Green Book

Ozone and Carbon Monoxide Design Value Calculations

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711
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MEMORANDUM

SUBJECT: Ozone and Carbon Monoxide Design Value Calculations

FROM: William G. Laxton, Director
Technical Support Division (MD-14)
TO: See Below

In discussions related to the Clean Air Act legislation, design values for ozone and carbon monoxide are receiving particular attention. Previously, it sufficed to designate areas as either attainment or nonattainment but now areas will be further classified into different categories based upon the magnitude of the appropriate design value. This additional classification step places added emphasis on the need to accurately determine these design values. The classification will be done according to concentration cutpoints, and on a schedule, specified in the legislation.

Obviously, once this process is set in motion we will be working very closely with you to develop these design values. However, I thought it would be appropriate to reiterate our design value computation procedures in advance to help people anticipate the types of data review questions that may arise. The computation procedures stated here are consistent with our previous methods. There are differences between the procedures for ozone and carbon monoxide because the National Ambient Air Quality Standard (NAAQS) is structured in terms of expected exceedances while the carbon monoxide NAAQS uses the older "once per year" format. The most apparent difference is that the CO design values are based upon 2 years of data while design values for ozone use 3 years. Another difference is that the ozone NAAQS uses the daily maximum ozone value while the CO NAAQS considers running 8-hour averages so that, even though they must be non-overlapping, it is possible to have more than one CO exceedance per day. Because of these differences, it is convenient to discuss each pollutant separately. With respect to terminology, you may hear the CO design value approach referred to as "the highest of the second highs', while the ozone design value is frequently simplified as "the fourth high in 3 years."

One point to remember is that all locations within an area have to meet the standard (NAAQS). Therefore, when we do our evaluations, we look at each individual site to make sure that every site meets the standard. A separate design value is developed for each site

that does not meet the NAAQS, and the highest of these design values is the design value for the area.

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Carbon Monoxide

CO design values are discussed in terms of the 8-hour CO NAAQS, rather that the 1-hour NAAQS, because the 8-hour NAAQS is typically the standard of concern. However, a 1-hour design value would be computed in the same manner. For 8-hour CO, we simply look at the maximum and second maximum (non-overlapping) 8-hour values at a site for the most recent 2 years of data. These values may be readily found on an AIRS AMP450, "Quick Look", printout. Then we choose the highest of the second highs and use this as our design value for that site. We then look at all design values within an area and the highest of these serves as the design value for the area. Note that, for each site, individual years of CO data are considered separately to determine the second maximum for each year - CO data are not combined from different years. It is probably worth commenting on this. The CO NAAQS requires that not more than one 8-hour average per year can exceed 9 ppm (greater than or equal to 9.5 ppm to adjust for rounding). We evaluate attainment over a 2-year period. If an area has a design value greater that 9 ppm, it means there was a monitoring site where the second highest (non-overlapping) 8-hour average was greater that 9 ppm in at least 1 year. Therefore, there were at least two values above the standard during 1 year at that site and thus the standard was not met.

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Hypothetical Case (two CO sites in an area)

                                (8-Hour Averages)
                                MAX 2nd High
                SITE 1    1987 14.6  8.9
                          1988 13.9 10.9
                                           10.9 is the Design Value
                                           for Site 1

                                (8-Hour Averages)
                                MAX 2nd High
                SITE 2    1987 12.2 11.1
                          1988 10.8 10.4
                                           11.1 is the Design Value
                                           for Site 2

            11.1 ppm would be the design value for the area.
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Ozone

The form of the ozone NAAQS requires the use of a 3-year period to determine the average number of exceedances per year. In its simplest form, the ozone standard requires that the average number of exceedances over a 3-year period, cannot be greater than 1.0. An area with four exceedances during a 3-year period, therefore, does not meet the ozone standard because four exceedances in 3 years averages out to more than once per year. Now, if the fourth highest value was equal to the level of the ozone standard, i.e. 0.12 ppm, then the area would have no more than three exceedances during the 3-year period and the average number of exceedances per year would not be greater 3

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than one. This assumes no missing data and is how the fourth high value in 3-years came to be used as the design value. Actually, an adjustment is specified in the ozone NAAQS to account for missing data in determining the expected exceedances for ozone. Because of considerations associated with control strategy modeling, the following basic approach for ozone design values has been in use since 1981. If there are 3 complete years of ozone data, then the fourth highest daily maximum during the 3-year period is the data, then the fourth highest daily maximum during the 3-year period is the design value for that site. If only 2 complete years of data are available, then the third highest is used and, if only one complete year is available, then the second highest is used. In this approach, a year of ozone data is considered complete if valid daily maximums are available for at least 75 percent of the ozone season. Note that because of the form of the ozone NAAQS, data are combined over multiple years but they are not combined from different sites.

