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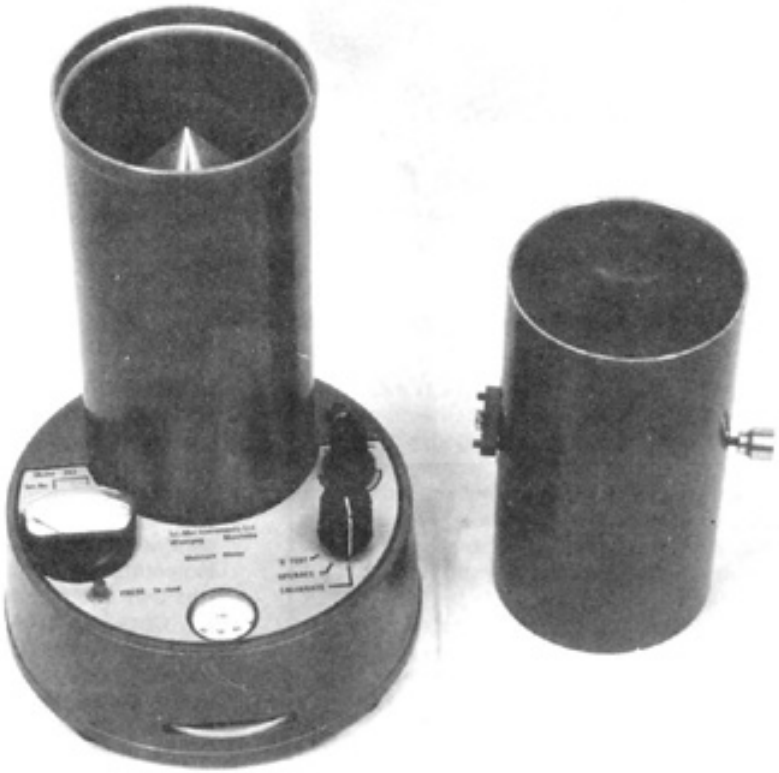

Tri-Met Model 393 Grain Moisture Meter

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

TRI-MET 393 GRAIN MOISTURE METER

MANUFACTURER AND DISTRIBUTOR:

Tri-Met Instruments Limited
1788 St. Matthews Avenue
Winnipeg, Manitoba R3H 0A5

RETAIL PRICE:

$675.00 (March, 1986, f.o.b. Lethbridge, Alberta, complete with thermometer, balance and conversion charts.)

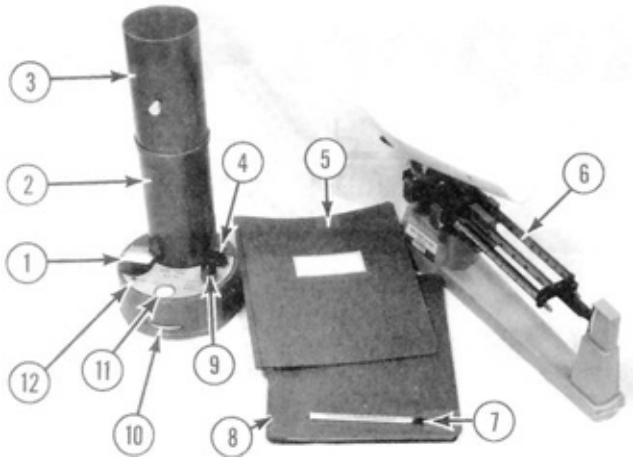

FIGURE 1. Tri-Met 393 Grain Moisture Meter: (1) Meter, (2) Sample Cell, (3) Dump Cylinder, (4) Calibration Knob, (5) Conversion Charts, (6) O-HAUS Triple.beam Scale, (7) Thermometer, (8) Operator's Manual, (9) Function Switch, (10) Adjust Wheel, (11) Dial Reading, (12) Power Switch.

SUMMARY

The accuracy of the Tri-Met 393 in wheat was very good over the entire range of moisture contents measured. Uncertainty and repeatability were both excellent. Accuracy in barley was excellent over the entire range of moisture contents measured. Uncertainty was excellent and repeatability was very good. The accuracy in canola (rapeseed) was excellent over the entire range of moisture contents measured. Uncertainty and repeatability were both excellent.

