FOSS

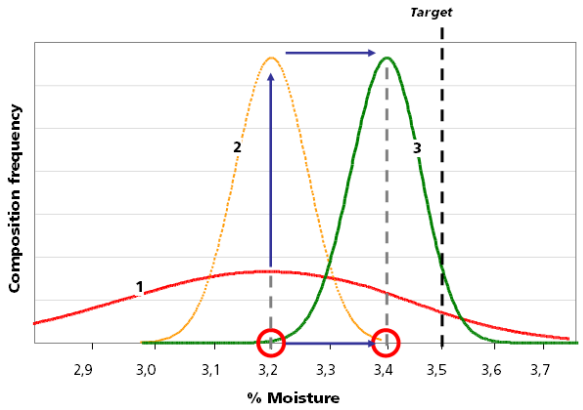
Application Note 32

ProFoss™
In-line skim milk powder application

Continuous process monitoring in food manufacturing is becoming increasingly important. Consistent and high-quality standardized products manufactured at low cost are a key goal for competitive success in a global market.

The ProFoss helps you to achieve this goal by reducing variation and streamlining your dairy powder manufacturing process. The solution provides you with fast, accurate, and continuous results ´real-time' for critical process parameters like moisture content.

You can use the results either for *manual* control of the drying process or for *automatic* control by interfacing the instrument with your process regulation system.



With the ProFoss system, you can run production much closer to specification limits giving you both an increased yield and improved final product quality.

The operator or the automatic process regulation system can immediately react to changes in the raw material or process. Even at start-up or recipe change, there is no need for calibration adjustment. You will get correct results with the first analysis and process regulation (optimisation) can start after one minute.

With the ProFoss solution you can:

- Track exactly how your process is performing instead of waiting hours for results from standard wet chemistry analysis in the laboratory.
- Control the manufacturing process to a precision limited only by your control system
- Detect not only the actual process situation but also predict a possible future out-of-specification situation and react before it actually happens
- Identify what you have in the process line at any time – product type, mix quality, etc. thanks to the unique ProFoss qualification software. In-line process qualification is a 'lifeguard' to the production and for preventing unreliable results to be used by your process regulation system.

In-line performance evaluation

This application note describes the results that can be expected when using the ProFoss solution for the in-line analysis of skim milk powder in the outlet of the fluid bed.

For an in-line solution it is important to measure the product composition levels as precise as possible. But equally important is the ability of the system to detect compositional changes (trends) quickly and reliably. The smaller the variation that can be detected (Process Variation Detection Limit - PVDL), the better process regulation can be applied and the production target can be moved closer to the product specification.

As measurements on the ProFoss are made at such short time intervals, corrections to production can be made much faster than with process monitoring using manual sampling and laboratory analysis where a time lag of several minutes or even hours is common.

In-line measurements also minimize possible sampling errors, and the effect of production variation no longer has significant influence on the overall performance.

Adjustment of a process is seldom based on a single sample manually collected - re-testing is required and this further increases the time lag in the regulation system.

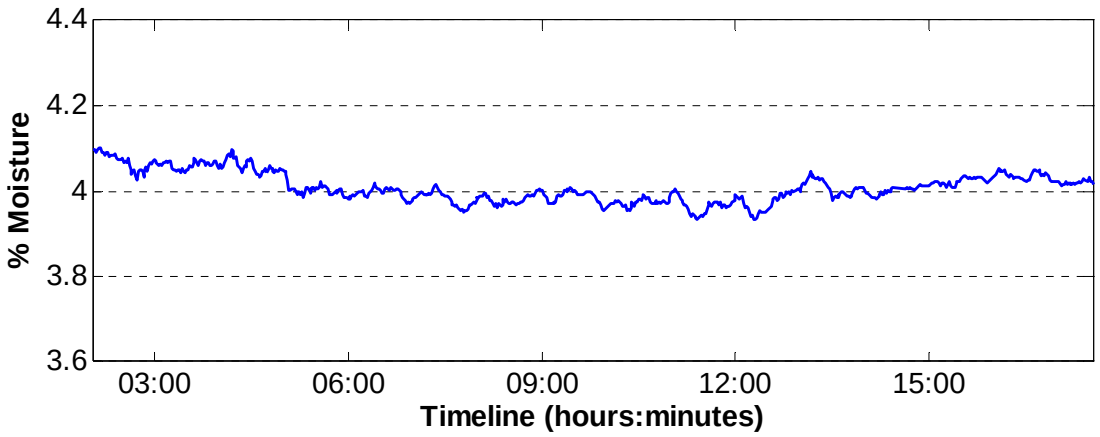
Using ProFoss the true production trend is obtained instantaneously.

