

Significant Figures

For permits drafted or modified on or after the date of this memorandum, all effluent limitations should be written using two significant figures. There are two exceptions - (a) bacteriological limits and (b) BOD only if a single digit effluent is to be required. Bacteriological data are based on “counts” and therefore not subject to significant figure rules and the method for determining BOD is not accurate enough to provide data beyond a whole number. Monitoring results reported on the Discharge Monitoring Report (DMR) should be reported to the same number of significant digits as the permit limit for a given parameter. If the permit does not clarify the number of significant digits to which results should be reported, the results should be reported to two significant digits, except in the case of BOD when single digit effluents are achieved.

An example of an ambiguous number of significant digits is “30”. If a permit has a limit of 30, the *intent* of that permit is that “32” will be a violation. If the number of significant digits is not defined as being two, however, rounding would allow “30” to be reported for values up to 34 without causing a violation. The problem with ambiguous number rounding is pervasive enough to cause EPA to recently change the MCL for arsenic in drinking water from 10 ppb to 0.010 ppm.

If there is not a method allowed by the permit that is accurate enough to measure two significant figures below the value of 1.0, it will be the permittees’ responsibility to provide documentation demonstrating that only one significant figure can accurately be reported.

It is important to follow a number of conventions in order to properly calculate limits and report monitoring results. The following rules for significant figures, rounding and precision apply to measured values, such as concentration and not to counted values, such as number of days, colony counts or conversion factors.

Significant Figures:

Regardless of the measuring device, there is always some uncertainty in a measurement. Significant figures include all of the digits in a measurement that are known with certainty as well as the last digit, which is an approximation.

Rules for Significant Figures:

- 1.) All non-zero digits (1-9) are to be counted as significant.
- 2.) All zeros between non-zero digits are always significant. Both 4308 and 40.05 contain four significant digits.
- 3.) For numbers that do not contain decimal points, the trailing zeros may or may not be significant. The number 470,000 may have two to six significant digits.
- 4.) For numbers that do contain decimal points, the trailing zeros are significant. Both .360 and 4.00 have three significant digits.
- 5.) If a number is less than 1, zeros that follow the decimal point **and** are before a non-zero digit are not significant. Both 0.00253 and .0670 contain three significant digits.

Rounding:

Rounding may be necessary to properly calculate values to be used for permit limits and to report results using the same number of significant figures as the permit limit. All calculations (i.e. averaging and multiplying) are performed prior to any rounding that is done.

Rules for Rounding

Examine the digit following (i.e., to the right of) the last digit to be reported. This digit is the one that is referred to as “being dropped” when rounding a number. Apply the following rules for rounding:

- 1.) If the digit being dropped is 1, 2, 3, or 4, leave the preceding number as it is. 20.3647 rounded to two significant figures, becomes 20.
- 2.) If the digit being dropped is 6, 7, 8, or 9, increase the preceding digit by one. 26.6462 and 26.9081, rounded to two significant figures, become 27 in both cases.
- 3.) If the digit 5 is being dropped, round off the preceding digit to the nearest even number (Zero is considered an even number when rounding off.): thus 2.25 becomes 2.2 and 2.35 becomes 2.4.

Example: Using two significant figures, 1048, 1053 and 1059 all round to 1000; 1060 rounds to 1100; 1153 rounds to 1200.

Precision:

Monitoring results should be reported with the same degree of precision that was achieved in the analysis/measurement of the value. This means that numbers resulting from calculations, this includes loadings, cannot be more precise than the raw data used in the calculations. Note: In cases where the permittee is allowed to treat a <QL as zero when averaging, that zero is to be considered as being “0.00”.

Rules for Precision:

- 1.) For addition or subtraction, the answer can contain no more decimal places than the least precise measurement.
 $13.681 - 0.5 = 13.181$ should be rounded off to the tenths place, with a correct answer of 13.2
- 2.) For multiplication or division, the least number of significant figures in any of the measurements determines the number of significant figures in the answer.
 $2.5 \times 3.42 = 8.55$ should be rounded off to two significant figures, with a correct answer of 8.6
- 3.) Numbers such as conversion factors or number of days are counted numbers and are not considered when determining the number of significant figures or decimal places in the calculation.
- 4.) If both addition/subtraction and multiplication/division are used in a calculation, follow the rules for multiplication/division.

Example: Calculate the suspended solids mass loading.

Permit limit: 75 kg/day, $Q = 0.67$ MGD, $C = 10.5$ mg/L

3.785 kg/mg/L/MG = Unit conversion for one gallon of water to one liter.

$Q \times C \times \text{Unit Conversion} = \text{Mass Loading}$

$$0.67 \times 10.5 \times 3.785 = 26.627475 \text{ kg/day}$$

Precision rule #2 applies.

The numbers 2 and 6 in the result, are the two significant digits.

The number 6 (in the tenths place) in the result, is rounded up. Increase the preceding digit by one. Enter 27 in the appropriate box.

Example: Calculate the 7-day average for ammonia

Permit Limit: 4.5 mg/L, sampled 4 times a week

$C = 0.56, 0.93, 2.53, 6.92$ mg/L

$$\frac{0.56 + 0.93 + 2.53 + 6.92}{4} = 2.735 \text{ mg/L}$$

Precision rules # 3 and # 4 apply (Note: The 4 in the denominator is a counted value).

The numbers 2 and 7 in the result, are the two significant digits.

The number 3 (in the hundredths place) in the result, is rounded down. Leave preceding number as is. Enter 2.7 in the appropriate box.