Eurachem ✪CITAC

Experimental validation of the evaluated measurement uncertainty

Anders Svaneborg
Prod. BU Manager
Department for Metals and Minerals
[Eurofins Environment, DK]

Skriv gärna Symboler med kursiv men subscript med vanlig *Typ*

S_I

1

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Agenda

- Eurofins DK – short presentation

- Method validation and initial evaluation of measurement uncertainty – how we do
  - References and procedures
  - Initial evaluation of measurement uncertainty

- Experimental validation of evaluated measurement uncertainty – how we do
  - References and procedures
  - Topdown approach
  - Contribution from random errors; within laboratory reproducibility, $u(R_w)$
  - Contribution from systematic errors; bias, $u(bias)$
  - Inclusion of contribution from other sources ?
  - Combining standard uncertainties
  - Calculating expanded uncertainty
  - Reporting expanded uncertainty

2

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Measurement uncertainty evaluation based on in-
house validation data

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
Eurofins DK – short presentation

- Eurofins Environment

- Eurofins Food/Feed

- Eurofins Agro

- Eurofins Product Testing

- Eurofins Pharma

- Eurofins Genomics

- < 1100 employees in total

3

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PROPOSE min 16 pt font

Method validation and initial evaluation of measurement uncertainty - how we do

References and procedures
- Eurachem Guide, The Fitness for Purpose of Analytical Methods, A Laboratory Guide to Method Validation and Related Topics, Second edition
- Eurolab Danmark, Vejledning vedr. metodevalidering i kemisk analytiske laboratorier, 1. udgave
- Internal procedure (Eurofins Environment); 60 5404 Metodevalidering (Kemi)

Layout
- Low control; sample with relevant matrix and known content at LOQ level
- High control; sample with relevant matrix and known content in middle or high range
- at least 16 replicates for both samples, over 2 (or more) days
- calculations: LOD, LOQ, S_w, S_b, S_t, RSD%, bias, u_{bias}, u_c (combined standard uncertainty), U_{rel} (= expanded standard uncertainty, normal range), U_{abs} (= expanded standard uncertainty at LOQ level)

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Method validation and initial evaluation of measurement uncertainty - how we do

Formulas

- LOD = 3 x S_w
- LOQ = 10 x S_w
- $u_{bias} = \sqrt{(bias)^2 + \left(\dfrac{s_b}{\sqrt{n}}\right)^2 + (u_{ref})^2}$
- $U_{rel} = 2x\sqrt{(u_{bias})^2 + (CV_t)^2}$
- $U_{abs} = 2x\sqrt{(u_{bias})^2 + (s_t)^2}$

Define symbols
Sw sb si cvi

5

5

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Experimental validation of evaluated measurement uncertainty – how we do
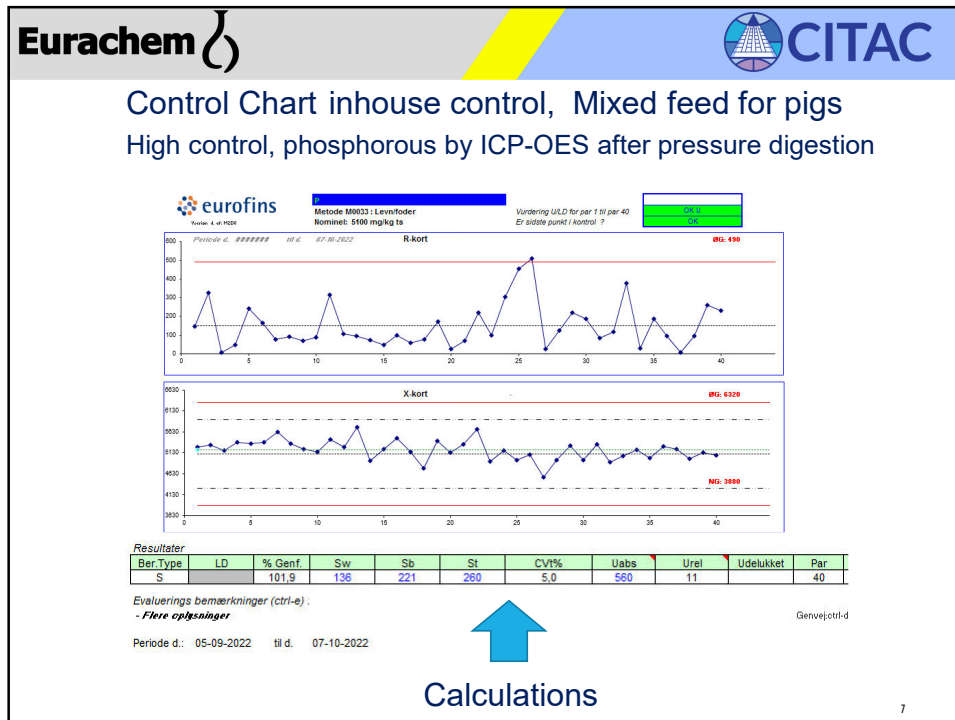
References
- EURACHEM / CITAC Guide CG 4, Quantifying Uncertainty in Analytical Measurement
- NORDTEST NT TR 537 edition 4 2017:11, Handbook for Calculation of Measurement Uncertainty in Environmental Laboratories