The lowest concentration level change that a process regulation system can react on is the process detection limit of the monitoring system. We can define the process variation detection limit as the repeatability of the monitoring system. As traditional repeatability cannot be calculated on an in-line process instrument (different samples all the time) the best measure of repeatability is the standard deviation of differences between adjacent results – this is an estimate of the smallest process change that can be detected by the analyser. This figure is often 5-10 times smaller than the figure for the calibration model accuracy calculated as Standard Error of Prediction (SEP).

The PVDL has been estimated based on the variance between 2 adjacent moving average measurements for a period of several hours where the production process is as stable.
In the table below, a calculated PVDL in terms of standard deviation of differences is given for all parameters included in the calibration.

Process variation detection limits

Component	PVDL
Moisture	0.010 %
Protein	0.022 %
Fat	0.010 %



Typical moisture measurement over a 12 hour period

Samples used in the calibration

The calibration is based on instant and regular skim milk powder data collected in-line at the outlet of the fluid bed and sieve. The calibration can be used for skim milk powder produced from cow's milk and contains calibration for Moisture, Protein and Fat. The concentration range covered with this calibration can be seen in the table below.

Component	N	Min	Max
Moisture	4982	2.30 %	4.50 %
Protein	4444	31.45 %	38.00 %
Fat	4136	0.18 %	2.08 %

N: Number of samples in the calibration set.
Min %: Minimum concentration in the calibration set.
Max %: Maximum concentration in the calibration set.

Performance

The calibrations were developed using a ANN modelling.

The performance was evaluated using independent validation sets and the results are presented in the table below.

Calibration version: ProFoss SMP vers 2000

Component	Model	N	Acc.	Min	Max	RSQ
Moisture	ANN	527	0.16	2.60 %	4.48 %	0.83
Protein	ANN	651	0.30	32.12 %	37.88 %	0.97
Fat	ANN	472	0.082	0.17 %	1.70 %	0.82

N: Number of independent samples in the validation set.
Acc.: Independent test set accuracy expressed as Standard Error of Prediction (SEP) corrected for bias (1 SD absolute)*.
Min.: Minimum reference value in validation set.
Max.: Maximum reference value in validation set.
RSQ: Linear correlation between ProFoss result and reference result.

* Accuracy of individual sets will depend on sample handling, reference method used and range. The performance example outlined in this note should only be regarded as a guideline for the expected performance of new installations. The performance of new installations will always depend on the uniformity of the flow and homogeneity of the product, as well as the reproducibility of the reference method used to verify the performance. An indication of the obtainable performance can be found as approximately 2 times the square root of the sum square reproducibility of the reference method and sampling error.

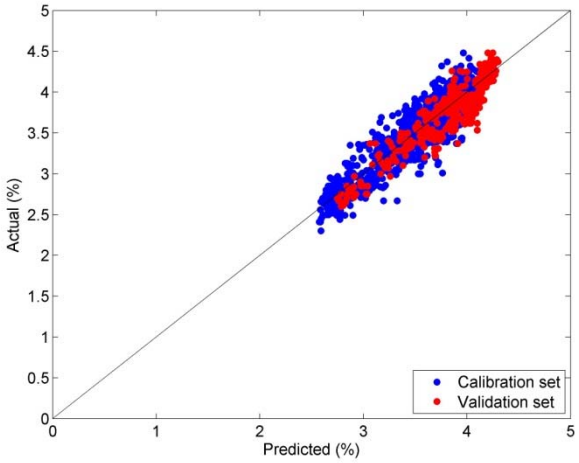
General:

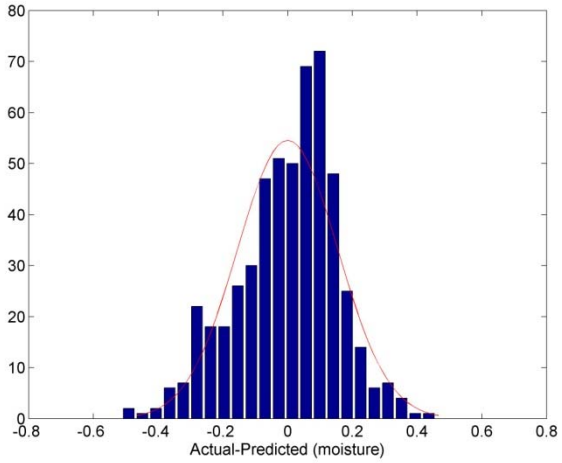
The performance of the calibration has to be validated with your samples (minimum 25 samples with reference values) according to the **International Standard IDF 201/ISO 21543 – "**Milk products – Guidelines for application of near infrared spectrometry".

If the samples you are measuring exceed the stated calibration ranges, or have non-common variations of other components, this might influence the performance of the calibrations.

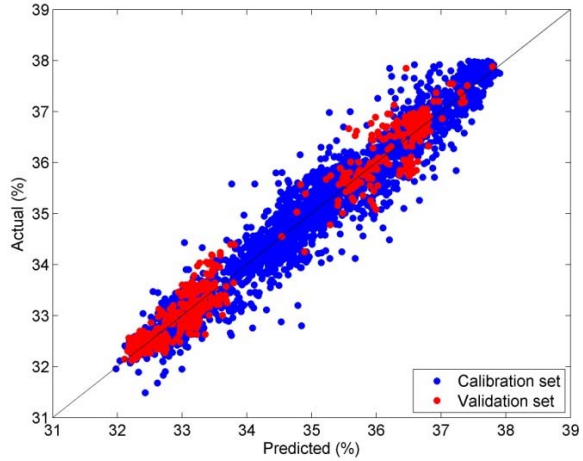
The graphs below show predicted results versus the reference ("actual") values for the independent validation sets. The histograms to the right show the individual performance of each sample in the independent validation sets, expressed by its residual (reference results – predicted results).