The meter was easy to operate and a moisture measurement could be made in less than two minutes. The meter itself was light and durable and could be easily transported for field use. The triple beam balance for accurate sample weighing was not readily transportable.

The instruction manual and moisture charts provided were clear and easy to understand.

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.

Manager/Senior Engineer: E. H. Wiens
Project Engineer: L. R. Coleman

GENERAL DESCRIPTION

The Tri-Met 393 grain moisture meter determines moisture content using the capacitance principle. The principle is based on the change in the dielectric properties of grain with changes in moisture content.

The dial reading scale is divided from 0 to 100 in increments of one. Readings from the dial, combined with the temperature of the grain sample, are used to obtain moisture content from moisture charts supplied for common grains grown on the prairies.

A dump cylinder is used to uniformly load the grain sample into the 3½ in (89 mm) diameter test cell.

The grain samples are weighed on an accurate, triple beam balance scale supplied with the meter.

Also supplied are a thermometer and a complete set of temperature and moisture conversion charts.

The meter operates on a 9-volt transistor battery. An AC-DC adapter is available as an option.

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

SCOPE OF TEST

The Tri-Met 393 meter was used to determine moisture contents of wheat, barley and canola (rapeseed). Meter readings were compared to moisture contents obtained using the American Association of Cereal Chemists oven method. This method is also used by the Canadian Grain Commission Research Laboratory. In addition, performance was compared to that of a PAMI reference moisture meter[1].

For each grain, artificially tempered samples (dry grain which was moistened in the laboratory and allowed to stabilize before moisture measurement) were used to determine meter performance.

The moisture content of each grain sample was measured five times with the meter. In total, over 400 measurements were made with the Tri-Met moisture meter. All results in the report are expressed on a percent wet-weight basis, consistent with common grain practice.

The meter 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 Tri-Met 393 was easy to operate. The meter circuit was fully transistorized and no warm-up period was required. It was necessary to accurately weigh the sample before determining its moisture content. Both the meter and scale required a level surface for best accuracy. Temperature compensation was made by measuring sample temperature (°C) and using the charts provided. In total, it took less than two minutes to complete a moisture measurement.

Conversion charts indicated both the sample weight and grain test weight for each grain. Test weight ("bushel weight") was easily obtained, provided the optional "litre measuring cup" was available. Test weight was obtained by weighing the contents of the measuring cup and converting to either pounds per bushel or kilograms per hectolitre.

The meter was easily calibrated by turning the function switch to the calibrate position, setting the dial reading to "Cal" and turning the calibration knob to obtain a minimum (null) meter reading. Calibration adjustment for the null position was extremely sensitive. However, once the meter was calibrated, it remained in calibration and did not drift.

The meter dial could be read to the nearest 0.5 division which resulted in moisture contents to the nearest 0.1%. The error due to reading the meter scale from an angle (parallax) could be as high as 1.0 division which could result in a 0.2% error in moisture measurements.

The meter was automatically turned off when not in use. This feature reduced premature battery failure.

The "Battery Test" feature of the Tri-Met 393 allowed for quick and easy testing of the battery. The 9-volt transistor battery was easily replaced by removing the battery cover of the meter, held in place by four screws.

[1]The PAMI reference moisture meter used for this series of tests was a Motomco model 919, similar to the moisture meter used in most prairie grain elevators. Accuracy results for the reference moisture meter are presented in APPENDIX II.

Field Use: Although the Tri-Met 393 meter itself was light and compact for transporting to the field in its cardboard shipping carton, the triple beam balance for accurate sample weighlng was not easily transportable. Aisc, a flat surface, protected from the wind, was required for accurate sample weighing. Consequently, the Tri-Met was not readily field transportable and should be considered primarily for use indoors.

QUALITY OF WORK

Weighing Accuracy: The triple beam balance supplied was accurate to 0.1 g and was easy to use. Sample size was dependent on the grain type tested and varied from 175 to 250 g for the 3½ in (89 mm) cell. Careful weighing with the triple beam balance resulted in the required sample weight accuracy to obtain accurate moisture content measurements. However, pouring the sample until the balance tipped, could result in errors in sample weight up to 5 g and a resulting 0.7% error in moisture content. Accurate sample weights are necessary to obtain accurate moisture content measurements.

