

**ANALYSIS OF THE UPPER TOLERANCE LIMIT
PROCESS PROPOSED BY EPA FOR DETERMINING THE
“MAXIMUM ACHIEVED HOURLY EMISSIONS RATE”
FOR ELECTRIC GENERATING UNITS**

PREPARED FOR

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ATTACHMENT 1

Table of Contents

<u>Section</u>	<u>Page</u>
1	Summary..... 4
2	Introduction 6
3	Analysis Methodology 9
3.1	Unit Selection.....9
3.2	Evaluation of EPA UTL Process9
4	EPA UTL Process Results 11
4.1	Evaluation of Unfiltered Datasets11
4.2	Evaluations of Datasets with Outliers Removed12
5	Evaluation of Adjustments to the EPA UTL Methodology 13
5.1	Results for UTL Method Sorted by Pollutant Emission Rate – Unfiltered.....13
5.2	Results for UTL Method Sorted by Pollutant – Outliers Removed13
5.3	Results for UTL Methodology with Equivalent Highest 10% Hourly Heat Input Post- Change Dataset.....14
5.4	Evaluation of the Impact of Independent Variables.....14
5.5	Evaluation of Pre-Change Five-Year Operating Period16
5.5.1	Evaluation of Calendar Years Against Highest Heat Input Year 16
5.5.2	Evaluation of Highest Heat Input Year Against 5-Year Hourly Emissions.... 16
5.6	Evaluation of a Revised UTL Calculation Process18
6	Conclusions 20
6.1	Evaluation of EPA UTL Process20
6.2	Evaluation of UTL Process Sorted by Pollutant Emission Rate20
6.3	Evaluation of UTL Process with Equivalent Post-Change Heat Input Sort Dataset20
6.4	Evaluation of Adjusting the UTL Independent Variables21
6.5	Evaluation of UTL for 5-Year Long Operating Period.....21
6.5.1	Comparing 5-Calendar Years UTL Emissions 21
6.5.2	Comparing 5 Calendar Years Hourly Emissions Against UTL Emissions 22
6.5.3	168-Hour Revision of the UTL Process..... 22
7	References..... 24
APPENDIX A	Normality Tests36
APPENDIX B	Five Year EPA UTL Analysis Data Plots55
APPENDIX C	Five Year Revised UTL Analysis Data 64

List of Figures

<u>Number</u>		<u>Page</u>
Figure 1	Impact of Confidence Limits on Standard Deviation Multiplier.....	27
Figure 2	Impact of Fraction of 365 Day Period on Standard Deviation Multiplier	27
Figure 3	Unit E1 Five Year Hourly NO _x Average	30
Figure 4	Unit E1 Five Year Hourly SO ₂ Averages	30
Figure 5	Unit 1 168 Hour NO _x UTL Results	34
Figure 6	Unit E 168 Hour SO ₂ UTL Results.....	35

List of Tables

<u>Number</u>		<u>Page</u>
Table 1	Electric Utility Units Selected for UTL Analysis.....	24
Table 2	Results for EPA UTL Method for 2006	24
Table 3	Results for EPA UTL Method for 2006, Potential Outliers Removed	25
Table 4	UTL Results for NO _x and SO ₂ Sorted Datasets for 2006, Unfiltered Dataset	25
Table 5	UTL Results for NO _x and SO ₂ Sorted Datasets for 2006, Outliers Removed	26
Table 6	Comparison of UTL False Positive Hours for Various Modifications to Datasets, Year 2006.....	26
Table 7	Five Year Comparison of UTL Results for Heat Input Sorting, Years 2002 through 2006	28
Table 8	Results for EPA Heat Input Sorting UTL Method for 5 Years, Comparing All Hourly Emissions Post-Change, Unfiltered	29
Table 9	Results for EPA Heat Input Sorting UTL Method for 5 Years, Comparing All Hourly Emissions Post-Change, Outliers Removed	30
Table 10	Results for EPA NO _x /SO ₂ Sorting UTL Method for 5 Years, Comparing All Hourly Emissions Post-Change, Unfiltered.....	31
Table 11	Results for EPA NO _x /SO ₂ Sorting UTL Method for 5 Years, Comparing All Hourly Emissions Post-Change, Outliers Removed	32
Table 12	Results for EPA NO _x /SO ₂ Rate Sorting UTL Method for 5 Years, Comparing All Hourly Emissions Post-Change, Outliers Removed.....	32
Table 13	Results for EPA NO _x /SO ₂ Rate Sorting UTL Method for 5 Years, Comparing All Hourly Emissions Post-Change – Unfiltered 1% Population @ 99.98CI	33
Table 14	Results for EPA NO _x /SO ₂ Rate Sorting UTL Method for 5 Years, Comparing All Hourly Emissions Post-Change – Filtered 1% Population @ 99.98CI	33
Table 15	Comparison of Proposed UTL and Revised UTL Methods, EPA Proposed Statistics (99.9 and 90.0)	34

1 Summary

EPA has proposed a process for determining if an electric generating unit (EGU) exceeds its pre-change “maximum achieved hourly emissions rate” by utilizing an upper tolerance limit process developed by the National Bureau of Standards. This process is governed by the following equation

$$UTL = \bar{x} + s * \left[\frac{Z_{1=p} + \sqrt{(Z_{1=p}^2) - \left[1 - \frac{Z_{1=q}^2}{2 * (n-1)}\right]} * \left[Z_{1=p}^2 - \frac{Z_{1=q}^2}{n}\right]}{1 - \frac{Z_{1=q}^2}{2 * (n-1)}} \right]$$

The variables in this equation are the mean emission level, its standard deviation and the population of the dataset. EPA has proposed utilizing the following process to estimate whether an EGU has increased its maximum hourly emissions after a change. The process is as follows:

1. Determine the highest heat input year from 5 years of CEMS or PEMS data prior to a proposed change;
2. Sort the data based on heat input rates and eliminate the lower 90 percent of the data;
3. Calculate the UTL given by the equation above and establish this as the maximum emission rate;
4. Compare this emission rate to each hourly emission rate post-change; and
5. An emission increase would result if the hourly post-change emissions rate exceeded the UTL emission level.

EPA hypothesized that this process captured the natural variability of EGUs emissions and would insure that the pre-change maximum achieved hourly emissions rate would not be exceeded simply by random variability of the system. Analyses were performed to determine if this process was viable for realistically comparing pre-change and post-change hourly emissions rates and to test EPA’s hypotheses. These analyses utilized actual CEMS data from 9 coal-fired EGUs. The analyses tested the usefulness of various variations to the UTL process, including some proposed by EPA, to attempt to improve the process. These analyses evaluated the following variations to the proposed UTL process:

1. Data sorting by heat input prior to applying the UTL process (the method proposed in the Federal Register notice);
2. Data sorting by pollutant species (NO_x and SO₂ emission rates) prior to applying the UTL process;
3. Variation of the statistical parameters;
4. Variation of the size of the filtered dataset;

5. Evaluation of an equivalent post-change dataset population (highest 10 percent of data, based on heat-input sort); and
6. Elimination of potential anomalous readings through statistical removal of outliers.

The basic finding of these evaluations was that EPA's proposed UTL process does not support EPA's hypotheses. The underlying cause for this failure to support the hypotheses is that the UTL process uses a statistical process with a given level of confidence and a relatively large pre-change dataset to compare against one hour emissions data post-change. In order for this process to be viable, either the pre- and post-change datasets must be similar or the confidence level must be extremely high (close to 100 percent). The highest post-change hourly emissions data point essentially represents the far right portion of the normal distribution tail. Any confidence level less than 100 percent would potentially cause an emission exceedance.

All of the analyses performed herein showed that EPA's proposed UTL process cannot be made to satisfy the EPA hypotheses based on actual EGU CEMS data. For any of the variations to the process listed above for the 2006 dataset, the best that could be achieved was that only 5 of the 9 units would not exceed the UTL utilizing the same set of data before and after change. This result was for a post-change dataset equal to the pre-change dataset, i.e., 10 percent highest heat-input points of the highest 365 day emissions. Utilizing post-change 2006 hourly emissions data (as proposed by EPA) resulted in all 9 units exceeding the UTL. These results clearly show that the EPA proposed UTL process for this application is flawed and would ensure that virtually all units subject to this process would have false positives, i.e., show emission increases where no increases have actually occurred. Analysis of the EPA UTL process for the five year datasets further confirmed that the process would show that the majority of units would have increases in emissions (false positives) by this method.

A slight revision to EPA's proposed UTL process results in fewer EGUs having false positives than that for EPA's original proposal. The revision more closely satisfies EPA's hypotheses stated in the Preamble. The revised UTL process follows the following steps:

1. Perform a 168-hour rolling average of the 5-year pre-change emission data,
2. Calculate the UTL based upon these 168-hour rolling averages,
3. Utilize the highest UTL to compare against the hourly emission data post-change.

This revised UTL process results in only 2 of the nine units having false positives for NO_x and 3 for SO₂. This compares to 7 units for NO_x and all nine units for SO₂ having false positives for the EPA proposed UTL process. But because even this revised UTL process does not eliminate false positives altogether, additional steps should be used to account for these false positives. For example, the following two steps can be added:

4. Test the pre-change hourly emissions for false positives, and
5. In determining whether there has been a significant increase in emissions after a change, allow as a safe harbor the number of hourly false positives that occurred during the pre-change period.

2 Introduction

On May 8, 2007, EPA published a supplemental proposal for a revised emissions increase test for electric generating units (EGUs) (72 Fed. Reg. 26202-227). This supplemental proposal includes a new statistical alternative that calculates a maximum “achieved” hourly emission rate on either an input- (lb/hr) or output- (lb/MW-hr) basis that cannot be exceeded for even a single hour during the five years after a project is undertaken. This calculated maximum achieved emission rate is based on actual emission data for the five years prior to a proposed change at the EGU. The statistical process is based on the upper tolerance limit statistical process (UTL) developed by the National Bureau of Standards (Ref. 1). This proposed UTL statistical process is represented by the equation below:

$$UTL = \bar{x} + s * \left[\frac{Z_{1-p} + \sqrt{\left(Z_{1-p}^2 - \left[1 - \frac{Z_{1-q}^2}{2 * (n-1)} \right] * \left[Z_{1-p}^2 - \frac{Z_{1-q}^2}{n} \right]}}{1 - \frac{Z_{1-q}^2}{2 * (n-1)}} \right] \quad \text{Equation 1}$$

Where:

X bar = Mean value of the dataset,
s = Standard Deviation of the dataset,
 Z_{1-p} = 3.090, Z score for the 99.9 percentage of the interval,
 Z_{1-q} = 2.326, Z score for the 99.0 percent confidence interval.

EPA believes “the statistical approach properly accounts for the variability inherent in EGU operations and air pollution control technology.” 72 Fed. Reg. 26215, col. 3. Further, EPA believes that this statistical process “helps to ensure that the emissions from an EGU will not exceed its pre-change maximum achieved hourly emissions rate simply through the random variability of the system” 72 Fed. Reg. 26215, col. 3. EPA has proposed the values of the Z_{1-p} parameter and the Z_{1-q} parameter above but requests comment on whether it would be appropriate to set these two parameters at lower levels of 90.0 percentage of the interval (Z_{1-p}) and either a 90.0 or 95.0 confidence interval (Z_{1-q}). This paper concentrates on the original proposed values of both Z_{1-p} (99.9%) and Z_{1-q} (99.0%) since these represent UTL values that would be higher than those for the other intervals. The impact of using higher values for these two parameters was also evaluated.

EPA’s statistical process can only be applied to EGUs that are equipped with CEMS or PEMS. This paper only evaluates datasets from CEMS since most utility units above 25

MW have installed CEMS for NO_x and SO₂. EPA's proposed UTL process begins by evaluating five years of CEMS data prior to the proposed change and selecting 365 contiguous days of data (not necessarily in the same calendar year) representing the highest heat input period for the EGU during the previous five years. The dataset is filtered to delete emissions data for periods of start-up and shut-down, periods of malfunction and periods of non-compliance with the appropriate emission limitations. Next these data are sorted by heat input and the highest 10 percent of the dataset are selected. For the rest of the analysis, under the proposal, the NO_x and SO₂ emissions rates are utilized to determine the mean and standard deviation of the datasets and each is substituted into Equation 1 along with the number of data points used in the analysis. The UTL values of NO_x and SO₂ derived from this process establish the pre-change maximum achieved hourly emission rate for these pollutants. These levels will later be compared to the highest hourly emission rates during the five years after the project. As with the pre-change data, periods of start-up and shut-down, periods of malfunction and periods of non-compliance with the applicable emission limitations are eliminated from the hourly data before determining the maximum post-change hourly emission rate. According to the proposal, any remaining hourly rate above the UTL value during the five years after the project would be deemed to be an increase in the hourly emissions rate, potentially triggering new source review (NSR).

EPA has also requested comments on the advantages of using the UTL process by first sorting on the emission rate of the actual specie (NO_x and SO₂ in this case) rather than sorting on the heat input to obtain the highest 10 percent of the hourly data. This paper addresses the advantages and disadvantages of this alternative sorting approach.

There are a number of uncertainties and limitations relative to how certain types of emissions data are handled by the proposed EPA process. These include, but are not limited to, the following:

1. Data for EGUs whose emission controls operate seasonally, e.g., only during the ozone season;
2. Data for common stack EGUs;
3. Elimination of periods of non-compliance:
 - a. Applicable emission limits may be based on averaging periods greater than one hour;
 - b. An hourly emission level higher than the applicable limit may not cause an actual non-compliance event due to trading, averaging or other compliance approaches;
4. How a malfunction is determined.

This paper provides insight into the efficacy of the UTL approach for single stack utility coal-fired EGUs¹ unit that operate with the same pollution control equipment throughout the entire year. Therefore, issues 1 and 2 do not come into play. The issue of elimination of non-compliance periods is not addressed here since the units selected for analysis comply

¹ EPA's proposed rule would apply to all fossil-fired EGUs, including electric utility steam generating units and combustion turbines. The analysis in this paper focuses on 9 coal-fired EGUs.

with their emission limitations, which are typically set for averaging periods greater than one hour. It is assumed in this analysis that none of the units had periods of non-compliance. As reported to EPA, none of the data used here is identified as resulting from a malfunction of pollution control equipment, the EGU or CEMS. Nevertheless, it may be that some of the outliers are due to such malfunctions. Accordingly, the effect of removing from the datasets potential malfunctions is evaluated by analyzing "filtered" datasets in which statistical outliers are eliminated.

3 Analysis Methodology

The following paragraphs discuss the unit selection process for the UTL analyses, the UTL analysis process, and potential variations of this process.

3.1 Unit Selection

CEMS data from nine coal-fired EGUs were obtained from the EPA Electronic Data Reporting (EDR) site. DOE data were used to ascertain the basic attributes of the population of coal-fired EGUs for those units operating during the year 2005 (2006 was not available). From this 2005 DOE database, units were selected that had the following attributes:

1. High utilization or hours of operation in 2005;
2. NO_x emissions representative of two control technologies:
 - a. Selective Catalytic Reduction (SCR), below 0.1 lb/MMBtu, and
 - b. Combustion controls, between 0.5 and 0.4 lb/MMBtu;
3. Units with both wall- and tangential-firing unit designs;
4. Units with single stack CEMS;
5. Different coal types (bituminous and sub-bituminous); and
6. Different SO₂ control processes (spray and venture scrubbers).

Using these criteria, nine coal-fired EGUs described in Table 1 below were selected.

