Liebherr Moisture Measurements in Collagen Casings

A: General Information

In-line (In-situ), accurate and repeatable constituent measurements can provide many benefits to a manufacturing process. **"Real-time"** data can result in better product consistency, savings on raw materials/labor, improved sustainability and customer satisfaction. This report summarizes our in-house testing on 25 samples ranging from 5% to 30% moisture on two types of meat casings.

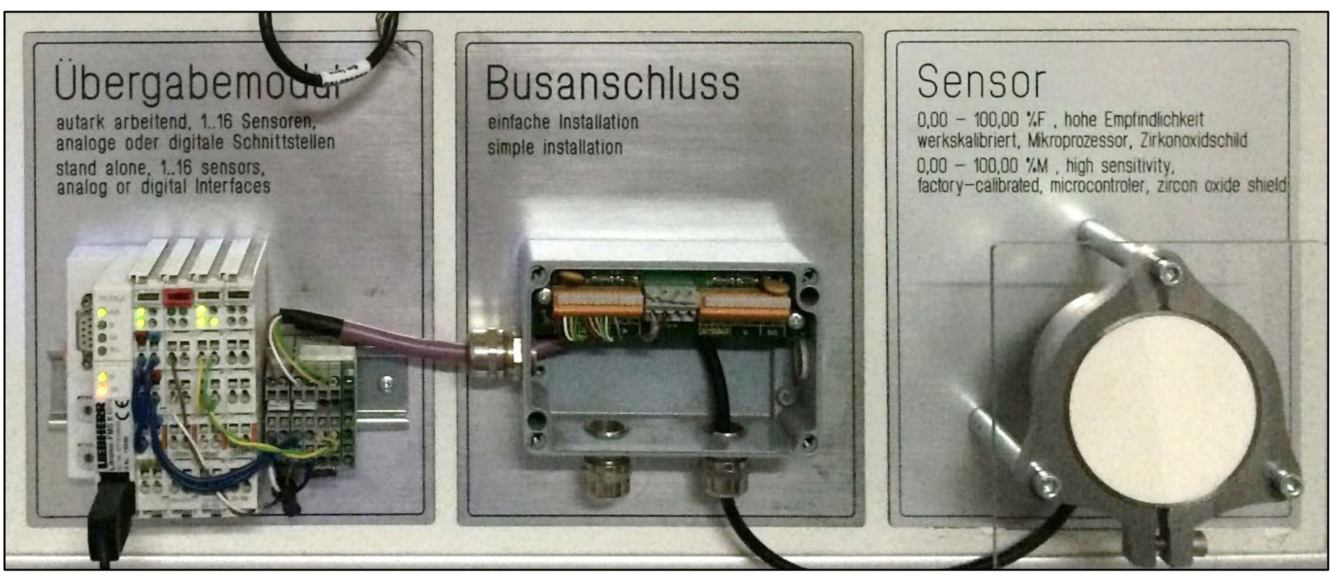
System used: An FMS-II Liebherr Litronic controller and **P30** food grade "PEEK" (30mm / 1.2" diameter) in-line sensor head configured for bench-top use.

Description: The Liebherr FMS-II Litronic is a robust and industrial analyzer used to measure moisture and other constituents in food, beverage, petro-chem, aggregates and other products. Sensor locations include conveyor belts, chutes, silos, webs, lab chambers and pipelines with up to 16 optional heads per single controller. Click here for a detailed down-loadable technical paper.

There are no moving parts and product interface options are: **1)**, food grade PEEK ® or **2)**, industrial grade Zirconium Alumina Oxide (ZrO_2 - Al_2O_3). Explosion and Dust Proof versions are available and with over 10,000 sensor heads installed over the past 35 years, reliability is ensured.

A Liebherr system consists of **a)**, a "Controller" that is connected to a customer PLC/SCADA system via RS232, Ethernet, Profibus, 4-20mA or 0-10V DC options to **b)**; an optional RS-485 extender bus (1,200-meters max.) to **c)**, a **"Smart"** sensor head that sends data back to the Liebherr Controller.

a. **b.** **c. (P78 sensor)**



B. Objectives and Preliminary Summary

Objectives:

1. To determine the feasibility of this application.
2. To determine instrument parameters for the measurement with regards to this product.
3. To obtain a preliminary indication of the precision of the instrument measuring the representative test product from the client.

Preliminary Summary:

Based on the results of the Validation results in section G, moisture measurements utilizing the Liebherr in-line P30 analyzer on this type of product would be an excellent application for this technology.

