Moisture in blanch oil-cooked French Fries ©

A: General Information

In-line (In-situ) constituent measurements can provide many benefits to a manufacturing process. Accurate and repeatable "Real-Time" data can result in product consistency, savings on raw materials/labor, improved sustainability and customer satisfaction. This report summarizes our in-house testing on a generic grocery store brand of crinkle-cut, oil blanched French Fries.

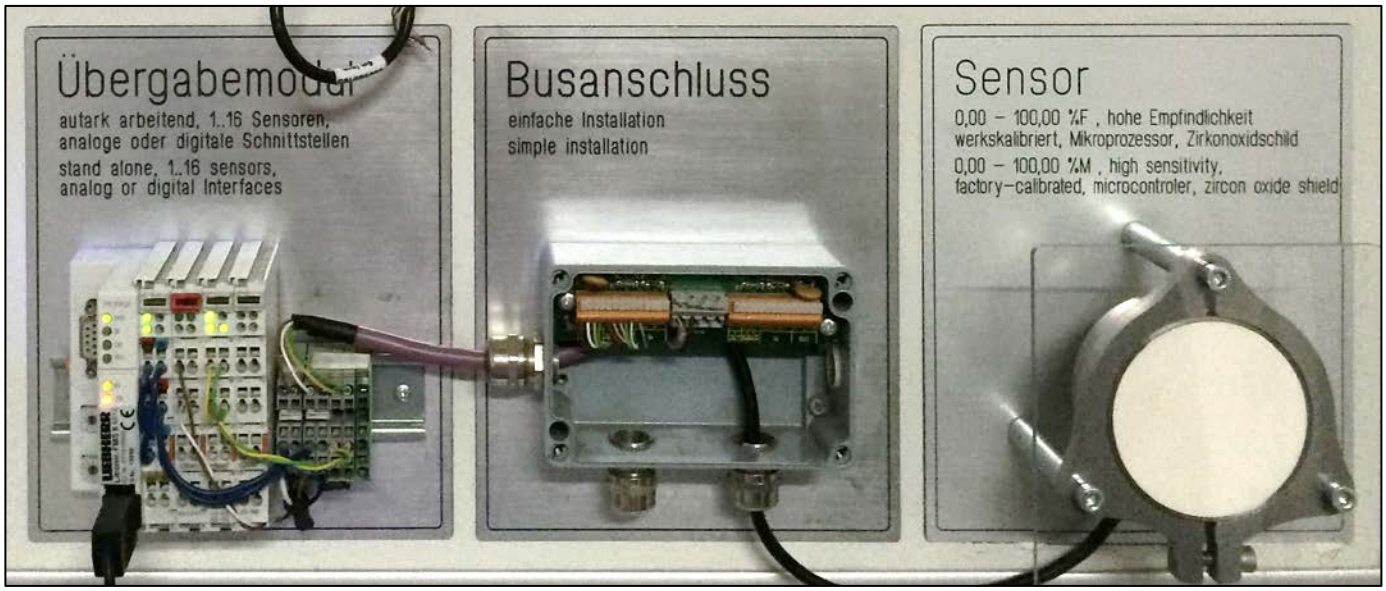
System setup and sensor head description: An in-line FMS-II controller was used with both the optional **P78** (3.0" diameter) and the smaller **P30** (1.1") sensor heads in static test configurations.

The Instrument: The Liebherr FMS-II Litronic is an industrial and robust in-line analyzer used to measure moisture and other constituents in food, beverage, petro-chem, aggregates and other flowing or static products. Sensor locations include conveyor belts, chutes, silos, webs, lab chambers and pipelines with up to 16 optional heads per single controller at distances of up to 3,900 feet away.

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 also available and with over 10,000 sensor heads installed over the last 35+ years, reliability is ensured.

A complete Liebherr analyzing system consists of **a)**, an "intelligent" sensor head connected via RS485 serial communication to **b)**, an optional sensor buss to **c)**, a separate controller that is connected to a customer interface system such as a PLC/SCADA system via RS232, Ethernet, Profibus, 4-20mA, 0-10V DC or Bluetooth options.

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



B. Objectives, Test Highlights & 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 sensitivity and precision of the instrument measuring the representative test product.

