Practical and Valid Guidelines for Realistic Estimation of Measurement Uncertainty in Pesticide Multi-Residue Analysis*

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Practical and Valid Guidelines for Realistic Estimation of Measurement Uncertainty in Pesticide Multi-Residue Analysis

- Introduction
- Measurement Uncertainty and Confidence in a Test Result
- ~~"Bottom-up"~~ and "Top-down" Evaluations
- EURACHEM and CODEX Guidelines
- CODEX Guidelines – Amendment 2011
- Sample Preparation (homogeneity) Uncertainty Component
- Use of Uncertainty for Compliance Decisions

GUM Fundamentals

GUM (BIPM, IEC, IFCC, ISO, IUPAC, OIML)

Guide to the Expression of Uncertainty in Measurement

(ISO, Geneva, 1993 - Reprinted 1995 – Reissued as ISO Guide 98-3, 2008)

"*A parameter associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributted to the measurand*"

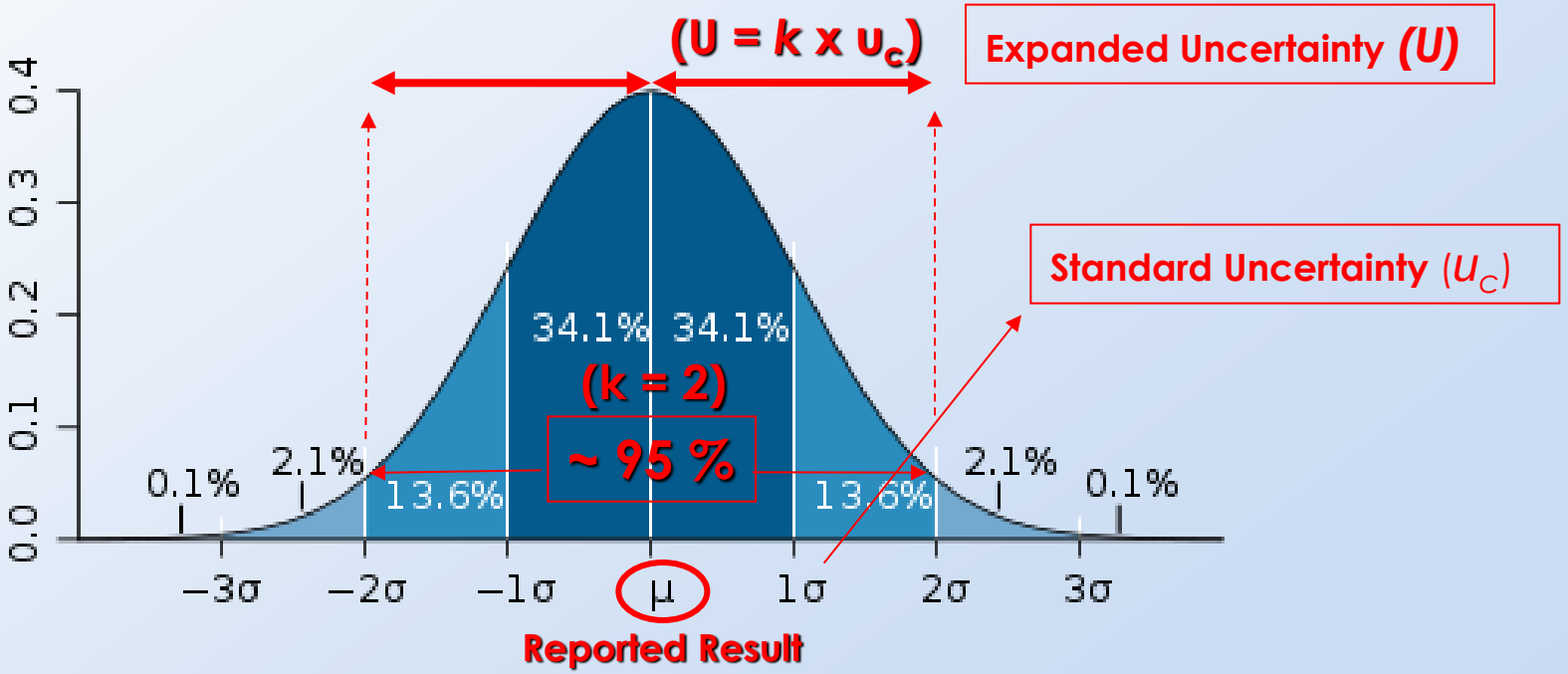
- Uncertainty is seen from a positive point of view.
- A realistic uncertainty statement always improve the quality of the result.
- Transparent, simple and standardised procedure for evaluation / expression.
- Type A and Type B evaluations (do not use random and systematic errors!).
- Combined Standard Uncertainty (u_c) / Expanded Uncertainty (U).