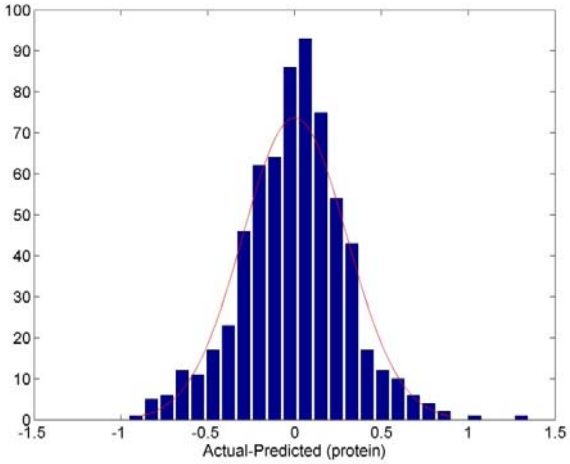
Moisture



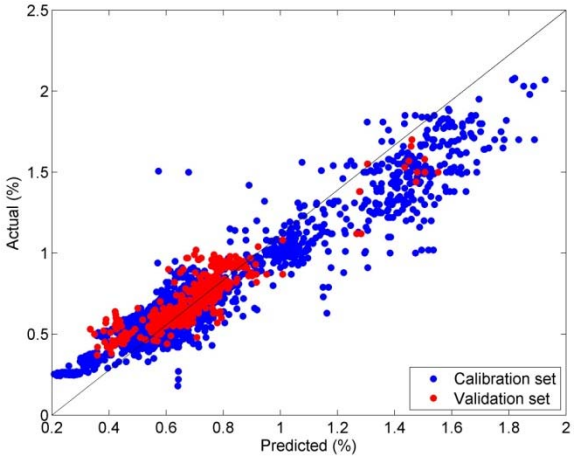


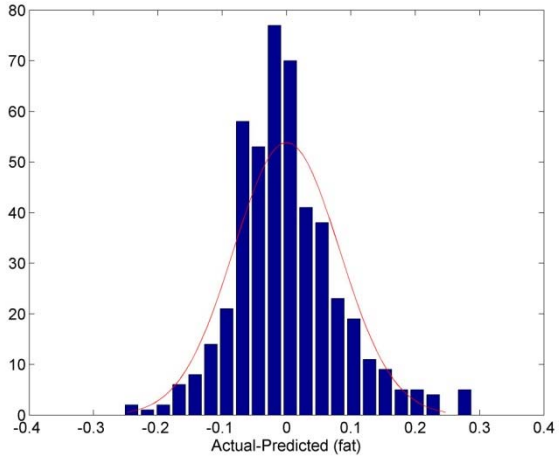
Protein





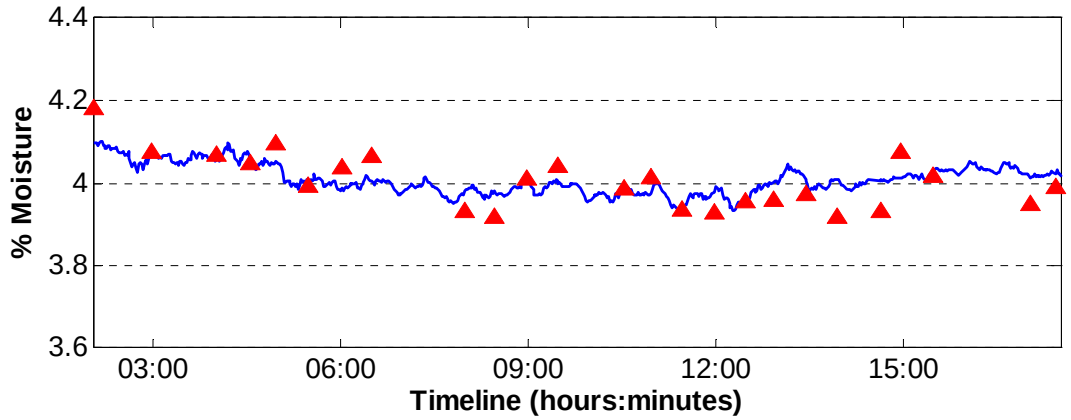
Fat



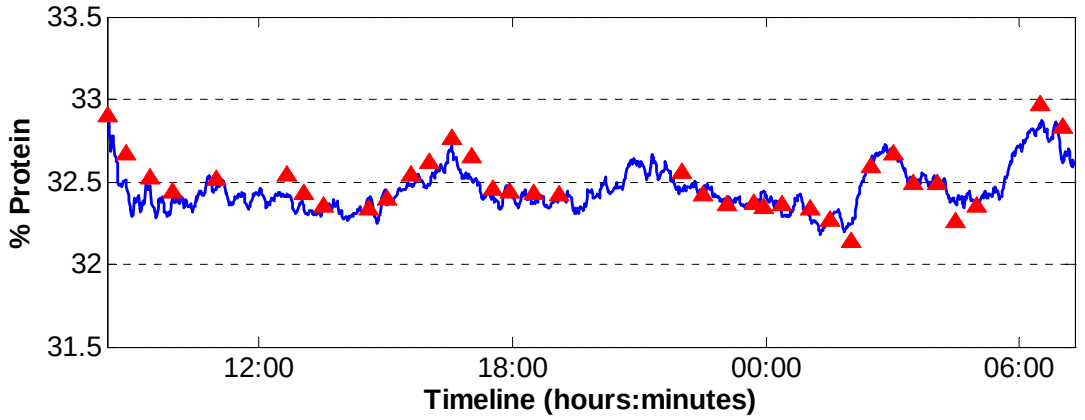


The graphs below show in-line predicted results (blue line) compared to laboratory results (red).

