5.7 Effluent Limit/Significant Figures & Rounding: Limit Determination & Discharge Monitoring Reports

Applicability:

Missouri State Operating Permits (operating permits) often use numeric limitations as a determination of compliance with the appropriate federal and state statutes and regulations. Limitations in operating permits are either derived from federal Effluent Limit Guidelines (ELGs), Water Quality Standards, or Antidegradation. These limits must be established in an operating permit and implemented by the permittee in order to remain in compliance. What is the role of Significant Digits as it applies to limitation development, permit limits, Discharge Monitoring Reports, and compliance?

Content:

Before determining the role of Significant Digits, Rounding, and Exact Values, rules need to be established.

Significant Digits and Rules:
Significant digits, which are also called significant figures, are very important in determining compliance with established effluent limitations in operating permits. Additionally, the calculations of these effluent limitations should also use significant digit determinations. The significance of a digit has to do with whether it represents a true measurement or not. The general rules are as follows:

- Non-zero digits are always significant regardless of their placement before or after a decimal location. (e.g., 22 has two significant digits; 65.4 has three; 456.4 has four);
- Zeroes placed before other digits are not significant. (e.g., 0.089 has two; 0.00541 has three; 0.2354 has four);
- Zeroes placed between other digits are always significant. (e.g., 5004 and 1.005 have four; 54003 has five);
- Zeroes placed after a digit but behind a decimal point are significant. (e.g., 7.90 has three; 56.70 has four; and 100.0 also has four);
- Zeroes at the end of a number but before the decimal place are ambiguous (e.g., 610000). It is not clear if the zeroes are significant or not. To avoid this, scientific notion is often used to avoid uncertainty. Therefore, 6.100×10^5 has four; 6.1×10^5 has two.
- When calculating limits or determining Reasonable Potential, staff should calculate values as established and use Significant Digits for the end product.

Rounding and Rules:
Rounding is considered necessary to properly calculate values to be used for permit limits and report results. There are several rounding conventions, but one of the most commonly used conventions is described in Part 1050 B of Standard Methods for the Examination of Water and Wastewater (21st Edition).

- All calculations should be performed prior to any rounding taking place;
- If the digit that is dropped is 6, 7, 8, or 9, the immediate next significant digit is increased by one unit. (e.g., if the number has three significant figures and the calculation or results are 12.36425, then the number is 12.4).
- If the digit that is dropped is 1, 2, 3, or 4, the immediate next significant digit remains unmodified. (e.g., if the number has three significant figures and the calculation or result is 12.34687, then the number is 12.3).

- If the digit that is dropped is 5, round off the preceding digit to the nearest even number. (e.g., 2.25 is 2.2; 2.35 is 2.4).

Exact Values:
Exact values are those that are counted without ambiguity, for example the number of cars in a parking lot is 43. Exact values are used by the Department and carry significance with them that seems to bend the rules. Example of this is the use of Ammonia's default upstream concentration of 0.01 mg/L. Significant Digit rules would have staff to believe that 0.01 has two (2) significant digit. However, exact values have infinite amount of significant digits and is only limited by the actual numbers in the value. Therefore, staff should use other values (e.g., criteria) for determining significant digits. Another example of this is a permit limitation and conversion factors. If a limitation is established as 45 or 30 mg/L, then it has two (2) significant digits. If the permit limit is 0.542 mg/L (or 542 µg/L) it has three. Likewise, if a conversion factor has a value of 8.34 (conversion factor for mass limits), it has three significant digits and should be used as is in calculations.

Methods:

Permit Limitations & Discharge Monitoring Reports
For permits drafted or modified on or after the approval date of this permit manual topic, previous compliance can not be determined using the conventions established below for Discharge Monitoring Reports (DMRs). It is important to note that following the rules for significant digits, rounding and precision apply to measured values (i.e., concentrations and mass limits) but not for counted values (i.e, numbers of days, colony counts, or conversion factors).

Reported DMR values will be rounded to match the number of significant digits in the permit limit by DNR staff before data entry so that MoCWIS can make the correct compliance determination. Sample results for samples collected by DNR staff will be rounded to match the number of significant digits in the permit limit before a compliance determination is made.

Suggested language that can help data entry staff could be placed in operating permits as follows:

"It is recommended that the permittee report at least the same number of significant figures for each specific limitation. Regardless of the rounding convention used (i.e., 5 always rounding up or to the nearest even number) by the permittee, the permittee should use either convention consistently and should recommend to their consulting laboratories employed by the permittee use the same convention."

