GLP 9

Good Laboratory Practice for Rounding Expanded Uncertainties and Calibration Values

A calibration is not complete until the expanded uncertainty associated with the calibration is determined and reported. Each Standard Operating Procedure (SOP) includes information regarding the calculation of uncertainties. The expanded uncertainty is generally reported with approximately a 95 % confidence interval. The confidence interval is determined by multiplying a coverage factor (often 2, but based on the degrees of freedom or effective degrees of freedom) times the root sum square of properly combined Type A and Type B evaluated components according to the ISO/IEC Guide to the Expression of Uncertainty in Measurement (GUM, 2008), Section 7, and in ISO 80000-1:2009, *Quantities and units, Part 1*.

The steps for reporting corrections and uncertainties are as follows:

1. Round the uncertainty to two significant figures following the rules given here.
2. Round the correction/error to the last figure affected by the uncertainty.
3. Report the rounded correction value and uncertainty to the same level of significance.

Rounding Rules

1. Identify the first two significant digits. Moving from left to right, the first non-zero number is considered the first significant digit. Zeros, which follow a decimal point, when there are only zeros ahead of the decimal point, are not considered significant figures.

2. Use the following rules to round measurement data, consistent with its significance:

    1. When the digit next beyond the one to be retained is less than five, keep the retained figure unchanged. For example: 2.541 becomes 2.5 to two significant figures.

    2. When the digit next beyond the one to be retained is greater than five, increase the retained figure by one. For example: 2.453 becomes 2.5 to two significant figures.

    3. When the digit next beyond the one to be retained is exactly five, and the retained digit is even, leave it unchanged; conversely if the digit is odd, increase the retained figure by one (even/odd rounding). Thus, 3.450 becomes 3.4 but 3.550 becomes 3.6 to two significant figures.

    Note: Even/odd rounding of numbers provides a more balanced distribution of results. Use of computer spreadsheets to reduce data typically follows the practice of rounding up.

4. When two or more figures are to the right of the last figure to be retained, consider them as a group in rounding decisions. Thus, in 2.4(501), the group (501) is considered to be greater than 5 while for 2.5(499), (499) is considered to be less than 5.

Several examples to illustrate the proper method of reporting corrections and uncertainties follow.

Example 1

Suppose the correction for a weight is computed to be 1.357 8 mg and the uncertainty is 0.577 5 mg. First, round the uncertainty to two significant figures, that is, 0.58 mg. Then state the correction as 1.36 mg. Notice that the uncertainty and the correction express the same number of decimal places. Report the correction as 1.36 mg ± 0.58 mg.

Example 2

The volume of a given flask is computed to be 2000.714 431 mL and the uncertainty is 0.084 024 mL. First, round the uncertainty to two significant figures, that is, 0.084 mL. (Do not count the first zero after the decimal point.) Round the calculated volume to the same number of decimal places as the uncertainty statement, that is, 2000.714 mL. Report the volume as 2000.714 mL ± 0.084 mL.

Example 3

The correction for a weight is computed to be 4.3415 mg and the uncertainty is 2.0478 mg. First, round the uncertainty to two significant figures, that is, 2.0 mg. (Notice that two significant figures are shown. The zero is a significant figure since it follows a non-zero number.) Then, round the correction to the same number of decimal places as the uncertainty statement, that is, 4.3 mg. Report the correction as 4.3 mg ± 2.0 mg.

Example 4

The correction for a weight is computed to be 285.41 mg and the uncertainty is 102.98 mg. Because this uncertainty is a large number, we first convert both values to the next larger commonly reported unit (i.e., 0.28541 g and 0.10298 g respectively). First, round the uncertainty to 0.10 g. (The first nonzero digit (1) is the first significant figure and the remaining digits are rounded to the nearest number following the first nonzero digit.) Then, round the correction to the point where the rounding occurred in the uncertainty statement. Round the correction to 0.29 g. Report the correction as 0.29 g ± 0.10 g.

Example 5

The correction for a weight is computed to be 285.41 mg and the uncertainty is 33.4875 mg. First, round the uncertainty to two significant figures, that is 33 mg. Then, round the correction to the same number of decimal places as the uncertainty statement, that is, 285 mg. Report the correction as 285 mg ± 33 mg.

Example 6

The length of a calibrated interval is computed to be 9.999 455 8 ft and the uncertainty is 0.003 561 7 in. First, make sure both values are reported in the same unit (i.e., convert the uncertainty to ft, 0.000 296 808 ft.) Then, round the value to two significant figures, that is, 0.000 30 ft. Then, round the length of the interval to the same number of decimal places as the uncertainty value, that is, 9.999 46 ft. Report the length of the interval as 9.999 46 ft ± 0.000 30 ft.

Rather than stating the uncertainty value with each correction, it is also proper to place the correction values in a column headed by the words "Correction" or "Error," etc., and place the uncertainties (without plus or minus signs) in a column headed "Expanded Uncertainty".