Calibration of on-line NIR Moisture Measurement Systems in Food Production Processes

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Contents

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Examples of moisture measurement

- Coffee
- Flour
- Cereals
- Ingredients
- Sugar
- Snack Foods
- Dairy Products

- Dried Fruits
- Tea
- Chocolate
- Animal foods
- Potato flakes
- Pasta,Noodles
- Breadcrumbs

- PET Foods
- Rice
- Confectionery
- Biscuits
- Starch
- Cheese
- Nuts

Benefits by using on-line gauges

- Increase yield
- Avoid over drying
- Improve product quality
- Reduced need for laboratory analysis
- Increase productivity

Installing on-line Gauges

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Expectations by user

- Results are based on local reference method
- Reliable data
- No need for re-calibrating after installation
- Easy handling of the instrument
- Improved product quality by closed loop control
- No down time

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Calibration – why ?

- Results are different from lab values
- Product shows different behaviour
- New developed product
- Process changes
- Gauge problem

Sources of errors

- Gauge itself
  linearity error of the gauge
- Reference laboratory method
  error in the method and procedure itself
- Sampling error
  not collecting the representative samples

Total Variance in NIR Calibration

$$SEP^2_{total} = S^2_{gauge} + S^2_{sampling} + S^2_{reference}$$

SEP = Standard Error of Prediction

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Reasons for re-calibrating

- Gauge design
- Environmental conditions
- Product or process changes

Critical factors for gauge design

- Temperature drift
- Selecting the right wavelengths for application
- Best algorithm for the parameter
- Changes due to source lamp variations
- Robustness of the gauge
- No down time
- Influence on pass height variations

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Critical factors to design for environmental conditions

- Ambient light
- Humidity of the air gap
- Temperature and dust

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Critical factors to product or process changes

- Seasonal variations
- Variations in particle size
- Irregular moisture distribution from top to bottom

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Improving Gauge Design

Problem	**Improvement**
Short term moisture variations in product	Larger patch size up to 60 mm
Signal to noise ratio Improve stability	Increased scanning speed up to 8000 scans/min
Filters and algorithms	Up to 10 filters to measure fat and protein at the same time
Easier handling for user	Pre-calibrated gauges and on-line help for calibration - trim function - sampling function

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On-line moisture applications

Product	Typical Range %	Typical Accuracy %
Cereals	0 - 5	0.1
Snack foods	0 – 25	0.1 – 0.3
Biscuits / Cookies	1.5 - 2.5	0.1
Non-dairy creamer	0 - 5	0.1
Chocolate	0 - 5	0.1
Salt	0 - 2	0.05
Tea	0 - 80	0.1 – 1.0

Factors of influence

- Drying temperature
- Drying time
- Product structure
- Distribution of the material
- Mass of the product sample
- No. of samples in the oven at a time
- Type of oven
- Weighing procedure

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Estimated error in oven reference method

Sreference = +/- (0.1 – 0.3)% absolute error

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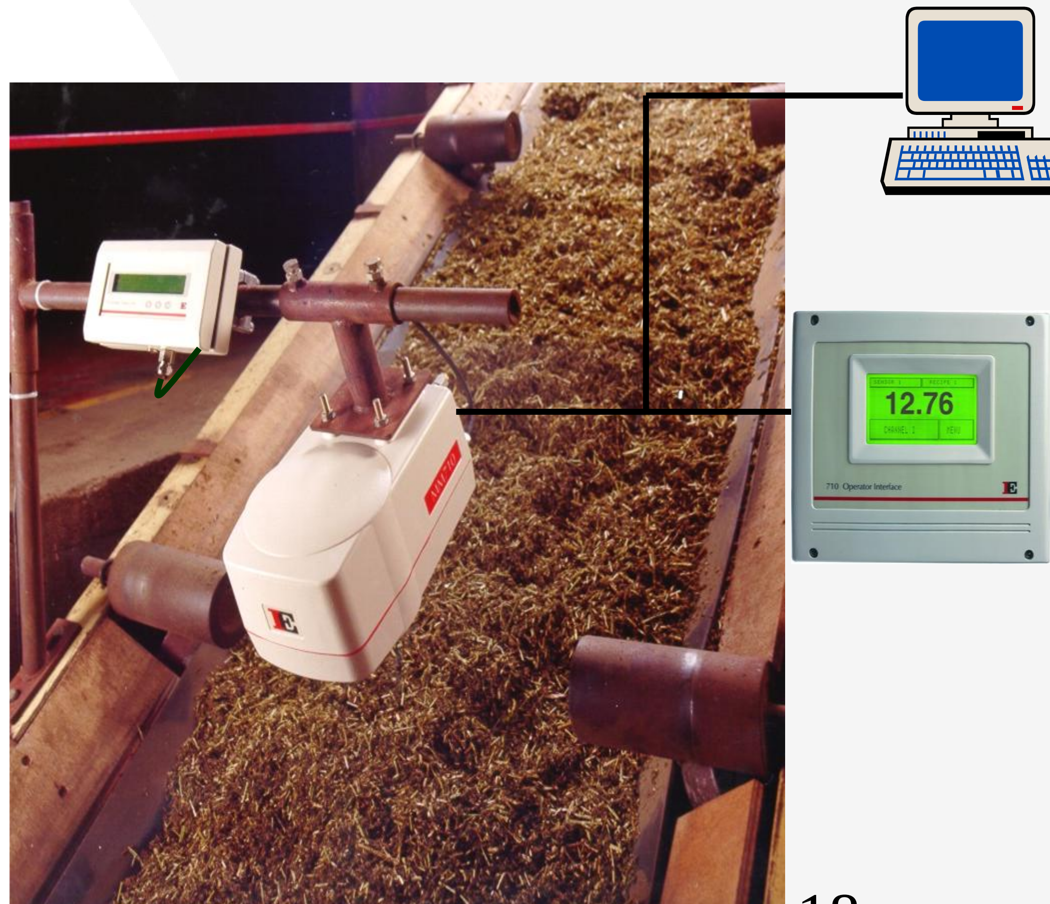
Areas of influence

