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Analyst: Darrel Butler
Phone: +1, 512-426-8215
Email: darrel@dtbtech.net

A. General Information

Application: Measurement of moisture in extruded “Activated Carbon” pellets.

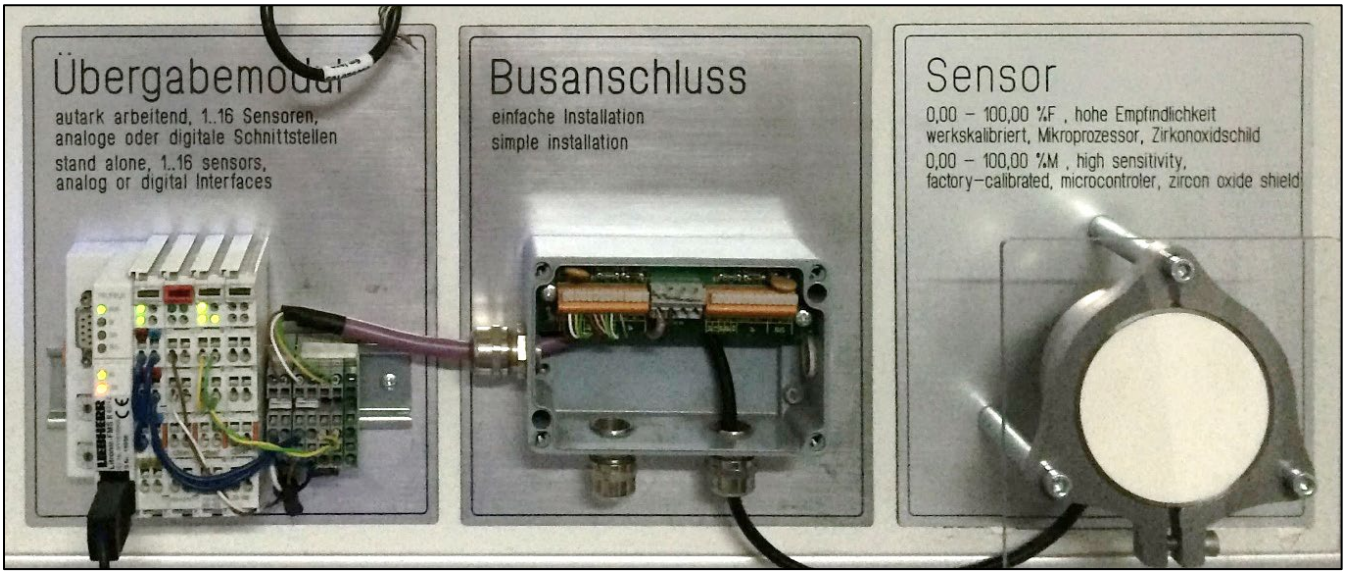
Test conditions and system type: An in-line FMS-II production analyzer was configured for an “at-line” test using a P30 (1.1” diameter) PEEK sensor head.

Analyzer description: The FMS-II Litronic is a robust in-line analyzer that measures moisture in food, beverage, petrochemical slurries, aggregates and other applications. Current sensor locations include conveyor belts, chutes, silos, webs and pipelines with up to 16 optional heads per single controller at distances of up to 3,900 feet in series via RS485. Click here for a technical description of the technology.

The Litronic has no moving parts and the sensor product interface material is PEEK. With 10,000 plus sensor head locations installed over 35 years, reliability is ensured.

A complete Liebherr system consists of **A.)**, a micro-controller that outputs data to a customer interface system such as a PLC via RS232, Ethernet, Profibus, 4-20mA or 0-10V DC to **B.)**, an optional length-extender RS485 J-Box to **C.)**, an **“Intelligent”** sensor head that is installed in the customer’s process and connected back to the controller.

A. **B.** **C. (P78 shown below)**



B. Objectives, Test Highlights & Preliminary Summary

Objectives:

1. To determine the feasibility of the application and instrument parameters for the measurement with regards to this product.
2. To get a preliminary indication of the sensitivity and precision of the instrument measuring representative test product from the customer.

Test highlights:

1. The instrument shows excellent sensitivity to varying moisture content.
2. There is high correlation between the P30 predicted and measured validation values and the prepared lab samples. An r2 correlation coefficient of 0.998 and standard error of +/- 0.79% was measured with the P30.

Preliminary Summary:

Based on the results of this report, the Liebherr instrument measuring % moisture on this product would be an excellent application for our technology.

