to the temperature measured by the built-in temperature sensor. No sample weighing was needed but for best accuracy and repeatability the sample should be ground. No grinder was supplied but a grinder is available as an option. It is recommended that a suitable grinder be supplied as standard equipment. A small top loading hand grinder was used for preparing ground samples for this evaluation. In total, it took about two minutes to complete a moisture measurement with ground grain and about one minute with whole grain.

The sliding crop scales for wheat, oats and barley were easily read to the nearest 0.5% moisture content. Rapeseed moisture content could easily be read to the nearest 0.25%.

The power switch was spring loaded and had to be manually depressed for temperature and meter readings. This prevented accidental battery failure since it was impossible to leave the meter turned on. The meter batteries lasted throughout the evaluation period. The batteries were readily obtainable and easy to replace.

Field Use: The RDS Grain Test 2 was provided with a leatherette carrying case for the meter and its accessories. It was light and convenient to transport. Sample grinding in the field was inconvenient with the small top loading grinder used throughout the evaluation.

QUALITY OF WORK

Sample Size: Sample weighing was not required. Sample size consisted of filling the test cell. This required only a small handful of grain. Errors from slight underfilling or overfilling of the test cell were insignificant.

Temperature Compensation: Temperature compensation with the Grain Test 2 was accomplished by positioning the sliding crop scale on the meter face according to the temperature (°C) measured by the built-in temperature sensor. Both grain and meter temperatures must be similar for the temperature compensation to be accurate. For example, with 14% Neepawa wheat, and the meter temperature maintained at 20°C, reducing the sample temperature from 200 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 RDS 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 sliding crop scales supplied with the RDS indicated the meter was capable of measuring moisture contents in ground grain from 9.5 to 35.0% in wheat and from 8.0 to 30.0% in barley and oats. Sliding crop scales indicated that in whole grain the RDS could measure moisture contents from 10.0 to 30.0% in wheat, 10.0 to 40.0% in barley and oats and 7.0 to 14.5% in rapeseed.

The RDS was evaluated with ground grain samples ranging from 9.4 to 18.6% 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 content could be obtained with either ground or whole grain. Grinding usually resulted in improved accuracy. Moisture content measurements of whole cereal grain samples above 23% were very inaccurate.

FIGURE 2 presents accuracy results for the RDS 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 rained upon) and eight samples of Neepawa wheat from Lethbridge which had received no rain while maturing in the windrow. Meter readings were 0.1% high throughout the range of moisture contents from 12 to 18.8%. 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 0.1% high reading for the RDS compares to a reading of 0.5% high for the PAMI reference moisture meter in the same grain.

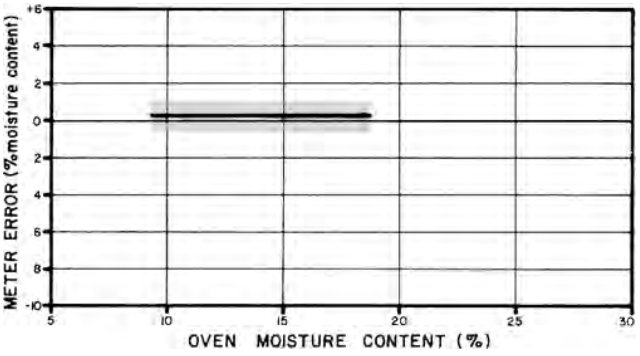

FIGURE 2. Accuracy of the RDS in Ground Wheat.

FIGURE 3 presents accuracy results for the RDS 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 12 samples of naturally tempered wheat from Lethbridge, Alberta and nine samples of Neepawa wheat from Lethbridge which had received no rain while maturing in the windrow. Meter readings in whole wheat varied from 0.1% high to 1.3% low in the range of moisture contents from 12 to 20%, respectively. At 14.5%, the upper limit for dry wheat the RDS read 0.3% low. This compares to a reading of 0.5% high for the PAMI reference moisture meter at 14.5% in the same grain.

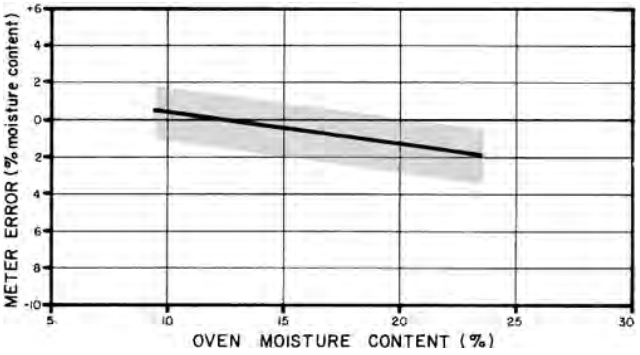

FIGURE 3. Accuracy of the RDS in Whole Wheat.