These units are generally representative of coal-fired EGUs commonly used in the United States. The combustion-controlled and the SCR-controlled units have very different NO_x characteristics. Furthermore, combustion-controlled, wall- and tangential-fired units have different characteristic NO_x curves relative to load. In addition, the bituminous and sub-bituminous-fired units generally have very different levels of NO_x emissions. The SO₂ controls include spray and venturi sulfur oxide removal processes. The purpose of using the units listed in Table 1 was to analyze a cross-section of utility units to gain insight into whether the UTL process was sensitive to these parameters, i.e., coal type, unit type, NO_x control type and, to the extent possible, sulfur oxide control type. In addition, other parameters such as sample size and confidence intervals were also analyzed.

3.2 Evaluation of EPA UTL Process

The purpose of the analysis of the nine selected units listed in Table 1 was to test the hypothesis that EPA established in its proposal, i.e., that the UTL method provides a reasonable maximum “achieved” hourly emission rate that accounts for the normal variability of EGU emission data. It tests EPA’s statement that the UTL process “helps to ensure that the emissions from an EGU will not exceed its pre-change maximum emission rate simply through random variability of the system.” Initially, to test these hypotheses,

EDR data from calendar year 2006 was downloaded from the EPA EDR website for each unit. These data were then subjected to the process delineated by EPA to determine the UTL based on Equation 1. Next, the assumption was made that, in the future after a hypothetical physical or operational change that occurs at the unit after 2006, these units would operate identically (loads, emissions, hours, etc) as they did in 2006. The hypotheses were tested by assuming that the UTL process accurately established the maximum achieved hourly emission rate during the 365 day baseline period and that during the subsequent five years, the unit will be operated identically to the five years before the project. That is, these units were assumed to have undertaken a change in the interim that, in fact, had no effect whatsoever on the units' emissions profile for the entire year. The analysis seeks to determine whether there are any occurrences of hours where the maximum achieved emission rate is exceeded. Any such false positives would indicate a flaw in the statistical procedure, because NSR would be triggered even though there had been no change whatsoever in the emissions profile at the unit. The CEMS data analyzed are for NO_x Method Code 1 or 2 EDR data and all SO₂ data which represent only actual emissions – no substituted data were used.

The UTL analyses were performed exactly as described in the proposal for the EPA UTL methodology together with several other variations of this process. These variations were for various sample sizes (1 to 10 percent), tolerance levels ($Z_{1-q} = 99.0$ to 99.9) and various percentages of the interval ($Z_{1-p} = 99.0$ to 99.98 percent). Also, since it was not possible to extract any potential unreported malfunctions of the unit or the pollution control equipment from the CEMS data, a parallel analysis was done to eliminate potential outliers. This outlier process eliminated any emissions from the 365 day dataset that were above three standard deviations from the mean.

These variations to the EPA-proposed UTL process were undertaken to evaluate the impact of the independent variables in the UTL procedure. All of the following analyses were performed to determine if the proposed UTL process was viable for evaluating post-change maximum hourly emission rates and to investigate whether adjustments to the process would improve this evaluation so that no false positives would result. Subsequent to this initial assessment, five years of CEMS data from 2002 through 2006 were also analyzed (this additional analysis is discussed in section 5.4).

4 EPA UTL Process Results

Two sets of analyses were performed utilizing the procedure delineated in EPA's supplemental proposal. The raw datasets from the nine units were analyzed first. A second set of analyses was performed by removing potential outliers. The outlier criterion assumed that any emissions data above three standard deviations from the mean emission level were anomalous and were removed before sorting the data by heat input. It is believed that these two sets of data bound the solution. The upper bound being the unfiltered dataset and the lower bound being for the dataset with potential outliers removed.

4.1 Evaluation of Unfiltered Datasets

Table 2 below shows the results of the analysis for the unfiltered dataset for both NO_x and SO₂. The column labeled "False Positives" represents the number of times the full 365 day dataset had hourly emission values above the UTL value.

As can be seen in Table 2, only one unit (Unit B) shows no false positives. Most of the units had varying amounts of false positives. For NO_x, this ranged from 1 to 129 hourly NO_x false positives. For SO₂, this ranged from 1 to 687 SO₂ false positives. Potentially, some of these exceedances could have been the result of outliers that may not be representative of normal variations in unit performance and control and measurement processes. The results for this unfiltered case should be considered as the upper bound of the potential exceedances.

The National Bureau of Standards UTL equation was developed for datasets that are normally distributed (Ref. 1). The Shapiro-Wilks (W) coefficient is a measure of the normality of a distribution – 1.0 being normal and those below potentially being non-normal. Datasets with W close to 1.0 could reasonably be considered normally distributed. The SO₂ rate datasets for the units analyzed have Shapiro-Wilks (W) coefficients which are generally around 0.97, however three units have a W coefficients of 0.438, 0.766 and 0.862. Similarly, the NO_x-rate W coefficients are generally around 0.97, but three are 0.438, 0.871 and 0.904. These low-coefficient units may have datasets that depart significantly from a normal distribution. In a perfectly normally distributed emission dataset, there would not be a finite maximum emission rate. However, there is a practical maximum emission rate dependent on the uncontrolled emission level and the amount of coal burned. Whether the actual distribution is normally distributed or not does not assure that the EPA hypotheses are valid. At the 99.9 percent confidence interval, the potential for over 400 false positives are possible in a five year period. Therefore whether the distribution is normal or not cannot significantly change the results since the tolerance limits establish the potential for exceeding the UTL. The only way to insure that the UTL process will satisfy the EPA hypotheses is to set the tolerance level extremely high (99.9977 % for one exceedance in 5 years). This will be illustrated in the analyses provided in Section 5. The normality of the emissions dataset may have less impact on

the attainability of the UTL method than the actual confidence levels used to set the UTL. The statistics for these 18 emission datasets are included in Appendix A.

4.2 Evaluations of Datasets with Outliers Removed

To set a lower bound for the potential failures of the UTL process, an outlier removal process was used on the datasets for the nine units analyzed above. As a surrogate for removing potential anomalous outliers, all emissions data above three standard deviations were removed from the datasets for the nine units. Table 3 shows the results for this lower bound analyses.

Even with the potential outliers removed, eight of the nine units still have many false positives after a hypothetical change at the unit. These filtered results (outliers removed) should be considered the lower bound of the potential false positives.

5 Evaluation of Adjustments to the EPA UTL Methodology

There are a number of adjustments to the proposed UTL methodology that might reduce the number of false positives found in Tables 2 and 3 above. EPA has suggested two possibilities:

1. Utilize the UTL methodology by sorting data by the pollutant (NO_x or SO₂ rate) rather than the heat input; or
2. Change the statistical parameters related to the confidence interval and percentage of data.

The following sections provide analyses related to changes that may improve the UTL process.

5.1 Results for UTL Method Sorted by Pollutant Emission Rate – Unfiltered

Analyses similar to that in Section 4.0 were performed to evaluate the effect of sorting the initial datasets by NO_x and SO₂ rates (instead of heat input) before eliminating the lower 90 percent of the data. From a phenomenological point of view, this makes much more sense than sorting by heat input. It is not necessarily true that high heat input translates into measured high emissions rates. It would make much more sense to sort by pollutant emission rate since that is what is used in the “After” change period to assess whether or not the UTL was exceeded. Table 4 shows the results of applying the UTL process on the datasets sorted by NO_x and SO₂ rates.

The major difference between these results and those shown in Table 2 are:

1. The single unit that did not have a false positive now had some; and
2. The overall, total number of false positives decreased dramatically.

While there were as many as 134 NO_x false positives for the methodology as proposed (i.e., sorting by hourly heat input rates), the maximum number of false positives for this adjustment resulted in a maximum of 28. Similarly, there were 682 SO₂ false positives for the methodology as proposed and only a maximum of 42 for the adjusted methodology. It appears that this methodology would be closer to satisfying EPA hypotheses than sorting by heat input. Nevertheless, none of the units were able to operate without triggering false positives for either NO_x or SO₂.

5.2 Results for UTL Method Sorted by Pollutant – Outliers Removed

To bound the potential false positives, the data for the pollutant-sorted analyses were performed for datasets with the outliers removed. All emissions data for NO_x and SO₂

emissions rates above 3 standard deviations from the dataset mean were eliminated. The UTL process was then performed on the remaining dataset. Table 5 shows the results for this filtered dataset.

As with the unfiltered data, none of the units were able to avoid false positives for both NO_x and SO₂. Again, it appears that this methodology would be closer to satisfying EPA's hypotheses than sorting by heat input. The maximum number of false positives for any unit for NO_x went from 28 to 18 and the maximum for SO₂ went from 42 to 11 by eliminating the outliers. But none could simultaneously avoid triggering false positives for both NO_x and SO₂.

5.3 Results for UTL Methodology with Equivalent Highest 10% Hourly Heat Input Post- Change Dataset

Currently, the process proposed by EPA calculates a UTL value based on 10 percent of the available data (sorted on the basis of heat input) in a 365 day period before a change and compares it to hourly data for the entire 365 day period after the change. It seems inappropriate to compare different populations of data before and after a change, since the UTL is determined for emission rates, not heat input rates. An adjustment that could make the UTL process more reasonable would be to compare the same type of data "before" and "after" the change. This adjustment would compare the hourly emission data from the highest 10 percent (sorted on the basis of heat input) of the dataset "after" the change to the UTL calculated on the basis of the highest 10 percent heat input dataset before the change. This would ensure that the before and after change datasets were based on the same sorting criteria.

Table 6 summarizes the results of this analysis. Columns 5, 6, 9 and 10 show the results for the UTL process using only the highest 10 percent of the heat input dataset, both for calculating the UTL and in the "after-change" dataset, for both unfiltered and filtered (outliers removed) datasets. For comparison purposes, columns 3, 4, 7 and 8 show the results for the UTL process using all of the emissions data "after" the change for both unfiltered and filtered datasets (i.e., using EPA's proposed sorting and comparison methods, as described earlier in section 4).

These results show that limiting the datasets before and after the change to the same highest 10 percent of heat input data improves the possibility of avoiding false positives. This is an improvement in the process, but some units still trigger false positives.

5.4 Evaluation of the Impact of Independent Variables

The independent variables that can be changed in the EPA UTL formula are:

1. Z_{1-p} , the percentage of the interval;
2. Z_{1-q} , the percent confidence interval; and
3. N , the percentage of the 365 day period used.

Since the analyses performed to this point have shown that setting the parameters at those proposed by EPA result in false positives at eight of the nine units analyzed, it is evident that the Z_{1-p} and the Z_{1-q} values must be increased, rather than decreased as suggested by EPA, to obtain more reasonable results. For the sake of illustration, the maximum for these parameters will be set at 99.98 percent which represents approximately 2 potential false positives per year. The following shows the impact of a range of these values:

1. Z_{1-p} from 99.0 to 99.98 percent
2. Z_{1-q} from 90 to 99.98 percent

Figure 1 shows the impact of these parameters on the standard deviation in the UTL equation.

The middle (red) line represents the EPA-proposed value for the percentage interval. The bottom (blue) line represents an alternate that EPA has suggested. Obviously, since the UTL as proposed results in many false positives, the lower values of these parameters are not appropriate. Comparing the low end factor for the data interval (99.0 %) with the high end value of the data interval (99.98 %) shows that the maximum increase in the standard deviation coefficient is approximately 18 percent. For some of the units, this is not sufficient to avoid false positives. Therefore, the only other independent variable to change would be the size of the dataset. Currently it is set at 10 percent of the 365 day period. Based upon the UTL equation, decreasing this parameter would increase the standard deviation multiplier and possibly allow all units to avoid false positives.

Decreasing the percentage of the 365 day data used to calculate the UTL also changes the value of the standard deviation. The results for simply decreasing the amount of data analyzed are shown below in Figure 2. This figure shows that as the size of the dataset is decreased, the standard deviation multiplier increases. For the sake of setting a lower bound for these parameters, one could analyze only one percent of the data and employ a 99.98 confidence interval. This would likely decrease the number of false positives provided that the standard deviation itself did not decrease drastically as well. Table 7 shows the results of these analyses for filtered datasets comparing the NO_x and SO_2 UTL before change to the highest hourly emissions rate after change and also to the highest emission rate for 1 percent of the data after change.

The number of false positives was determined for the nine units for the case where only one percent of the data was used in the UTL determination. For the analysis comparing all of the hourly emission data after change, 3 units had NO_x false positives and 4 units had SO_2 false positives. For the analysis for 1 percent of the highest heat input data after change, 1 unit had NO_x false positives and the same unit had a SO_2 false positive. This latter analysis method, using 1 percent of the data before and 1 percent after, comes very close to satisfying the EPA hypotheses.

5.5 Evaluation of Pre-Change Five-Year Operating Period

The following analyses utilize five years (2002 to 2006) of emission data for the 9 units. Previous sections concentrated on the statistical nature of the process. The following provides insight into the year-to-year variation of the UTL and also provides analyses of the UTL process for the original proposed methodology (i.e., using 5 years worth of data, instead of just one year -- 2006).

5.5.1 Evaluation of Calendar Years Against Highest Heat Input Year

The previous analyses compared the 2006 pre-change UTL against the same dataset post-change. The following analysis compares the UTL for the highest heat input calendar year against the 4 other calendar years and against the highest heat input calendar year as well. Table 8 shows the results of these analyses. This table illustrates several shortcomings of EPA's proposed method using the 10 percent highest heat input for a 365 calendar day period against hourly emissions for the calendar year ("All Data After" columns). In addition, results are shown in Table 8 for an analysis in which the UTL process is modified by using the same 10 percent of the highest heat input both pre- and post-change data ("10% Data After" columns). The data shown in Table 8 is for the unfiltered emission data (no outliers removed).

In addition to the fact that it was previously shown that the process may not be viable due to basic statistical issues, the major shortcomings that become evident as a result of the five-year period analyses are briefly summarized below:

1. The highest UTL year for NO_x is not necessarily the highest year for SO₂ for 4 of the 9 units as illustrated by the green shaded data.
2. Maximum emissions in calendar years other than the highest UTL calendar year cause false positives for 4 of the 9 units as illustrated by the yellow shaded data, i.e., the highest UTL year did not capture the highest emission rate.
3. The UTL varies significantly for year to year.

Utilizing a sort by pollutant (EPA's alternate approach) would potentially solve item 1 above. It would not solve the issues related to other years with maximum emissions greater than the highest UTL year during the five year period.

5.5.2 Evaluation of Highest Heat Input Year Against 5-Year Hourly Emissions

Analyses were performed for the exact UTL process proposed by EPA for the five year period from 2002 to 2006 (i.e., assuming a change that is undertaken at the end of 2006). The highest heat input year was determined from this five year dataset irrespective of the calendar year. The UTL calculated from this highest year established the maximum NO_x and SO₂ emission rates. Figures 3 and 4 illustrate this process for Unit E1. Appendix B contains similar plots for the other 8 units analyzed. Tables 9 and 10 show the results for

the proposed methodology sorting on heat input for the dataset with all EDR emission data (no exclusions) and for the same dataset with potential outliers removed, respectively.

For this analysis the five-year period was assumed to be exactly the same for pre-change and post-change. That is, each unit was assumed to operate identically in all respects in the 5 years after a hypothetical change undertaken at the end of 2006 to the way the unit operated before that change. Table 9 shows that 7 out of the 9 units had false positives for NO_x and that all had false positives for SO₂.

Table 10 illustrates the same results for the emission dataset filtered to eliminate potential outliers. For this filtered dataset, 5 out of the 9 units had false positives for NO_x and 7 out of 9 had false positives for SO₂. Two units (B5 and D4) had no false positives for either NO_x or SO₂. Consequently, 7 out of the 9 units had false positives for either NO_x or SO₂. While this shows that some units could meet the test, the majority would not.