Measurement Uncertainty

This parameter may be:

- A standard deviation ***(combined standard uncertainty "u_c")***
- The width of a confidence interval ***(expanded uncertainty "U")***
- $U = k \cdot u_c$ *(usualy, 95% confidence with k = 2)*

If the dispersion attributed to the measurand is a NORMAL DISTRIBUTION:



Reporting a Result with its Uncertainty

Result with a previously fixed level of confidence

Result = Value ± expanded uncertainty (k = 2; 95%)

A Realistic Pesticide Residue Test Result

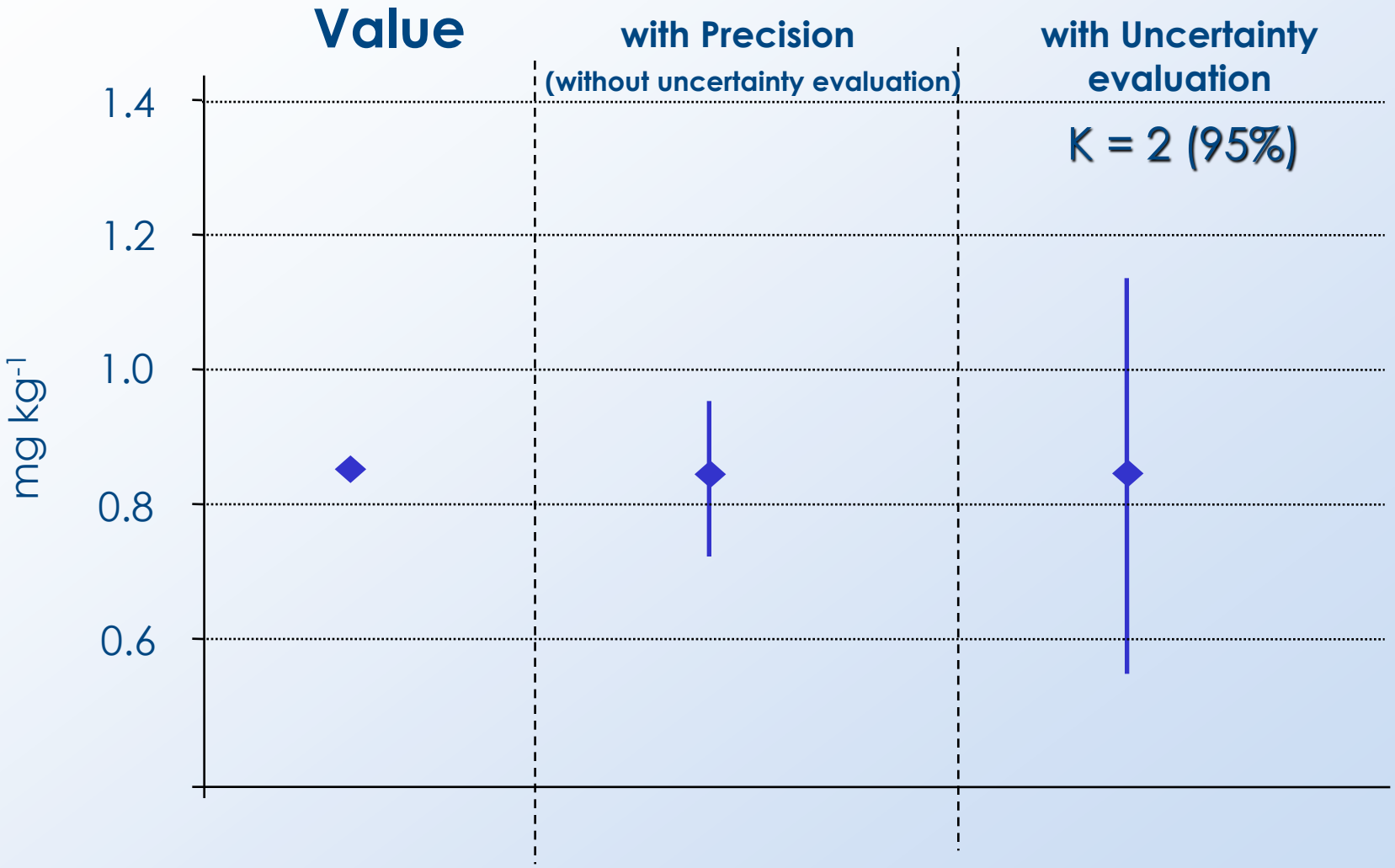
0.85 ± 0.30 mg/kg (k = 2; 95%)

from 0.55 to 1.15 mg/kg!