Test highlights:

1. The instrument shows good sensitivity to varying moisture content in blanch cooked French fries.
2. There is high correlation between the predicted results and the prepared lab samples. The results are a multiple linear **r2** coefficient of 0.92 for the P78 sensor and 0.94 with the P30.

   Because the sensor scans 40x per second, sample errors are substantially mitigated with consistent product flow and signal smoothing using the Liebherr controller or an end users PLC or SCADA system.

Preliminary Summary:

Based on the test results of this report, moisture measurements using the Liebherr in-line analyzer on this type of product would be an excellent application for this technology.

C. Sample Preparation & Lab Analysis Procedure

1. The bulk sample bag was thawed and drained overnight at room temperature followed by blot removal of all surface moisture. A baseline sample was removed and became **Sample #1**.
2. Eight aluminum sample pans were labeled and weighed using a three-decimal place digital scale.
3. The remaining seven samples were portioned and laid flat in orientation on oven racks in a pre-heated 225-degree Fahrenheit oven. Samples were successively removed at +10 minutes, +20, +35, +50, +65, +80 and +95 minutes. This reduced moisture in varying steps and created samples #2 thru #8.
4. The eight samples were allowed to equilibrate and then analyzed using both sensors as described in step D2 below.
5. All samples were then “wet weighed” prior to final drying that was then performed at 225°F for three hours. All attempts were made to avoid “cooking off” any volatile oils which could skew the moisture result.
6. All dried samples were then removed from the oven and weighed immediately for final moisture lab analysis.

Sample ID	OvenTime Minutes (+) @ 225F	Pan Weight	Wet Weight	Dry Weight	Oven Dry H2o
1	**0**	0.127	7.152	3.424	53.07
2	**10**	0.145	7.983	4.216	48.06
3	**20**	0.144	7.508	4.403	42.16
4	**35**	0.131	7.776	4.946	37.02
5	**50**	0.151	7.474	4.815	36.31
6	**65**	0.133	7.001	4.551	35.67
7	**80**	0.144	6.595	4.304	35.51
8	**95**	0.132	5.121	3.429	33.91
				Min =	**33.9**
				Max =	**53.1**

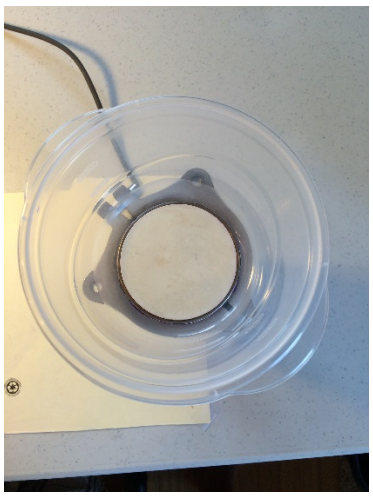
D. Test environment, Procedure & Sample Presentation

1. The FMS-II Liebherr in-line analyzer was tested using an “at-line” static configuration in ambient temperature, pressure and humidity conditions.

2. Eight test samples with a lab moisture range of 34% to 53% were analyzed with both sensor heads and no physical packing. They were “slightly” shaken a few times to settle the fries, thereby mimicking dynamic line conditions, then measured. This “fill and refill” procedure was performed five times for each sample with the mean value of these fills recorded for later statistical analysis.

   NOTE: The test was performed using one size of “crinkle cut” French fry. Typically, there are many shapes and sizes in a production process. The unit is able to store hundreds of different curves giving a customer the flexibility to add as many product recipes as necessary.

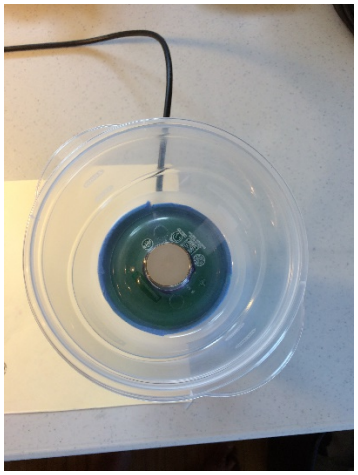
The samples were presented to the sensors as shown below