Temperature Compensation: The conversion charts compensated well for temperature. When the same sample of wheat was warmed from 10 to 23°C, temperature compensation was accurate to within 0.1% moisture content.

Measurement Range: The range of moisture content of greatest concern is between 12 and 20% for cereal grains and between 8 and 15% for canola. These ranges include dry, tough and damp stages. The Tri-Met 393 was capable of moisture measurement throughout these ranges.

Charts supplied with the Tri-Met 393 indicated that, at room temperature, it was capable of measuring moisture contents ranging from 9.5 to 25.7% in wheat, 9.7 to 25.8% in barley and 6.6 to 14.7% in canola.

The Tri-Met 393 was evaluated with samples ranging in moisture content from 9 to 25% in wheat, 11 to 25% in barley and 6.5 to 15% in canola.

Meter Performance (Accuracy, Uncertainty and Repeatability): To assess meter performance, three factors; accuracy, uncertainty and repeatability, should be considered. Accuracy indicates how close the average meter reading is to true moisture content. Uncertainty is a measure of scatter over the range of moisture contents measured, or how close the readings follow a "best-fit" line. The shaded belts (APPENDIX II) 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 a wide scatter and measurement uncertainty, whereas a narrow belt shows good meter certainty. 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.

The accuracy of the Tri-Met 393 in wheat was very good over the complete range of moisture contents from 9 to 25% . At 14.5% moisture content, the upper limit for dry wheat, the average meter reading was 0.4% low. This compared to a 0.4% low reading for the PAMI reference moisture meter. Uncertainty and repeatability were both excellent over the entire moisture content range.

The accuracy of the Tri-Met 393 in barley was excellent over the entire range of moisture contents measured. At 14.8% moisture content, the upper limit for dry barley, the average meter reading was accurate (i.e. reading was 14.8%). This compared to a reading of 0.5% low for the PAMI reference moisture meter. Uncertainty was excellent and repeatability was very good.

The accuracy of the Tri-Met 393 in canola (rapeseed) was excellent over the entire range of moisture contents measured. At 10.5% moisture content, the upper limit for dry canola, the average meter reading was 0.2% low while the PAMI reference moisture meter read 0.3% low. Uncertainty and repeatability were both excellent.

It is of interest to note that especially for barley and canola, the meter error for the Tri-Met 393 was similar over the entire moisture content range (i.e. the average line in FIGURE 2, APPENDIX II is almost parallel to the "zero" meter error line). Also, meter uncertainty and repeatability were either very good or excellent. This type of meter performance would allow the meter to be recalibrated to make the meter completely accurate over the entire range of moisture contents.

Errors trom 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 scales 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. 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 was durable and no problems were encountered with meter operation throughout the evaluation.

OPERATOR'S MANUAL

The operator's manual contained operating and maintenance instructions. A separate manual contained grain moisture content and temperature conversion tables for various grains and seeds. The two manuals were clear and concise and contained all the information necessary for accurate moisture content measurements.

APPENDIX I

SPECIFICATIONS

MODEL:	Tri-Met 393
SERIAL NUMBER:	410
MANUFACTURER:	Tri-Met Instruments Limited 1788 St. Matthews Avenue Winnipeg, Manitoba R3H 0A5
ELECTRICAL POWER REQUIREMENT:	9 V transistor battery or 110 V AC-DC adapter
OVERALL HEIGHT:	9.6 in (244 mm)
OVERALL DIAMETER:	6.6 in (167 mm)
TOTAL WEIGHT:	3.67 lb (1665 g) (with dump)
PRINCIPLE OF OPERATION:	Capacitance
SAMPLE SIZE:	Wheat - 225 or 250 g (0.50 or 0.55 lb) Barley - 200 or 225 g (0.44 or 0.50 lb) Canola (Rapeseed) - 250 g (0.55 lb)