For the alternate methodology suggested by EPA, the emission data were sorted by species (NO_x or SO₂ emission rates) and the highest 365 day period for these were used to set the UTL maximum emission level. Tables 11 and 12 show the results for unfiltered and filtered emission datasets, respectively. Similar to the heat-input sorted results (Tables 9 and 10), the majority of the units had false positives. For the unfiltered dataset (Table 11), all units had false positives. For the filtered dataset (Table 12), all but one unit had false positives. As with the heat-input sort methodology, the emission rate sort alternative methodology resulted in the majority of the units having false positives.

Shortening the sorting period to one percent and changing the basic statistics to 99.98 percent confidence interval potentially would be a method for improving the UTL process. EPA appears to have selected the ten percent sorting criterion as a way to characterize the emissions rate of a unit at maximum output. If that is the case, one percent would be even more characteristic of the emissions rate of the unit at maximum output.

The NSR consequences of an EGU failing the NSR test are much greater than those for rulemakings in which an emission rate standard (or limit) is set, such as NSPS. Therefore, if EPA uses a statistical method, such as the UTL process, to determine whether there has been an increase in the hourly emissions rate after a project, it is extremely important to assure that the UTL process does not show false positives for the population of EGUs. For the nine units analyzed, EPA's proposed statistics for the NSR test may result in as many as 124 and 425 false positives in five years for either NO_x or SO₂, respectively. Unlike the exceedance of an emissions limit, such as an NSPS, failure of the NSR test for a significant emission increase has potential monumental costs associated with retrofits of costly control equipment. One failure of the test could result in the EGU being required to retrofit controls costing many hundreds of millions of dollars. Since the current statistics (99.9 and 90.0 %) have the potential to fail the test numerous times, the statistics should justifiably be increased to allow fewer potential exceedances. For one exceedance in five years, the confidence interval would have to be set at 99.998 percent. EPA has in the past established a 1 violation of the NSPS in 10 years criterion. For 24 hour block days, this amounts to a confidence interval of 99.9726 percent which was used in the 1978 NSPS and subsequent rulemakings (References 2, 3, 4 & 5). Had the 1978 NSPS been on an

hourly basis, the confidence interval would have been set at 99.9989 percent for one hourly violation in 10 years.

Table 13 and 14 show the results for the data sorted by species for a one-percent sorting criterion and a confidence interval of 99.98 for both unfiltered and filtered data, respectively. While this decreases the number of units that have false positives, still only two units can have no false positives for both SO₂ and NO_x.

The process analyzed above is exactly that proposed by EPA. The results show that a majority of the units analyzed could not operate without false positives regardless of the sorting method, statistics or population size.

5.6 Evaluation of a Revised UTL Calculation Process

EPA proposed to utilize a two step process for calculating the upper tolerance limit for EGU emissions. The first step was to identify the highest 365 day period for either heat input or NO_x and SO₂. The second step was to determine the highest 10 percent of the values for these parameters and calculate the UTL based on this 10 percent population. By selecting only the highest values of the parameters within the 365 day period, the process effectively distorts the natural variability of the data during that period. It essentially minimizes the standard deviation of the data (variability) and causes the UTL to be lower than that for the actual 365 day dataset. This process makes the UTL artificially low particularly when it is to be tested against hourly data after the change.

An improvement to eliminate this artificially low UTL would be to calculate it using all of the data in the highest period. In the case of the EPA proposed methodology, this would be for the entire 365 contiguous days. The disadvantage of utilizing this large population (8760 hours) is that it masks the true normal response of a utility EGU. Utility EGUs have both diurnal and weekly variation depending upon the time of year. These variations within a day or a week can be much greater than those represented by an annual average and significantly greater than the highest 10 percent of the annual average. Therefore, a more realistic time period for selecting the highest emissions would be in the order of a week (168 hours). This captures both the diurnal and weekly variations that typical utility EGUs experience during the year. Utilizing the UTL calculated on this basis likely would more closely fit the hypotheses stated by EPA in the preamble.

The methodology for this revised UTL process would be to first determine the rolling average 168-hour periods for both NO_x and SO₂ during the 5 years prior to the change. Then determine their UTLs based upon the statistics for these periods. And finally, select the highest UTL for the two species and utilize this value to compare against the hourly NO_x and SO₂ emissions levels after the change. Since this revised process and the UTL process proposed by EPA both have the potential for resulting in false positives of the NSR test, a test for internal consistency should be utilized to prevent false positives that might have actually occurred during the before change period. As a check against internal consistency, the number of false positives would be determined for the five year period prior to the change. The resulting number of false positives determined in the before

change period would then be allowed for the 5-year period after the change. If the number of measured hourly emissions rates that exceed the UTL in the 5 years after the project is not more than the allowed number of exceedances, there is no increase in the maximum achieved hourly emissions rate.

Figures 5 and 6 show the 168-hour UTL process described above for Unit E using the statistics proposed by EPA, i.e., $Z_{1-p} = 3.090$ for the 99.9 percentage of the interval and $Z_{1-q} = 2.326$ for the 99.0 percent confidence interval. As can be seen from the figures, the maximum UTL values for NO_x and SO_2 for this process were 6007 and 1658, respectively. Utilizing these UTL values resulted in no false positives for NO_x and 15 false positives for SO_2 . This compares with 41 false positives for NO_x and 425 false positives for SO_2 for the proposed EPA UTL process. Table 15 shows the results for this revised 168-hour UTL process for the nine units analyzed previously. Appendix C provides plots of the 168 hour rolling averages for remaining 8 units analyzed. Clearly this revised 168-hour UTL process minimizes the number of units with false positives compared to the original process proposed by EPA. In addition, it minimizes the number of allowed false positives.

Increasing the NSR statistics to something greater than presently proposed would result in fewer potential failures for both the EPA proposed process and the alternate 168-hour UTL process. For the alternate 168-hour process, it would likely result in only one of the nine units failing the NSR test without the use of an allowed number of exceedances.

6 Conclusions

The analyses described in the previous sections were performed to evaluate EPA's proposed Upper Tolerance Limit (UTL) method for establishing an EGU's pre-change maximum "achieved" hourly emission rate. Specifically, the analyses were performed to test EPA's hypotheses regarding whether the UTL process adequately captures the variability of EGU emissions and whether the UTL level is properly set so that no "false positives" will result. The analyses considered data from 9 coal-fired EGUs. The following briefly summarizes the conclusions:

6.1 *Evaluation of EPA UTL Process*

- X The UTL process applied to raw EDR data for 9 units showed that 8 had false positives.
- X The UTL process applied to filtered (outliers removed simulating unreported malfunctions) EDR data for 9 units also showed that 8 had false positives.

The conclusion based on these analyses is that the UTL process for the majority of utility units would likely result in false positives.

6.2 *Evaluation of UTL Process Sorted by Pollutant Emission Rate*

- X The UTL pollutant sort process applied to unfiltered raw EDR data for 9 units showed that all would have false positives.
- X The UTL pollutant sort process applied to filtered EDR data for 9 units again showed that all would have false positives.

The conclusion based on these analyses is that, while sorting on the basis of pollutant emission rates improves the process (i.e., shows less overall false positives), all of the units analyzed would have false positives.

6.3 *Evaluation of UTL Process with Equivalent Post-Change Heat Input Sort Dataset*

- X The UTL process applied to unfiltered EDR data for 9 units showed that 5 had false positives.
- X The UTL process applied to filtered EDR data for 9 units showed that 4 had false positives.

The conclusion based on these analyses is that utilizing the same population (highest 10 percent heat input rates) post-change decreases the number of false positives. Nevertheless, many units still would have false positives.

6.4 Evaluation of Adjusting the UTL Independent Variables

- X Decreasing the Z_{1-p} and Z_{1-q} parameters below those proposed would result in more false positives.
- X Increasing the Z_{1-p} and Z_{1-q} parameters to 99.98 percent (representative of ~ 2 potential failures per year) would likely result in significantly fewer units having false positives.
- X Decreasing the heat input sample size N below 10 percent would likely result in significantly fewer units having false positives provided the standard deviation was approximately the same.
- X The UTL process applied to filtered EDR data for 9 units for the parameter extreme values of $Z_{1-p} = 99.98$, $Z_{1-q} = 99.98$ and $N = 1$ percent for the entire 365 day period shows that 3 units had NO_x false positives and 4 units had SO_2 false positives.
- X The UTL process applied to filtered EDR data for 9 units for the parameter extreme values of $Z_{1-p} = 99.98$, $Z_{1-q} = 99.98$ and $N = 1$ percent for the same post-change population (i.e., highest 10 percent heat input dataset) shows that 2 units had NO_x false positives and 1 unit had SO_2 false positives.

Based on these analyses, even if the UTL parameters were set at the extremes, many units would still have false positives.

6.5 Evaluation of UTL for 5-Year Long Operating Period

The following analysis shows the results of applying the UTL process to five years of data for the 9 units. The first analysis compared the UTL calculated for each calendar year to that for other calendar years. The second analysis compared the UTL calculated based on the 365-day period with the highest parameter (heat input, NO_x or SO_2 emissions rates) to the hourly emission rate for the five year period. This latter analysis simulates the proposed and alternate UTL processes described in the supplemental proposal.

6.5.1 Comparing 5-Calendar Years UTL Emissions

- X Comparing 5 calendar years of emission data against the other 4 years using the heat input sort UTL process showed that the highest UTL year for NO_x was not necessarily the highest year for SO_2 for 4 of the 9 units for unfiltered emission datasets.
- X Comparing 5 calendar years of emission data against the other 4 years using the heat input sort UTL process showed that the maximum emissions in calendar years other than the highest UTL calendar year caused false positives

- for 4 of the 9 units for unfiltered emission datasets, i.e., the maximum emissions did not occur in the highest UTL calendar year.
- X The UTL varies significantly from year to year.

6.5.2 Comparing 5 Calendar Years Hourly Emissions Against UTL Emissions

- X Comparing 5 years of emission data using the heat input sort UTL process proposed by EPA resulted in all 9 units having false positives for the unfiltered dataset.
- X Comparing 5 years of emission data using the heat input sort UTL process proposed by EPA resulted in 7 of the 9 units having false positives for the unfiltered dataset.
- X Comparing 5 years of emission data using the alternate NO_x and SO₂ emission-rate sort UTL process proposed by EPA resulted in all 9 units having false positives for the unfiltered dataset.
- X Comparing 5 years of emission data using the alternate NO_x and SO₂ emission-rate sort UTL process proposed by EPA resulted in 8 of the 9 units having false positives for the unfiltered dataset.

6.5.3 168-Hour Revision of the UTL Process

- X Revising the UTL period from 365 days to 168 hours and utilizing the statistics from this 168-hour period improves the UTL process.
- X The revision more closely satisfies EPA's original hypotheses,
- X The number of units showing false positives under the UTL test for NO_x decreased from 6 to 2 in the revised process,
- X The number of units showing false positives under the UTL test for SO₂ decreased from 9 to 3 in the revised process,
- X For units showing false positives under the UTL test, the maximum number of NO_x false positives decreased from 124 to 8 in the revised process,
- X For units showing false positives under the UTL test, the maximum number of SO₂ false positives decreased from 490 to 15 in the revised process.

The general conclusion based on these analyses for CEMS data from 9 coal-fired EGUs is that the hypothesis that EPA used to establish its proposed UTL process was not proven out by applying it to typical EGU CEMS datasets. The datasets utilized avoided the potential complications brought into the process by CEMS data for units that do not operate with the same emission requirements during the entire year (Ozone Season units). Since the analyses were performed for units with high capacity factors, it also did not address the complications arising from cyclic operation of EGUs with relatively small capacity factors. As a consequence, the analyses performed herein are felt to be the best that could be expected. Therefore, under the best conditions, EPA's proposed UTL process does not support the EPA hypotheses.

There were two analyses discussed in this paper that resulted in a reasonably small number of positives: (1) the proposed UTL process, revised to use a one-percent sorting criterion and a confidence interval of 99.98; and (2) the 168-hour UTL process. These analyses minimized the number of false positives, but they did not eliminate them. Therefore, additional steps should be used to provide internal consistency and account for the remaining false positives. For example, the following two steps can be added:

- X Test the pre-change hourly emissions for false positives, and
- X In determining whether there has been a significant increase in emissions after a change, allow as a safe harbor the number of hourly false positives that occurred during the pre-change period.

7 References

1. Mary Gibbons Natrella, "Experimental Statistics," NBS Handbook 91, U.S. Department of Commerce, 1963.
2. Standards of Performance for Electric Utility Steam Generating Units for which construction commenced after September 18, 1978 40 CFR 60, Subpart Da, promulgated June 11, 1979.
3. Proposed New Source Performance Standards for Industrial-Commercial – Institutional Generating Units, 40 CFR, Subpart Db, proposed June 19, 1986.
4. Statistical Analysis of Wet Flue Gas Desulfurization Systems and Coal Sulfur Content, Volume 1: Statistical Analysis, Radian Corporation, August 18, 1983 EPA Report No. 68-20-3816.
5. Fed. Reg. Vol. 40, No. 194 – Monday, October 6, 1975, 60.45.

TABLE 1 Electric Utility Units Selected for UTL Analysis

Plant	Unit	Unit Size, MW	Boiler Type	NOx Control	SO2 Control	Fuel
E	1	780	Tangential	Combustion	Venturi	Sub-Bituminous
A	2	775			Spray	Bituminous
C	3	510			Spray	Bituminous
B	5	770	Dry Bottom Wall	Combustion	Spray	Bituminous
F	1	700			Spray	Bituminous
G	1	790			Spray	Bituminous
D	4	800			Spray	Sub-Bituminous
H	1	635	Dry Bottom Wall	SCR	Spray	Bituminous
I	8	650	Tangential	SCR	Venturi	Sub-Bituminous

TABLE 2 Results for EPA UTL Method For 2006

Plant	Unit	N	NOx			SO2		
			UTL NSR NOx Before	Max NOx - All Data After	Number False Positive Hrs	UTL NSR SO ₂ Before	Max SO ₂ - All Data After	Number False Positive Hrs
E	1	795	4361	4829	11	1,096	2,117	49
A	2	775	2985	2854	0	9,766	10,257	2
C	3	506	544	561	1	2,538	2,561	1
B	5	769	4848	4686	0	9,443	9,328	0
F	1	759	4337	4319	0	6,092	6,170	1
G	1	788	3886	4614	33	5,388	6,705	1
D	4	793	2525	2603	4	2,332	3,595	687
H	1	783	1309	2801	129	1,825	15,366	400
I	8	857	311	603	36	1,325	1,551	123

TABLE 3 Results for EPA UTL Method for 2006
Potential Outliers Removed

Plant	Unit	NOx			SO ₂		
		UTL NSR NOx Before	Max NOx - All Data After	Number False Positive Hrs	UTL NSR SO ₂ Before	Max SO ₂ - All Data After	Number False Positive Hrs
E	1	4361	4829	11	1023	1061	19
A	2	2985	2854	0	9766	10257	2
C	3	544	561	1	2538	2561	1
B	5	4848	4686	0	9443	9328	0
F	1	4337	4319	0	6092	6170	1
G	1	3810	4254	10	5350	4214	0
D	4	2525	2603	4	2333	3055	682
H	1	785	1123	134	1829	4084	317
I	8	311	331	7	1325	1431	98

TABLE 4 UTL Results for NOx and SO₂ Rate Sorted Datasets for 2006
Rate Sorted Datasets for 2006
Unfiltered Dataset

