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Title

White Sugar Colour *in Solution*,

Comparison of Laboratory and In-Line Methods

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Abstract

Two different methods for determining white sugar *colour in solution* values have been compared at the Union SDA factory at Origny. The first was the standard laboratory procedure and the second was an in-line method using the Neltec ColourQ 800 colorimeter to measure directly reflectance from crystalline sugar on a conveyor. Results from the laboratory determinations were used to calibrate the in-line method, and for more than a full campaign the factory has sampled the sugar produced and compared the two methods.

Measurements taken over two campaigns have proven the in-line instrument to be robust and accurate, fully capable of operating in industrial conditions, and achieving very precise readings, with SEP values as low as 0.8 IU over extended periods. After extensive tests, the instrument was connected to the conveyor controls, and it now automatically switches sugar between two silos, to separate low and high colour sugar.

Introduction

Sugar colour changes, with little notice, all the time. If all sugar goes into one silo, it is difficult to utilise high-quality, low-colour sugar as such, because it becomes mixed with higher-colour sugar in the silo. Thus, arrangements to divert higher colour sugar away from low-colour streams can be very advantageous, allowing the producer to benefit from having two silos, each with more homogenous sugar.

Unfortunately, however, the standard procedure of taking a sample every four hours and determining the colour in the laboratory is too slow for controlling the sugar stream to the silos. Sometimes the sugar can show a considerable colour change between the four-hour samples. In such cases, sugar with low colour may be sent to a silo with higher colour sugar, or –worse – sugar with higher colour may be sent to a low-colour silo. Worse still, this may continue for up to four hours, wasting the time and money spent in separating the low and high quality products.

A method for in-line and real-time measurement of the sugar colour is required to maximise the benefits of the system. Preferably, the method should also measure the colour in units equivalent to those of the laboratory method - *ICUMSA colour in solution* – like the in-line technique described here, using data derived from the Neltec ColourQ 800 colorimeter.

Method

Principle of operation

Figure 1 shows the instrument's principle of operation. Weak light flashes illuminate the sugar, the detector receives reflected light, and it is analysed in several spectral bands.

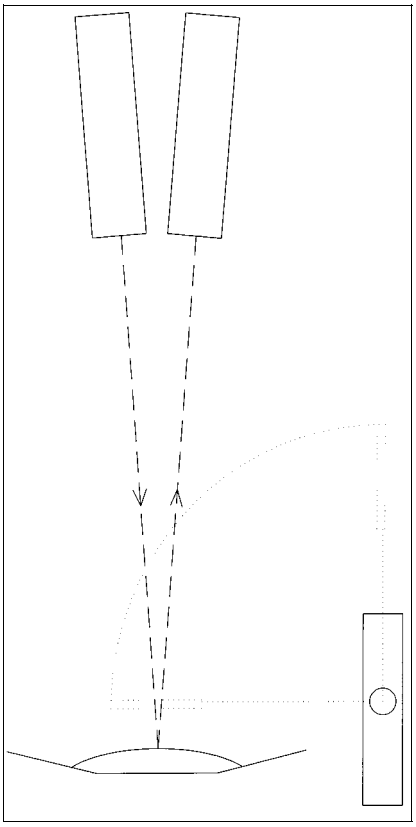

Fig. 1
Illumination and detection of reflected light

The unit to the right of the belt is for automatic compensation of drift in the instrument. At regular intervals, a white ceramic tile is automatically placed in the light path. The reflection is measured and the measurements are adjusted. The white tile is shielded from dust when not in use.

Both illuminator and detector are housed in 90mm stainless steel tubing.

An ultrasonic sensor detects when the belt is empty, so the measurements can be stopped and false alarms avoided.

Installation on conveyor line

The installed measuring unit can be seen in the Figure 2.

Fig. 2
Neltec ColourQ 800 installed above a conveyor belt

In the photo, you see the tile in its rest position.

To prevent contamination of the instrument's apertures, protective tubing extends beyond the windows of the illuminator and the detector. A slow stream of air away from the glass surfaces keeps them clean.

The instrument takes measurements of the sugar without requiring any levelling of the surface. The scraper seen in the photo was installed to test a video camera.

Calibration

During the campaign of 1998, many samples were taken for calibrating the instrument to conform to the ICUMSA method. The samples were taken during normal production and were determined in the factory's laboratory. After calibration, the accuracy was checked with new samples.