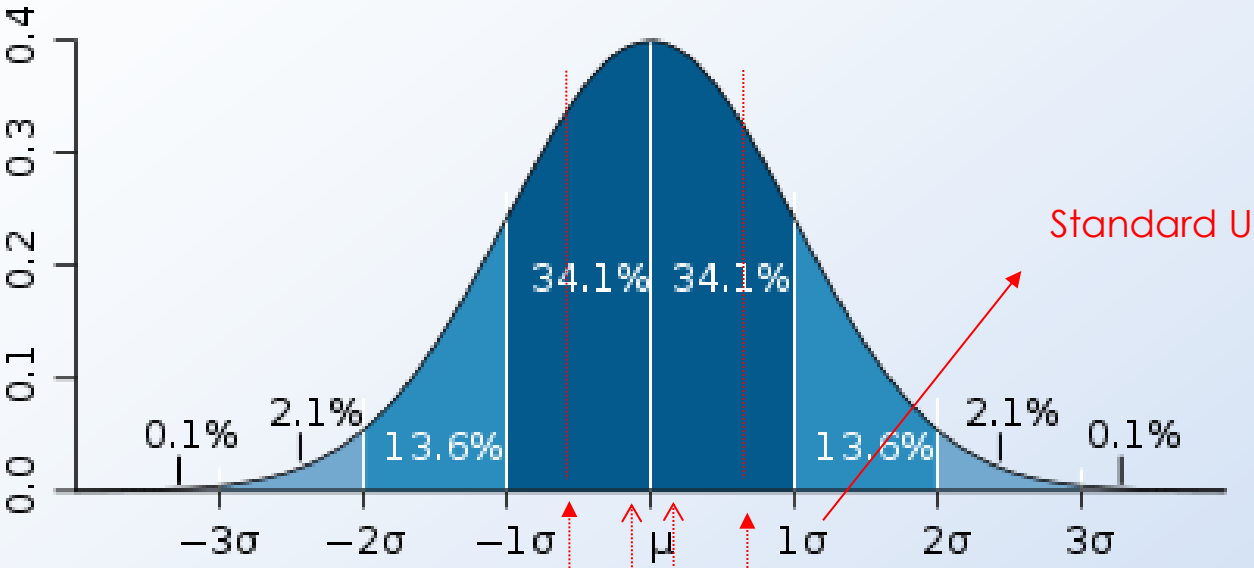
The estimated uncertainty must be realistic and reliable for the intended purpose, if not the result has no value !!!

~~0.85 ± 0.01 mg/kg~~

Reporting a Result



"Quality" of ("Confidence" in) the Result



Standard Uncertainty (u_c)

0.85 mg/kg (~ 2.5%)

0.845 - 0.854

just the Value

0.85 ± 0.10 mg/kg (~ 50%)

0.75 - 0.95

with precision ± 0.10 mg/kg

0.85 ± 0.30 mg/kg *(95%)*

1.15 - 0.55

with expanded uncertainty, k=2

($U = k \times u_c$)

previously fixed Confidence Level

Reported Result

Uncertainty – Analytical Measurement Guidelines

EURACHEM / CITAC Guide CG 4 (QUAM:2012.P1)
Quantifying Uncertainty in Analytical Measurement
(3rd Edition, 2012)

NORDTEST Technical Report TR537
Handbook for Calculation of Measurement Uncertainty in Environmental Laboratories (2003)

EUROLAB Technical Report No. 1/2002
Measurement Uncertainty in Testing (2002)

EUROLAB Technical Report No. 1/2006
Guide to the Evaluation of Measurement Uncertainty for Quantitative Test Results (2006)

EUROLAB Technical Report No. 1/2007
Measurement Uncertainty Revisited: Alternative Approaches to Uncertainty Evaluation (2007)

