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1.9 Measurements of Uncertainty

In an effort to comply with ISO considerations and in as much as scientific measurements, in general, are subject to variability, a budget estimating of uncertainty of measurement for alcohol and quantitative drug analysis is presented.

1.9.1 Uncertainty Components

Components of uncertainty need to be classified into distinct categories. These categories will be designated as Type A and Type B uncertainties. In this model, Type A uncertainties for alcohol analysis will include duplicate blood alcohol (BAC) results for an individual case. Type A uncertainties for drug analysis will include historical control and calibrator results. Type B uncertainties for both areas will be based on manufacturer's specifications for analytical glassware or other equipment and reagents.

1.9.1.1 Blood Alcohol Analysis

Type A:

1. Blood alcohol result (lower of two results as per current protocol).

Type B:

1. Class A volumetric pipet (5 ml)
2. 100 ml volumetric flask
3. 1 ml glass syringe
4. 2 liter volumetric flask
5. Diluter/dispenser
6. Ethanol standard reference material

1.9.1.2 Drug Toxicology Analysis

Type A:

1. Historical calibrator and control results

Type B:

1. Pipettors of various sizes
2. 2 ml serological pipettes
3. 1000 ml graduated cylinder
4. 5000 ml dispensette
5. Cerrilliant reference materials

1.9.2 Calculations

Uncertainties may be correlated or uncorrelated. If correlated, they may cancel each other out and if uncorrelated they are combined using the Root Sum Squares formula:

$$U_{combined} = \sum_{1}^{n} \left((U_1)^2 + (U_2)^2 + (U_3)^2 \ldots (U_n)^2 \right)^{1/2}$$

Once the Combined Uncertainty has been calculated an Expanded Uncertainty can then be obtained. The Expanded Uncertainty is a final estimated uncertainty obtained by multiplying the combined uncertainty

by a coverage factor(k) that relates to a particular level of confidence. For a 95% confidence level, k=2 and for 99.7%, k=3.

Once the expanded uncertainty has been calculated, a statement of the findings can be generated. The Final Statement should declare the identity of the analyte, the uncertainty range and the appropriate level of confidence.

1.9.2.1 Blood Alcohol

The following worksheet shows an example of estimation of uncertainty for alcohol analysis. Uncertainty is generally approximately 5%. The Unit's protocol of reporting the lower of the two measured values, rather than the mean of the two plus an uncertainty statement, is the more conservative approach of the two as it reports a lower value and thus gives the benefit to the defendant.

Source of Uncertainty	Value	Distribution	Divisor	Uncertainty (U_n)
BAC #1	0.151	normal	1	
BAC #2	0.154	normal	1	
BAC Average	0.153			
BAC STD DEV	0.0015			
Convert BAC STD DEV to %	0.9836%	Gaussian	#2	0.69551%
Volume of Calibrators				
Class A Volumetric pipet: 5.0ml +/- 0.01ml	0.200%	rectangular	#3	0.1155%
Volumetric flask: 100ml +/- 0.08ml	0.0800%	rectangular	#3	0.04619%
Volume of Internal Standard				
Syringe: 1.0ml +/- 0.1%	0.1%	rectangular	#3	0.058%
Volumetric flask: 2.0 liter +/- 0.3ml	0.01500%	rectangular	#3	0.00866%
Volume of Specimen (50 ul)				
Diluter/ Dispenser error	0.008%	rectangular	#3	0.00462%
Concentration of Calibrators				
200 +/- 6.2	3.10000%	rectangular	#3	1.78979%

Combined Uncertainty RSS	1.80%			
Confidence level	99.70%			
Expanded Uncertainty	5.38517%			
Uncertainty	0.153 +/- 0.0082			
Uncertainty Declaration	**0.153 +/- 0.0082 @ 99.7% Confidence Level**			

Notes: U(combined): $(U^2_1 + U^2_2 + U^2_3 + \ldots)^{1/2}$
U(expanded): U(combined) X k
Uncertainty: Sample value X U(expanded)
Uncertainty Declaration: sample value +/- uncertainty @ 99.7% Confidence Level

1.9.2.2 Drug Toxicology

Toxicology quantitative measurements are made only once. Therefore, there is no mean and standard deviation associated with values given for any analyte in any individual case. However, for each assay, estimates of uncertainty of measurement may be calculated for each of the four calibrators and two controls, and an average measurement of uncertainty generated for the quantitative range of the assay. The following shows the average % uncertainty calculated at the 99.7% confidence level, given by assay, analyte and matrix. Overall, uncertainty is approximately 8% across all procedures.

Assay	% Uncertainty
acid/neutral/basic drugs (ANB) (alprazolam, amphetamine, benzoylecgonine, butalbital, carisoprodol, chlordiazepoxide, cocaine, codeine, diazepam, hydrocodone, methadone, methamphetamine, meprobamate, morphine, nordiazepam, oxycodone, phenobarbital, propoxyphene, tramadol, zolpidem)	**8.35**
cannabinoids blood: THC, THC-COOH urine: THC-COOH	**7.98**
GHB (blood and urine)	**7.80**
negative chemical ionization (NCI) (clonazepam, lorazepam, oxazepam, temazepam, triazolam)	**7.80**
CO	See Performance Tables, p. 103, OSM3 User's Handbook

1.9.2.3 References

1. LeBeau, Mark. Uncertainty of Measurement in Forensic Toxicology. S.O.F.T. Workshop, 2006.

2. LeBeau, Mark. Uncertainty of Quantitative Measurements S.O.F.T. Workshop, 2008.
3. Westgard QC. Time to engage in measurement and uncertainty. www.westgard.com.
4. ISO/IEC 17025:2005(E)

1.9.2.4 Internet Resources

1. http://physics.nist.gov/Pubs/guidelines/
2. http://stattrek.com/Lesson3/Variability.aspx