Example A: Facility A has a Monthly Average for BOD_5 of 30 mg/L. In keeping with the above rules, here are some examples:

1. Facility A reports 29.54 mg/L as a monthly average. DMR data entry staff would need to establish this as 30 mg/L.
2. Facility A reports 30.45 mg/L as a monthly average. DMR data entry staff would need to establish this as 30 mg/L.
3. Facility A reports 30.56 mg/L as a monthly average. DMR data entry staff would need to establish this as 30 mg/L.
4. Facility A reports 30.61 mg/L as a monthly average. DMR data entry staff would need to establish this as 31 mg/L – and the facility would be in violation of their operating permit limitations.

Example B: Facility B has a Daily Maximum for Zinc, Total Recoverable of 230 µg/L.

1. Facility B reports a 230.45899 µg/L as a daily maximum. DMR data entry staff would establish this as 230 µg/L.
2. Facility B reports a 229.511 µg/L as a daily maximum. DMR data entry staff would establish this as 230 µg/L.
3. Facility B reports a 230.6111 µg/L as a daily maximum. DMR data entry staff would establish this as 231 – and the facility would be in violation of their operating permit limitation.
4. Facility B reports a 230.599 µg/L as a daily maximum. DMR data entry staff would establish this as 230 µg/L.

Example C: Facility C has a Monthly Average of 8.1 µg/L as a Monthly Average.

1. Facility C reports a 8.129 µg/L as a monthly average. DMR data entry staff would establish this as 8.1 µg/L.
2. Facility C reports a 8.154 µg/L as a monthly average. DMR data entry staff would establish this as 8.2 µg/L – and the facility would be in violation of their operating permit.
3. Facility C reports a 8.16 µg/L as a monthly average. DMR data entry staff would establish this as 8.2 µg/L.

<u>Establishing and Calculation of Limits:</u>
There are two basic ways of determining an effluent limitation: (1) directly from regulation, or (2) calculation. Direct application of limitations is basically taking the value directly from the regulations and applying it to an operating permit like BOD_5, TSS, pH, ect..., and its application into an operating permit only uses Significant Digits. Example would be using 30 mg/L as a Monthly Average from 10 CSR 20-7.015. It is established in an operating permit as 30 mg/L.

For permit limitations that include any form of calculations, Department staff must consider Significant Digits, Rounding, and Exact Values.

In keeping with the rules above, here are some examples.

Example 1 Concentration:

C_e = ((10.08 + 0.25)1.5 – (0.25 * 0.01))/10.08
(the smallest value has two significant digits)

Thus:
WLA = ((10.08 + 0.25)1.5 – (0.25 * 0.01))/10.08
WLA = ((10.33)1.5 – (0.0025))/10.08
WLA = ((15.495) – (0.0025))/10.08
WLA = 15.4952/10.08
WLA = 1.536954....
WLA = 1.5

LTA = 1.5 mg/L (0.780)
(the smallest value has two significant digits)

Thus:
LTA = 1.5 (0.780)
LTA = 1.17
LTA = 1.2

MDL = 1.2 (3.11)
(the smallest value has two significant digits)

Thus:
MDL = 1.2 (3.11)
MDL = 3.732
MDL = 3.7

Example 2 Mass:

ELG of 100 mg/L as daily maximum
Production (actual flow) of 345,000 gpd.
8.34 conversion factor

Lbs/day = $(Flow_{MGD})(concentration_{mg/L})(8.34)$
Lbs/day = (0.345 MGD)(100 mg/L)(8.34)
(smallest value has three significant digits)

Thus:
Lbs/day = (0.345 MGD)(100 mg/L)(8.34)
Lbs/day = (0.345 MGD)(100 mg/L)(8.34)
Lbs/day = 287.73
Lbs/day = 288

Legal References:

Code of State Regulation:

10 CSR 20-7.010(9)	General Conditions
10 CSR 20-7.030	Water Quality Standards – Table A

Federal Code of Regulation

40 CFR 122.45(f)	Mass Limitations
40 CFR 122.41(l)(4)	Reporting Requirements

Other Links:

Standard Methods: For the Examination of Water & Wastewater, 21st Edition, Section 1050B
Guidance Memorandum No. 06-2016, Significant Figures for Discharging Monitoring Reports, Common Wealth of Virginia

Key Words:

Significant Digits, Significant Figures, Rounding, Rounding off, Exact Values, Limit calculations, Discharge Monitoring Reports

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