NOTE: Because the sensor scans 35 times per second, sample errors present in this test such as sample warpage, coverability etc. can be substantially mitigated with consistent product flow and signal smoothing using the Liebherr controller or an end users' PLC/SCADA control system.

C. Test environment and Sample Procedure

The FMS-II P30 was tested in ambient temperature, pressure and humidity conditions. The procedure below took approximately 5 minutes for each of the 25 samples. 10 each of ~ 1.25" width white and 0.750" width red casing samples were used for the calibration. Five "Blind" samples (three whites and two reds) were used for prediction.

1. The samples were attached to a pin vice and stretched across the sensor head as shown below.
2. The Liebherr ***"Digits"*** were recorded as seen in this video while slowly pulling the sample across the sensor for approximately 12 inches of product. The average digit over this time was used to predict % water using regression analysis at a later step. Steps one and two were repeated on all samples.

NOTE: Due to the nature of this static test there were two major sources of error.

1. The samples were "wrinkled" that prevented an even presentation above the surface of the sensor.
2. The red samples did not completely cover the head. This is not a problem in a factory installation as the casing will always be in the exact same position. It is also because of the different widths our white and red "Global" calibration had poor results and should be ignored.

D: Sensor Setup Photos (note wrinkles)

P30 Configuration

"White" Casing

"Red" Casing

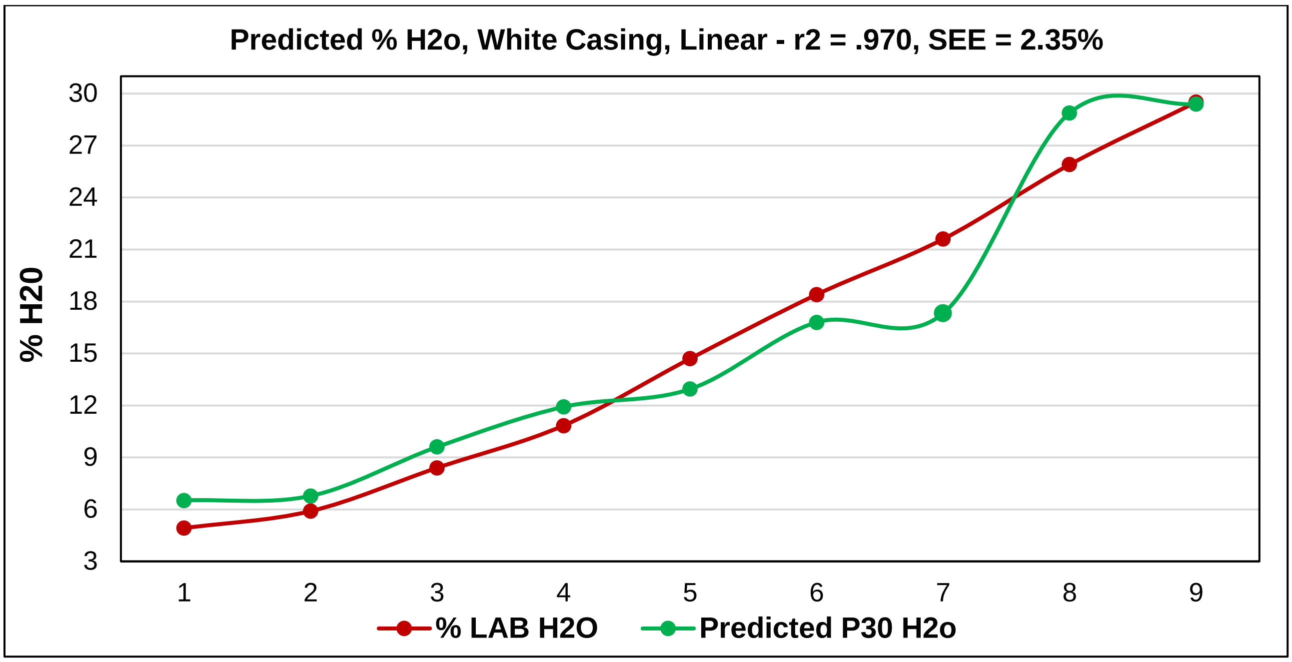
E: Calibration, Validation and Graph Explanations