Shortly after the beginning of the 1999 campaign, the sugar had a lower colour than seen in 1998. Since the instrument was then required to measure outside of the calibrated range, further calibrations were performed.

Presentation of results to the operator

Results from the measurements are presented to the operator on the computer's VDU as in the photograph in Figure 3 (actual illustration taken from a similar, more easily photographed, installation at the Danisco beet sugar factory in Assens).

The upper curve shows the colour measured. It is updated every five seconds with a new measurement.
The lower curve shows the colour registered up to 48 hours back. This curve is updated every three minutes with the average colour value for the intervening period.

The yellow and magenta lines show warning and alarm levels for the operator.

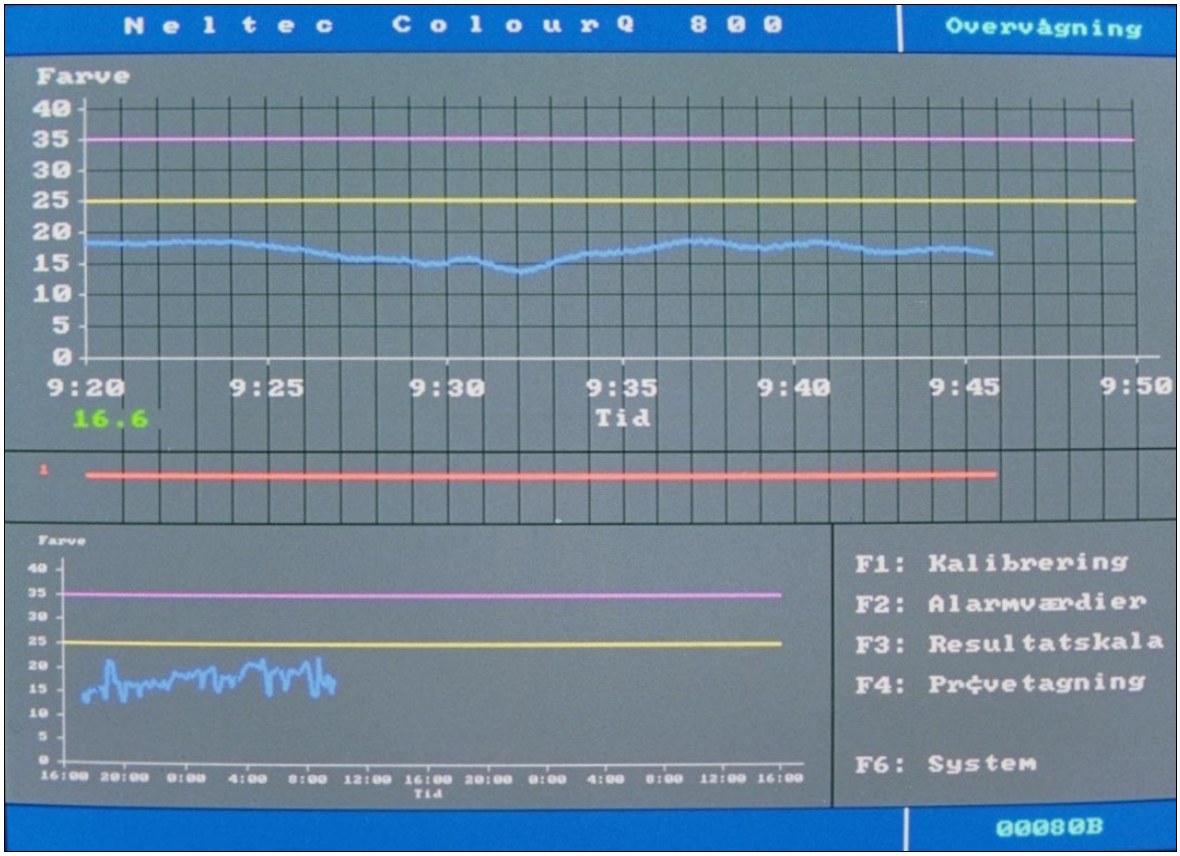

Fig. 3

Real-time presentation of results
on the computer screen

Results

1997 campaign

In October 1997, the instrument was calibrated. The samples for the calibration covered the range of 18 to 50 ICUMSA units (IU). The Standard Error of Calibration (SEC) was 2.0 IU. After the calibration, twelve duplicate samples were taken to compare the instrument readings with the laboratory determinations. The results of this comparison are shown in Table 1 and Figure 4. The Standard Error of Prediction (SEP) was just 0.8 IU.