Plant	Unit	NOx			SO ₂		
		UTL NSR NOx Before	Max NOx - All Data After	Number False Positive Hrs	UTL NSR SO ₂ Before	Max SO ₂ - All Data After	Number False Positive Hrs
E	1	4,272	4,829	15	1,356	2,117	17
A	2	2,862	2,854	0	9,311	10,257	10
C	3	539	561	1	2,512	2,561	2
B	5	4,421	4,686	5	8,720	9,328	11
F	1	4,137	4,319	5	5,210	6,170	9
G	1	4,123	4,614	28	4,439	6,705	4
D	4	2,479	2,603	8	3,108	3,595	4
H	1	2,357	2,801	5	11,969	15,366	42
I	8	412	603	23	1,504	1,551	5

TABLE 5 UTL Results for NO_x and SO₂ Rate Sorted Datasets for 2006
Outliers Removed

Plant	Unit	NO _x			SO ₂		
		UTL NSR NO _x Before	Max NO _x - All Data After	Number False Positive Hrs	UTL NSR SO ₂ Before	Max SO ₂ - All Data After	Number False Positive Hrs
E	1	4,272	4,829	15	1,064	1,061	0
A	2	2,862	2,854	0	9,311	10,257	10
C	3	539	561	1	2,512	2,561	2
B	5	4,421	4,686	5	8,720	9,328	11
F	1	4,137	4,319	5	5,210	6,170	9
G	1	3,772	4,254	11	4,275	4,214	0
D	4	2,479	2,603	8	3,073	3,055	0
H	1	1,143	1,123	0	3,508	4,084	10
I	8	303	331	18	1,461	1,431	0

TABLE 6 Comparison of UTL False Positive Hours for Various Alterations to Datasets
Year 2006

Plant	Unit	NO _x				SO ₂			
		EPA UTL Method - Unfiltered	EPA Method - Filtered	EPA Method - Unfiltered using 10% Highest HI Data After	EPA Method - Filtered using 10% Highest HI Data After	EPA UTL Method - Unfiltered	EPA Method - Filtered	EPA Method - Unfiltered using 10% Highest HI Data After	EPA Method - Filtered using 10% Highest HI Data After
1	2	3	4	5	6	7	8	9	10
E	1	11	11	8	8	47	16	8	2
A	2	0	0	0	0	2	2	0	0
C	3	1	1	0	0	1	1	0	0
B	5	0	0	0	0	0	0	0	0
F	1	0	0	0	0	1	1	0	0
G	1	33	10	4	0	1	0	0	0
D	4	4	4	4	4	662	658	17	17
H	1	129	134	17	3	331	327	8	7
I	8	36	7	2	2	125	99	11	11

FIGURE 1 Impact of Confidence Limits on Standard Deviation Multiplier

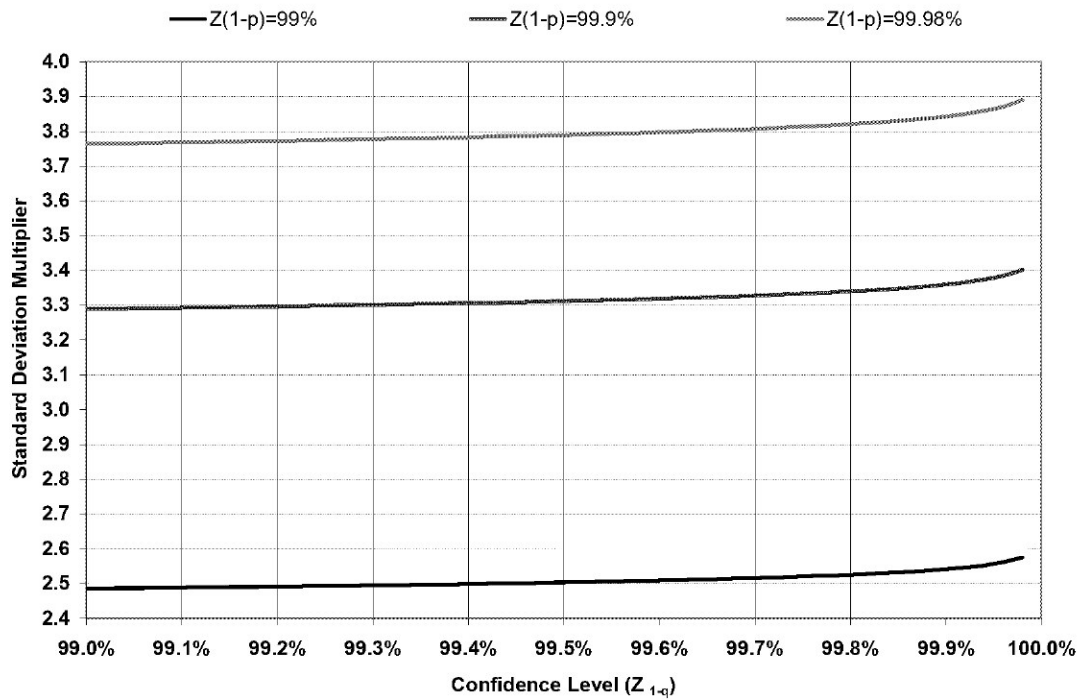


Figure 2 Impact of Fraction of 365 Day Period on Standard Deviation Multiplier

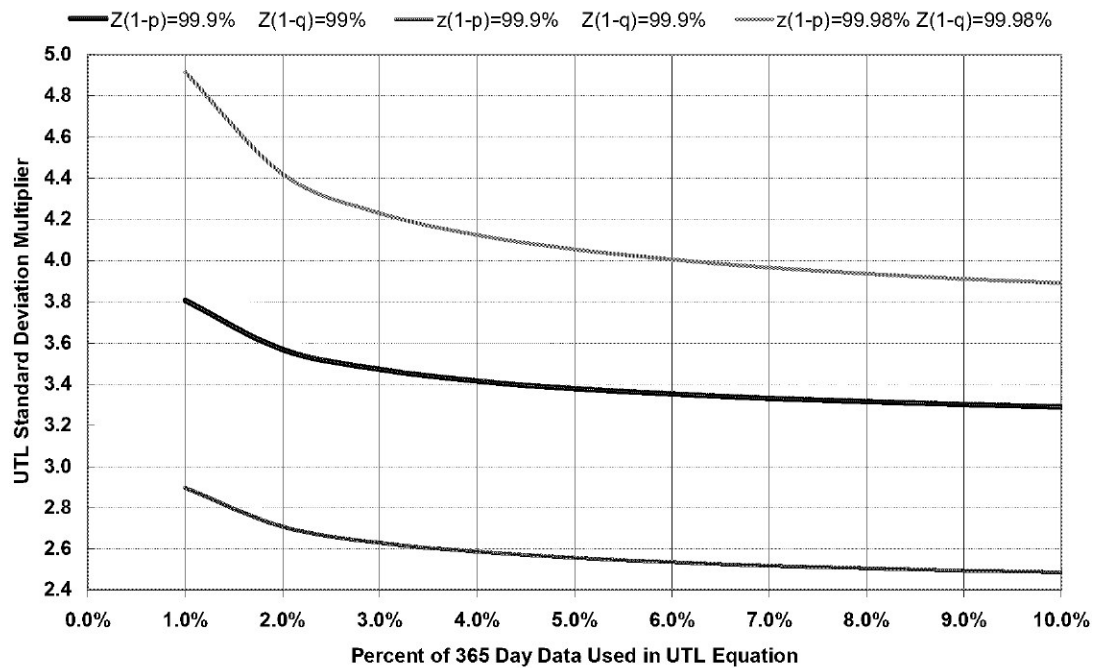


TABLE 7 Comparison of UTL False Positive Hours for One Percent of Dataset
Year 2006 Sorted on Highest Heat Input for Filtered Data
Z1-p and Z1-q = 99.98 for 1 Percent of Data

Plant	Unit	NOx		SO ₂	
		EPA Method - All Data After Change	EPA Method - 1 % Of Data After Change	EPA Method - All Data After Change	EPA Method - 1 % Of Data After Change
E	1	0	0	16	0
A	2	0	0	0	0
C	3	0	0	0	0
B	5	0	0	0	0
F	1	0	0	0	0
G	1	25	0	1	0
D	4	0	0	21	0
H	1	5	2	135	1
I	8	27	0	0	0

**Table 8 Five Year Comparison of UTL Results for Heat Input Sorting
Years 2002 Through 2006**

Plant and Unit	Operating Year	NOx					SO2				
		UTL NSR NOx Before	All Data After		10 % Data After		UTL NSR SO2 Before	All Data After		10 % Data After	
			Max NOx - All Data After	Number Hours Exceeding	Max NOx - 10% Data After	Number False Positive Hrs		Max SO2 - All Data After	Number Hours Exceeding	Max SO2 - 10% Data After	Number False Positive Hrs
E1	2002	4334	4485	5	4485	5	1045	1020		1020	
	2003	3817	3943	10	3943	10	1005	1015	6	1015	6
	2004	4098	4354	10	4354	10	1097	1084		1084	
	2005	4068	4138	6	4138	6	1014	1007		1007	
	2006	4272	4829	15	4829	15	1064	1061		1061	
A2	2002	3162	3230	2	3230	2	9725	10123	4	10123	4
	2003	2996	3063	1	3063	1	9737	9916	5	9916	5
	2004	2655	2760	6	2760	6	9639	10717	19	10717	19
	2005	2776	2776	1	2776	1	9177	9466	9	9466	9
	2006	2862	2854		2854		9311	10257	10	10257	10
C3	2002	627	653	7	653	7	2728	2661		2661	
	2003	699	787	9	787	9	3178	3114		3114	
	2004	640	671	9	671	9	2624	2605		2605	
	2005	552	571	2	571	2	2739	2710		2710	
	2006	539	561	1	561	1	2512	2561	2	2561	2
B5	2002	4393	4762	9	4762	9	8296	8618	8	8618	8
	2003	4302	4337	4	4337	4	8130	8355	15	8355	15
	2004	4091	4460	8	4460	8	7998	8013	1	8013	1
	2005	4842	5084	4	5084	4	9532	10082	4	10082	4
	2006	4421	4686	5	4686	5	8720	9328	11	9328	11
F1	2002	4590	4907	6	4907	6	6607	6485		6485	
	2003	4047	4376	10	4376	10	6489	6484		6484	
	2004	4144	4325	4	4325	4	5126	5375	11	5375	11
	2005	4305	4424	4	4424	4	5521	5750	7	5750	7
	2006	4137	4319	5	4319	5	5210	6170	9	6170	9
G1	2002	5193	4905		4905		3796	3878	7	3878	7
	2003	5324	5196		5196		3803	3922	4	3922	4
	2004	4507	4538	1	4538	1	3902	4077	11	4077	11
	2005	4055	4139	2	4139	2	4527	4679	5	4679	5
	2006	3772	4254	11	4254	11	4275	4214		4214	
D4	2002	2951	3070	6	3070	6	2534	2449		2449	
	2003	2908	3080	7	3080	7	2700	2820	2	2820	2
	2004	2370	2471	16	2471	16	2185	2219	3	2219	3
	2005	2340	2384	8	2384	8	2296	2327	4	2327	4
	2006	2479	2603	8	2603	8	2085	2825	18	2301	13
H1	2002	2860	2786		2786		2042	1978		1978	
	2003	5692	4633		4633		2990	2903		2903	
	2004	4132	3388		3388		3982	4146	3	4146	3
	2005	1715	1402		1402		3425	4177	21	4177	21
	2006	1143	1123		1123		3508	4084	13	4084	13
I8	2004	537	586	15	586	15	1485	1413		1413	
	2005	314	353	12	353	12	1366	1337		1337	
	2006	303	331	18	331	18	1461	1431		1431	

Figure 3 Unit E1 Five Year Hourly NO_x Averages
 UTL for NO_x Calculated for Highest 365 Day Heat Input

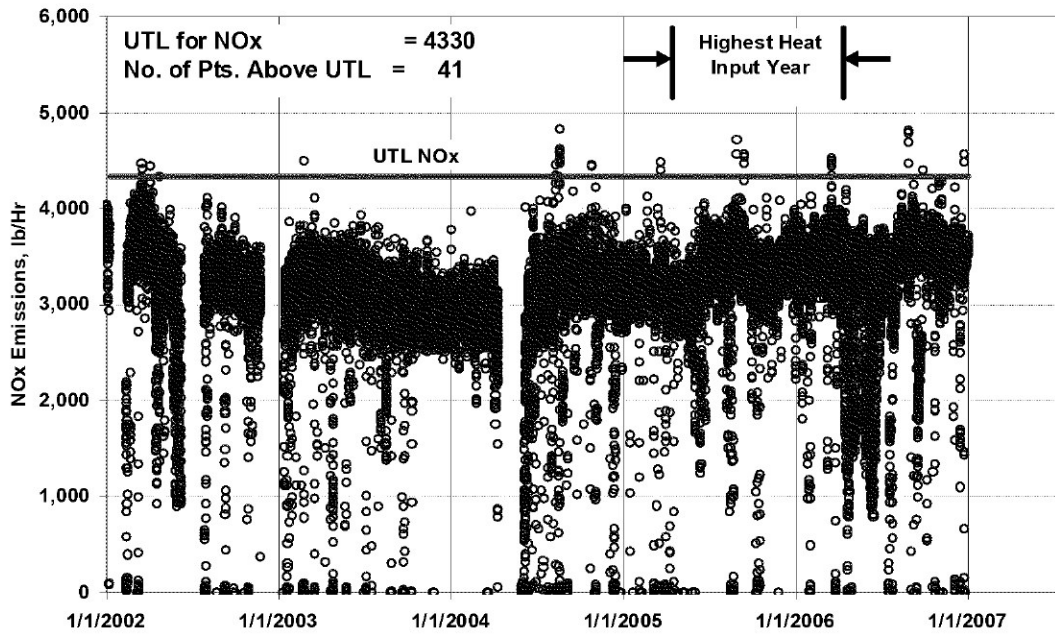


Figure 4 Unit E1 Five Year Hourly SO₂ Averages
 UTL for SO₂ Calculated for Highest 365 Day Heat Input

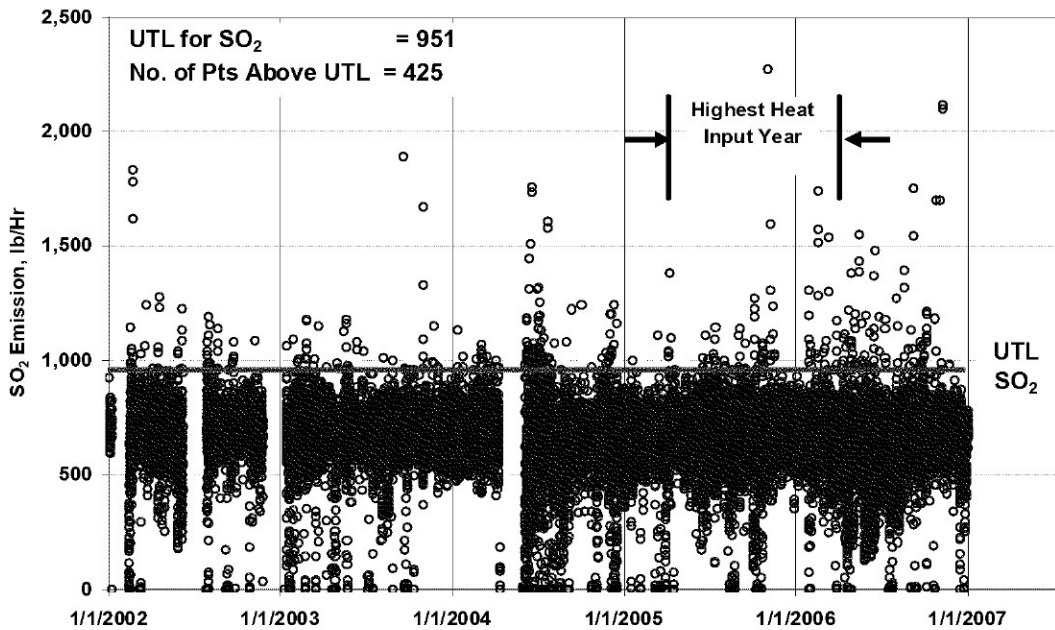


TABLE 9 Results for EPA Heat Input Sorting UTL Method for 5 Years
Comparing All Hourly Emissions Post-Change Unfiltered