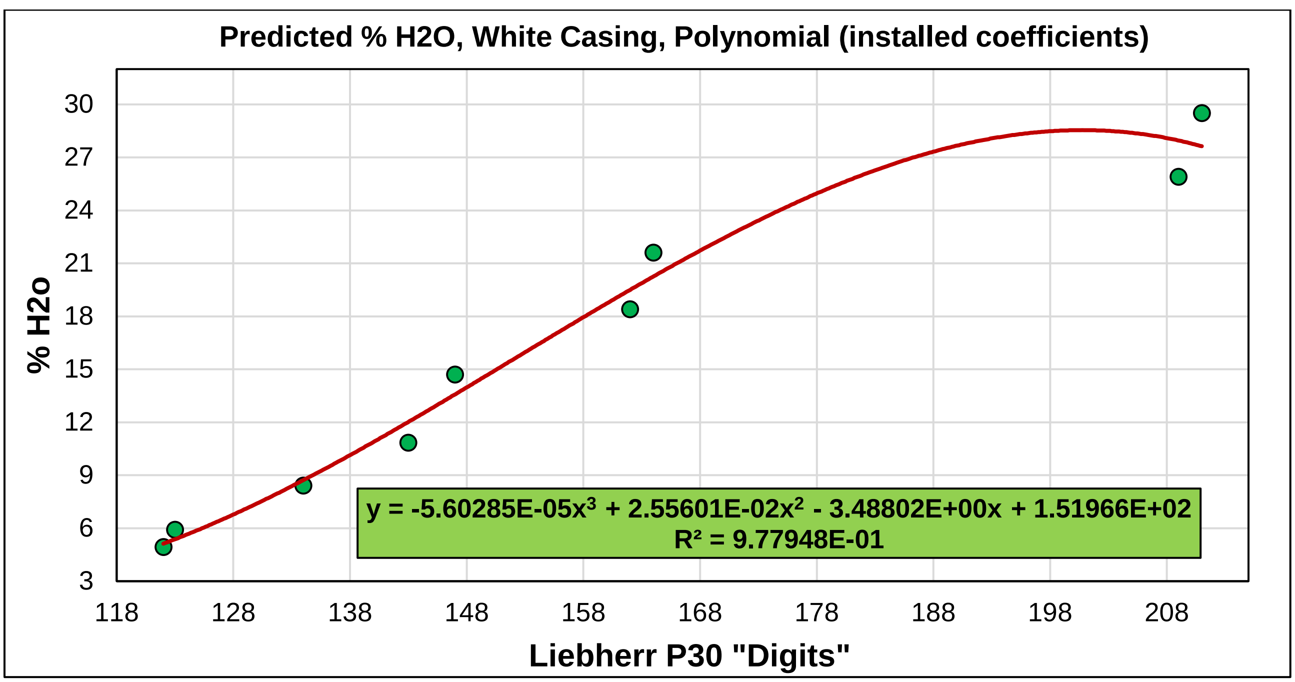
1. **CALIBRATION results:** The 20 calibration ***Digit*** readings were used to generate coefficients for moisture using a 3rd-order polynomial for a non-linear prediction and Y = (m*x) + b for linear predictions. Both results are shown in sections **F1 (white) and F2 (red)** casings.

2. **VALIDATION results:** Four independent calibration curves using 3rd-order Polynomial and linear equation coefficients were uploaded to the sensor. Live instrument moisture values were recorded using the same test method in section C. The corrected measured moisture results are shown in sections **G1 (Polynomial) and G2 (Linear)**. Note: Using standardized residuals, two to three samples were dropped.

