Significant Figures: Policy of the DEP Bureau of Laboratories

Significant Figures

Every measurement is uncertain to a given extent. The exactness or precision of the measurement depends on the limitations of the measuring device and the skill with which it is used. The precision of a measurement is indicated by the number of figures (or digits) used to record it. The digits in a properly recorded measurement are significant figures, which are those digits in a number that are known with certainty, plus the first uncertain digit. The last digit of the number is generally considered uncertain by +/- 1 unit, in the absence of any qualifying information.

For example, when weighing out a sample using a certain top-loading balance that is accurate to one decimal place, the balance read-out is "12.3 grams". The first 2 digits are certain, (i.e., we know that the sample weighs greater than 12 but less than 13 grams), but the third figure (0.3 grams) is somewhat uncertain and represents an estimate of 0.3 +/- 0.1 grams (i.e., the value is somewhere between 12.2 and 12.4). Since the balance is only accurate to one decimal place, the final result should not be recorded as "12.30" grams. This would mean that the actual weight of the sample falls between 12.29 and 12.31 grams, which would be indicating a precision greater than this top-loading balance is capable of delivering. It is important that the digits used to record analytical data always conform to the precision of the measuring instrument.

Propagating Uncertainty

The final result for an analysis is often calculated from two or more experimental measurements, each of which has an associated uncertainty. When adding or subtracting measured quantities, the result should be reported to the same number of decimal places as that of the term with the least number of decimal places. All digits to the right are rounded to the first uncertain term. For example,

130.031 grams + 5.6 grams + 35.31 grams = 170.9 grams

In multiplication or division, the product or quotient should contain no more significant figures than the least number of significant figures of any number used in the calculation. All digits to the right are rounded to the first uncertain term. In the following example, the multiplier "2.1" has the least number of significant figures (2). Thus, the answer must have only two significant figures and is 42, NOT 41.6.

$$\frac{20.2 \text{ ug/mL} \times 2.1 \text{ mL}}{1.02 \text{ liters}} = 42 \text{ ug/L}$$

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Rounding of Numbers

When rounding a result to its final number of significant figures, round the result up if the digit to the right of the last significant figure is greater than 5. Round down if the digit to the right is less than 5. If the digit to the right is 5 and there are digits other than zero to the right of the 5 round up. If the digit to the right is exactly five (i.e., 5 followed by zeros only or no digits) then follow the 'round-to-even' method i.e. round up if the resultant rounded digit will be even, round down otherwise

For example, when reporting the following results to two significant figures:

Calculated Result	Reported Result
138.22	140
133.99	130
125.01	130
125.00	120
135.00	140

Rounded results greater than or equal to 1000 or less than or equal to 0.001 should be converted to scientific notation and reported as such, with one, two or three significant figures (depending on the measurement techniques involved in generating the result). For example, when reporting the following results to two significant figures:

Calculated Result	Reported Result
995	1.0 E+03
1350	1.4 E+03
12,540	1.3 E+04
0.000135	1.4 E-04
0.0001254	1.3 E-04

Appendix of Significant Changes

10/05/2011 Edited Rounding of Numbers section to accurately reflect the procedure used by the QC Manager.

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