C. Test environment, Procedure & Sample Presentation

1. The P30 analyzer was configured in an “at-line” configuration at ambient room temperature, pressure and humidity. Prior to measuring, each sample was lightly “folded” in a SST bowl with the goal of re-distributing the moisture due to settling during shipment.

2. Eight test samples of varying moisture content were then analyzed with the P30 sensor without any physical or vibrational packing. They were measured four times with a “fill-refill” process to duplicate in-line dynamic conditions, i.e.; product moving in a process line. Two “blind” samples were also tested (S7 and S8)

   IMPORTANT NOTE: The two blind samples % moistures were outside the range of the calibration samples used to develop the coefficient curve. Ideally, the blind samples should have been within the minimum/maximum samples provided for the calibration.

3. The **P30** sensor was placed underneath the Carbon sample with one-inch of cover material to replicate the customers desired sensor location.

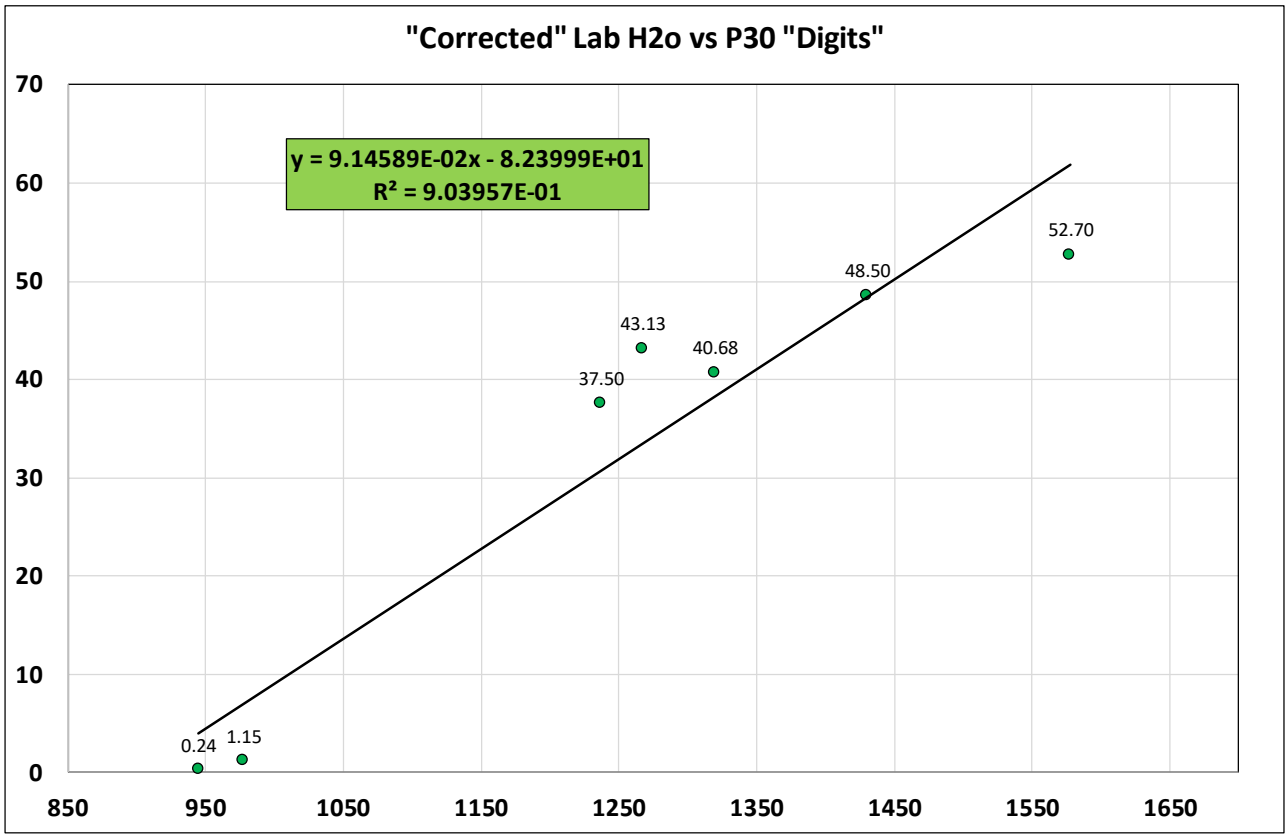
Empty P30 (note 1” mark)

Filled P30 to 1”

4. The samples were independently measured and regressed to the customer lab values. Known sample number 2 was dropped as an “outlier” based on its high Standardized Residual of > +/- 1.5% from the customer, “corrected results on next page.

