FOSS

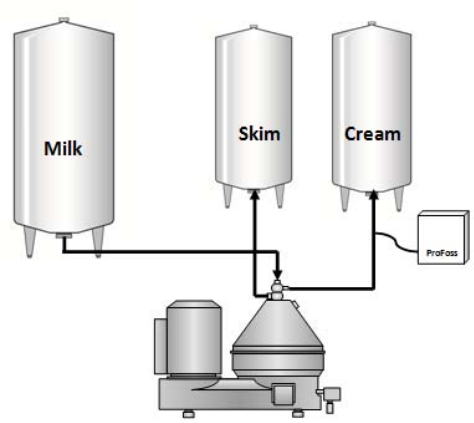
Application Note

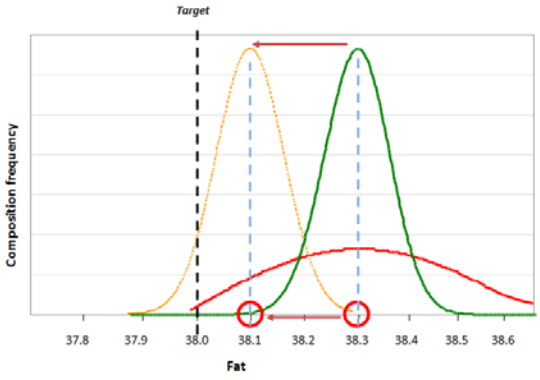
AN 0046

Rev. 1

ProFoss™

In-line Cream Calibration Model





Continuous in-line 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 achieve this goal by reducing variation and streamlining your cream manufacturing process. The solution provides you with fast, accurate, and continuous results ´real-time` for critical process parameters like fat content.

Continuous in-line analysis of the fat content in the outlet of the cream separator will give you the possibility to control the cream separator and during processing take correction action if the production is outside specification.

You can use the results either for manual adjusting the cream separator or for automatic control by interfacing the ProFoss with your automatic process regulation system.

Using ProFoss the operator or the automatic process regulation system can immediately react to changes in the raw material or process. Even at start-up, desludging or product change, there is no need for calibration adjustment or large delays. You will get correct results with the first analysis and process regulation (optimisation) can start immediately.

With the ProFoss system, you can run your process with a production target much closer to the product specification giving you an increased yield with a consistent product quality over time.

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 follow trends and predict possible future out-of-specification situations and react before they actually happen
- Identify what you have in the process line at any time – product type, 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 cream in the outlet of a cream separator.

For an in-line analysis solution it is important to measure the product composition level as precise as possible. But equally (or perhaps more important) is the ability of the system to detect process variations (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 short term production variations no longer have 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 product concentrations and trends are 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 changes 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 stable.

In the table below, a calculated PVDL in terms of standard deviation of differences is given for the fat calibration.

Process Variation Detection Limits

Component	PVDL
Fat	0.03 %

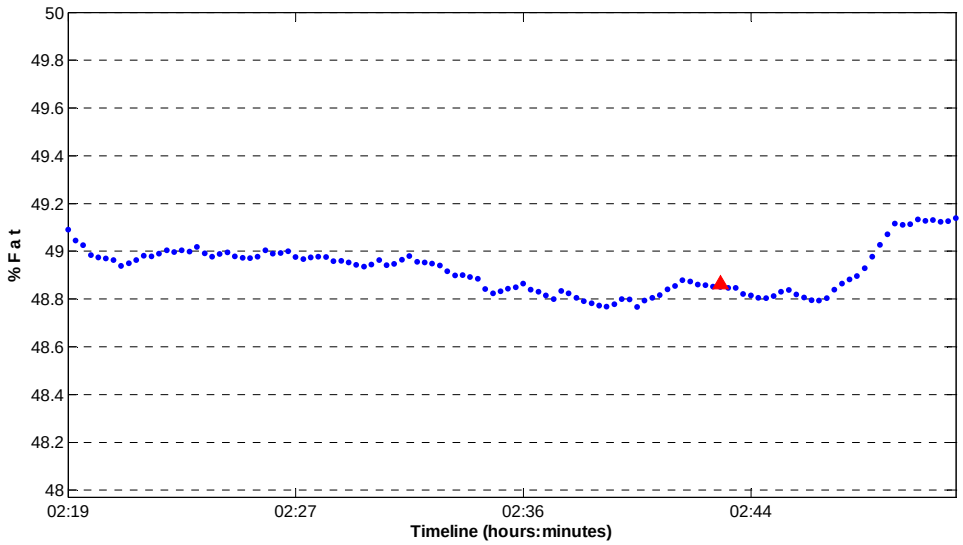


Fig. 1 Typical fat measurement over a 1 hour period

Samples Used in the Calibration

The calibration is based on cream data collected in-line with the ProFoss in the outlet of a cream separator. The calibration can be used for cream produced from cow's milk and contains calibration for Fat. The concentration range included in this calibration can be seen in the table below.

Component	N	Min %	Max %
Fat	1666	14.5	51.4
N:	Number of samples in the calibration set.		
Min %:	Minimum concentration in the calibration set.		
Max %:	Maximum concentration in the calibration set.		

Table 1

Performance

The calibrations for Fat were developed using a PLS modelling.

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

Calibration version: ProFoss Cream vers 1000.