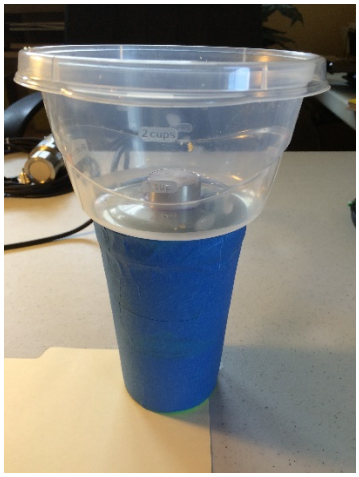
P78 top view

P78 side view

P78 filled view



P30 top view



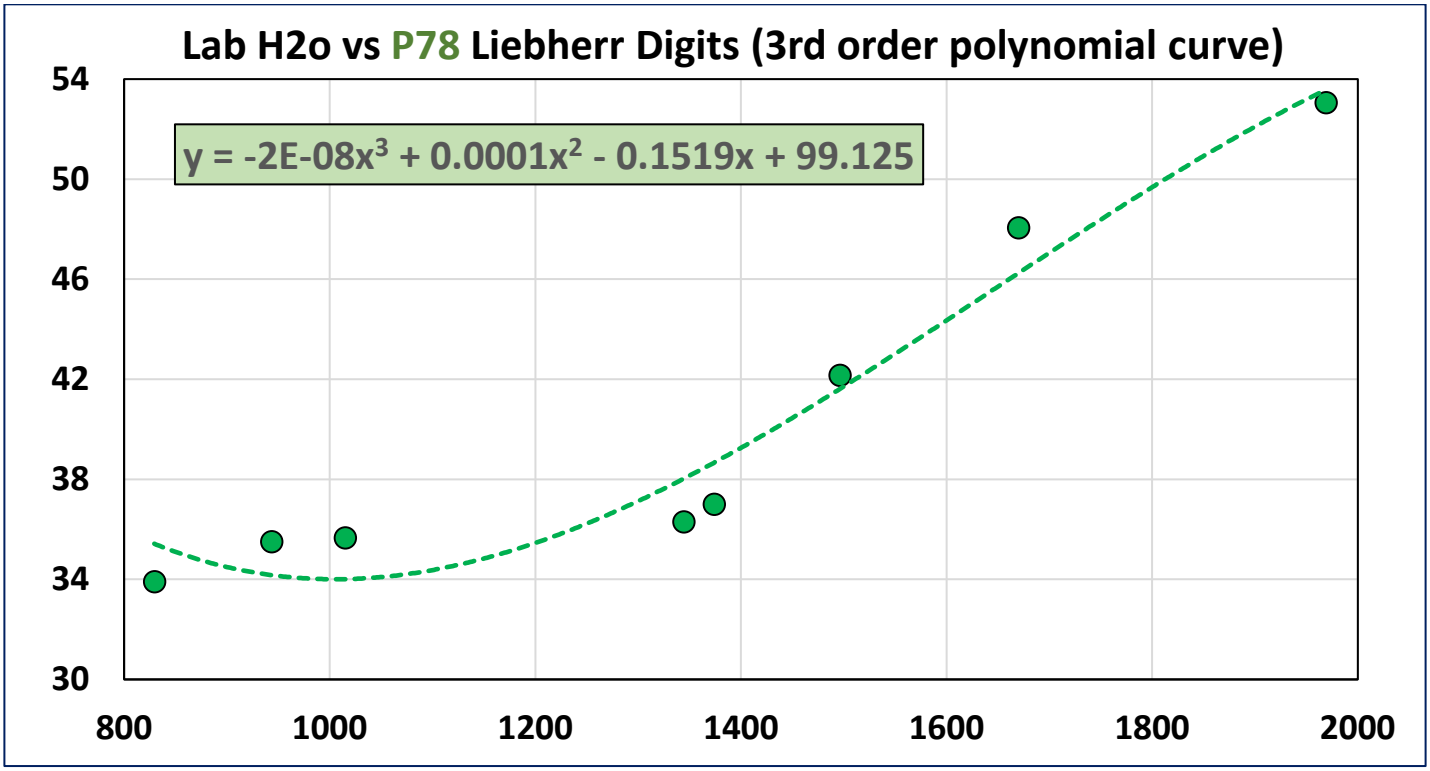
P30 side view

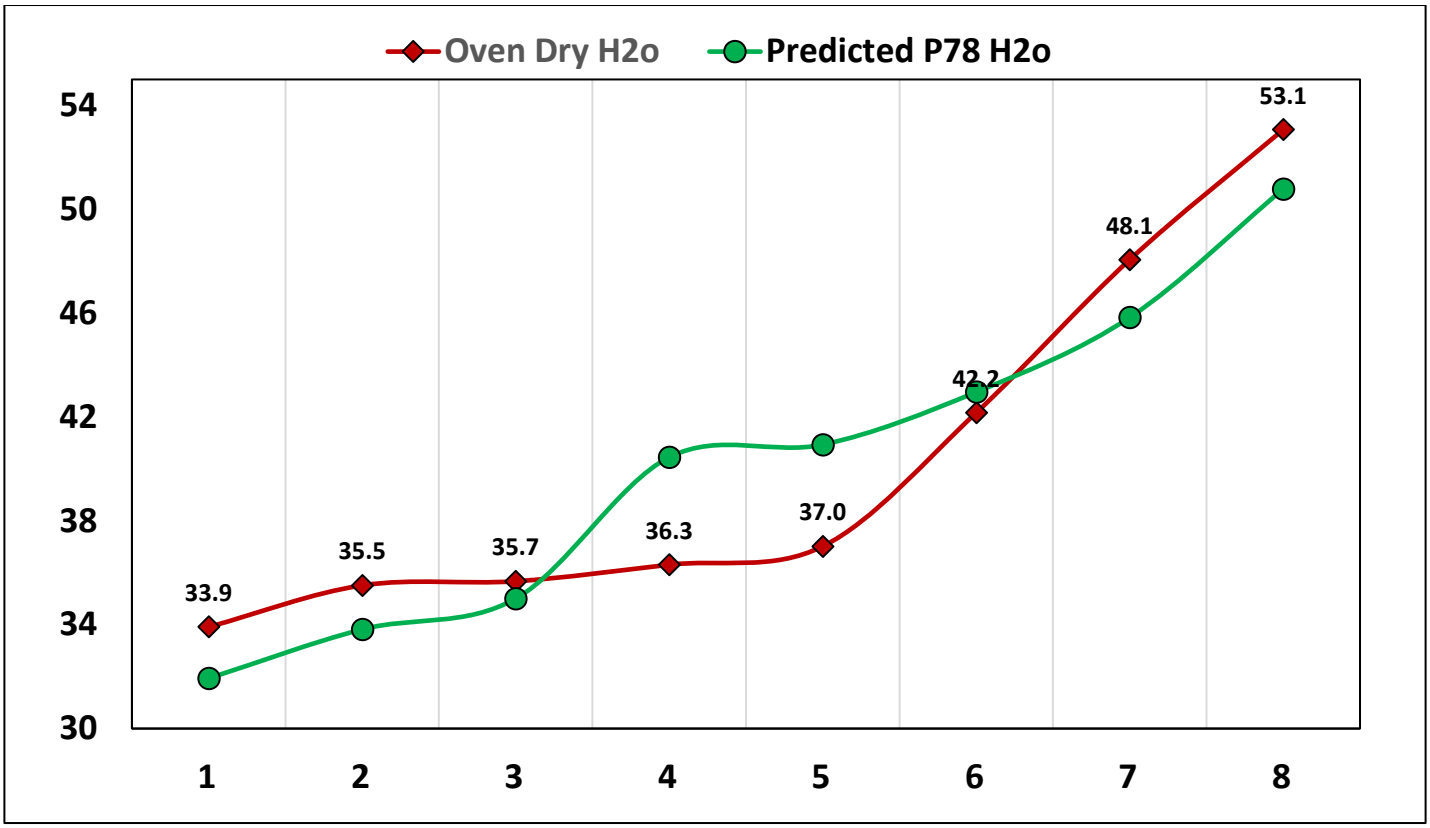
P30 filled view

3. The data was analyzed using Microsoft Excel to evaluate the performance of the instrument and generate coefficients that were used to predict moisture using **Y = (m*x) + b** as the base formula.