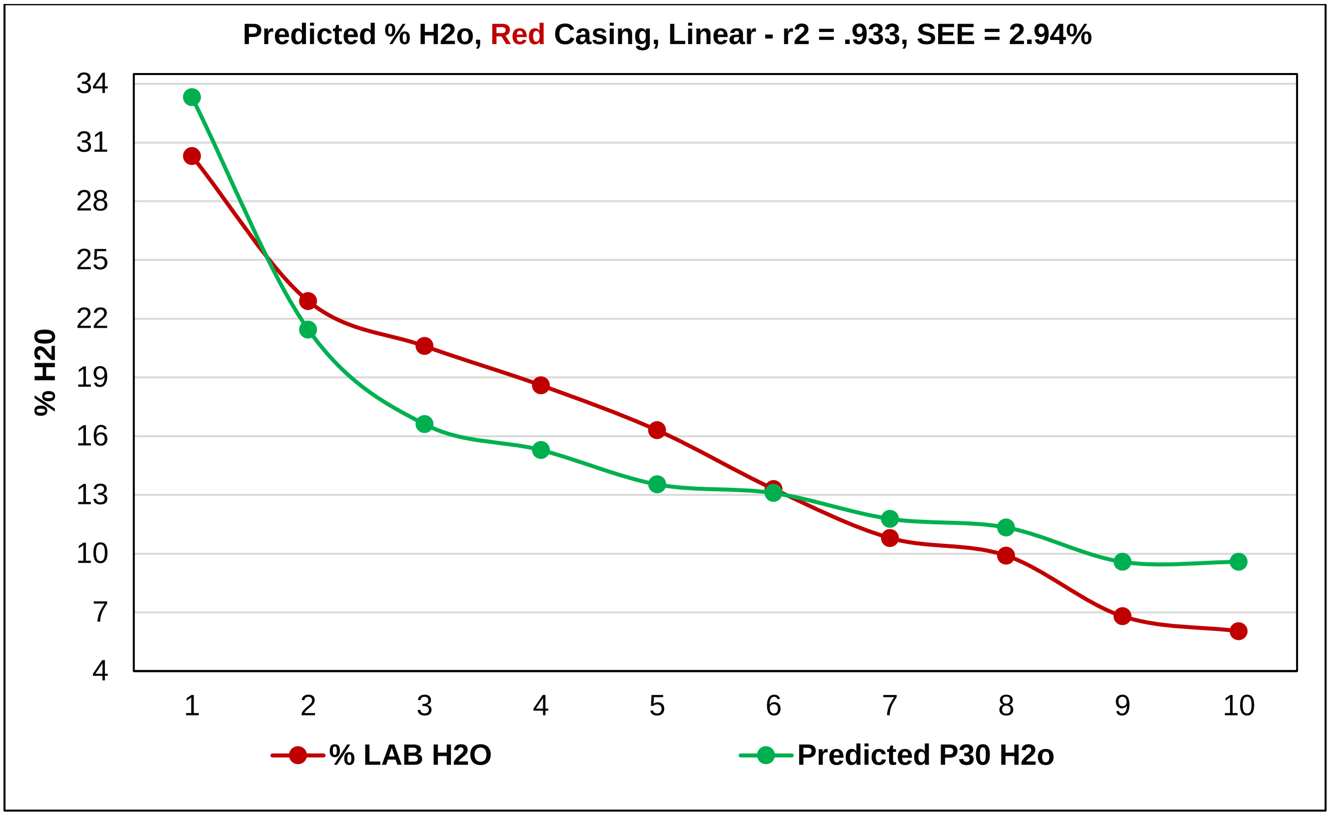
3. **BLIND Predicted and Measured results:** Using the same coefficients as step 2 above the Blind samples were measured and recorded with results in section **H**.