Hypothetical Case (two O3 sites in an area, each year at least 75% complete)

FOUR HIGHEST DAILY MAXIMUM VALUES

		Max	2nd Hi	3rd Hi	4th Hi
SITE 1	1986	.127	.123	.122	.110
	1987	.129	.124	.121	.116
	1988	.142	.136	.134	.115

The design value for Site 1 is 0.129 ppm, the fourth highest daily maximum value during the three year period.

FOUR HIGHEST DAILY MAXIMUM VALUES

		Max	2nd Hi	3rd Hi	4th Hi
SITE 2	1986	.110	.100	.095	.090
	1987	.110	.100	.095	.090
	1988	.180	.175	.160	.110

The design value for Site 2 is 0.110, the fourth highest value during the three year period.

0.129 ppm would be the design value for the area.

There are a few additional comments warranted on the ozone example. First, note that data from each site was treated independently in computing the design value for that site. Assuming no missing data, the second site would meet the ozone NAAQS but the area would not because the other site shows that the NAAQS is not being met. Also, it should be noted that the high

Page 4 values for a year are considered even if the data for that year did not satisfy the 75 percent data completeness criterion. For example, if a site had 2 years of data that met the 75 percent data completeness requirement and 1 year that did not, then the third highest value during the 3-year period would be the design value because there were only 2 complete years of data but the data from all 3 years would be considered when determining the third highest value. This ensures that valid high ozone measurements in a particular year are not ignored simply because other data in that year were missing. When computing data completeness, the number of valid days can be increased to include days that may be assumed to be less than the standard level as stated in the ozone NAAQS. Also, for new sites that have just come on line, the 75 percent data completeness requirement for the start-up

year may be applied beginning with the first day of actual monitoring as long as the data set is at least 75 percent complete for June through August.

A final practical complication that must be addressed in determining ozone design values is the case where a site reports data but has no year that meets the 75 percent data completeness requirement. Admittedly, this is an unusual situation but, for the sake of completeness, it needs to be addressed. At the same time, however, the reason for this consistent data completeness problem should be examined because ozone monitoring data completeness is typically greater that 90 percent. In general, if a site has no complete years of data and fewer than 90 days of data during the 3-year period, the design value will be determined on a case by case basis. In such cases, the data base is so sparse that it would be extremely difficult to describe general rules that would apply and a careful evaluation would have to be made to determine why this situation occurred and what is the most appropriate way to use the data. For a site without a single complete year of data but at least 90 days of data during the 3-year period, the following steps are followed in determining the ozone design value:

1. Divide the number of valid daily maximums during the 3-year period by the required number of monitoring days per year. As noted earlier, the number of valid days can be increased by including the number of days that may be assumed to be less than the standard level as specified in the ozone NAAQS.

2. Add 1.0 to the above total and then use the integer portion of the result as the rank of the design value.

These steps are not as complicated as they may initially appear. For example, suppose a site with a required ozone monitoring season of 214 days each year reports 0, 121, and 130 valid days of ozone data during the 3-year period. Step 1 would give (0+121+130)/214=1.17. In step 2, 1.0 is added to this total giving 2.17. The integer portion of 2.17 is 2 and so the design value is the second highest value during the three year period. Again, this type of situation should not occur that often and the reasons for the data completeness problems should be identified.

When discussing data completeness for ozone, it is important to recognize that monitoring sites are occasionally discontinued for valid

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practical reasons. In such cases, if data are available from another site that is representative of the same situation, then data from the discontinued site may be superceded by data from the other site. The intent is to ensure that a single year of data from a monitor that was discontinued 2 years ago, does not dictate the design value if data are available from another, equally representative, site. This is not intended to eliminate the missing data penalty when a site is discontinued and there is no data available from a similar monitor.

I have not discussed certain basic data handling conventions, such as computing 8-hour CO averages with missing data, determining the non-overlapping second maximum 8-hour average, or the definition of a valid daily maximum 1-hour ozone daily maximum. All of these conventions have been in place since the 1970's and are routinely incorporated into AIRS outputs so I have not bothered to discuss these points.

Addressees:

http://www.epa.gov/air/oaqps/greenbk/laxton.html
Last updated on Wednesday, December 23rd, 2009.

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Note to reader:

This copy of the Laxton memo is a retyped version of the original. As a result, the page breaks had to be forced after the last word on each page on the original document.