FIGURE 4 presents accuracy results for the RDS in ground barley. The best-fit line gives the average results for 11 samples of tempered Betzes barley, nine samples of tempered Gait barley

[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 ara presented in Evaluation Report E2379H.

and four samples of Gait barley which had received no rain while maturing in the windrow. Meter readings varied from 0.1 to 0.8% 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 RDS read 0.4% high. This compares to a reading of 0.1% high for the PAMI reference moisture meter at 14.8% in the same grain.

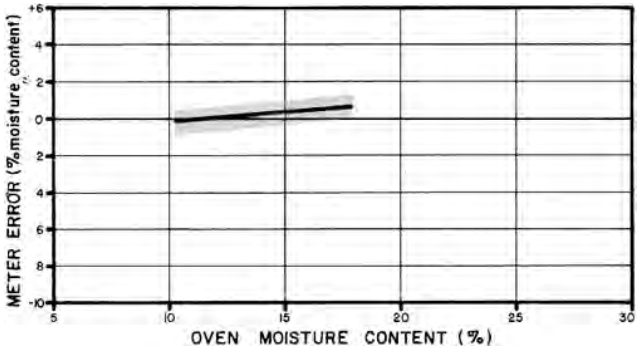

FIGURE 4. Accuracy of the RDS in Ground Barley.

FIGURE 5 presents the accuracy results for the RDS 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 six samples of Gait barley which had received no rain while maturing in the windrow. Meter readings in whole grain varied from 0.2 to 1.0% low over the range of moisture contents from 12 to20%, respectively. At 14.8%, the upper limit for dry barley, the RDS read 0.4% low, compared to 0.1% high for the PAMI reference moisture meter with the same grain.

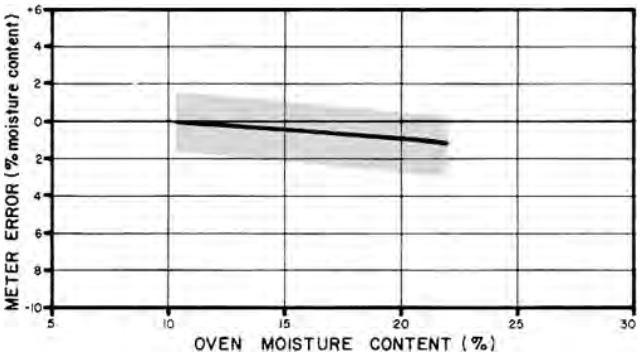

FIGURE 5. Accuracy of the RDS in Whole Barley.

Accuracy results for the RDS 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 0.7 to 0.6% low 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 RDS read 0.6% low while the PAMI reference moisture meter for the same grain samples read 0.1% low.

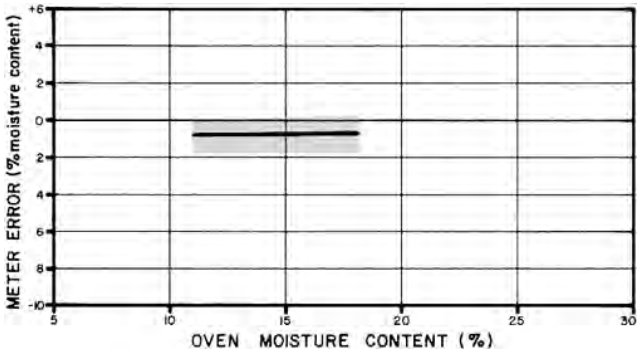

FIGURE 6. Accuracy of the RDS in Ground Oats.

Accuracy results for the RDS in whole oats is given in FIGURE 7. This figure gives the average results for 16 samples of artificially tempered Sioux oats and three samples of naturally tempered oats. Meter readings in whole grain varied from 0.3 to 0.7% high over the range of moisture contents from 12 to 20%, respectively. At 14%, the upper limit for dry oats, the RDS read 0.4% high while the PAMI reference moisture meter for the same oat samples read O. 1% low.