Guidelines - Codex Alimentarius

Specific Guidelines for Pesticide Residue Analysis
(Codex Committee on Pesticide Residues - CCPR)

CAC/GL 59-2006

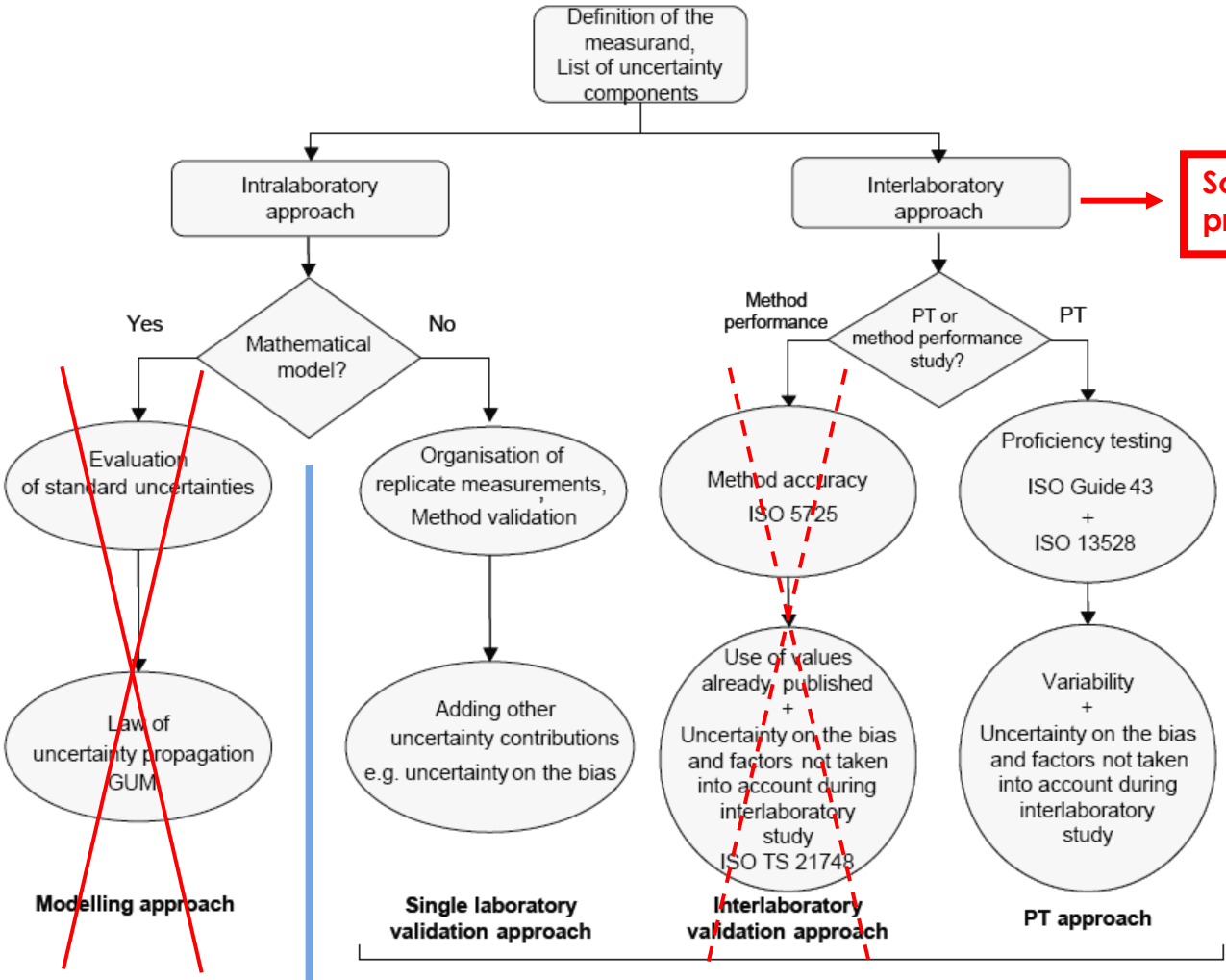
Guidelines on Estimation of Uncertainty of Results

↓ CCPR 43rd Session (Beijing, P.R. China, 4-9 April 2011)