Sample no.	Lab A	Lab B	Neltec A	Neltec B	Sq(Dif. A)	Sq(Dif. B)	SEP
54	21,5	20,7	21,6	21,8	0,01	1,21	
55	18,9	18,6	18,9	18,8	0,00	0,04	
56	20,7	19,5	19,1	19,1	2,56	0,16	
57	20,0	18,7	18,6	18,6	1,96	0,01	
58	17,9	17,9	18,3	18,5	0,16	0,36	
59	19,5	19,2	19,2	19,0	0,09	0,04	
60	18,4	17,9	18,2	18,3	0,04	0,16	
61	18,2	18,4	18,0	18,2	0,04	0,04	
62	17,9	17,9	18,0	18,1	0,01	0,04	
63	17,7	17,7	17,3	17,2	0,16	0,25	
64	16,1	16,1	17,1	17,1	1,00	1,00	
65	15,3	15,9	17,0	17,0	2,89	1,21	
							0,75

Table 1

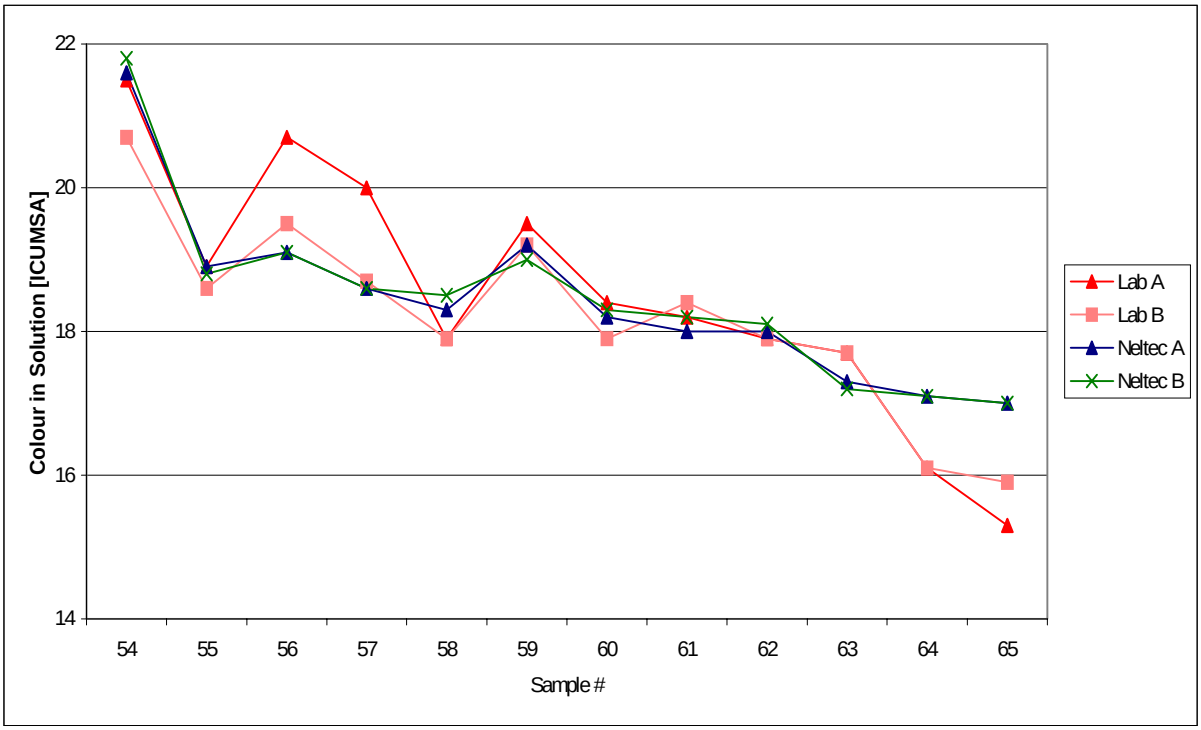

Figure 4

1998 campaign

Shortly after the beginning of the 1998 campaign the sugar produced had a lower colour than seen in the previous campaign, so measurements had to be made outside the colour range for which the instrument was calibrated. In Figure 5, you can see the instrument had difficulty in following the laboratory measured colour downwards, so the calibration was simply extended, to cover lower colours.

