

# Evaluation Report 214



## Froment NJF 1210 Forage Moisture Tester

A Co-operative Program Between



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PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

# FROMENT NJF 1210 FORAGE MOISTURE TESTER

## MANUFACTURER:

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Stamford PE9 3NP  
England

## DISTRIBUTOR:

N. J. Froment & Co., Ltd.  
P.O. Box 758  
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## RETAIL PRICE:

\$359.00 (June 1981, f.o.b. Winnipeg, Manitoba).

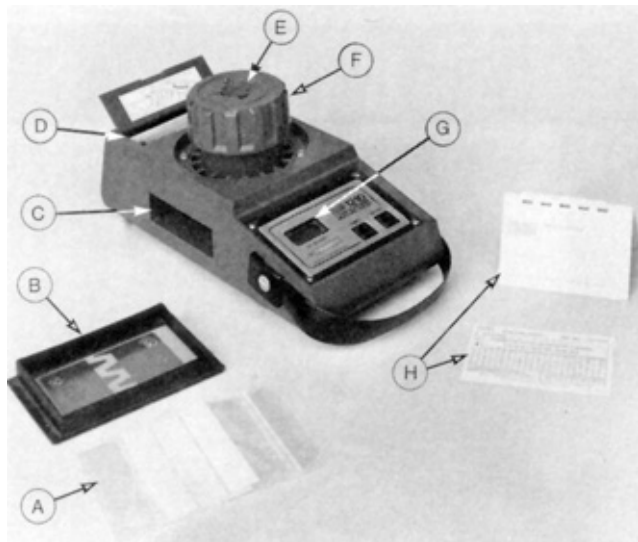


Figure 1. (A) Forage Sample Bags, (B) Grain Sample Tray, (C) Sample Chamber, (D) Storage Compartment, (E) Pressure Indicator, (F) Pressure Control Knob, (G) Digital Display, (H) Moisture Conversion Tables.

## SUMMARY AND CONCLUSIONS

Functional performance of the Froment forage moisture tester was *very good*, however the accuracy of supplied moisture conversion tables was *unsatisfactory* for alfalfa and corn. The accuracy of a second corn moisture conversion table was *fair*.

Recalibrating was necessary for prairie forage crops, to correctly read moisture content. In chopped alfalfa, the moisture conversion tables indicated moisture contents which varied from 3% high (at 30% moisture content) to 8% low (at 70% moisture content), with accurate readings at 40% moisture content. In chopped corn, one moisture conversion table indicated moisture contents varying from 15% high (at 34% moisture content) to 6% high (at 76% moisture content). A second corn moisture conversion table indicated moisture contents varying from 6% low (at 34% moisture content) to 1% low (at 72% moisture content).

It was best to average measurements from several samples in each forage batch to reduce errors from moisture variation within the forage. The errors were reduced from an average of  $\pm 10\%$  in chopped alfalfa and  $\pm 12.8\%$  in chopped corn for single sample measurements to an average of  $\pm 1.4\%$  and  $\pm 2.4\%$  respectively by averaging several measurements. Meter repeatability was *very good* in both alfalfa and corn.

Operating ease was *excellent*. The Froment 1210 was convenient to use in the field. Best results were obtained with uniformly chopped forage samples, Polyethylene bags were used to isolate the forage sample, preventing gumming of the sample chamber. Correct bag loading was critical. A single moisture determination took about four minutes,

Corrections for sample temperature and clamping pressure, provided by the manufacturer, were found to have little

significance due to the large variations found among individual forage samples. As a result, considerably simplified measurement procedures are possible.

The battery lasted the duration of the test.

## RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Improving the quality of sample bags to reduce rupturing.
2. Providing moisture conversion tables suitable for typical prairie forage crops.
3. Including sample preparation instructions in the operator's manual, for determining the moisture content of unchopped hay.

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## THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Some earlier production sample bags did not meet our specified strength. Recent reports indicate that this problem has been overcome.
2. Log readings for similar material but from different locations, sometimes vary. In most cases the tables provide acceptable results; if not, a correction factor can be applied once the error is known. We recommend seasonal Checks and the application of correction factors if needed.
3. We recommend the use of a core sampler for obtaining representative samples from hay bales. Large variations in moisture content will be evident between hay taken from the top and bottom of a window.