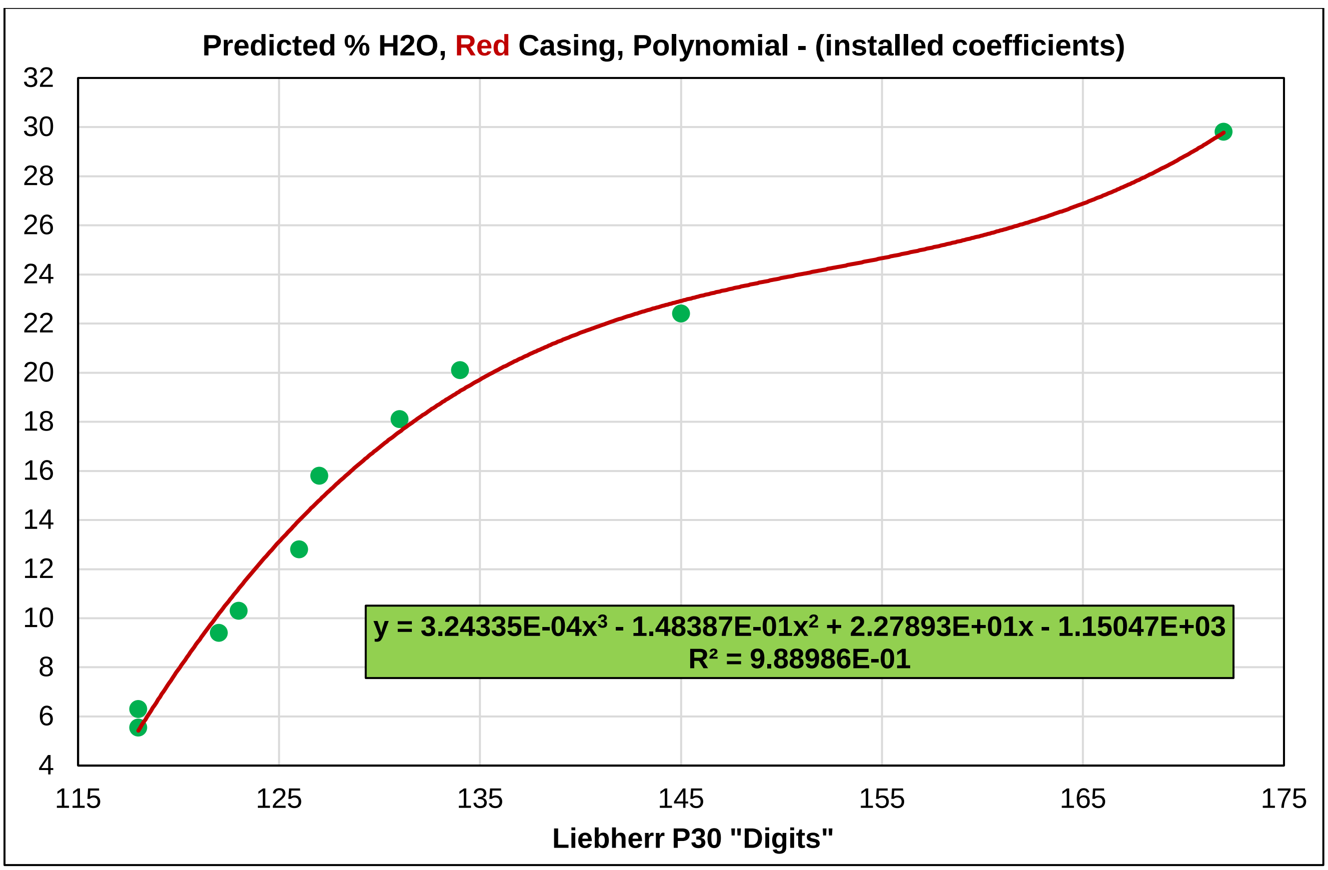
F1. % H2o in White casing only - "Predicted" Results