Amendment 2011

Introduction of an ANNEX with some examples on practical aproaches for the estimation of uncertainty of results in pesticide residue tests (CX/PR 11/43/10)

EUROLAB road map for uncertainty estimation approaches
(modified for Multiresidue Analysis of Pesticides)



Default-Fixed Fit-For-Pourpose Value

Scientific judgements previous experience

Horwitz Equation concentration -dependent

~~bottom-up~~ top-down

ISO/IEC 17025: 2005
5. Technical requirements

5.4. Test methods and method validation

5.4.6. Estimation of uncertainty of measurement

"… Testing laboratories shall have and shall apply procedures for estimating **uncertainty** of measurement. In certain cases the nature of the test method may preclude rigorous, metrologically and statistically valid, calculation of uncertainty of measurement …"

No doubt, pesticide multi-residue analysis is one of these cases !!!

EURACHEM/CITAC Guide CG 4 (QUAM:2012.P1)

Quantifying Uncertainty in Analytical Measurement

(3rd Edition, 2012)

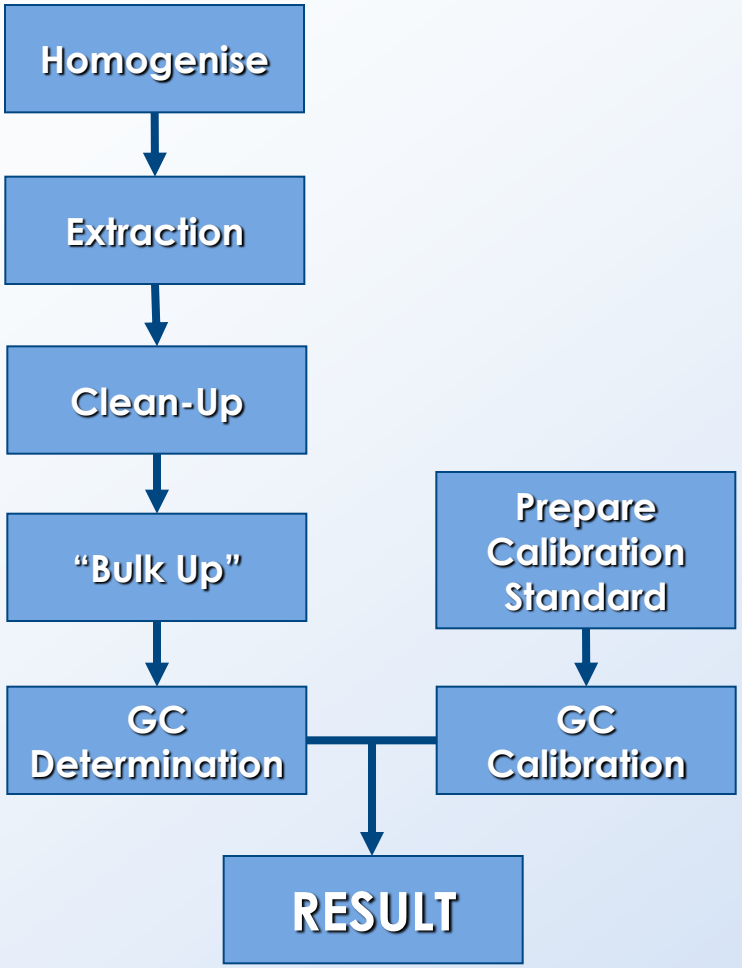
Example A4

Uncertainty Estimation from In-House Validation Studies

Determination of Organophosphorous Pesticides in Bread

Obtaining an overall uncertainty estimate by evaluation of a representative selection of typical pesticides on a wide variety of matrices and levels representing the overall scope of the method !!!

Organophosphorus Pesticides Analysis



Measurand:

$$P_{op} = \frac{I_{op} \bullet c_{ref} \bullet V_{op}}{I_{ref} \bullet Rec \bullet m_{sample}} \bullet F_{hom} \bullet F_I \ (mg/kg)$$

- P_{op}: Level of pesticide in the sample (mg kg^{-1})
- I_{op}: Peak intensity of the sample extract
- c_{ref}: Mass concentration of the reference standard (µg ml^{-1})
- V_{op}: Final volume of the extract (ml)
- I_{ref}: Peak intensity of the reference standard
- Rec: Recovery
- m_{sample}: Mass of the investigated sub-sample (g)
- F_{hom}: Correction factor for sample inhomogeneity
- F_I: Correction factor for intermediate precision