## MANUFACTURER'S ADDITIONAL COMMENTS

It does not matter how accurate a moisture tester is if representative sampling of the batch is not carefully conducted. Good sampling and the averaging of several tests are fundamental to the accuracy of the test,

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

## GENERAL DESCRIPTION

The Froment NJF 1210 is a portable, electronic forage moisture tester. It determines moisture content by measuring electrical impedance.

Special polyethylene sample bags are filled with chopped forage and compressed in the sample chamber. Moisture content is determined from moisture conversion tables which relate the meter reading to the number of turns of the pressure control knob. The NJF 1210 may also be used for grain moisture determination<sup>1</sup> by using a grain sample tray in place of the forage sample bag.

The Froment is supplied with conversion tables for typical chopped forage and grains. Instructions are included for preparing moisture conversion tables for other crops.

The tester operates on a 9V transistor battery and is equipped with a carrying strap and component storage compartment for field use.

Detailed specifications are given in APPENDIX I.

## SCOPE OF TEST

The NJF 1210 was used to determine moisture contents of a variety of chopped alfalfa and corn forages. Meter readings were compared to moisture contents obtained using a standard oven method<sup>2</sup>. Samples were collected in a large number of fields at various stages of crop maturity. The moisture contents of four

<sup>1</sup>For an evaluation of the Froment 1210 in grains, see PAMI Evaluation Report E2379E.

<sup>2</sup>PAMI T7830 Detailed Test Procedures for Forage Moisture Testing Devices.

representative samples were measured from each batch. In total, more than 250 forage samples were tested with the Froment 1210.

The Froment was evaluated for ease of operation, quality of work and suitability of the operator manual.

## RESULTS AND DISCUSSION

### EASE OF OPERATION

**Portability:** The Froment was easy to Use. It was light and portable, with a self-contained power source, making it convenient for field use. The tester did not have to be levelled since sample weighing was not needed.

**Sample Selection:** One of the main problems in forage moisture measurement is obtaining a representative sample. The operator manual clearly detailed instructions for preparing a suitable sample from a large sample or batch of chopped forage. It also recommended that from three to five samples be taken from different parts of a batch to arrive at an average moisture content.

Best results were obtained using a uniformly chopped forage sample of about 10 mm (0.75 in) cut length. Most samples from a forage harvester were suitable for direct measurement. Standing or windrowed crop samples had to be chopped before being placed in the sample bags. A pair of shears could be used to prepare a suitable sample from unchopped hay. The operator manual did not include instructions on sample preparation of unchopped hay. It is recommended that suitable instructions outlining correct sample preparation procedures, be included.

**Operating Procedure:** The zip-lock polyethylene sample bag is hand filled, with a representative forage sample to a thickness of about 20 mm (1 in) and placed in the sample chamber. The proper amount of forage has to be loaded into the bag so that from 4 to 5-1/2 turns of the pressure control knob are needed to bring the pressure indicator, incorporated in the knob, into view. After the compressed sample has stabilized for about 25 seconds, the sample key is pressed and a reading taken. The bag is then removed from the sample chamber and the sample temperature measured with a thermometer. The moisture content, corresponding to the tester reading, the number of control knob turns and the sample temperature is then read from the appropriate moisture conversion table. A single moisture measurement can be completed in about four minutes.

**Sample Bags:** Filling the sample bags properly became easier with familiarization. Trial and error were needed initially to determine an appropriate sample size and filling procedure.

Quality of the sample bags varied. Many split at the seams during compression. It is recommended that the manufacturer improve sample bag quality to reduce this problem.

**Controls:** The Froment 1210 had two push button keys for activating the display. One button was for checking battery voltage while the second was for moisture content readings. The digital display was easy to read.

**Battery:** The battery needed replacement, at the end of the test, after measuring about 250 samples. Battery replacement was easy, requiring only a screwdriver.

**Cleaning:** The Froment 1210 stayed clean due to the isolation of the forage samples in the plastic bags. As a result, the sample chamber was not subject to gumming.