Plant	Unit	NOx				SO2			
		Mean NOx	UTL NSR NOx Before	Max NOx - All Data After	Number False Positive Hrs	Mean SO ₂	UTL NSR SO ₂ Before	Max SO ₂ - All Data After	Number False Positive Hrs
E	1	3537	4330	4838	41	665	951	3,616	425
A	2	2586	3111	5749	47	8,216	10,132	10,717	12
C	3	541	653	787	35	2,178	3,073	3,114	12
B	5	4195	5449	5084	0	8,124	10,723	11,841	2
F	1	3400	4181	4907	124	4,361	6,260	7,154	21
G	1	3352	5103	7712	41	2,773	4,204	7,719	61
D	4	2652	3061	3080	3	1,652	2,919	7,630	77
H	1	1697	6083	5819	0	1,289	2,922	21,546	490

TABLE 10 Results for EPA Heat Input Sorting UTL Method for 5 Years
Comparing All Hourly Emissions Post-Change - Outliers Removed

Plant	Unit	NOx			SO2		
		UTL NSR NOx Before	Max NOx After	Number False Positive Hrs	UTL NSR SO ₂ Before	Max SO ₂ After	Number False Positive Hrs
E	1	4282	4542	32	946	1,048	277
A	2	3111	3230	10	10,132	10,717	12
C	3	653	715	31	3,073	3,114	12
B	5	5449	5084	0	10,685	10,082	0
F	1	4181	4658	120	6,260	6,380	10
G	1	5063	4835	0	4,194	4,370	32
D	4	3061	2948	0	2,873	2,630	0
H	1	5136	3473	0	2,748	3,754	298

TABLE 11 Results for EPA NOx/SO₂ Rate Sorting UTL Method for 5 Years
Comparing All Hourly Emissions Post-Change - Unfiltered

Plant	Unit	NOx				SO2			
		Mean NOx	UTL NSR NOx Before	Max NOx After	Number False Positive Hrs	Mean SO ₂	UTL NSR SO ₂ Before	Max SO ₂ After	Number False Positive Hrs
E	1	3784	4219	4838	64	839	1,250	3,616	46
A	2	2777	3162	3162	2	8,925	9,684	10,717	33
C	3	562	669	787	26	2,394	2,888	3,114	51
B	5	4575	4841	5084	4	8,780	9,611	11,841	6
F	1	3660	4127	4907	172	4,902	5,542	7,154	295
G	1	4030	4831	7712	125	3,437	4,068	7,719	102
D	4	2697	2950	3080	10	1,954	2,595	7,630	364
H	1	2640	3512	5819	811	2,867	9,969	21,546	101

TABLE 12 Results for EPA NOx/SO₂ Rate Sorting UTL Method for 5 Years
Comparing All Hourly Emissions Post-Change - Outliers Removed

Plant	Unit	NOx				SO2			
		Mean NOx	UTL NSR NOx Before	Max NOx After	Number False Positive Hrs	Mean SO ₂	UTL NSR SO ₂ Before	Max SO ₂ After	Number False Positive Hrs
E	1	3531	4282	4542	32	712	950	1,048	260
A	2	2587	3115	3162	0	8,216	10,132	10,717	12
C	3	541	653	715	31	2,178	3,073	3,114	12
B	5	4195	5449	5084	0	8,120	10,685	10,082	0
F	1	3451	4302	4658	50	4,518	5,980	6,380	83
G	1	3369	5014	4835	0	3,013	3,934	4,370	149
D	4	2652	3061	2948	0	1,571	2,379	2,630	546
H	1	2408	3083	3473	232	1,285	3,078	3,754	145

TABLE 13 Results for EPA NOx/SO₂ Rate Sorting UTL Method for 5 Years

Comparing All Hourly Emissions Post-Change - Unfiltered 1% Population @ 99.98 CI

Plant	Unit	NOx				SO ₂			
		Mean NOx	UTL NSR NOx Before	Max NOx After	Number False Positive Hrs	Mean SO ₂	UTL NSR SO ₂ Before	Max SO ₂ After	Number False Positive Hrs
E	1	4072	5030	4838	0	1,040	2,627	3,616	2
A	2	3020	3332	5749	37	9,423	10,239	10,717	10
C	3	637	754	787	3	2,753	3,353	3,114	0
B	5	4745	5065	5084	1	9,282	11,450	11,841	2
F	1	3980	4478	4907	17	5,331	6,215	7,154	26
G	1	4573	5304	7712	24	3,837	5,356	7,719	9
D	4	2866	3110	3080	0	2,349	4,370	7,630	38
H	1	3270	4725	5819	89	8,068	27,684	21,546	0

TABLE 14 Results for EPA NOx/SO₂ Rate Sorting UTL Method for 5 Years

Comparing All Hourly Emissions Post-Change - Filtered 1% Population @ 99.98 CI

Plant	Unit	NOx				SO ₂			
		Mean NOx	UTL NSR NOx Before	Max NOx After	Number False Positive Hrs	Mean SO ₂	UTL NSR SO ₂ Before	Max SO ₂ After	Number False Positive Hrs
E	1	3998	4418	4542	22	940	1,076	1,048	0
A	2	3020	3332	3230	0	9,423	10,239	10,717	10
C	3	637	754	715	0	2,753	3,353	3,114	0
B	5	4745	5065	5084	1	9,249	10,898	10,082	0
F	1	3980	4478	4658	13	5,331	6,215	6,380	15
G	1	4503	5064	4835	0	3,774	4,284	4,370	10
D	4	2866	3110	2948	0	2,194	2,566	2,626	25
H	1	3082	3573	3473	0	3,271	4,874	3,754	0

Table 15 Comparison of Proposed UTL and Revised UTL Methods
EPA Proposed Statistics (99.9 and 90.0)

Plant	Unit	NOx False Positives		SO ₂ False Positives	
		EPA Method	168 Hr Method	EPA Method	168 Hr Method
E	3	35	0	12	0
A	3	41	0	425	15
C	2	47	0	12	0
B	5	0	0	2	0
F	1	44	0	145	0
G	4	3	0	77	2
D	1	124	0	21	0
H	1	41	1	490	3
I	8	87	8	315	0

Figure 5 Unit E1 168 Hour NOx UTL Results

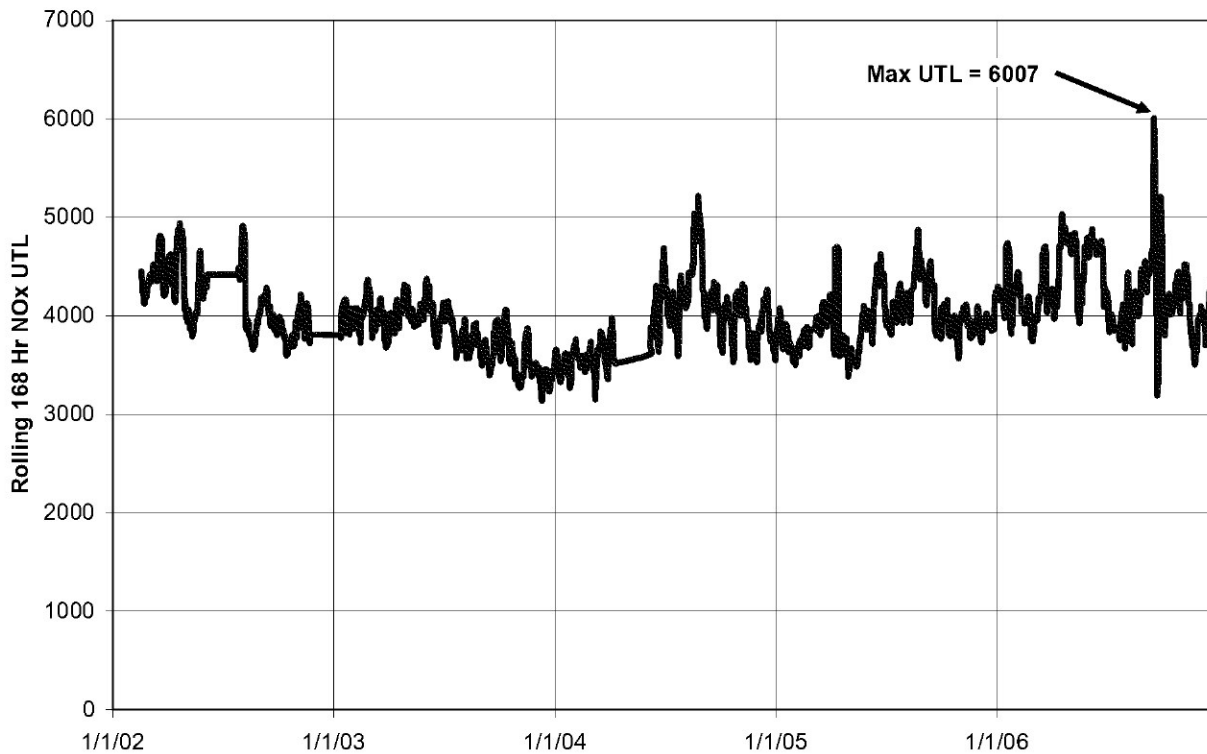
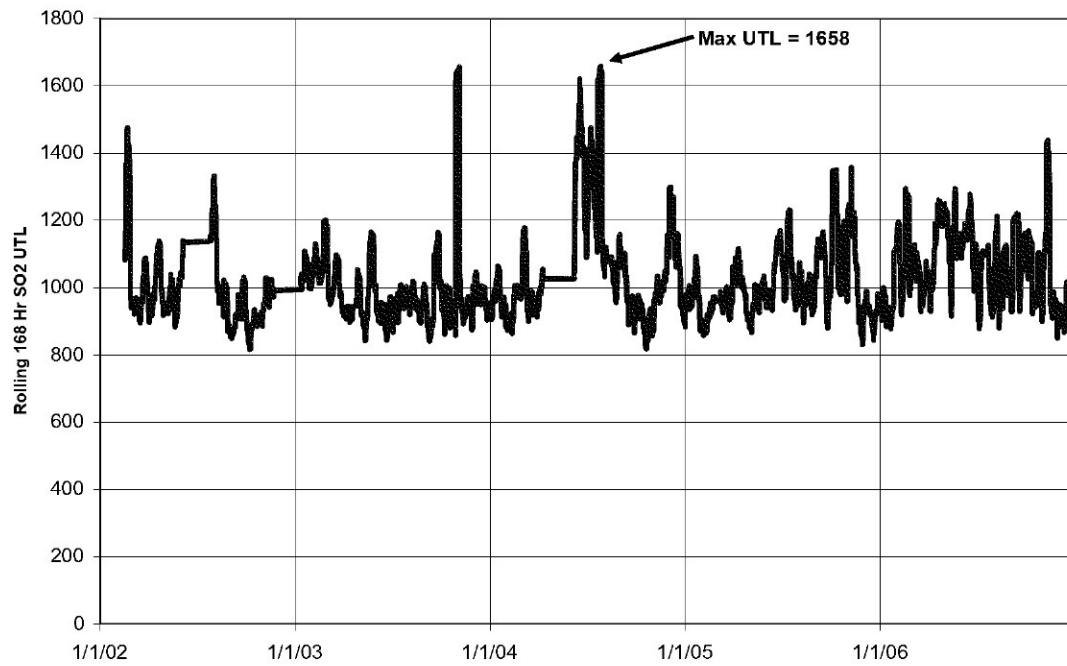


Figure 6 Unit E1 168 Hour SO2 UTL Results



APPENDIX A

Normality Tests

Unit C3 NOx Normality Test

Moments			
N	495	Sum Weights	495
Mean	217.332576	Sum Observations	107579.625
Std Deviation	52.0433222	Variance	2708.50738
Skewness	0.1105995	Kurtosis	0.69811394
Uncorrected SS	24718559.8	Corrected SS	1338002.65
Coeff Variation	23.9463973	Std Error Mean	2.33917338

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.965804	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.101974	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.174798	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	6.637608	Pr > A-Sq	<0.0050

Unit C3 SO₂ Normality Test

Moments			
N	495	Sum Weights	495
Mean	779.235152	Sum Observations	385721.4
Std Deviation	161.04918	Variance	25936.8385
Skewness	-1.5592683	Kurtosis	5.39238441
Uncorrected SS	313380472	Corrected SS	12812798.2
Coeff Variation	20.667597	Std Error Mean	7.23862235

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.87108	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.132511	Pr > D	<0.0100
Cramer-von Mises	W-Sq	2.219216	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	14.14721	Pr > A-Sq	<0.0050

Unit E1 NOx Normality Test

Moments			
N	809	Sum Weights	809
Mean	1774.19197	Sum Observations	1435321.3
Std Deviation	484.345308	Variance	234590.378
Skewness	0.54147479	Kurtosis	0.60875723
Uncorrected SS	2736084555	Corrected SS	189549025
Coeff Variation	27.2994871	Std Error Mean	17.0286742

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.978899	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.088927	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.009841	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.954598	Pr > A-Sq	<0.0050

Unit E1 SO₂ Normality Test

Moments			
N	795	Sum Weights	795
Mean	471.098365	Sum Observations	374523.2
Std Deviation	209.983818	Variance	44093.2038
Skewness	0.56555629	Kurtosis	0.498716
Uncorrected SS	211447271	Corrected SS	35010003.8
Coeff Variation	44.5732428	Std Error Mean	7.44735856

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.974141	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.0669	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.639596	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.210138	Pr > A-Sq	<0.0050

Unit H1 NOx Normality Test

Moments			
N	783	Sum Weights	783
Mean	440.915014	Sum Observations	345236.456
Std Deviation	271.622058	Variance	73778.5421
Skewness	1.89939919	Kurtosis	3.42654247
Uncorrected SS	209914757	Corrected SS	57694819.9
Coeff Variation	61.6041751	Std Error Mean	9.70698042

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.76175	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.305423	Pr > D	<0.0100
Cramer-von Mises	W-Sq	14.20566	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	70.99845	Pr > A-Sq	<0.0050

Unit H1 SO₂ Normality Test

Moments			
N	783	Sum Weights	783
Mean	688.703959	Sum Observations	539255.2
Std Deviation	1262.26472	Variance	1593312.22
Skewness	4.69787168	Kurtosis	25.646491
Uncorrected SS	1617357344	Corrected SS	1245970153
Coeff Variation	183.281176	Std Error Mean	45.1096609

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.437925	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.31442	Pr > D	<0.0100
Cramer-von Mises	W-Sq	28.77426	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	144.3258	Pr > A-Sq	<0.0050

Unit A2 NOx Normality Test

Moments			
N	775	Sum Weights	775
Mean	812.832318	Sum Observations	629945.047
Std Deviation	135.638381	Variance	18397.7703
Skewness	-0.3076543	Kurtosis	1.13710541
Uncorrected SS	526279567	Corrected SS	14239874.2
Coeff Variation	16.6871294	Std Error Mean	4.87227446