1. Gauge settings for sampling
2. Process conditions
3. Synchronizing gauge reading and sampling
4. Collect a representative sample from the line

Sampling Procedure

Steps for sampling

- Response time to 1 s
- Sampling time 10 s
- Evaluate product variations $\bar{x}$, s

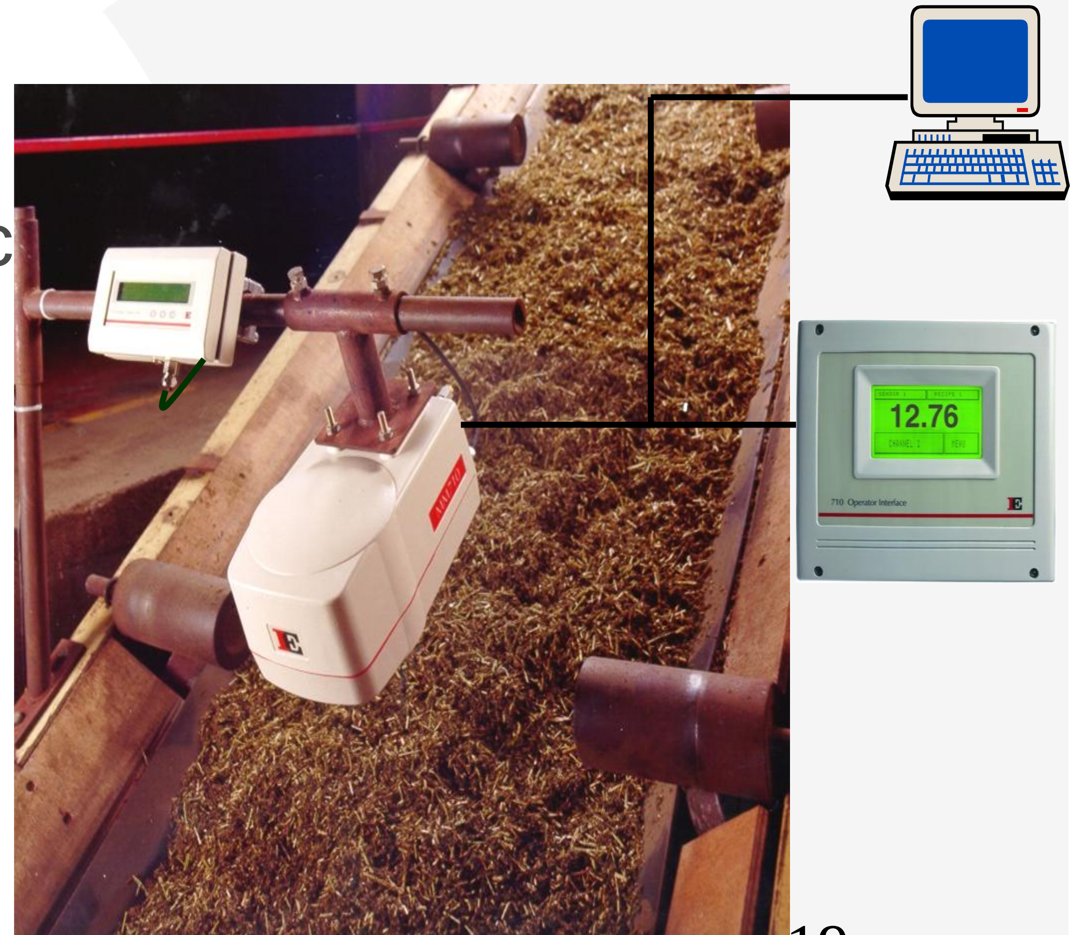


- Process settings low, medium, high moisture

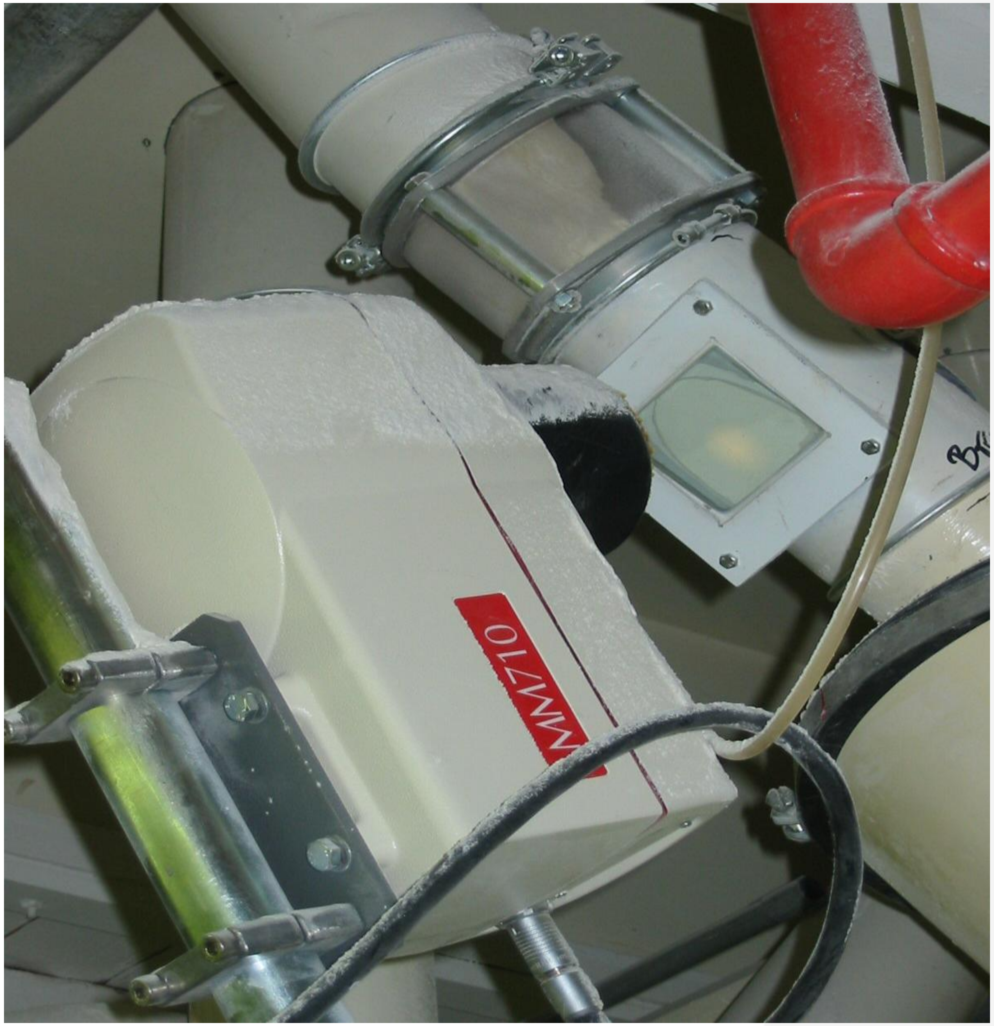
Sampling Procedure

Steps for sampling

- Collect samples within the preset 10 s
- Put samples in a plastic bag
- Standard deviation within expected magnitude?
- Transport to laboratory mixing in the closed bag



Moisture measurement in flour



Source: NDC Infrared Engineering

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Total variance in calibration

Assumption: s_{gauge} = +/- 0.1 %
$s_{reference}$ = +/- 0.2 %
$s_{sampling}$ = +/- 0.3 %

SEP^2 total = S^2gauge + S^2sampling + S^2reference

SEP total = +/- 0.374 % (including sampling)

SEP total = +/- 0.224 % (without sampling)

SEP = Standard Error of Prediction

Summary

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- User should know about the errors in calibration
- Calibration has become easier
  - Pre-calibrated gauges
  - Trim adjustments
  - Sampling system
  - High stability by design
- Accuracy of on-line moisture systems
  - laboratory method on site,
  - sampling method
  - quality of gauge design