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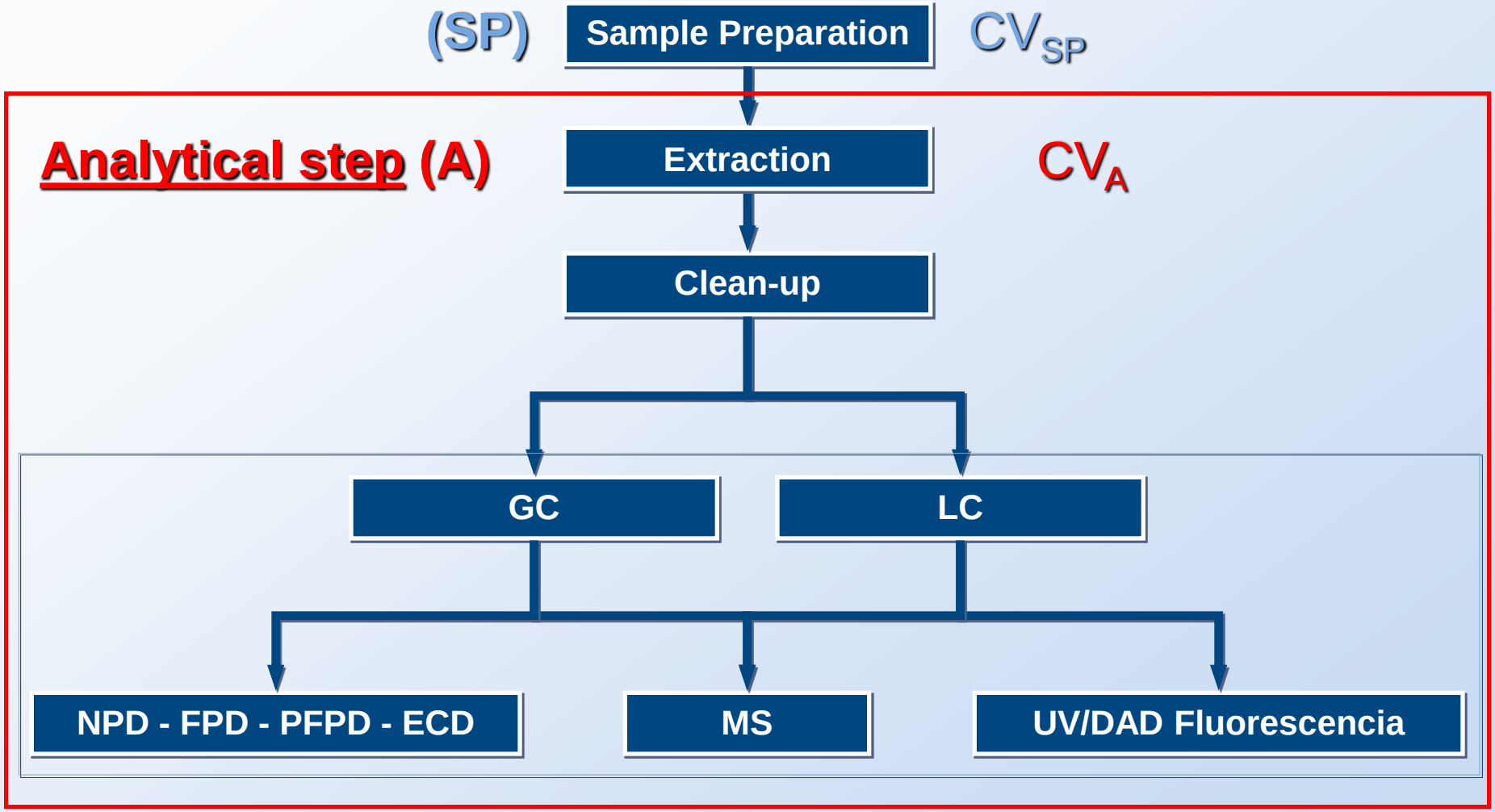
Measurement Uncertainty of the Laboratory

Standard Deviation (S_L) or Relative Standard Deviation (CV_L)



Guidelines - Codex Alimentarius

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Guidelines on Estimation of Uncertainty of Results

$$CV_{Res} = \sqrt{CV_S^2 + CV_L^2} \quad \text{and} \quad CV_L = \sqrt{CV_{Sp}^2 + CV_A^2}$$