D. Corrected P30 sensor test results

Correlation Coefficient: 0.904



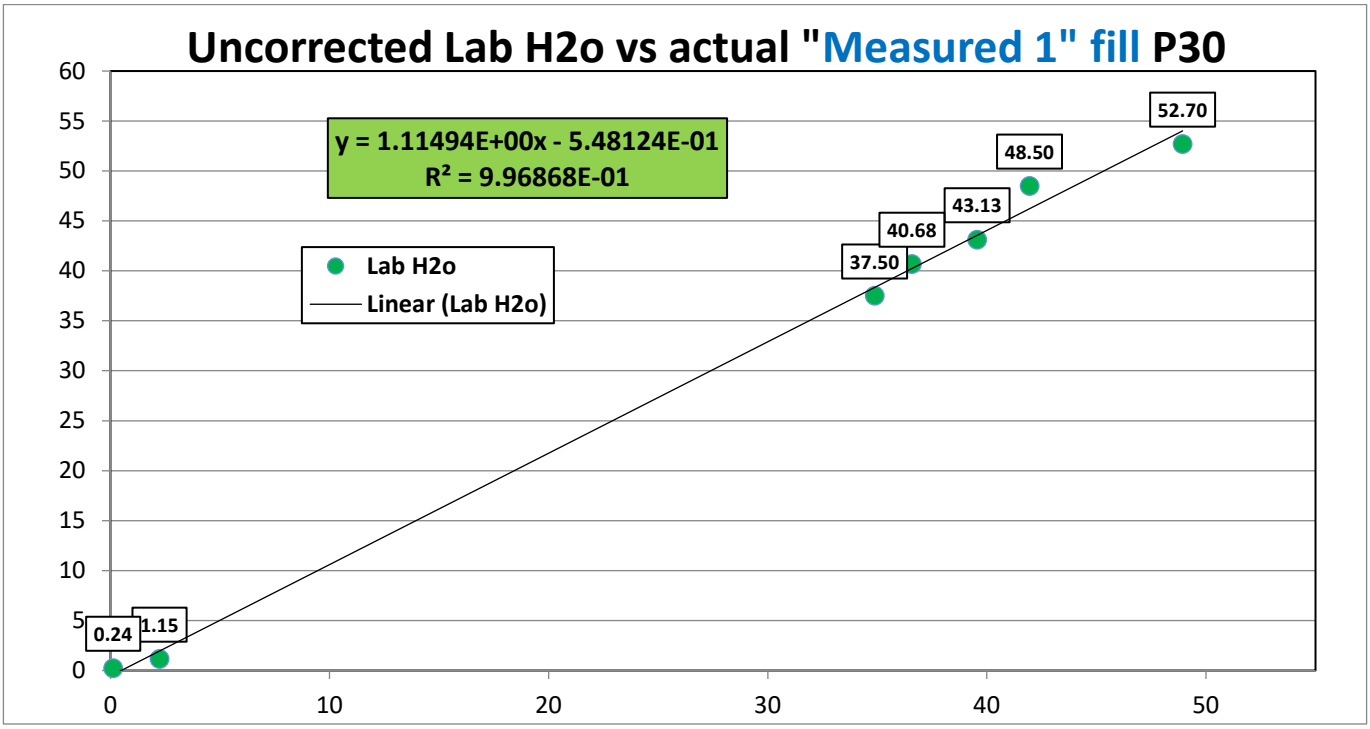
E. Validation

The calibration curve from above, **y = 9.14589E-02x - 8.23999E+01** was installed into the P30.

F. <u>Uncorrected</u> "Blind" samples numbers 7 and 8:

Below are the results of the UNCORRECTED Blind measurements using the y = 1.11494E+00x - 5.48124E-01 curve. As previously noted, because these samples were outside the calibration curve, blind sample error is expected. ***Sample # 7 is an outlier based on a STD residual of 1.7%***