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 5 below. 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 meter 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	FIGURE NO.	REGRESSION	CORRELATION COEFFICIENT	STD. ERROR OF ESTIMATE	SAMPLE SIZE	SAMPLE MEAN
TRI-MET 393						
Wheat, 9 to 25% m.c.	2	M = 0.97T + 0.07	1.00	0.24	13	14.55
Barley, 11 to 25% m.c.	3	M = 1.02T - 0.29	1.00	0.26	12	15.97
Canola, 6.5 to 15% m.c.	4	M = 0.98T - 0.02	1.00	0.15	7	10.38
PAMI REFERENCE METER						
Wheat, 9 to 25% m.c.	5	M = 0.96T + 0.21	1.00	0.11	10	15.03
Barley, 11 to 25% m.c.	5	M = 1.00T - 0.57	1.00	0.26	14	15.78
Canola, 6 to 15% m.c.	5	M = 0.93T + 0.34	1.00	0.16	10	10.87

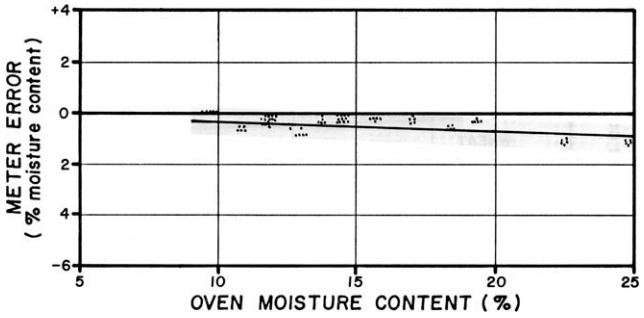

FIGURE 2. Accuracy of the Tri-Met 393 Meter in Wheat.

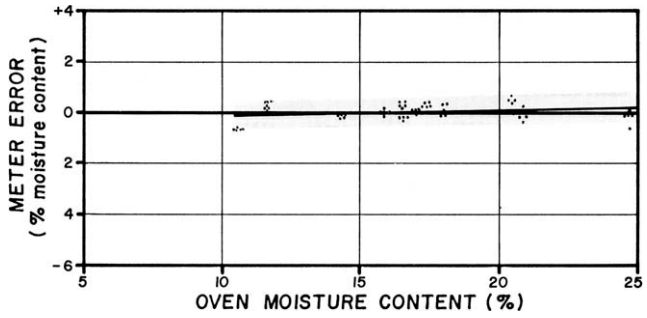

FIGURE 3. Accuracy of the Tri-Met 393 Meter in Barley.

APPENDIX III
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent
Very Good
Good
Fair
Poor
Unsatisfactory

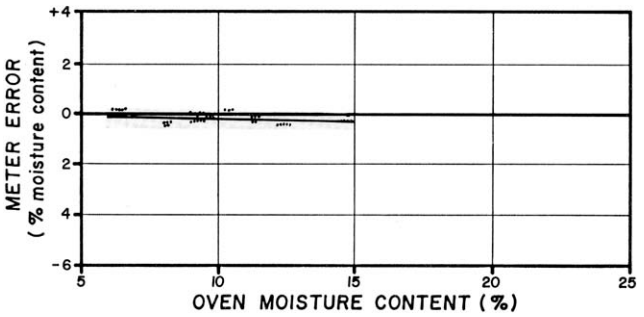

FIGURE 4. Accuracy of the Tri-Met 393 Meter in Canola (Rapeseed).

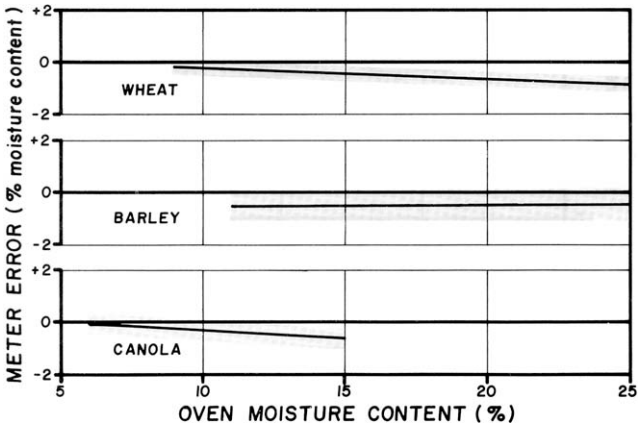

FIGURE 5. Accuracy of the PAMI Reference Moisture Meter in Wheat, Barley and Canola.

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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