### QUALITY OF WORK

**General:** Chopped forage is a non-uniform material. As detailed in the operator manual, it was important to obtain a representative sample of forage for moisture determination. Since large variations in moisture content occur in the field, samples should be taken from several locations within a batch of forage to get a good indication of the average moisture content.

The dielectric properties of similar forages may also vary, due to many uncontrollable factors such as crop variety, geographical location, maturity and weathering. The manufacturer's tables are an attempt to accurately represent average properties for one crop type. It is difficult to predict dielectric properties, for example, of all varieties of chopped corn forage and to accurately present them in a single table. The manufacturer allowed for this by outlining a calibration procedure for specific crops in the operator manual.

**Range of measurement:** The tables supplied with the Froment 1210 indicated that it was capable of measuring moisture contents varying from 29 to 77% in chopped grass and alfalfa and

from 39 to 78% in chopped corn. The Froment 1210 was evaluated with chopped alfalfa samples ranging from 20 to 76% moisture content and with chopped corn ranging from 34 to 72% moisture content. When chopping forage to store as silage, the moisture content typically ranges from about 35 to 75%, well within the measurement range of the Froment 1210.

**Accuracy:** FIGURE 2 presents results for the Froment in chopped alfalfa when using the manufacturer's moisture conversion table for green chopped alfalfa/lucerne. Each moisture content is determined from an average of four readings on the same batch, as recommended by the manufacturer. The best fit line gives average results for 128 samples of chopped alfalfa collected in a variety of fields around Portage la Prairie.

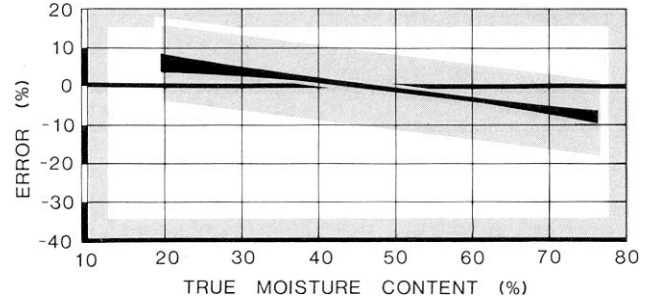


FIGURE 2. Accuracy in Chopped Alfalfa (Froment Chart No. 1210249).

Average moisture contents indicated by the Froment 1210, varied from 3% high (at 30% moisture content) to 8% low (at 70% moisture content) with accurate results at about 40% moisture content.

FIGURES 3 and 4 similarly show the accuracy of the Froment 1210 in chopped corn when using the manufacturer's moisture tables for green chopped corn/maize. FIGURE 3 gives results using the table originally supplied with the tester, while FIGURE 4 gives results for an updated chart. Average moisture contents indicated by the Froment varied from 15% high (at 34% moisture content) to 6% high (at 76% moisture content) when using the original moisture table.

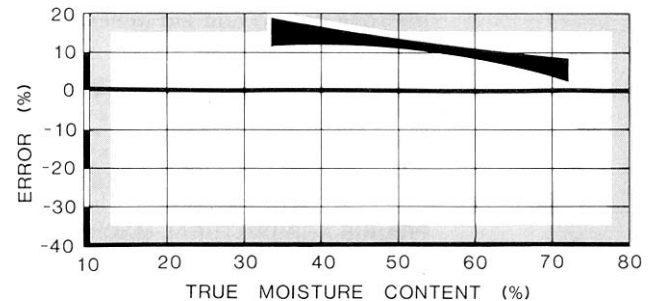


FIGURE 3. Accuracy in Chopped Corn with Original Corn Chart, (Froment Chart No. 1210349).

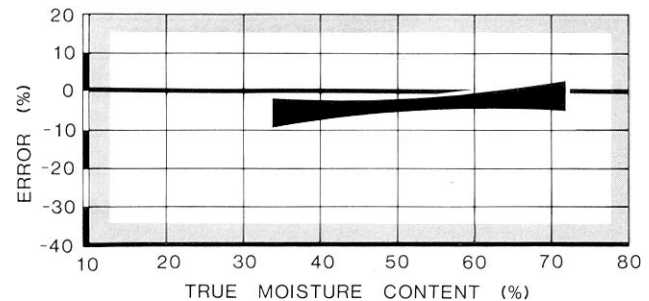


FIGURE 4. Accuracy in Chopped Corn with Updated Corn Chart, (Froment Chart No. 1210448).