Procedures
- Topdown approach: Use data from Internal Quality control
  - Run in every sequence 2 low control and 2 high controls samples
  - Plot results in XR chart
  - The following parameters can all be calculated for any chosen period ;
    - LOD, LOQ, S_w, S_b, S_t, RSD%,
    - bias, u_{bias}, u_c (combined standard uncertainty),
    - U_{rel} (= expanded standard uncertainty, normal range),
    - U_{abs} (= expanded standard uncertainty at LOQ level)
  - Compare bias for control samples with bias achieved in proficiency testings

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Control Chart inhouse control, Mixed feed for pigs
High control, phosphorous by ICP-OES after pressure digestion

Calculations

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Calculations of uncertainty, high control

From control chart , Phosphorous, mixed feed for pigs

- recovery = 101,87 % → bias = 1,87 %
- s_{bias} = 4,25 %
- n = 40
- u_{ref} = 0 (means u_{ref} is not taken into account)
- CV_t = 5,00 %

$\Rightarrow u_{bias}$ = sqroot (1,87^2 + (4,25/sqroot(40))^2 + 0^2)

= 1,99 %

$$u_{bias} = \sqrt{(bias)^2 + \left(\frac{s_b}{\sqrt{n}}\right)^2 + (u_{ref})^2}$$

$\Rightarrow U_{rel}$ = 2 x sqroot(1,99^2 + 5,00^2)

= 10,76 %

≈ 11 %

$$U_{rel} = 2x\sqrt{(u_{bias})^2 + (CV_t)^2}$$

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## Is anything missing ?

- Are control samples certified ? or "just" inhouse control samples ?
  If inhouse: "True" value might be wrong, and systemativ errors (bias) might be wrongly estimated (typically underestimated, but might also be overestimated)

- Are control samples more homogeneous than real customer samples ?
  If yes: Random errors might be underestimated

- Does control samples undergo total analysis, including all sample preparation steps ? If not, both random and systematic errors might be underestimated

- What about uncertainty arising from sampling in the field ?
  According to ISO 17025 the lab shall include this.   But national / local regulation can have other demands. E.g. Environmental monitoring in Denmark: Uncertainty arising from sampling in the field is *not*, and shall *not* be included

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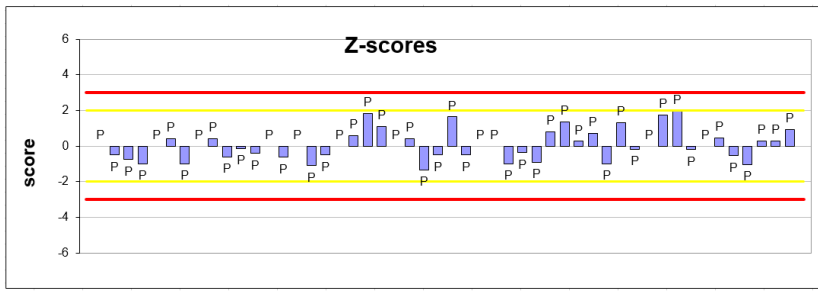**Eurachem** **CITAC**

Estimating u_{bias} from proficiency testing

Trend curve, phosphorous by ICP-OES after pressure digestion

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Measurement uncertainty evaluation based on in-house validation data

Slide 11

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Estimating u_{bias} from proficiency testing