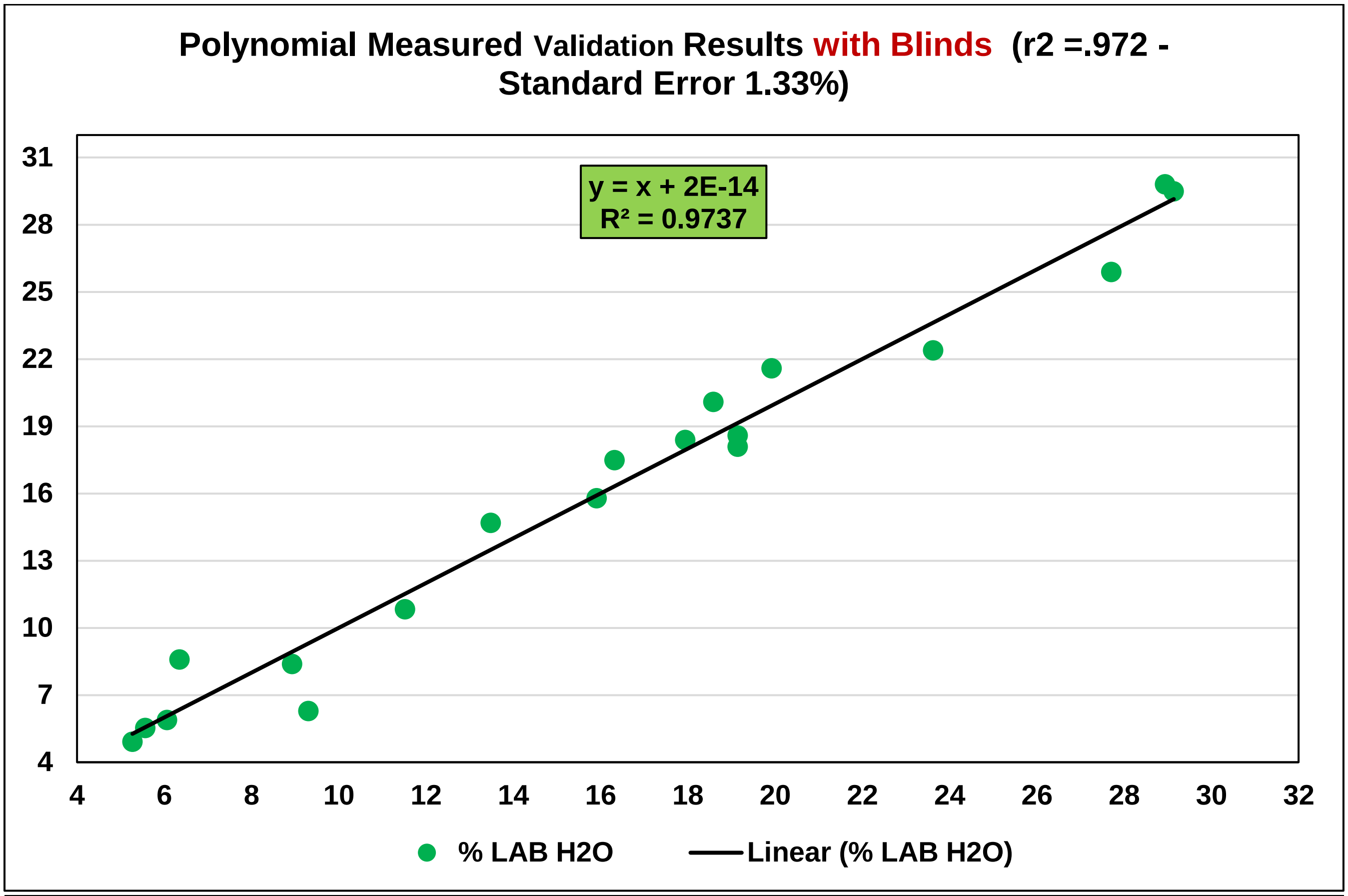


F2. % H2o in Red casing only - "Predicted" Results

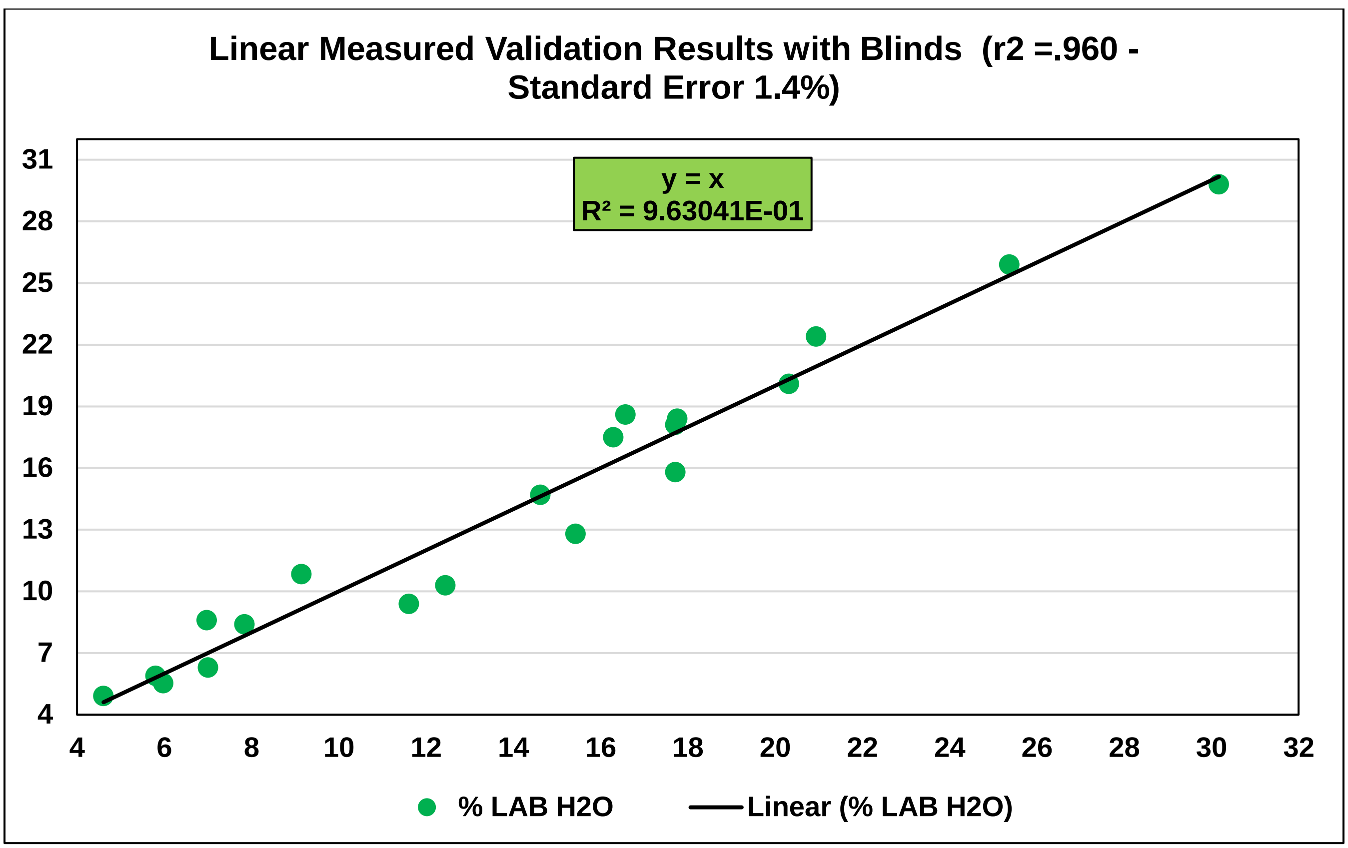




G1. % H2o Polynomial Measured Validation (white and red with "Blinds")

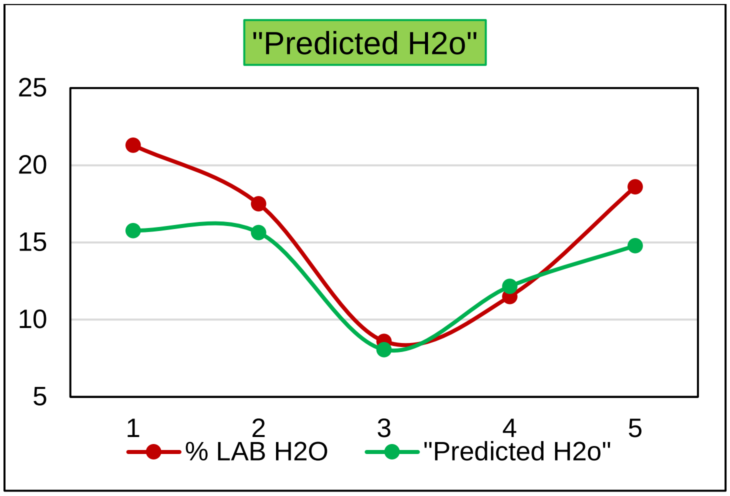


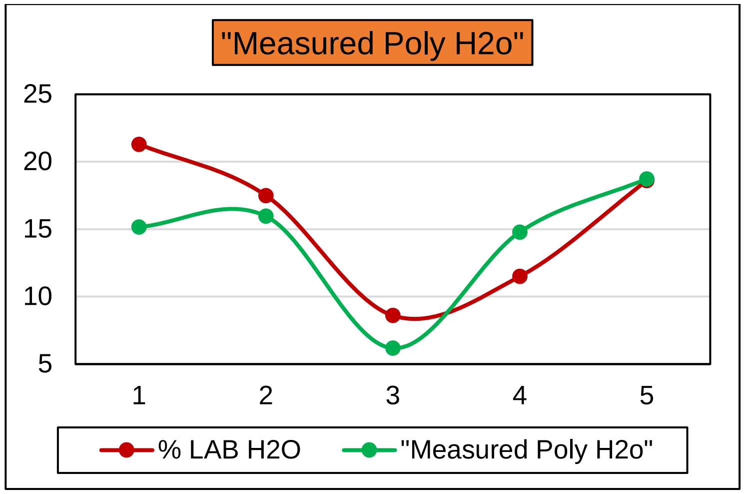
G2. % H2o Linear Measured Validation (white and red with "Blinds")