With the updated table, results varied from 6% low (at 34%) to 1% low (at 72%). An accuracy of 5% is an acceptable level of accuracy for most forage operations.

**Uncertainty:** Uncertainty is indicated by the 95% confidence.

limits displayed by the width of the line in FIGURES 2 to 4. This uncertainty results from both sample variation and meter repeatability.

The wide, shaded area (scatter) indicated in FIGURE 2 shows the effect sample variation will have on the meter reading when only single measurements from a forage batch are taken. The manufacturer recommends that from three to five readings be taken per batch to reduce uncertainty from sample variation. Averaging four readings in alfalfa reduces this uncertainty from a scatter of  $\pm 9.7\%$  for single meter readings down to a scatter varying from  $\pm 0.8\%$  to  $\pm 2.0\%$ . Similarly, in corn, the uncertainty was reduced from a scatter varying from  $\pm 11\%$  to  $\pm 14.5\%$  for single meter readings down to a scatter varying from  $\pm 1.1\%$  to  $\pm 3.7\%$  when averaging four readings. This difference in the scatter shows the importance of averaging a number of readings when determining moisture content.

**Repeatability:** Meter repeatability (APPENDIX II) is a measure of how consistently a meter gives the same reading if the same sample is measured several times. It indicates how subject the measurement method is to both operator error and instrument error. The repeatability of the Froment 1210 was very good in both alfalfa and corn.

**Temperature Compensation:** Temperature corrections had to be applied to meter readings when determining moisture content. Sample temperature was read with the supplied thermometer and entered into a temperature correction table below the moisture table for each crop. Data analysis indicated that over a sample temperature range from 10 to 30°C, temperature correction improved meter accuracy only very little. The variation of meter readings due to the scatter in samples was much more significant than the variation due to sample temperature.

**Pressure Control Knob:** Meter readings had to be related to the number of turns of the pressure control knob needed to fully compress the forage sample. These corrections were incorporated into the crop moisture chart. Analysis indicated that corrections for the number of control knob turns, over a range from 4 to 5-1/2 turns was of little significance to the meter accuracy, as long as the sample was properly compressed.

**Calibration Curves:** FIGURES 5 and 6 (APPENDIX II), present PAMI calibration curves for the Froment 1210 in alfalfa and corn, respectively. These curves are based on a wide variety of alfalfa and corn crops in the Portage la Prairie area and are for a sample temperature of 20°C and a control knob position of 5 turns to achieve proper sample compression. Only negligible errors resulted when the curves were used for sample temperatures from 10 to 30°C and for control knob positions from 4 to 5-1/2 turns. The confidence belts on these curves indicate expected scatter due to sample variation when the meter reading is based on an average of four measurements on each batch.

Since significant errors resulted from using the manufacturer's moisture tables for prairie forage crops, it is recommended that the manufacturer supply charts or calibration curves more suitable for these crops.

## OPERATOR MANUAL

The operator manual was easy to read and understand. It contained comprehensive operating instructions, discussed sample selection procedures and contained moisture conversion tables for three types of forages. As discussed previously, the supplied tables were not suitable for typical prairie forage crops. As well, no procedure for preparing unchopped samples was provided.

The operator manual contained blank tables and instructions for providing new tables to suit specific crops. These instructions were clear, however the procedure required accurate weighing equipment and a drying oven.

## APPENDIX I

### SPECIFICATIONS

<i>Make:</i>	Froment
<i>Model No.:</i>	1210
<i>Serial No.:</i>	820937
<i>Electrical Power Requirements:</i>	1 - 9V Battery (NEMA Type 1604)
<i>Overall Dimensions:</i>	
-- length	280 mm
-- width	130 mm
-- height	135 mm
<i>Weight:</i>	1.1 kg
<i>Forage Sample Size:</i>	40 g ( @ approx. 60% moisture content)
<i>Principle of Operation:</i>	electrical impedance

## APPENDIX II

- (a) **Froment Calibration Curves derived from PAMI Test Data:** To use the calibration curves, enter the reading obtained from the digital display on the meter into the vertical axis and read true moisture content from the horizontal axis. For example, in corn, a meter reading of '60' corresponds to a true moisture content of 67%.