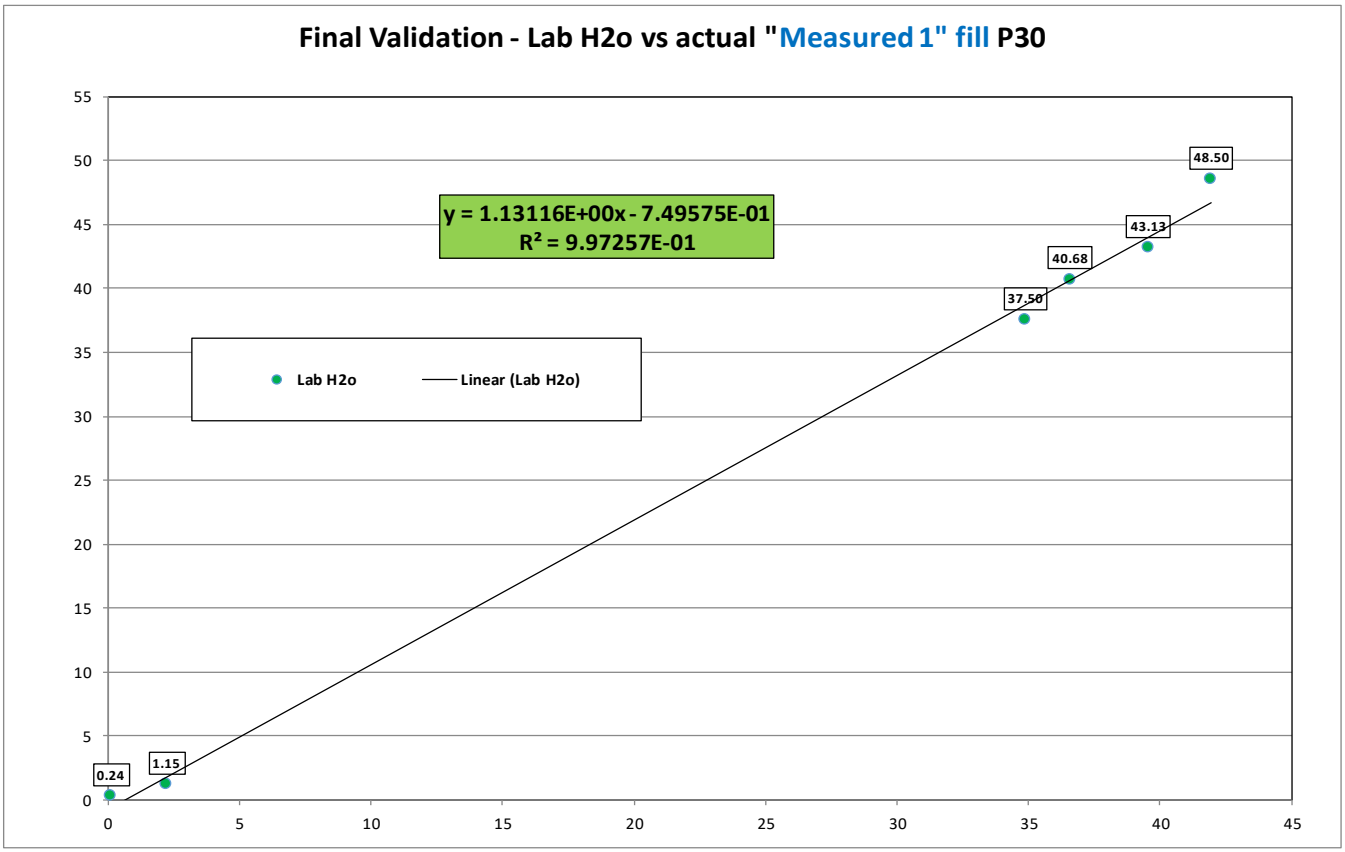
Sample ID	Fill #1	Fill #2	Fill #3	Fill #4	Average Measured P30 H2o	Lab H2o	Measured P30 offset/slope adust
1	3.13	2.83	0.73	2.27	2.24	1.15	**2.31**
3	0.17	0.00	0.00	0.33	0.13	0.24	**0.18**
4	42.00	36.51	39.49	40.22	39.56	43.13	**39.83**
5	39.07	32.02	35.00	33.42	34.88	37.50	**35.13**
6	39.45	36.09	34.97	35.81	36.58	40.68	**36.84**
7	**50.00**	**45.62**	**48.07**	**52.05**	**48.94**	**52.70**	**49.26**
8	42.32	42.51	40.45	42.51	41.95	48.50	**42.24**

