SAN JOAQUIN VALLEY UNIFIED
AIR POLLUTION CONTROL DISTRICT
COMPLIANCE DEPARTMENT

COM 1135

APPROVED: **Signed** **DATE:** **December 28, 2006**

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Director of Compliance

TITLE: **SIGNIFICANT FIGURES**

SUBJECT: **DEFINITION AND USE OF SIGNIFICANT FIGURES IN CALCULATIONS AND DATA DISPLAY,AND DIRECTION IN THE USE OF ROUNDING**

OBJECTIVE:

To provide guidance in the use of significant figures and rounding in data collection and calculations used to determine compliance with District rules and permit conditions.

PURPOSE:

A wide variety of data are collected in the course of inspections and these data are used in a variety of calculations. It is the purpose of this policy to provide guidelines in the collection of data, use of calculated results, and in the display of results. This policy is intended to address the calculations encountered during regular inspections, it is not intended to address the calculations used in source testing or in the evaluation of source tests. These calculations are addressed in the District Source Testing Policy or in the references for specific test methods.

POLICY STATEMENT:

1. BACKGROUND

Many of the data used to determine compliance are exact quantities such as the number of cyclones serving a cotton gin or the number of tanks at a refinery. However, many other figures are less precise such as the number of acres involved in a burn, or may involve calculations such as the amount of VOC in a clear coat. All of these values are used to determine compliance, and it is important to follow established guidelines for the collection of, calculation with, rounding of, and display of data.

2. DATA COLLECTION

When a number is expressed with more or fewer digits, the number of digits should provide an indication of the precision of the measurement or calculation that produced the number. By convention, the last digit is the result of rounding and is considered uncertain. For example, if the size of a burned wheat field is reported as 2 acres, because values between 1.5 and 2.4 round to 2, the assumption is that the field's actual size lies between 1.5 and 2.4 acres. This is a margin of error of +/- one half an acre (21780 square feet). When reported as 2.0 acres, the field's actual size lies between 1.95 and 2.04 acres, for a much smaller margin of error of +/- 0.05 acre (2178 square feet). Of course, a suitably precise measurement must be made (to the nearest 0.1 acre) to justify such a small margin of error.

Data should be collected with this process in mind. If the data will be used in precise calculations to determine compliance, it should be measured at least as precisely as the applicable limit. Conversely, if the only determination needed is whether a property is larger than an acre, measurements can probably be made with the odometer in a District vehicle.

To eliminate uncertainty, report results with the same number of significant digits as the specified limit: 200 hours per year (3 significant digits, the zeroes are significant in permit or rule limits) should be reported with 3 significant digits. For example, report 199 hours/year (compliant) or 203 hours/year (a violation). Or, if the limit were 30 ppm NOx (2 significant digits), report 28 ppm NOx (compliant) or 38 ppm NOx (a violation). The calculations should reflect as much precision as the data allow, but the result should be rounded to the appropriate number of figures.

3. USE OF SIGNIFICANT DIGITS AND ROUNDING

When a number ends in one or more zeroes, the implied precision is ambiguous. For example, if a report states that the exhaust flow is 800 cubic feet per minute, it is unclear whether the flow was measured as between 750 and 849 cfm, or 795 and 804, or between 799.5 and 800.4 cfm. Precision can be specified by stating the measurement precision such as 800 +/- 5 cfm, or with the use of scientific notation such as 8.0×10^2 cfm.

When a permit or rule limit is expressed with one or more zeroes it should assume that the zeroes are significant. For example, a limit of 100 hours per year is precise to the hour, it is not intended that anything between 50 and 149 hours is compliant.

The precision of a calculated result depends on the least precise input. For example, consider a coating operation where the VOC of reducer in a 1:1 mix is 5.37 lbs/gal and the topcoat VOC is 2 lbs/gal. Because the VOC of the topcoat is reported with only one significant figure, the actual VOC of the topcoat can range from 1.5 to 2.4 lbs/gal. This range can produce calculated values from 3 to 4 lbs/gal and compliance with the 3.5 lbs/gal limit is unknown (see below).

(5.37 lbs/gal + 1.5 lbs/gal)/2 = 3.43 rounded to 3 lbs/gal (compliant)
(5.37 lbs/gal + 2.0 lbs/gal)/2 = 3.69 rounded to 4 lbs/gal (non-comp.)
(5.37 lbs/gal + 2.4 lbs/gal)/2 = 3.88 rounded to 4 lbs/gal (non-comp.)

Note that in this example, the imprecision of the topcoat data do not allow the result to be displayed in as many significant digits as the rule limit. If no more precise data is available, action should be taken as indicated by the calculations. In this case, an illegal coating is indicated.

As in the example above, calculations are performed with the data before rounding. The results are subsequently rounded. Do not round the values before performing calculations.

Permit Services Policy APR 1105 provides guidance on the use of significant figures. Insignificant digits should be dropped from results via rounding. The digit to be dropped determines the value of the remaining number. If the digit to be dropped is 0, 1, 2, 3, or 4 the remaining number is not changed. If the digit to be dropped is 5, 6, 7, 8, or 9 the remaining number is increased by one.

Another example involves the use of portable emission analyzer data. The data are recorded to different levels of precision by different machines and different gasses. In the example below, the O2 data are the most precise (4 significant figures). The oxygen correction calculation is performed with the raw data, the results averaged, and then the average is rounded to compare to the rule limit.

				(To 15% O2, ppm)	
Time	NOx (ppm)	CO (ppm)	O2 (%)	NOx corr.	CO corr.
09:15:03	147	720	10.27	81.896	401.124
09:15:18	151	717	10.24	83.889	398.333
09:15:32	143	722	10.23	79.370	400.737
09:15:47	145	719	10.21	80.331	398.329
Averages				81.371	399.631
Result Rounded to permit limit (2 sig. dig.)				81	400

The O2 correction equation used above is:
(Observed NOx or CO) * ((20.95% O2 – 15% O2)/(20.95% O2 – Observed O2))

Note that the un-rounded NOx value is actually out of compliance with District emission monitor policy (> 125% of limit) for a lean burn engine operating under Rule 4702 limits (65 ppm). However, the rounded figure would not result in an immediate NOV.