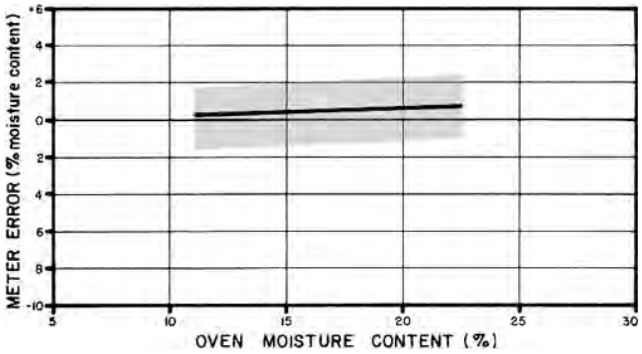

FIGURE 7. Accuracy of the RDS in Whole Oats.

The best-fit line for the RDS 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 0.3% high to 3.1% low in the range of moisture contents from 8 to 15%, respectively. At 10.5%, the upper limit for dry rapeseed, the RDS read 0.9% low while the PAMI reference moisture meter, with the same rapeseed samples, was accurate.

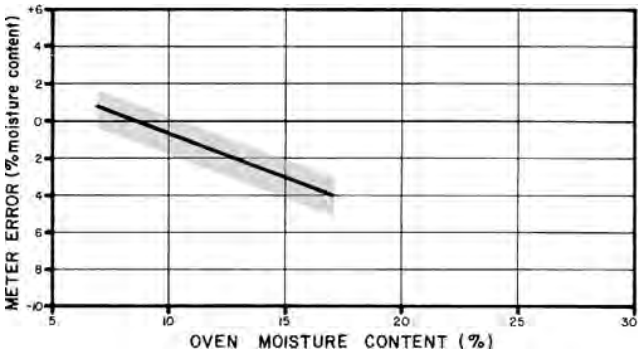

FIGURE 8. Accuracy of the RDS in Rapeseed.

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 RDS in ground grain was very good in wheat and oats and excellent in barley. In whole grain, uncertainty was good in wheat, barley and oats, and very good in rapeseed. 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 RDS in ground grain was excellent in wheat and very good in barley and oats. In whole grain, repeatability was very good in wheat and oats, good in barley and excellent in rapeseed. This compares to a repeatability of 9xcellent 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 grains 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%.

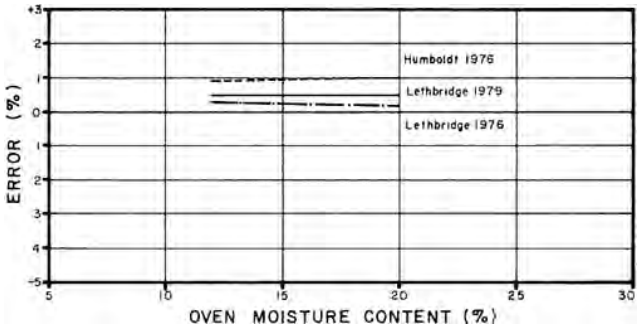

FIGURE 9. Deviations of Meter Readings for the PAMI Reference Moisture Meter in Three Different Groups of Wheat.

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 RDS 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

The meter, as supplied, was not functional due to a poor soldering connection at the power switch. The connection was repaired and no more problems were encountered throughout the evaluation period.

OPERATOR'S MANUAL

The instructions were easy to read and understand. It is recommended that operating instructions also be printed on the meter body 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:	Grain Test 2
Serial Number:	G.T. 100879-269
Electrical Power Requirements:	2, 9 V transistor batteries
Overall Height (with cell):	130 mm
Overall Width:	210 mm
Overall Length: 1	30 mm
Total Weight (in carrying case):	1.8 kg
Principle of Operation:	Resistance
Size of Grain Sample:	Fill test cell (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 RDS 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
Ground Grain:						
Wheat	2	M = 1.00T + 0.12	0.99	0.37	25	15.15
Barley	3	M = 1.11T - 1.19	1.00	0.29	24	14.49
Oats	4	M = 1.02T - 0.92	0.99	0.43	15	13.57
Whole Grain:						
Wheat	5	M = 0.82T + 2.27	0.98	0.70	34	16.24
Barley	6	M = 0.90T + 1.05	0.97	0.79	35	16.00
Oats	7	M = 1.05T - 0.34	0.98	0.80	19	16.72
Rapeseed	8	M = 0.51T + 4.23	0.97	0.44	21	10.15
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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