How to calculate standard uncertainties for each source of uncertainty?

In evaluating the combined uncertainty of a testing method from various sources of uncertainty, we need to ensure that we work on a platform of standard uncertainties expressed as standard deviations throughout, because in addition to the standard uncertainty (u) values obtained by our own evaluation (Type A uncertainty), we may also encounter the so-called Type B uncertainty contributions which are uncertainty (U) values given by a third party or from experience and other information in different forms.

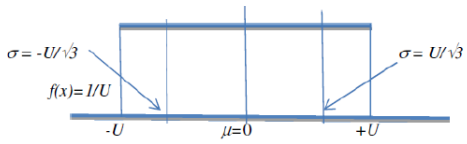
For example, an uncertainty contributor to the overall uncertainty estimation may come from a certified reference material with a stated uncertainty (U), or may be based on the uncertainty (U) provided on a calibration certificate.

These uncertainties are actually expanded uncertainty which is a product of a standard uncertainty, u, and a coverage factor, k, in equation $U = u \times k$. If the certified value is accompanied with a statement of confidence level, say 95%, we generally use $k = 2$. To be exact, k should be 1.96, the z-value of a normal probability distribution at 95% confidence level. So, in this case, we need to calculate its standard uncertainty by dividing the U with k before we proceed to do the overall combined estimation of standard uncertainty.

There are rules to convert the uncertainty to an estimated standard uncertainty (u) as shown below:

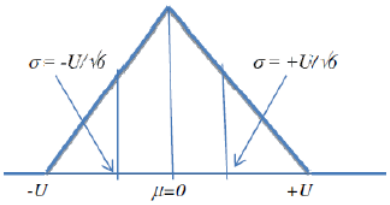
a. When a laboratory conducts replicated analysis on a test method over time, the standard deviation s of the mean value after n observations is an intermediate precision (also known as intermediate reproducibility) of the method. The standard uncertainty in the mean value is simply the standard deviation s of the mean value divided by $\sqrt{n}$.
b. If the precision of a validated method for a similar material has been established with a relative standard deviation R', the uncertainty due to random variation when using only a single observation (x) is then calculated as xR'.
c. When an uncertainty (U) of a value (a) is obtained from a third party such as chemical supplier or apparatus catalogue without standard confidence level, we shall estimate its standard uncertainty in the form of $a/\sqrt{3}$ by assuming a rectangular distribution which describes a variable which can take any value within a particular range with *equal* probability.

Rectangular probability distribution



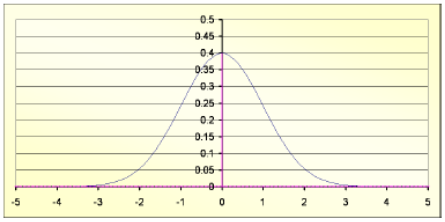
d. If there is good reason to expect observed values to be near to a more likely, we can assume a triangular distribution and estimate the standard uncertainty as $a/\sqrt{6}$.

Triangular probability distribution



e. On the other hand, if an uncertainty (U) of a value (a) is stated with a 95% confidence level, normally from a formal calibration certificate, then the standard uncertainty is taken as $a/1.96$ by assuming a normal distribution which is a characteristic of a normal error distribution.

Normal probability distribution



f. Lastly, given an expanded uncertainty in the form of '$a \pm U$', with a stated coverage factor k, the standard uncertainty (u) is then U/k.