- ~~Sampling (CV_S)~~
- Sample Preparation (CV_{SP})
- Analytical step (CV_A)
- Laboratory (CV_L)

EURACHEM / CITAC Guide CG 4 (QUAM:2012.P1)

$$u'_c = \sqrt{u'_{hom}{}^2 + u'_{rep}{}^2 + u'_{bias}{}^2}$$

CV_{SP}^2 CV_A^2

CAC/GL 59-2006 – Amendment 2011 (Annex)

3 Intra-Laboratory Validation/QC/PTs Data

$$u' = (u'_{Rw}{}^2 + u'_{bias}{}^2)^{1/2}$$

Relative intra-laboratory reproducibility SD (QC)

a $(u'_{bias})_{PT}$ → Root Mean Square of relative PTs bias & $u'(C_{ref})_{PT}$

b $(u'_{bias})_{QC}$ *No-correction* → Root Mean Square of relative QC bias & $u'(C_{ref})_{QC}$

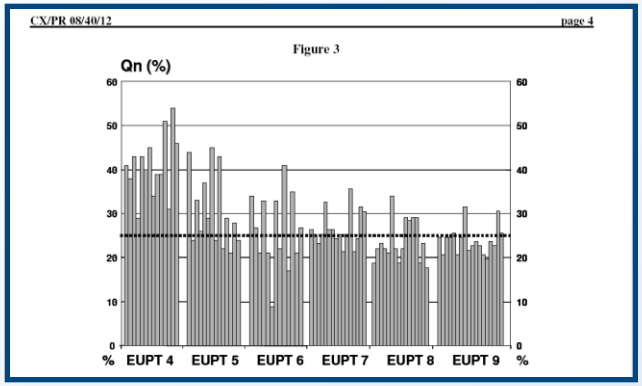
c $(u'_{bias})_{QC}$ *Mean Rec. Correction* → $u'(\text{Mean Rec.})_{QC}$ & $u'(C_{ref})_{QC}$

$(\sum(\text{bias})^2/n)^{1/2}$

$u'_{Rw} / n^{1/2}$

CAC/GL 59-2006 – Amendment 2011 (Annex)

1



Default-Fixed Value (50% / EU)

2

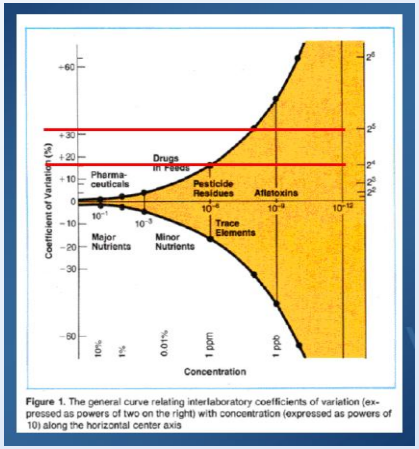


Figure 1. The general curve relating interlaboratory coefficients of variation (expressed as powers of two on the right) with concentration (expressed as powers of 10) along the horizontal center axis

Concentration-Dependent Formula (HORWITZ)