Component	Model	N	Acc. %	Min %	Max %	RSQ
Fat	PLS	188	0.36	35.2	48.3	0.99

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

Table 2

General

The performance of the calibration has to be validated with your samples (minimum 25 samples with reference values) following the International Standard IDF 201/ISO 21543 – "Milk products – Guidelines for application of near infrared spectrometry" or the FOSS ProFoss Operation and Performance qualification documents.

If the samples you are measuring exceed the stated calibration validation 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).

[1] Accuracy of individual sets will depend on sampling, 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 square root of the square sum of the sampling error and the intra laboratory reproducibility of the reference method

Fat

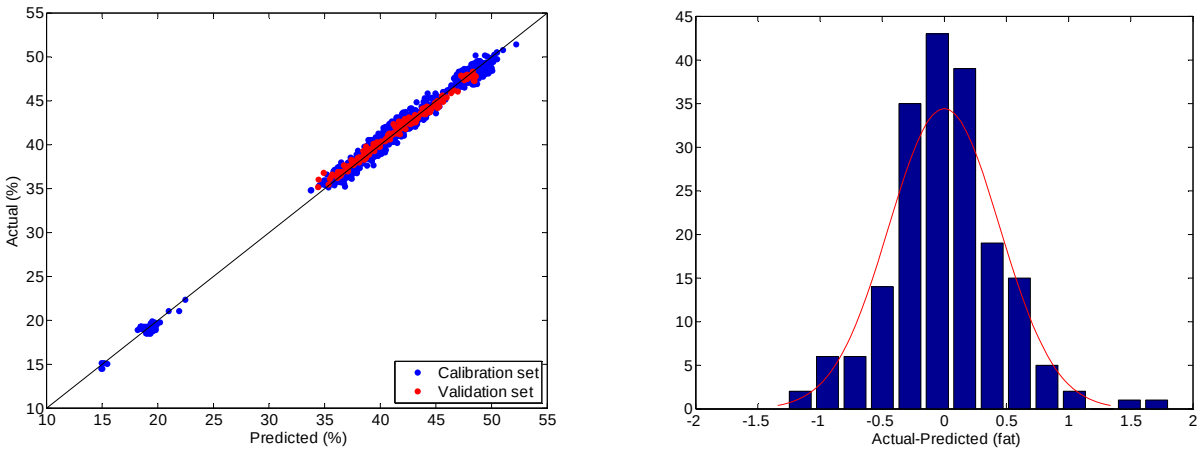


Fig. 2 Calibration and residual plot

Fat

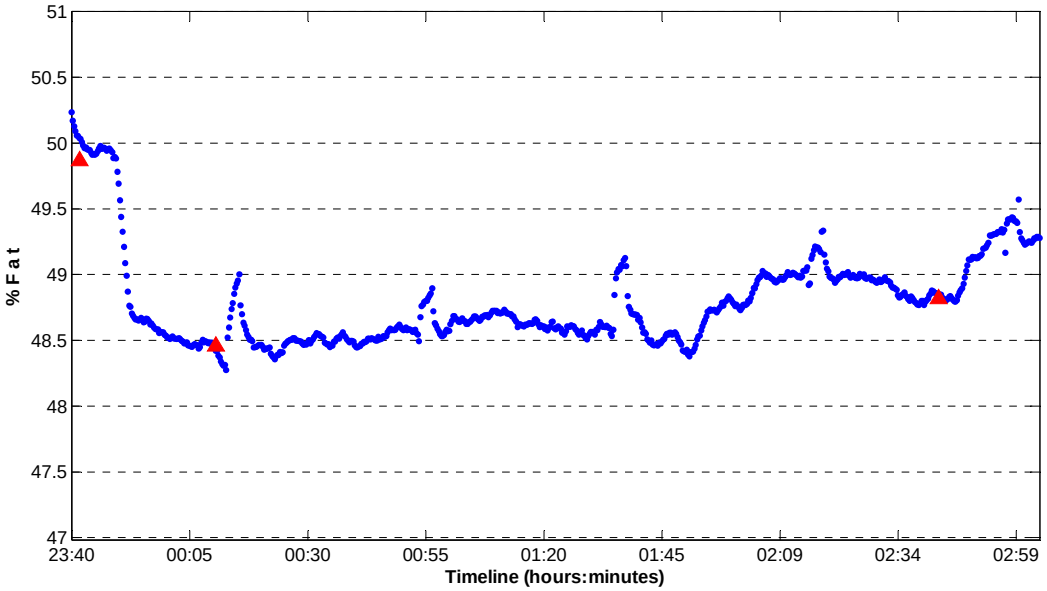


Fig. 3 In-line predicted results (blue line) compared to laboratory results (red) for a period of about 3 hours.

Installation, Measuring Point, Sensors and Analysis

ProFoss is installed at the outlet of the cream separator in a pipe with an upward product flow.

The pipe should be filled with product at all time at the measuring point. This is easily obtained if there is some level of back pressure in the system at the installation point – back pressure is automatically generated if installed in a pipe with upward flow.

If installed in a horizontal pipe install the Lateral transmittance interface at the bottom of the pipe.

For detailed information see the ProFoss cream installation guide.

Reference Analysis 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.
- Sampling — ISO707/IDF50. Milk and milk products – Guidance on sampling.
- Fat: — IDF 16 / ISO 7328 (2008). Cream Determination of Fat Content – Gravimetric Method.

If an indirect reference method such as the MilkoScan is used for calibration development, it has to be fully calibrated and validated against a primary reference method.

It is always recommended to use a primary method for calibration validation and calibration surveillance.