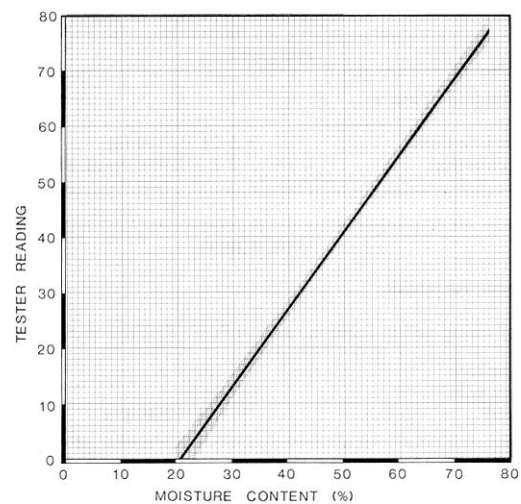


FIGURE 5. PAMI Calibration Curve for Alfalfa.

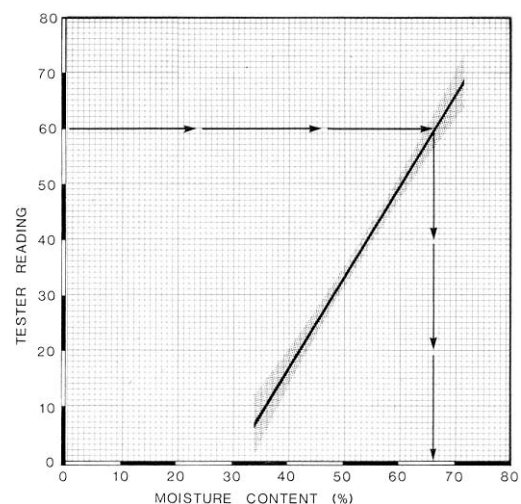


FIGURE 6. PAMI Calibration Curve for Corn.

- (b) **Regression Equations:** TABLE 1 presents regression equations for the Froment 1210 in corn and alfalfa. In the table,  
 R = the meter digital display reading;  
 T = the sample temperature, °C, with 10 [ T [ 30;  
 N = the number of turns of the pressure control knob, with  
 4 [ N [ 5.5;  
 M = the sample moisture content, percent wet basis, over the  
 ranges specified on FIGURES 5 and 6.

**TABLE 1. Regression Equations**

CROP	FIGURE NO.	REGRESSION EQUATION	CORRELATION COEFFICIENT
Alfalfa	5	R = 1.40 M - 28.82	0.95
		R = 1.36 M + 0.44 T - 34.97	0.95
		R = 1.36 M + 0.45 T - 1.59 N - 27.27	0.95
Corn	6	R = 1.67 M - 49.90	0.75
		R = 1.78 M + 0.94 T - 72.15	0.79
		R = 1.81 M + 0.89 T - 2.56 N - 61.40	0.79

- (c) **Meter Repeatability:** To eliminate the effect of sample variation, Moisture meter repeatability was determined by relating the coefficient of variation (CV) of the meter test to that of the oven dry method. These coefficients of variation were determined by expressing the standard deviation as a percent of the mean for each of the four samples taken from each forage batch. The values, 2.9% in alfalfa and corn, for the meter; and 2.0% in alfalfa and 2.3% in corn, for the oven method, are the average coefficients of variation for all samples. The equation used to determine the meter repeatability was:

$$\text{Repeatability} = \frac{[(CV \text{ meter})^2 - (CV \text{ oven})^2]}{2}$$

Repeatability for the Froment 1210 was 2.1% in alfalfa and 1.8% in corn.

#### APPENDIX III

##### CONVERSION TABLE:

1 millimetre (mm)	= 0.04 inches (in)
1 kilogram (kg)	= 2.2 pounds mass (lb)

#### APPENDIX IV

##### 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



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