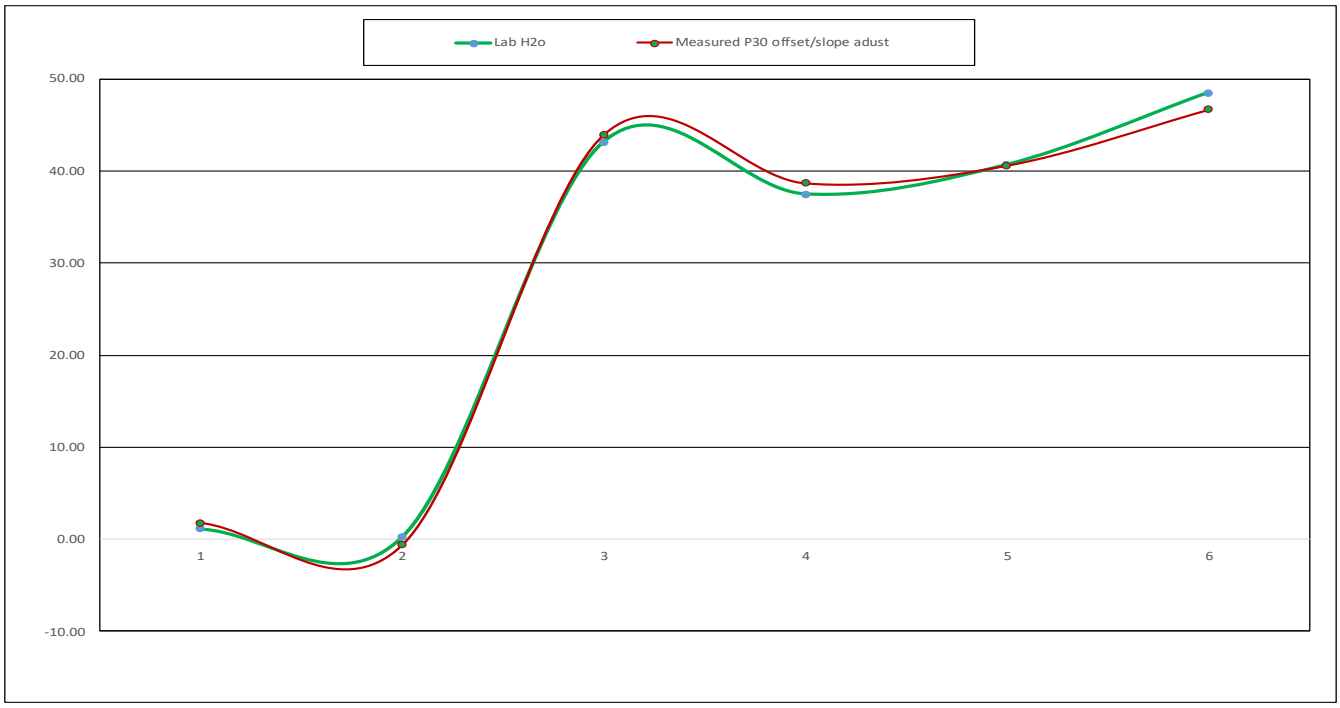


G. Corrected final validation, sans outliers:

Below are the results of the CORRECTED Blind measurements using a new **y = 1.13116E+00x - 7.49575E-01** curve proving the P30 is clearly capable of making this measurement. Graphs of this data are seen on page 5.

Sample ID	Fill #1	Fill #2	Fill #3	Fill #4	Average Measured P30 H2o	Lab H2o	Measured P30 offset/slope adust
1	3.13	2.83	0.73	2.27	2.24	1.15	**1.78**
3	0.17	0.00	0.00	0.33	0.13	0.24	**-0.61**
4	42.00	36.51	39.49	40.22	39.56	43.13	**43.99**
5	39.07	32.02	35.00	33.42	34.88	37.50	**38.70**
6	39.45	36.09	34.97	35.81	36.58	40.68	**40.63**
8	42.32	42.51	40.45	42.51	41.95	48.50	**46.70**


Final Validation - Lab H2o vs actual "Measured 1" fill P30
y = 1.13116E+00x - 7.49575E-01
R² = 9.97257E-01
Lab H2o
Linear (Lab H2o)
0.24
1.15
37.50
40.68
43.13
48.50
55
50
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45


Lab H2o
Measured P30 offset/slope adust
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
1
2
3
4
5
6

H. Discussion, Definitions & Conclusion

The preceding information constitutes a preliminary report for our customer to review. The statistical values presented are based on data generated in our laboratory with a limited quantity of material samples supplied by the customer. 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 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.

R-Squared (r2)

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 is perfect but for most in-line applications > .90 is a minimum.

Standard Error:

The standard error is the variability between samples that you would obtain if you took multiple samples in the same data set. The standard error estimates the variability between samples. It is also a function of the scatter of data points around the linear regression line and is an indication of how closely the regression 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.

Darrel Butler

dtb Technologies LLC
darrel@dtbtech.net
http://www.dtbtech.net/
Phone +1, 512-426-8215