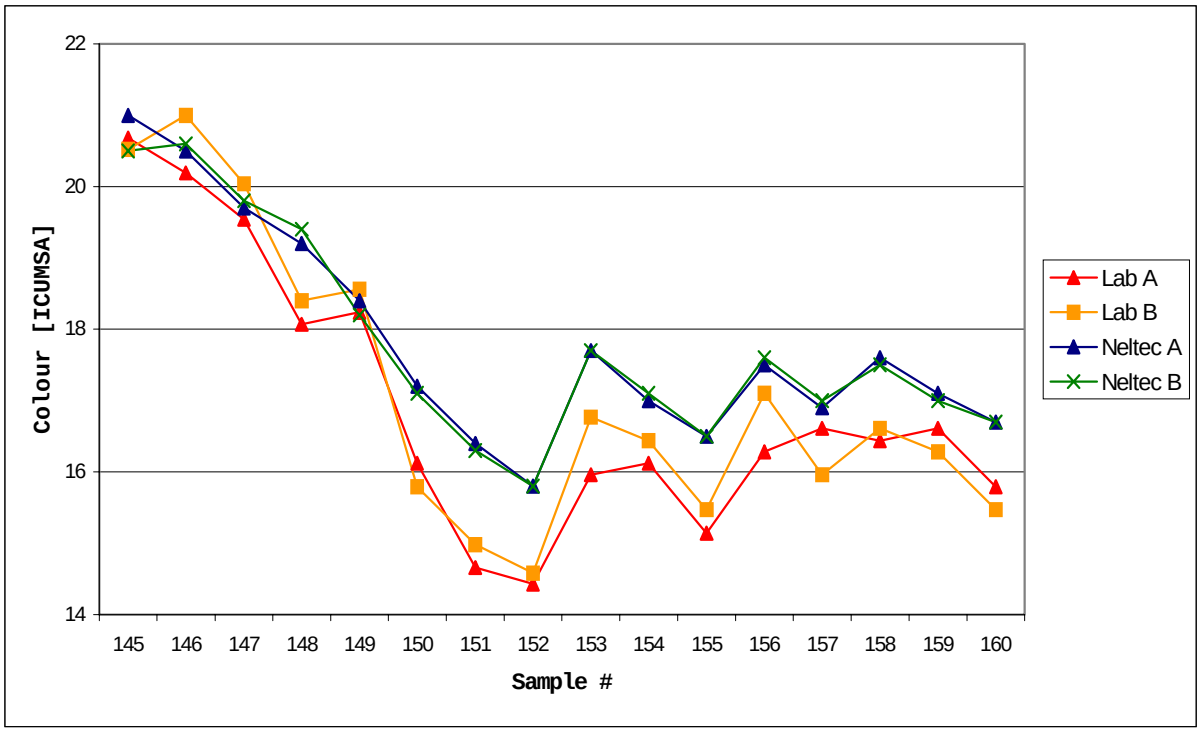

Figure 5
Measurements outside
calibration range

***1998 campaign** (continued)*

In Figure 6, data from all the samples taken during the 1998 campaign are presented. Samples 140 to 165 were measured with the 1997-calibration, and samples from 166 onwards were measured with the 1998-calibration. The SEP for the whole campaign was 1.4 IU. For the 1998-calibration alone, the SEP was 1.2 IU.