Date	PT	Nominel værdi	Målt værdi	bias %
21-01-2019	Metal - ID 2011 - Bipea 67 pet food 5-1067-0074	0,22	0,22	0,00
14-03-2019	Metal - ID 2015 - Bipea 67 pet food 6-1367-0119+0128	0,17	0,16	-5,88
15-03-2019	Metal - ID 2016 - Bipea 67 pet food 5-1567-0017	2,41	2,39	-0,83
14-05-2019	Metal - ID 2050 - Bipea 67a 6-0167-0011+0012 wet cat food	0,26	0,24	-7,69
14-05-2019	Metal - ID 2051 - Bipea 67a 6-0367-0004 Dog food	0,74	0,74	0,00
14-05-2019	Metal - ID 2052 - Bipea 67a 6-2167-0070 Vitamin supplements	0,42	0,43	2,38
14-05-2019	Metal - ID 2050 - Bipea 67a 6-0167-0011+0012 wet cat food	0,26	0,24	-7,69
14-05-2019	Metal - ID 2051 - Bipea 67a 6-0367-0004 Dog food	0,74	0,74	0,00
14-05-2019	Metal - ID 2052 - Bipea 67a 6-2167-0070 Vitamin supplements	0,42	0,43	2,38
04-09-2019	ID2079	0,27	0,26	-3,70
05-09-2019	Metal-ID2100-IAG International analytical group	2,9	2,91	0,34
05-09-2019	Metal-ID2100-IAG International analytical group	6,7	6,6	-1,49
18-11-2019	Metal - ID 2132 - NEPT 17	0,8	0,8	0,00
18-11-2019	Metal - ID 2132 - NEPT 17	0,24	0,23	-4,17
21-11-2019	Metal - ID 2105 - Bipea Dog premix 6-0767-0093	0,09	0,09	0,00
20-01-2020	Metal - ID 2137 - Fapas 1897 milk powder	996,3	951,3	-4,52
05-03-2020	Metal - ID 2183 - Bipea wet dog food 7-1367	0,27	0,26	-3,70
05-03-2020	Metal - ID 2184 - Bipea fish meal 6-1567	2,06	2,06	0,00
25-03-2020	Metal - ID 2139 - Internal PT Metals Food - Round 1 wheat flour	3051	3100	1,61

$$RMS_{bias} = \sqrt{\frac{\sum (bias_i)^2}{N}}$$

$$u(Cref) = \frac{\sum_{i=1}^{N} u(Cref_i)}{N}$$

$$u(bias) = \sqrt{RMS_{bias}^2 + u(Cref)^2}$$

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Slide 12

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Estimating u_{bias} from proficiency testing

From proficiency testing
- N = 49 (number of PT)
- $\sum (bias_i)^2 = 5,47 \%$ SKALL STÅ RMS?
- u(Cref) = 3,21 %

$\Rightarrow u_{bias} = \sqrt{5,47^2 + (3,21^2)}$

= 6,34 %

$\Rightarrow U_{rel} = 2 \times \sqrt{6,34^2 + 5,00^2}$
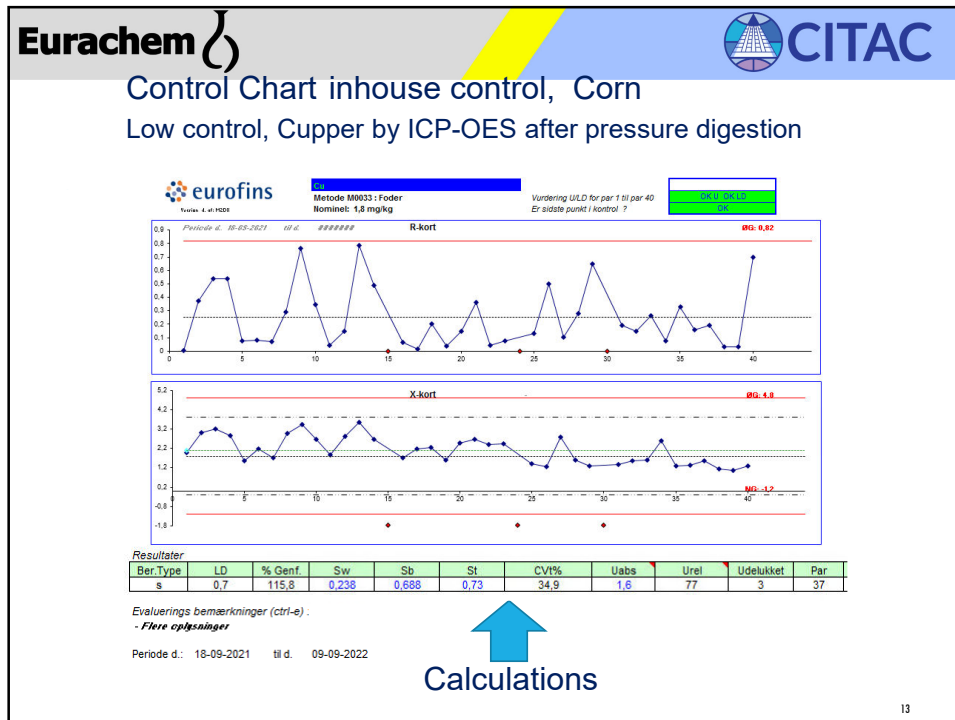
= 16,15 %

