**[lab name]**

**Rounding and Significant Figures**

 **[#]**

**In Compliance with V1M2 5.9.3.(a).(v)**

**In support of V1M2 5.6.4 (measurement uncertainty) and V1M2 5.4.7.1 (calculation checks)**

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**New SOP**

**Revision History**

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| Version number and effective date | Revisions made |
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# Introduction

Observations and instrument readings are applied to formula and evaluations to determine both the final analytical results and for the assessment of quality control functions. The outcome of these operations can be through computer programs, calculators, or even manual computations. When carrying out these operations, there is application of rounding procedures and the establishment of significant figures.

# Procedure

## Recording of Instrument readings

When recording written records of values provided by instrument readings or observations they are to be recorded at the observed or displayed value. Values are not to be rounded or have any number of significant figures applied at this point.

## Intermediate Computations

All computations before the final result that are performed by hand, including the use of calculator, are to be carried out using the same number of significant figures derived from the instrument reading.

Significant figures for volumes is 6 significant figures. For example, 10mL is 10.0000mL, 1 liter is 1.00000L or 1,000.00mL.

Significant figures for standard concentrations is 6 significant figures. For example, a solution that is 10µg/L is actually 10.0000µg/L. The following are exceptions.

* Glucose/Glutamic acid solutions for BOD testing are 3 significant figures.
* Chlorine solutions that are not standardized against standard reductant are 2 significant figures.

When recording volumes or standard concentrations, it is not necessary to record as stated above and volumes are to be written as measured. The number of significant figures is retained only in the background to be used when computing the final concentration.

## Final Computations

When computing the final concentration, the number of significant figures comes into play. Examine the various numerical inputs and determine the one with the least number of significant figures. After computing the result, record the value only to that number of significant figures. Examples are provided below.

## Rounding Convention

When rounding, use the process sometimes called the Bankers Rule. Select the number of significant figures to be considered. Examine the digit to the right of the selected figures and if it is 1, 2, 3, or 4 do not change the digit. If it is 6, 7, 8, or 9, then change the digit to the next higher value. If the digit is 5, then change the digit to the nearest even number. Examples are given below.

## Exceptions

The following are exceptions based on the nature of the test or the reporting conventions.

* Direct reading instruments are to be recorded as observed, but are to be rounded to the demanded reporting number of significant figures. Example – a pH is read as 7.42 and is rounded for reporting to 7.4.
* BOD tests using glass BOD bottles. The error in the glass bottle is significant. Compute all intermediate BOD values to 3 significant figures. The final average BOD can be rounded to 2 significant figures. This exception does not apply if using plastic disposable bottles as the error is significantly smaller than the glass bottles.
* PT testing. Report to three significant figures unless instructed to do otherwise by the vendor provided instruction sheet.
* Bacterial enumerated values. When multiplying MPN/100mL or CFU/100mL by any dilution factor, retain the same number of significant figures as the value obtained from the table. This does not apply to reporting CFU/mL per *Standard Methods*… 9215B. Section 5 of the method refers to 9215A, section 9 for reporting, which requires reporting to 2 significant figures.

## Using Excel Spreadsheets as calculators

Excel spreadsheets are used both as calculators (computations performed by the spreadsheet, but values recorded on the worksheet and the spreadsheet is not saved) and as worksheets (computations performed by the spreadsheet and the spreadsheet is saved – no values recorded on the worksheet). Excel retains all values at 8 significant figures regardless of what value is entered in. Displayed results may be set to the desired number of significant figures or decimals, but the value underneath retains 8 significant figures. **Do Not** set Excel to double precision (16 significant figures).

## Using Computer software associated with an analytical instrument

When an instrument uses a computer and associated software, then the number of significant figures the software uses is to be retained. If the software allows or demands that the displayed concentrations have significant figures set, then set them to one more than the reported value. For example, if reporting is to 3 significant figures, then have the software display 4 significant figures.

# Examples

## Computation of a sample concentration

The reported value is to have 3 significant figures. Sample diluted 1 to 5.

Concentration from the calibration curve = 22.34 µg/L.

Equation computation of a concentration by dilution

$$Corrected concentration=22.34 ^{μg}/\_{L}×5.00000=111.7^{μg}/\_{L} $$

Reported concentration is 112 µg/L.

## Computation of a recovery of a Positive Control (LCS)

The recovery is computed in percentage and is to have 3 significant figures. The target concentration is 1.00000 mg/L.

The concentration from the calibration curve = 1.015 mg/L

Equation computation of a recovery

$$\%Recovery=100×\left[\frac{1.015}{1.00000}\right]=101.5\%$$

The recovery is 102%

## Computation of recovery from a spiked sample

Th recovery is computed in percentage and is to have 3 significant figures. The added concentration is 5.00000 mg/L.

The concentration of the native sample is 3.126 mg/L and the concentration of the spiked sample is 7.995 mg/L.

Equation computation of a spike recovery

$$\%Recovery=100×\frac{\left(7.995-3.126\right)}{5.00000}=100×\frac{4.869}{5.00000}=97.38\%$$

The recovery is 97.4%.

# References

* *Management and Technical Requirements for Laboratories Performing Environmental Analyses*, The NELAC Institute (TNI), Rev 2.1, September 1, 2016

# Definitions and Acronyms

Words specific to this document or used outside of their dictionary definition are defined here. Acronyms can be defined in the text above on their first appearance.

## Definitions

## Acronyms