E1. Prediction Test Results, P78 sensor head % H2o

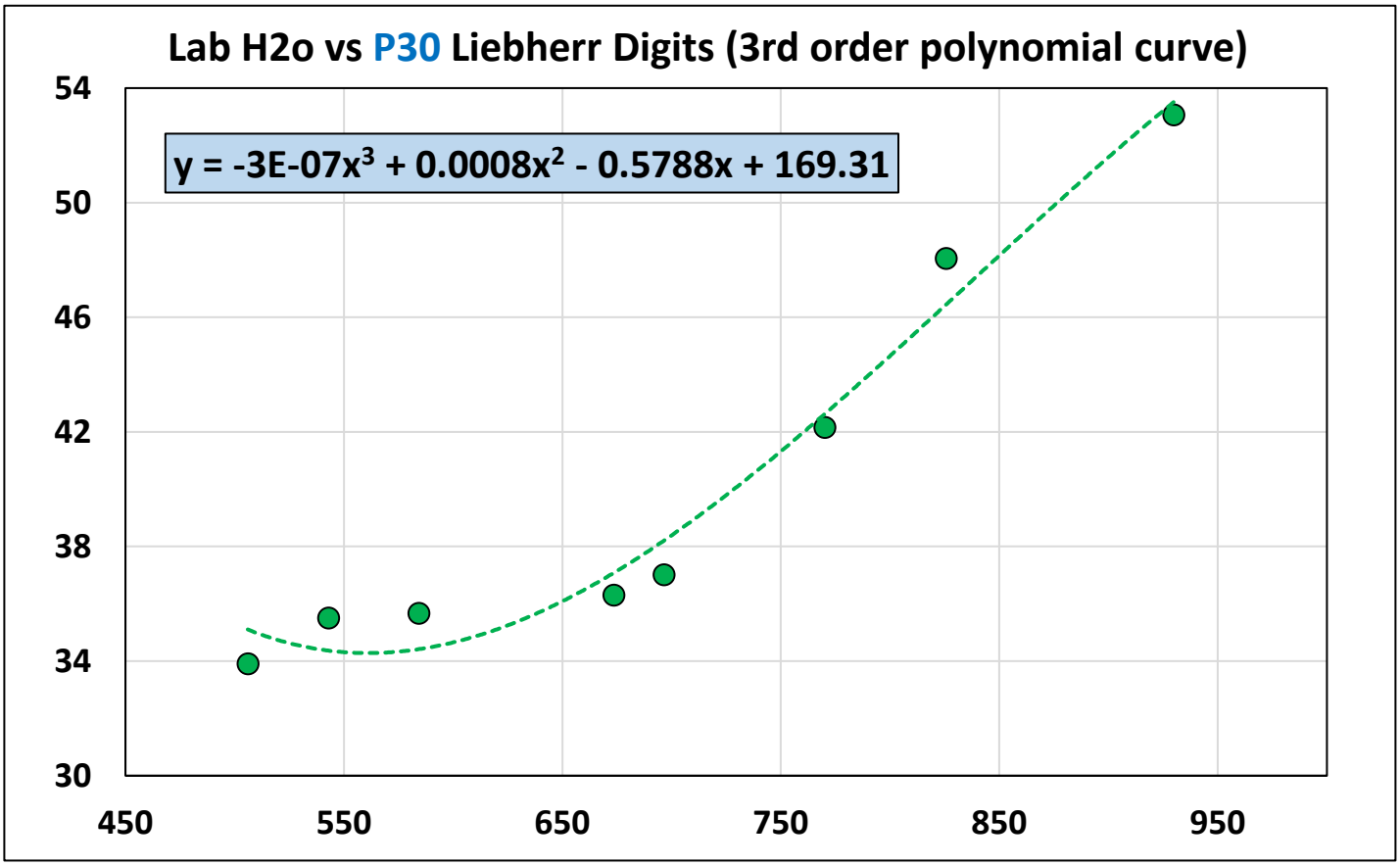
Linear Correlation Coefficient: **0.92** Standard Error: **2.90%**