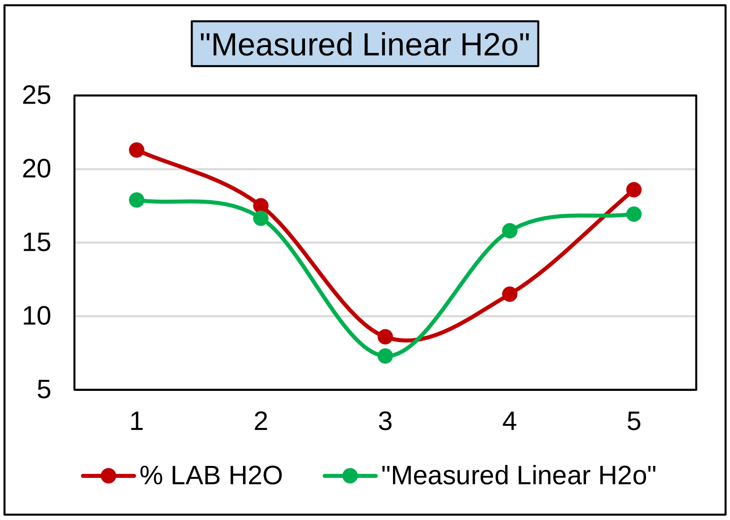


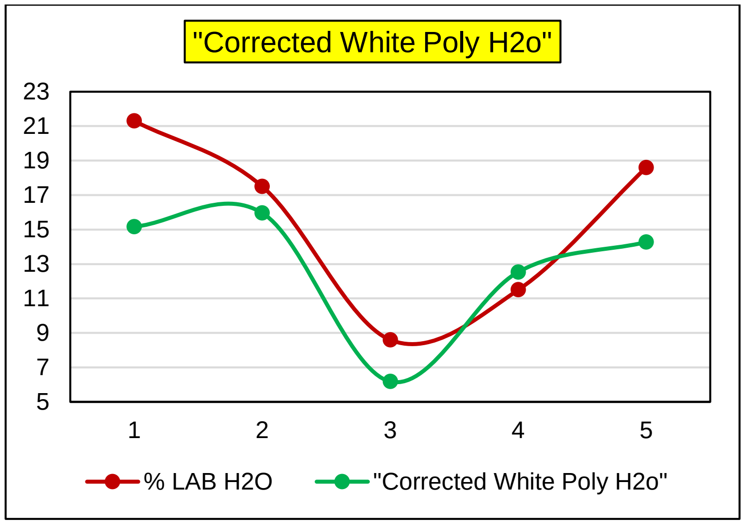
H. % Predicted and Measured “Blind” Results

Sample Name	% LAB H2O	"Predicted H2o"	% LAB H2O	"Measured Poly H2o"	% LAB H2O	"Measured Linear H2o"	% LAB H2O	"Corrected White Poly H2o"
Blind B1 (suspect)	21.30	15.77	21.30	15.16	21.30	17.90	21.30	15.16
Blind B2	17.50	15.64	17.50	15.96	17.50	16.67	17.50	15.96
Blind B3	8.60	8.06	8.60	6.18	8.60	7.30	8.60	6.18
Blind A1 (suspect)	11.50	12.15	11.50	14.79	11.50	15.80	11.50	12.54
Blind A2	18.60	14.79	18.60	18.73	18.60	16.95	18.60	14.27









Blind Correlation Results	% LAB H2O
% LAB H2O	1
"Predicted H2o"	**0.937029563**
% LAB H2O	1
"Measured Poly H2o"	**0.765351593**
% LAB H2O	1
"Measured Linear H2o"	**0.835504321**
% LAB H2O	1
"Corrected White Poly H2o"	**0.862649871**

Note: All blind results shown. Samples A1 and B1 that were proven to be “outliers” during the Validation were not deleted above

I. Discussion, Definitions and Conclusion of this Report

The preceding information constitutes a preliminary report for review. The statistical values presented are based on data generated in our laboratory versus a limited quantity of material samples. Accuracy may differ somewhat from these results, depending on variations in material and actual process line conditions. In addition, poor sampling and lab analysis techniques will add to in-line instrument errors.

Inconsistent voids or gaps in front of the sensor will cause variations in the instrument readings. Using various analyzer settings, these false readings can be ignored under most circumstances. ***Consistent presentation of the product will improve the measurement for any in-line system and often have less error than the lab analyzer.*** This is purely based on the large number of readings on all the material under test, not just small portions that are collected for off-line analysis.

For these reasons, any in-line instrument evaluation must be done with the sensor installed in the optimal location plus, “best lab” practices used to mitigate these errors.

R-Square (r2) **definition:**

The correlation coefficient, r2 is a mathematical expression of the randomness of the data points around a linear regression line. It is a function of both the accuracy of the measurement and the range of moisture values in the calibration sample standards. A value of 1.0 is perfect nor possible, however for many applications a value of >.80 is considered acceptable in most industries.

Standard Error definition:

The standard error is the variability between samples that you would obtain if you took multiple samples in the same data set. It is also a function of the scatter of data points around the linear regression line and is an indication of how closely this line predicts the measured test values with a value of 0 being perfect. In theory, 68% of calibrated instrument readings will be within +/- one standard error of the real moisture value while approximately 95% of calibrated values fall between +/- two standard error values.

Please contact us with comments and for more information on the Liebherr analyzer.

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