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.976013	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.065263	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.877073	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.820102	Pr > A-Sq	<0.0050

Unit A2 SO₂ Normality Test

Moments			
N	775	Sum Weights	775
Mean	2365.60645	Sum Observations	1833345
Std Deviation	258.372181	Variance	66756.1841
Skewness	-0.7004401	Kurtosis	2.61806914
Uncorrected SS	4388642047	Corrected SS	51669286.5
Coeff Variation	10.9220273	Std Error Mean	9.28100273

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.962366	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.057033	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.50806	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	3.890565	Pr > A-Sq	<0.0050

Unit B5 NOx Normality Test

Moments			
N	769	Sum Weights	769
Mean	1328.13423	Sum Observations	1021335.22
Std Deviation	321.663135	Variance	103467.172
Skewness	-0.5181826	Kurtosis	-0.3121306
Uncorrected SS	1435933052	Corrected SS	79462788.4
Coeff Variation	24.2191737	Std Error Mean	11.5994693

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.964562	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.065287	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.076395	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	8.014388	Pr > A-Sq	<0.0050

Unit B5 SO₂ Normality Test

Moments			
N	769	Sum Weights	769
Mean	3462.85748	Sum Observations	2662937.4
Std Deviation	576.735806	Variance	332624.19
Skewness	-0.4337334	Kurtosis	-0.5043948
Uncorrected SS	9476828065	Corrected SS	255455378
Coeff Variation	16.6549103	Std Error Mean	20.7976251

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.974875	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.057843	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.810927	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	5.411698	Pr > A-Sq	<0.0050

Unit I8 NOx Normality Test

Moments			
N	857	Sum Weights	857
Mean	196.123721	Sum Observations	168078.029
Std Deviation	52.0784426	Variance	2712.16418
Skewness	1.47640305	Kurtosis	10.9861023
Uncorrected SS	35285701.1	Corrected SS	2321612.54
Coeff Variation	26.5538723	Std Error Mean	1.77896571

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.861744	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.107319	Pr > D	<0.0100
Cramer-von Mises	W-Sq	2.631251	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	17.32757	Pr > A-Sq	<0.0050

Unit I8 SO₂ Normality Test

Moments			
N	857	Sum Weights	857
Mean	722.87853	Sum Observations	619506.9
Std Deviation	205.502307	Variance	42231.1983
Skewness	-0.1698377	Kurtosis	-0.5152756
Uncorrected SS	483978143	Corrected SS	36149905.7
Coeff Variation	28.4283318	Std Error Mean	7.01982509

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.982579	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.065399	Pr > D	<0.0100
Cramer-von Mises	W-Sq	1.122564	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	6.182175	Pr > A-Sq	<0.0050

Unit D4 NOx Normality Test

Moments			
N	801	Sum Weights	801
Mean	1566.91496	Sum Observations	1255098.88
Std Deviation	313.687393	Variance	98399.7804
Skewness	-2.1447492	Kurtosis	4.9275006
Uncorrected SS	2045353040	Corrected SS	78719824.3
Coeff Variation	20.0194268	Std Error Mean	11.083599

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.765549	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.183144	Pr > D	<0.0100
Cramer-von Mises	W-Sq	9.566471	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	54.96793	Pr > A-Sq	<0.0050

Unit D4 SO₂ Normality Test

Moments			
N	793	Sum Weights	793
Mean	1851.8454	Sum Observations	1468513.4
Std Deviation	733.619565	Variance	538197.666
Skewness	-0.3349436	Kurtosis	-1.3199864
Uncorrected SS	3145712332	Corrected SS	426252551
Coeff Variation	39.6155946	Std Error Mean	26.0515946

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.903737	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.167885	Pr > D	<0.0100
Cramer-von Mises	W-Sq	5.183818	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	29.88853	Pr > A-Sq	<0.0050

Unit F1 NOx Normality Test

Moments			
N	760	Sum Weights	760
Mean	1783.1991	Sum Observations	1355231.32
Std Deviation	503.229313	Variance	253239.741
Skewness	-0.6522447	Kurtosis	-0.0351421
Uncorrected SS	2608856226	Corrected SS	192208964
Coeff Variation	28.2205903	Std Error Mean	18.2540457

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.96053	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.061201	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.906918	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	7.163965	Pr > A-Sq	<0.0050

Unit F1 SO₂ Normality Test

Moments			
N	758	Sum Weights	758
Mean	2039.48496	Sum Observations	1545929.6
Std Deviation	819.166081	Variance	671033.068
Skewness	-0.3110148	Kurtosis	-0.6091456
Uncorrected SS	3660872201	Corrected SS	507972032
Coeff Variation	40.1653406	Std Error Mean	29.7534519

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.977796	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.047927	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.521363	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	4.103342	Pr > A-Sq	<0.0050

Unit G1 NOx Normality Test

Moments			
N	786	Sum Weights	786
Mean	1355.80702	Sum Observations	1065664.32
Std Deviation	396.797275	Variance	157448.078
Skewness	0.08074266	Kurtosis	0.92305045
Uncorrected SS	1568431911	Corrected SS	123596741
Coeff Variation	29.2665009	Std Error Mean	14.1532901

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.985978	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.037563	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.207288	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	1.668778	Pr > A-Sq	<0.0050

Unit G1 SO₂ Normality Test

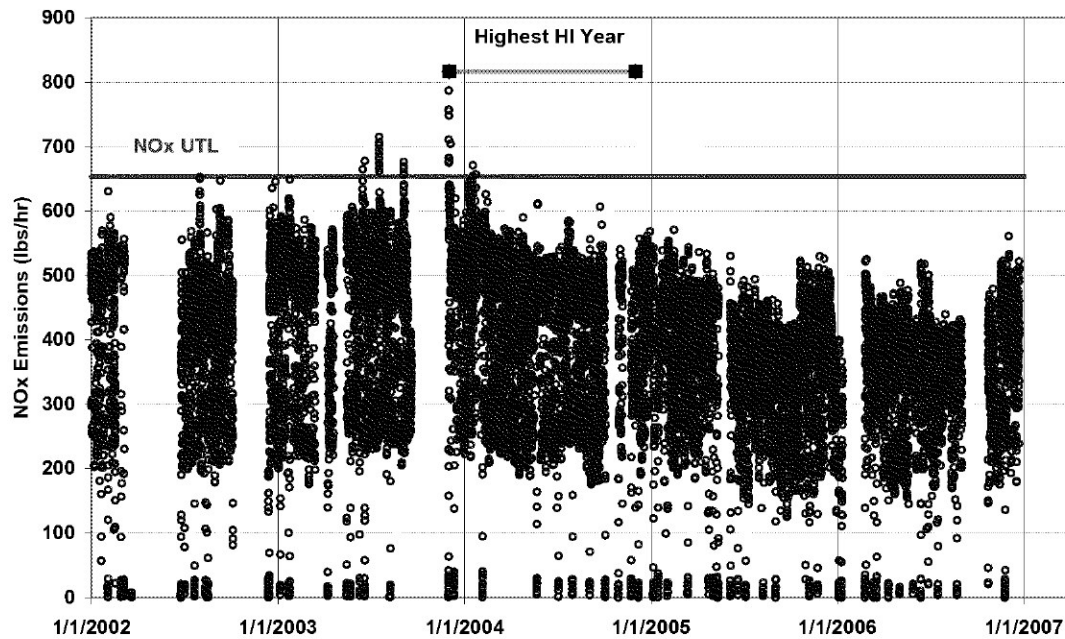
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N	782	Sum Weights	782
Mean	1440.34399	Sum Observations	1126349
Std Deviation	538.588917	Variance	290078.021
Skewness	0.39690362	Kurtosis	0.04711258
Uncorrected SS	1848880947	Corrected SS	226550935
Coeff Variation	37.3930756	Std Error Mean	19.2599003

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.984928	Pr < W	<0.0001
Kolmogorov-Smirnov	D	0.050488	Pr > D	<0.0100
Cramer-von Mises	W-Sq	0.416161	Pr > W-Sq	<0.0050
Anderson-Darling	A-Sq	2.60673	Pr > A-Sq	<0.0050

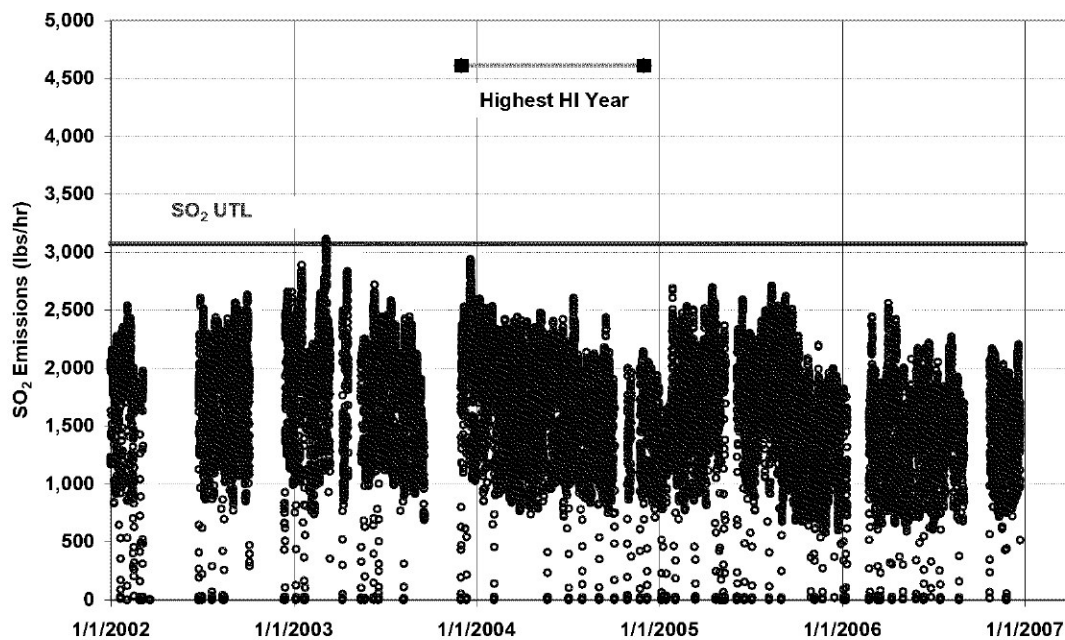
APPENDIX B

Five Year EPA UTL Analysis Data Plots

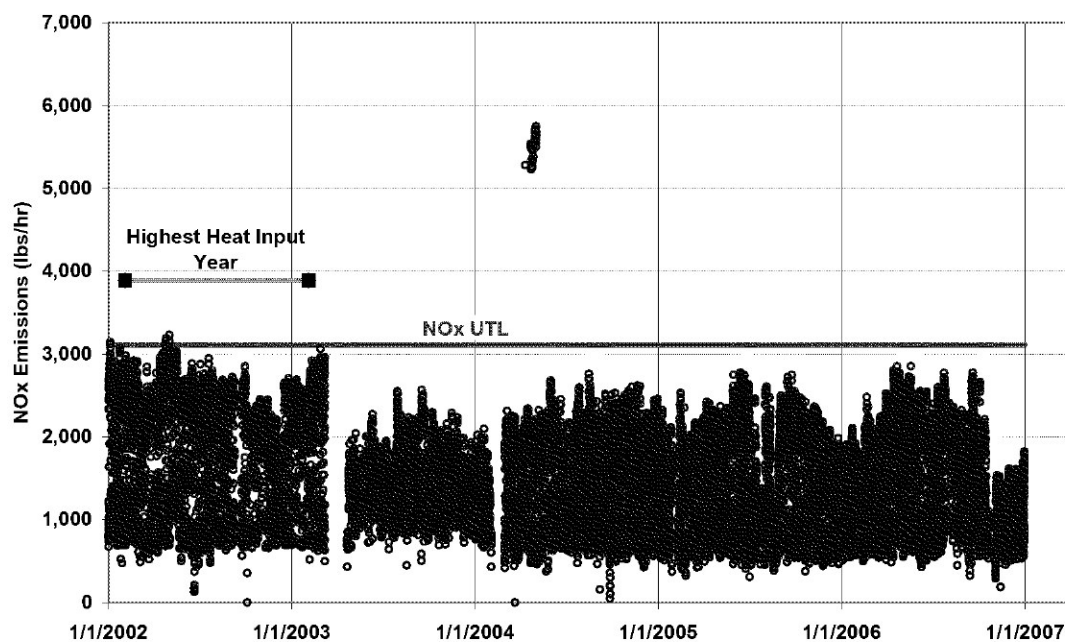
Unit C Hourly NOx 2002 to 2006
Unfiltered Data



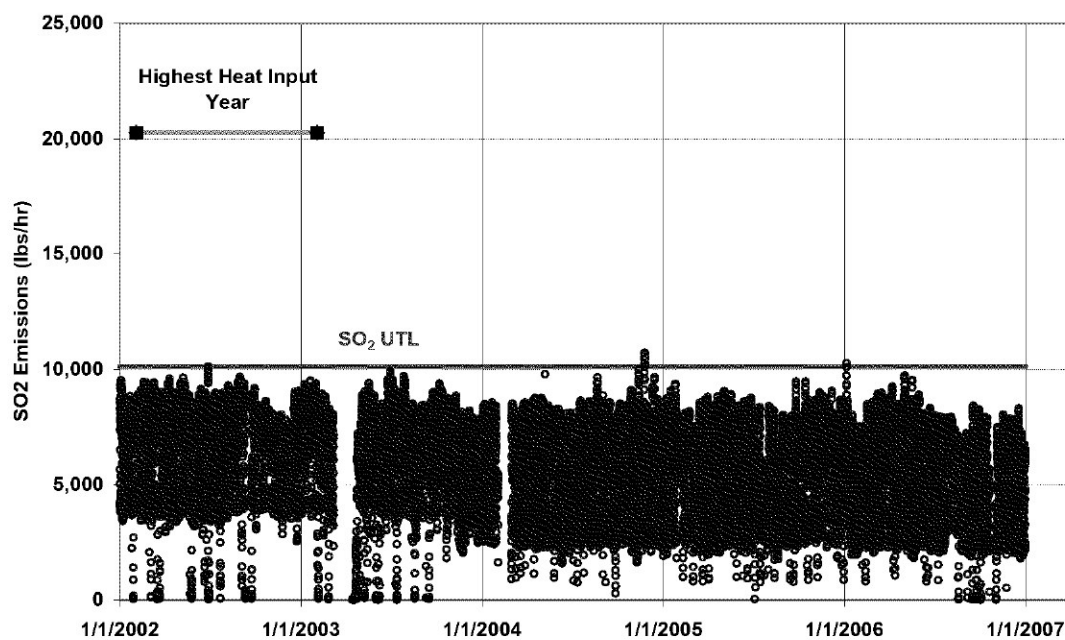
Unit C Hourly SO2 2002 to 2006
Unfiltered Data