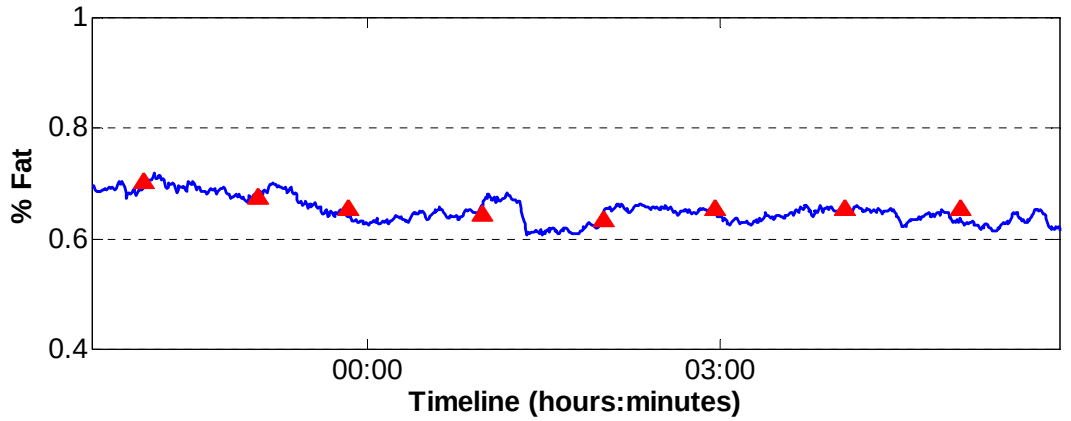
Moisture



Protein



Fat



Installation, measuring point, sensors and analysis

ProFoss is installed at the outlet of the fluid bed-sieve in a place where the powder is free falling in a vertical pipe – see the ProFoss installation guide for details.

Measurements will be made with a PCTFE (no glass) reflectance spoon probe installed directly into pipe. The probe has to be installed at an angle of about 30 - 40° from horizontal. The positioning (depth) shall be adjusted so the probe tip is positioned in the main powder flow.

If installed in an angle pipe, the probe should be installed on the underside of the pipe and the depth of the probe should be at a minimum to be in the main product flow.

The probe is automatically cleaned with pressurized air between each analysis.

Reference method

We recommend you to evaluate the performance of the calibrations using the appropriate joint ISO/IDF standards methods according to the procedure described in IDF201.

The test sets used for evaluation of the performance were analysed by means of the following methods:

Validation	**ISO21543/IDF 201: 2006.** Milk products – Guidelines for the application of near infrared spectrometry.
Moisture:	**ISO 5537:2004 / IDF 26 (2004)**, Dried milk – Determination of Moisture content (Reference method).
Protein:	**ISO 8968-1:2001 / IDF 20-1 (2001),** Milk -- Determination of Nitrogen content -- Part 1: Kjeldahl method.
Fat:	**IDF 9,** Dried milk, dried whey, dried buttermilk and dried butter serum; Determination of Fat content (Röse Gottlieb reference method).
	ISO 1736:2000, Dried milk and dried milk products -- Determination of Fat content –Gravimetric method (Reference method).

Ordering information

P/N 60038788 ProFoss Skim Milk Powder calibration for Moisture, Protein and Fat.

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Dedicated Analytical Solutions

FOSS Analytical
FOSS Alle 1
DK-3400 Hilleroed

Tel: +45 7010 3370
Fax: +45 7010 3371
E-mail: info@foss.dk
Web: www.foss.dk