Estimation of Uncertainty of Measurements

Uncertainty is defined as the parameter associated with the result of a measurement that characterizes the dispersion of values that could reasonably be attributed to that measurement (Heinbaugh, AIHA Guidelines for Measurement of Uncertainty, 2005) Uncertainties allow the client to properly interpret data in a report and are used in determining how good a test result actual is.

It is generally accepted that there are two major contributers to uncertainty (See Attachment 3). The first is termed “Type A” and includes values that may be determined statistically (aka “random contributers”). The second is the “Type B” contributer and are those that can not be determined by statistical means.

“Type A” uncertainties may include but are not limited to:

Uncertainty in repeatability

Uncertainty due to instrument drift

Uncertainty due to instrument non-linearity

Uncertainty due to rounding of instrument readings

Uncertainty of volumes associated with Class A glassware

Uncertainty of volumes associated with glass pipettes and/or Eppendorf pipettes

Uncertainty associated with temperature/volume changes

Uncertainty associated with analytical balance weighing

“Type B” uncertainties may include but are not limited to:

Uncertainty associated with chemical purity of reference materials and standards

Uncertainty in atomic weights

Once both “Type A” and “Type B” errors have been determined, they may be combined using the technique of root-mean square to obtain an estimate of total uncertainty:

$$\mu_o = \sqrt{\sum \mu_i^2}$$

However, in most cases for chemical analyses, the “Type B” contribution is usually insignificant and may be ignored. Given this assumption, then only error associated with “Type A” uncertainties need be considered.

Uncertainty resulting from “Type A” contributers can be estimated using the overall uncertainty in the entire analytical procedure. This can be determined by measuring the dispersion of values obtained from a known certified reference standard using the proper number of data points (20-30 points is typically recommended). Both bias (average % yield – 100) and precision (standard deviation of % yield) can be determined and reported for any given analytical technique.

Due to the nature of the services provided by the ARL, estimating a numerical value for uncertainties of measurement associated with sampling is not possible. The ARL does not provide its own sampling group and how the sample is handled prior to its arrival at the lab is an unknown quantity. The client should be aware that the ARL's estimate of uncertainty does not include any error associated with sampling handling or collection prior to that sample's arrival at the laboratory.

Estimates of Uncertainties for ARL Certified Analytes		
Analyte	**Bias**	**Precision**
Al	+ 0.80	± 6.47%
B	+ 2.49	± 4.85%
Ba	+ 1.66	± 1.93%
Ca	+ 2.21	± 3.36%
Cd	+ 2.98	± 2.41%
Cu	+ 1.31	± 2.95%
Fe	- 3.73	± 3.46%
K	+ 2.03	± 3.60%
Mg	+ 0.37	± 3.87%
Mn	+ 1.42	± 3.32%
Na	+ 1.19	± 2.76%
Ni	+ 1.52	± 2.90
P	+ 2.03	± 3.60%
Pb	+ 0.73	± 2.64%
Zn	- 1.83	± 3.56%
NOx	+ 0.95	± 3.61%
NH3	+ 0.31	± 2.61%
Total P	- 2.74	± 3.90
Ortho P	+ 1.46	± 3.16%
TKN	+ 0.06	± 6.58%
Cl	+ 1.81	± 4.35%
pH	- 0.95	± 8.54%
EC	+ 0.53	± 2.94%