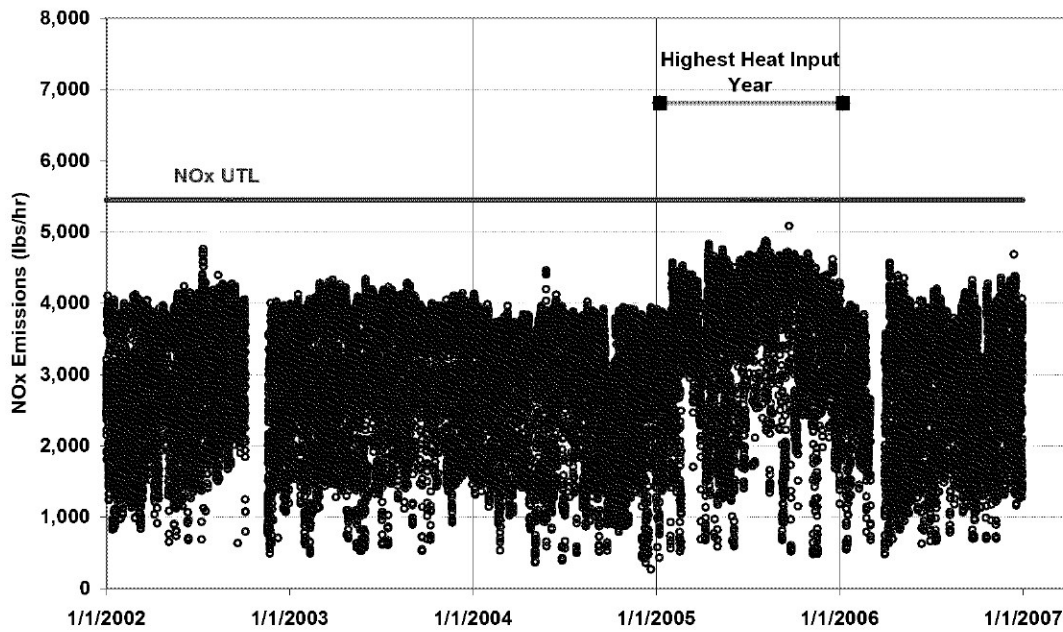
Unit A Hourly NO_x 2002 to 2006
Unfiltered Data



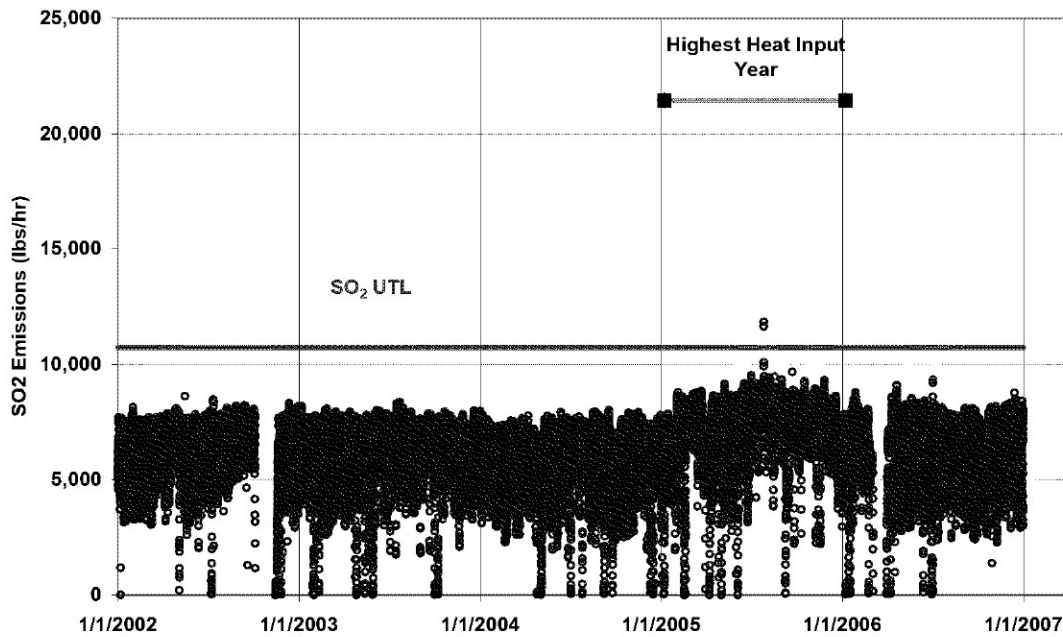
Unit A Hourly SO₂ 2002 to 2006
Unfiltered Data



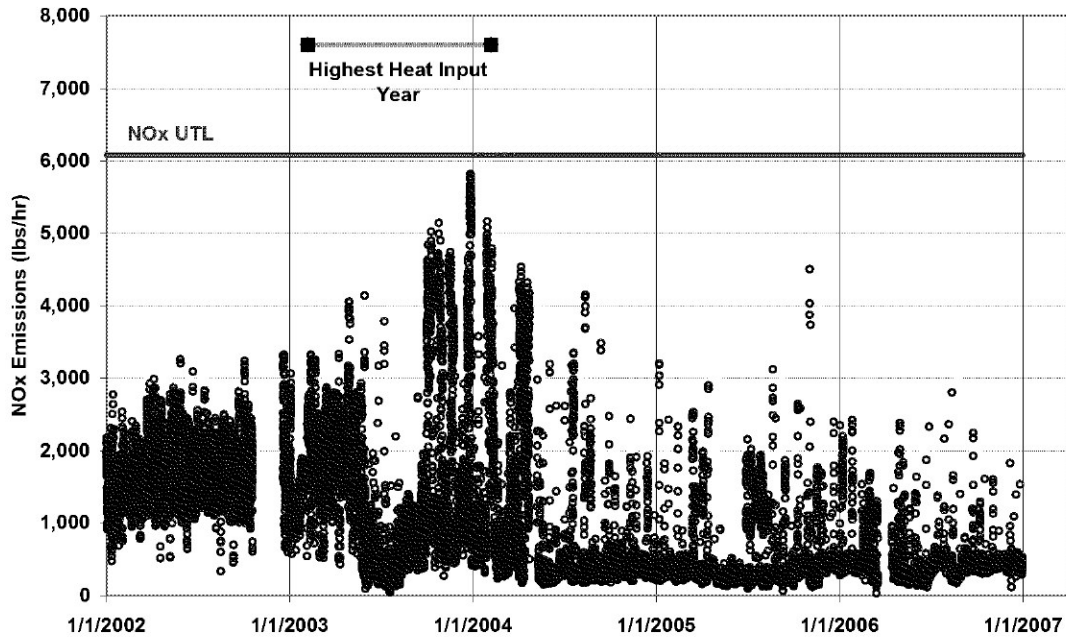
Unit B Hourly NO_x 2002 To 2006
Unfiltered Data



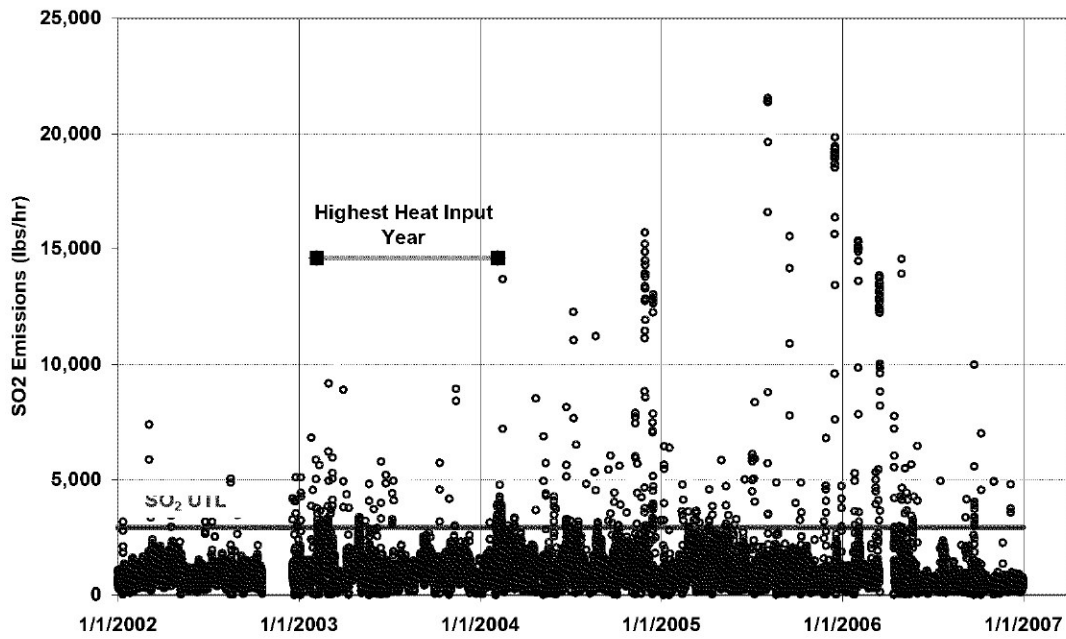
Unit B Hourly SO₂ 2002 To 2006
Unfiltered Data



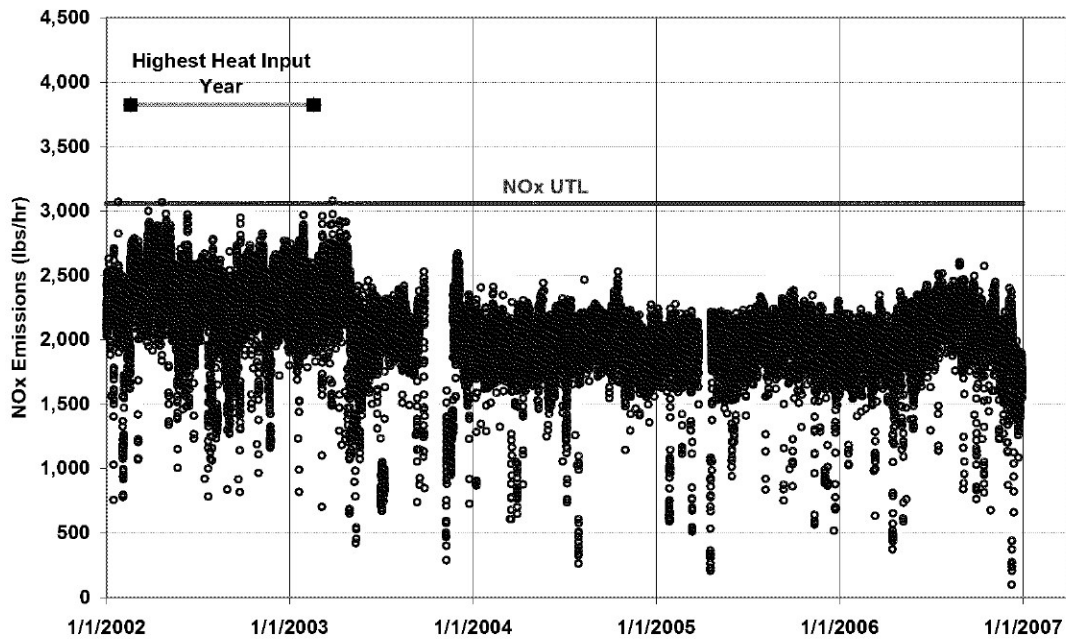
Unit H Hourly NO_x 2002 To 2006
Unfiltered Data



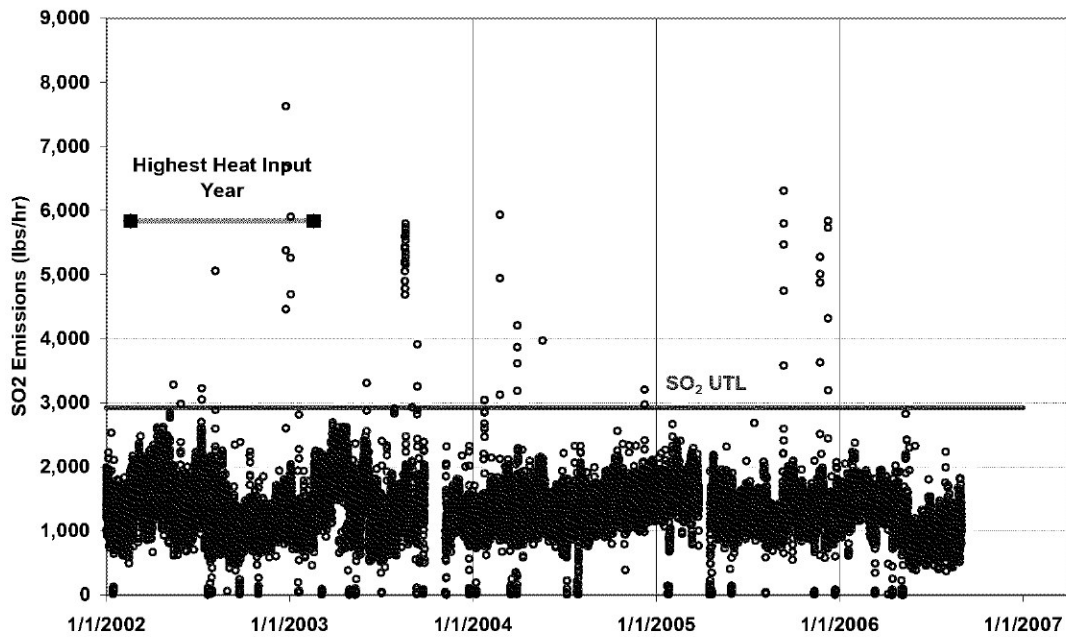
Unit H Hourly SO₂ 2002 To 2006
Unfiltered Data



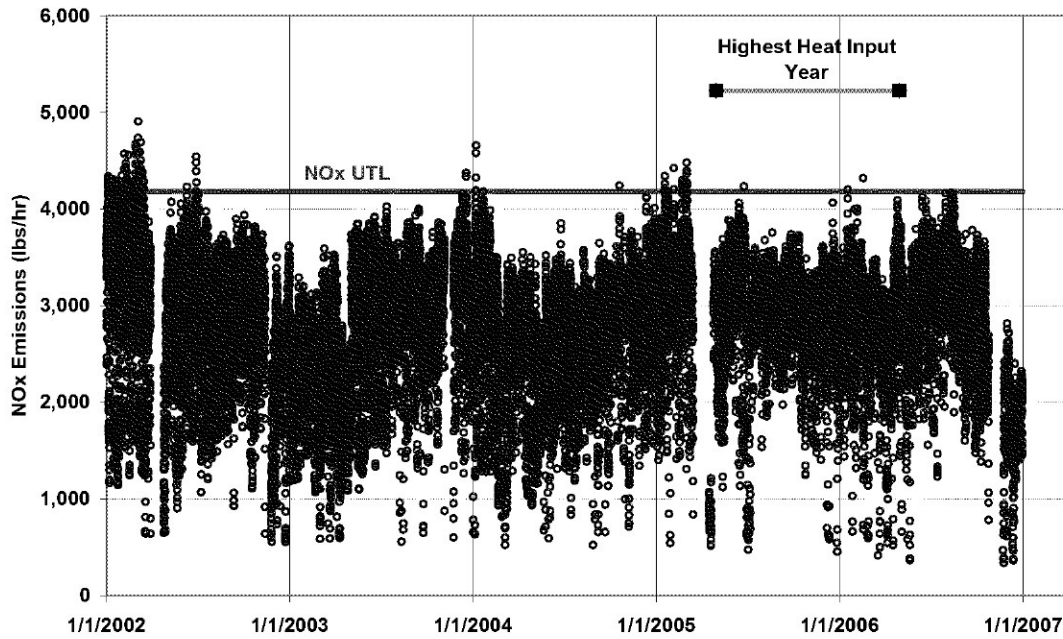
Unit D Hourly NO_x 2002 To 2006
Unfiltered Data