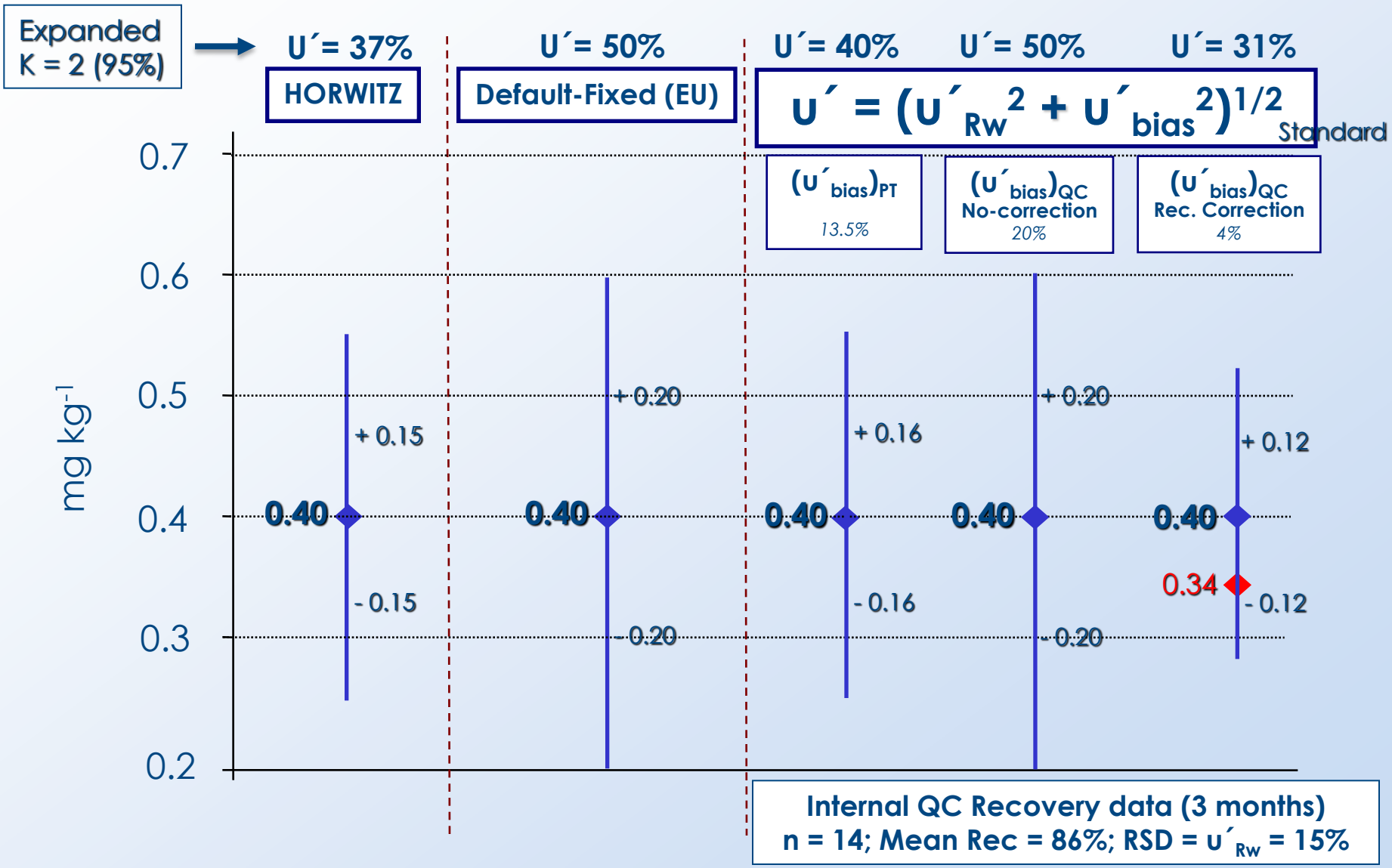
$$RSD_R = 2^{1-0.5\log c} = 2 * c^{-0.1505}$$

C (kg/kg)

$$U = k \,.\, RSD_R$$

CAC/GL 59-2006 (Annex)

Reporting a Result of 0.40 mg/kg



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Sample Preparation (homogeneity) Uncertainty Component

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$$CV_{Res} = \sqrt{CV_S^2 + CV_L^2} \quad \text{and} \quad CV_L = \sqrt{CV_{Sp}^2 + CV_A^2}$$

- ~~Sampling (CV_S)~~
- Sample Preparation (CV_{SP})
- Analytical step (CV_A)
- Laboratory (CV_L)

Usualy, not included in the uncertainty evaluations !!!

EURACHEM / CITAC Guide CG 4 (QUAM:2012.P1)

$$u_c = \sqrt{u_{hom}^2 + u_{rep}^2 + u_{bias}^2}$$

u_{hom}^2 = CV_{SP}^2 ; u_{rep}^2 = CV_A^2

Sample Preparation (homogeneity) Uncertainty Component

Usualy, not included in the uncertainty evaluations

(1) (2) (3) (4) (6) (7) (8)

CV_A

CV_L

CV_{SP}

(1) (2)

$$CV_{SP} = \sqrt{CV_L^2 - CV_A^2}$$

The uncertainty resulting from the procedures applied to a laboratory sample to obtain the test portion may be an important component of the combined uncertainty of the laboratory

Eurachem

CITAC

Co-Operation on International Traceability in Analytical Chemistry

EURACHEM / CITAC Guide

Use of uncertainty information in compliance assessment

First Edition 2007

Many thanks for your attention!