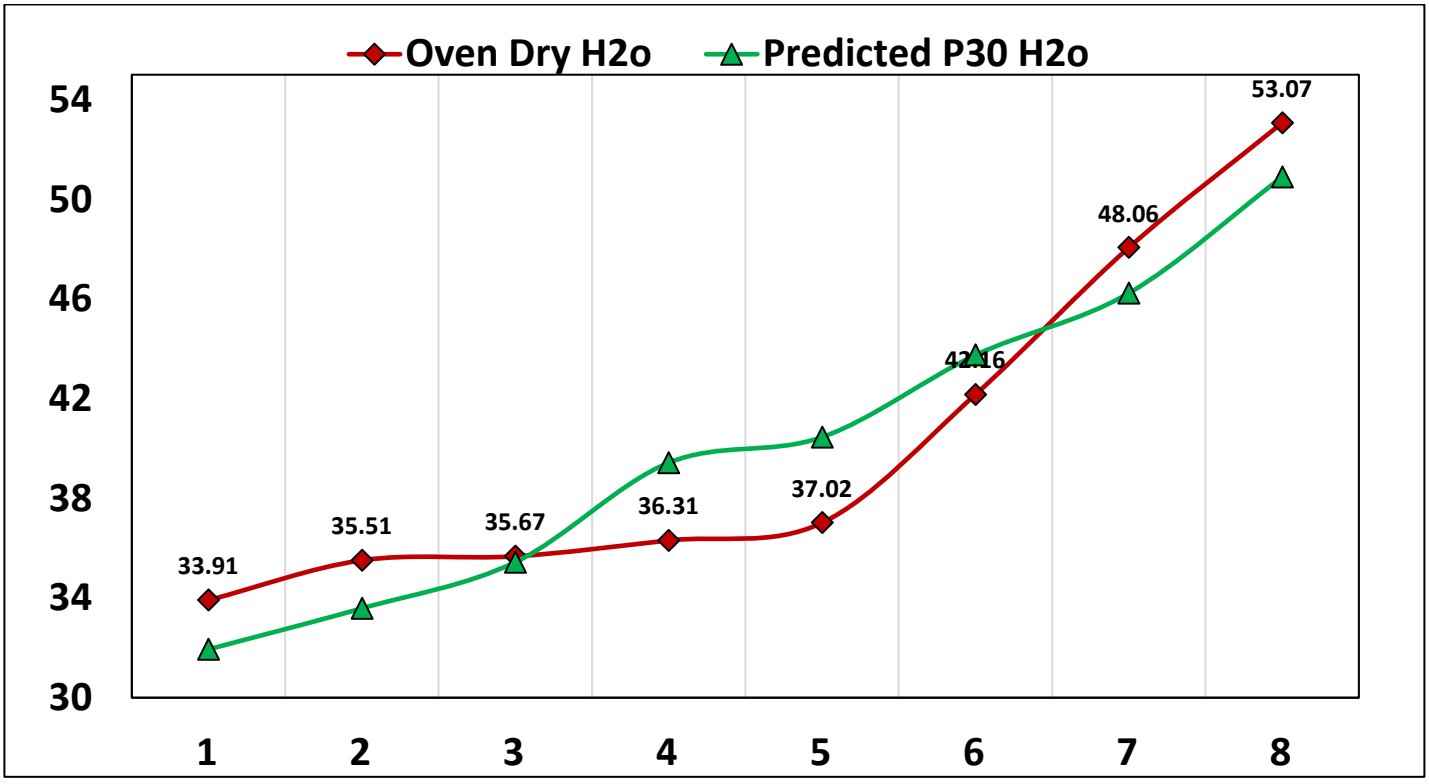




E2. Prediction Test Results, P30 sensor head % H2o

Linear Correlation Coefficient: **0.94** Standard Error: **2.57%**





F. Test Validation

Due to the limited number of prepared samples and the need for final drying for lab analysis, there was no validation performed at this time. The predicted results however clearly show the Liebherr analyzer is very capable of this measurement.

G. Discussion, Definitions & Conclusion

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 technique will add to instrument error. For these reasons, any study or statistical evaluation for any in-line measurement should be done with the sensor installed in the optimal production location.

Inconsistent voids or gaps in front of the sensor will cause variations in the instrument readings, however using various analyzer settings these false readings can be ignored. Consistent presentation of the product will improve the measurement for any in-line system and oftentimes have less error than the lab or at-line system based on the infinitely large number of readings on all the material, not just a small portion.

R-Square (r2) description:

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 (and not possible), however for many applications a value of >.80 is many times considered acceptable.

Standard Error description:

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 questions, comments or interest regarding our in-line analyzers.

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