$$RMS_{bias} = \sqrt{\frac{\sum (bias_i)^2}{N}}$$

$$u(Cref) = \frac{\sum_{i=1}^{N} u(Cref_i)}{N}$$
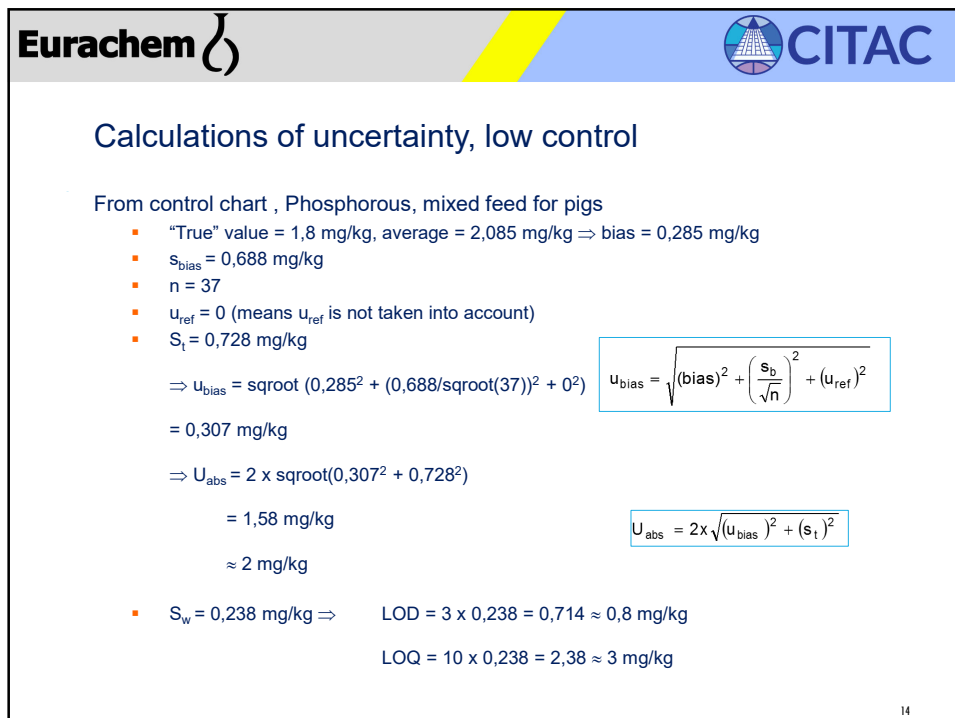
$$u(bias) = \sqrt{RMS_{bias}^2 + u(Cref)^2}$$

$$U_{rel} = 2x \sqrt{(u_{bias})^2 + (CV_t)^2}$$

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Slide 13

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Control Chart inhouse control, Corn
Low control, Cupper by ICP-OES after pressure digestion

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Slide 14

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Calculations of uncertainty, low control

From control chart , Phosphorous, mixed feed for pigs

- "True" value = 1,8 mg/kg, average = 2,085 mg/kg $\Rightarrow$ bias = 0,285 mg/kg
- s_{bias} = 0,688 mg/kg
- n = 37
- u_{ref} = 0 (means u_{ref} is not taken into account)
- S_t = 0,728 mg/kg

$\Rightarrow u_{bias}$ = sqroot (0,285^2 + (0,688/sqroot(37))^2 + 0^2)

$$u_{bias} = \sqrt{(bias)^2 + \left(\frac{s_b}{\sqrt{n}}\right)^2 + (u_{ref})^2}$$

= 0,307 mg/kg

$\Rightarrow U_{abs}$ = 2 x sqroot(0,307^2 + 0,728^2)

= 1,58 mg/kg

$$U_{abs} = 2x \sqrt{(u_{bias})^2 + (s_t)^2}$$

$\approx$ 2 mg/kg

- S_w = 0,238 mg/kg $\Rightarrow$ LOD = 3 x 0,238 = 0,714 $\approx$ 0,8 mg/kg

         LOQ = 10 x 0,238 = 2,38 $\approx$ 3 mg/kg

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Reporting uncertainty

- .... (to be finished)

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