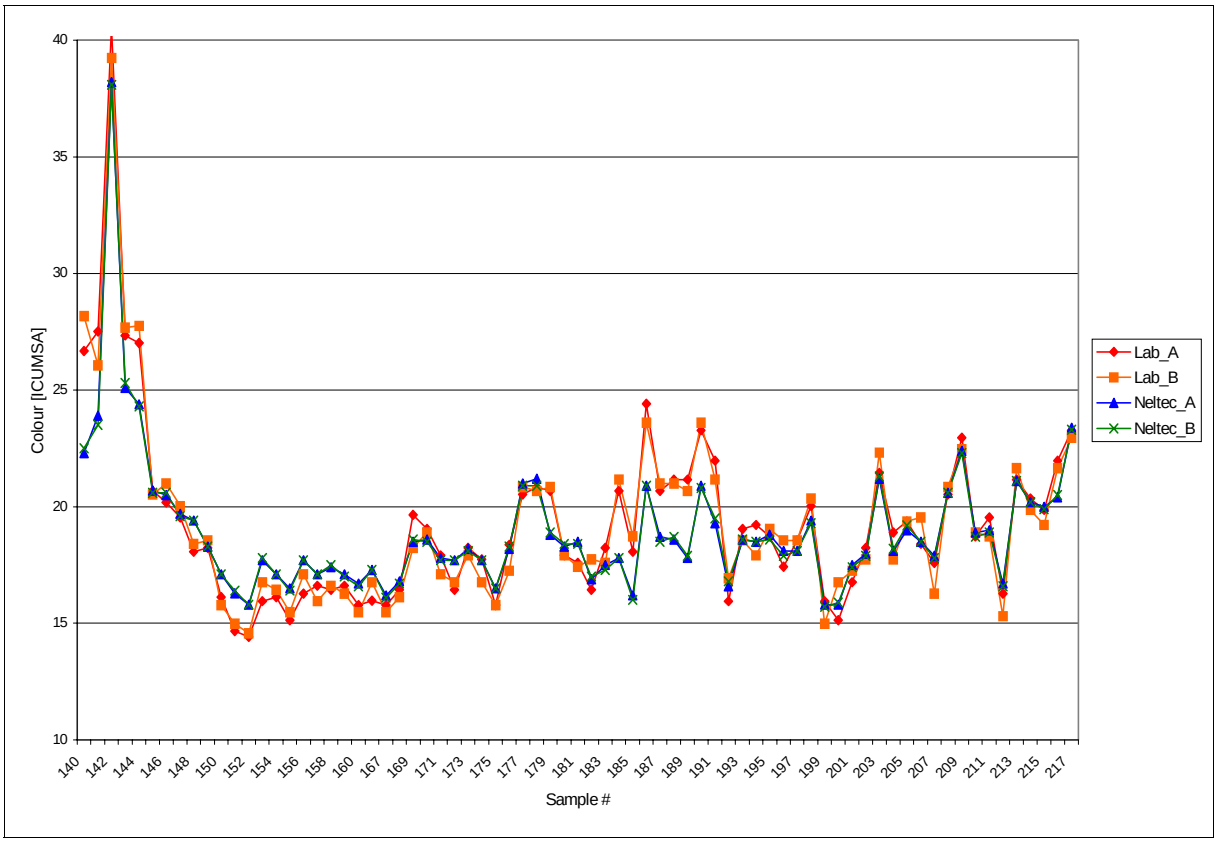

Figure 6
Comparison of the two methods over the whole 1998 campaign

ICUMSA requirements for Precision

ICUMSA Method GS2/3-9 (1994) for White Sugar Solution Colour has the following requirement for precision:

8.2 Precision

For sugars with ICUMSA Colour values up to 50 IU, the absolute difference between two results, obtained under repeatability conditions, should not be greater than 3 IU.

For sugars with ICUMSA Colour values up to 50 IU, the absolute difference between two results, obtained under reproducibility conditions, should not be greater than 7 IU.

The ”absolute difference” is equal to 2.8 times the SEP, so under repeatability conditions, the SEP should not be larger than 1.1 IU and under reproducibility conditions, the SEP should not be larger than 2.5 IU.

Conclusion

The measurements over two campaigns have shown that the Neltec ColourQ 800 is a robust and stable instrument. It has worked without any problems in the production environment.

The SEP for the instrument includes, by definition, the SEP of the laboratory measurements. Thus, the additional inaccuracy introduced by the instrument is so small it is negligible.

After completion of the tests, the instrument was connected to the conveyor controls. It now automatically switches the sugar between two silos.

The instrument is a convenient, effective tool for managing the sugarhouse. Problems are reported immediately so corrective action can be taken without delay.

References

1. Nielsen, B. C. (1996). In-line colour measurement of sugar in ICUMSA units. Proc. Sugar Proc. Res. Inst. Workshop on Separation Processes, pp. 215-227.
2. Nielsen, B. C. (1996). Colour measurement for process control. Int. Sug. J. 98: 524-527.
3. Buchholz, K. and M. Bruhns. (1995). The 1994/95 campaign in Germany and new technological developments. (In German) Zuckerindustrie 120: 357-358.
4. Buchholz, K. and H. Puke. (1995). Report of the investigation of the NELTEC-instrument for measurement of white sugar colour in solution at the Nordstemmen factory of Union-Zucker Südhannover GmbH. (In German).
5. Edye, L. A., Clarke, M. A., and Nielsen, B. C., (1997). On-line Measurement of Colour in Raw and Refined Sugars. Proc. Sugar Ind. Tech. Inc. Conf., pp 57-68.
6. Nielsen, B. C., Malgoyre, R., and Verhaeghe, F., (1999). Centrifugal Washing Optimisation by Real-Time Colour Measurement. Proc. Sugar Ind. Tech. Inc. Conf., pp 323-330.