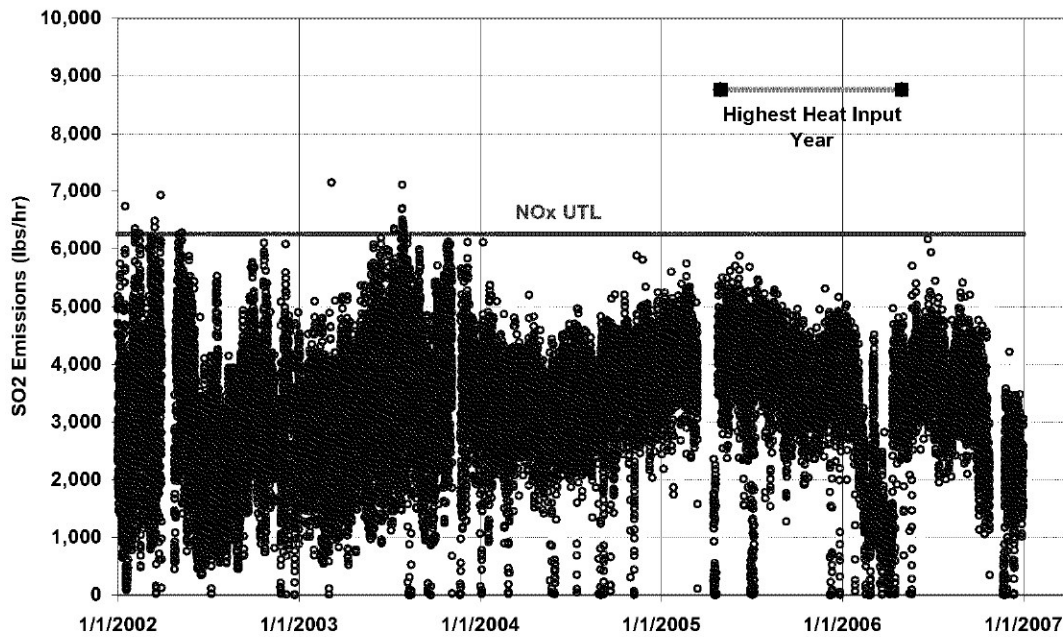
Unit D Hourly SO₂ 2002 To 2006
Unfiltered Data



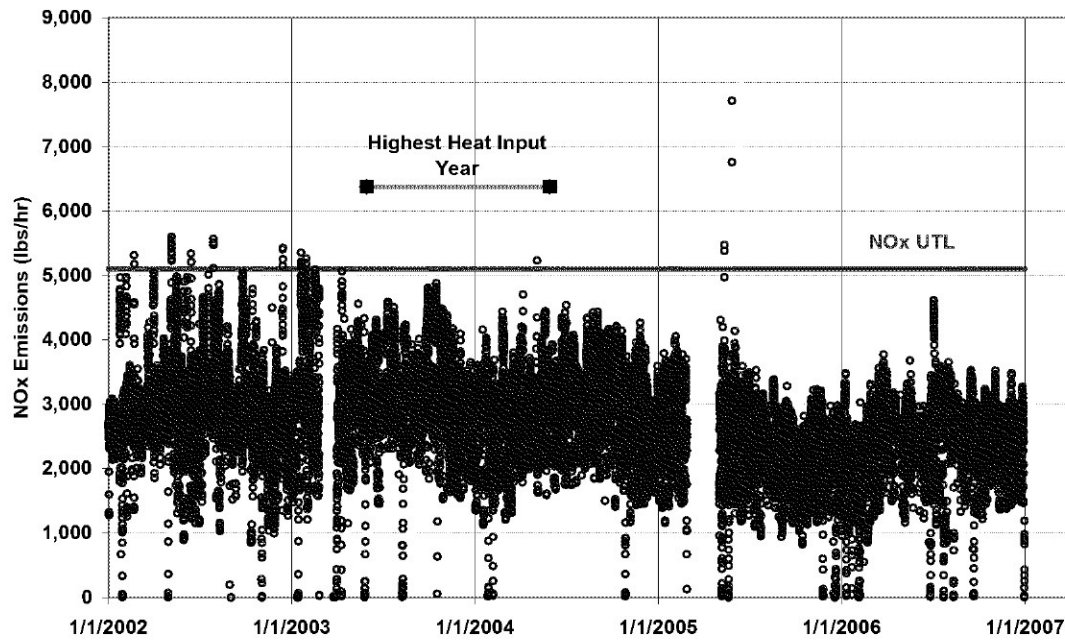
Unit F Hourly NO_x 2002 To 2006
Unfiltered Data



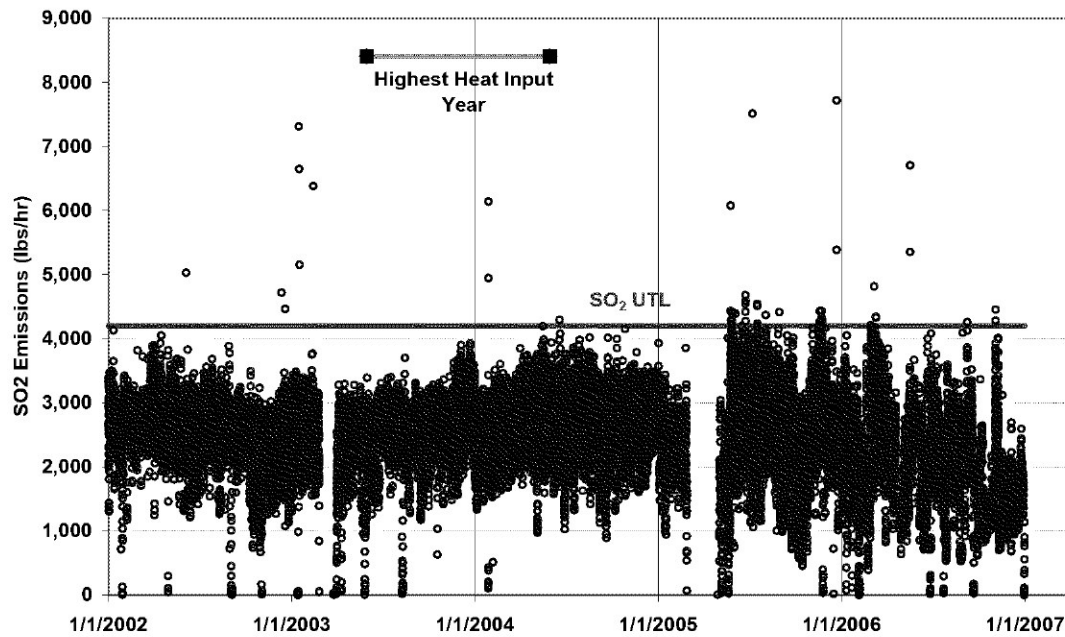
Unit F Hourly SO₂ 2002 To 2006
Unfiltered Data



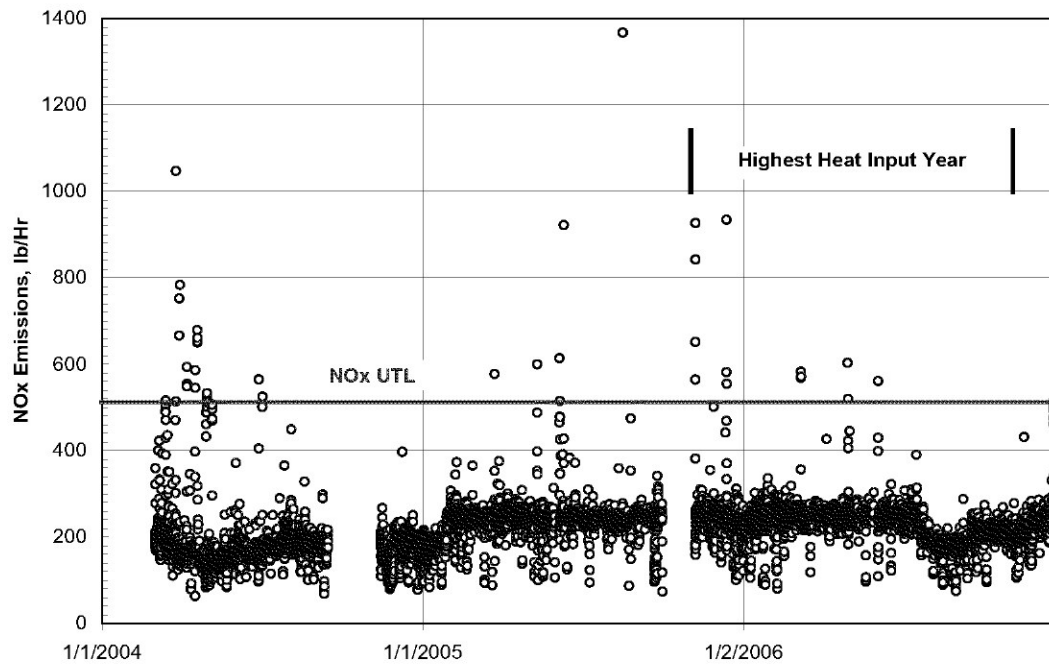
Unit G Hourly NO_x 2002 To 2006
Unfiltered Data



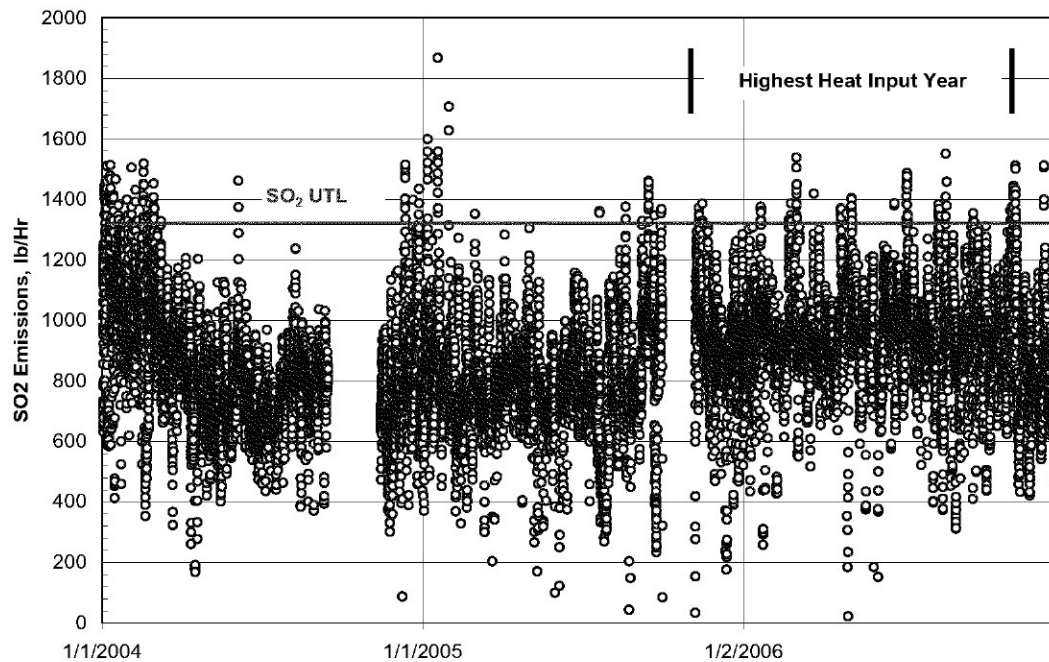
Unit G Hourly SO₂ 2002 To 2006
Unfiltered Data



Unit I Hourly NOx 3/1/04 to 2006



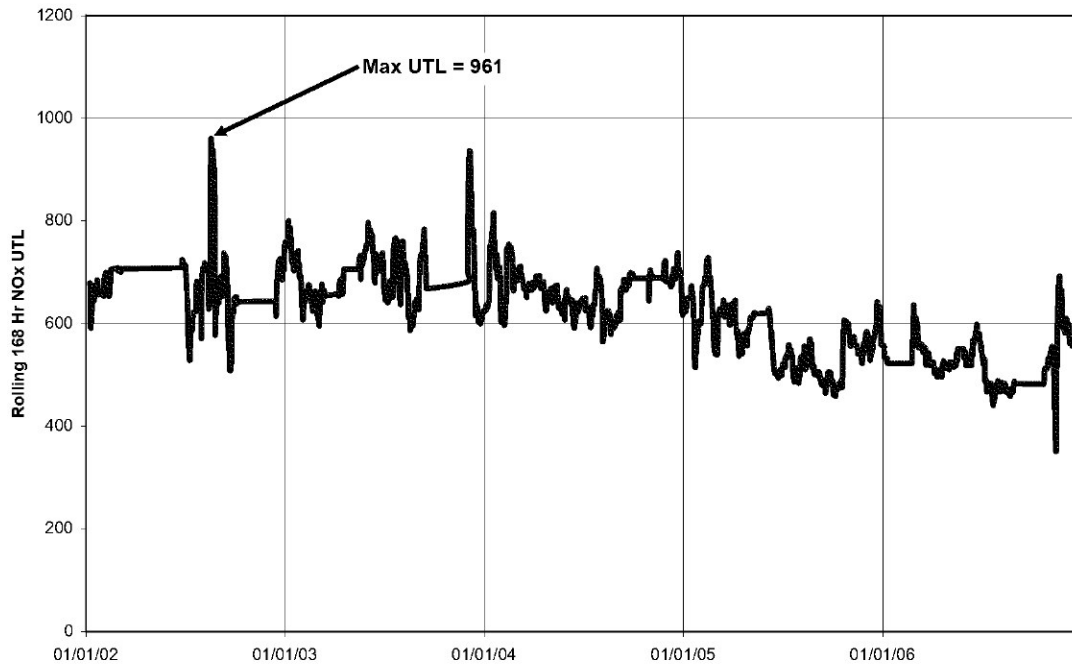
Unit I Hourly SO2 2004 to 2006



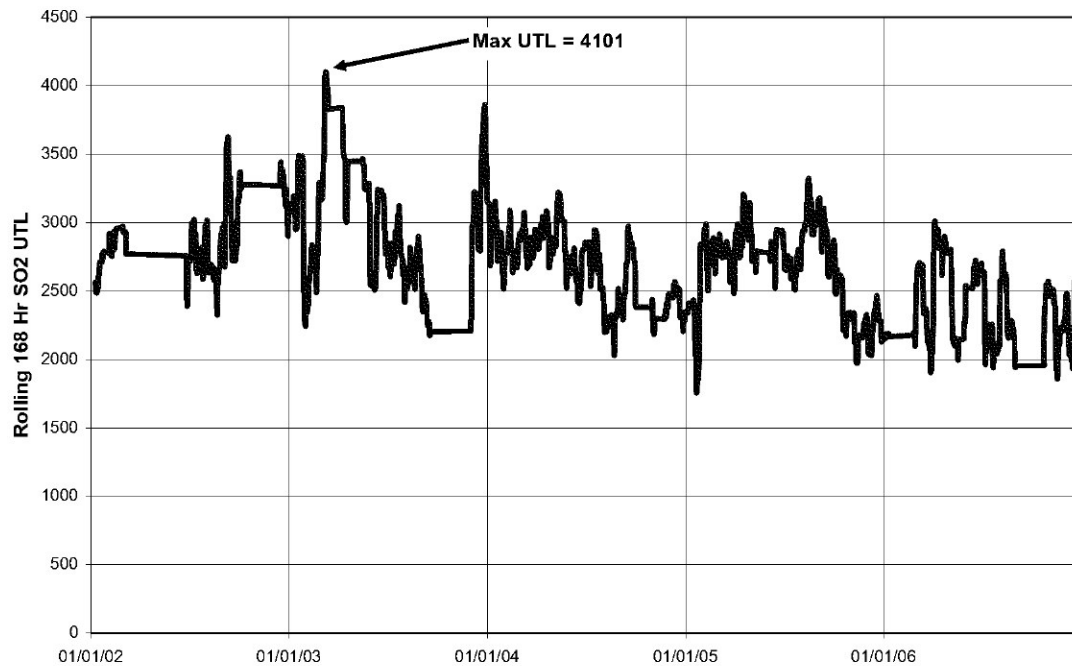
APPENDIX C

Five Year Revised UTL Analysis Data

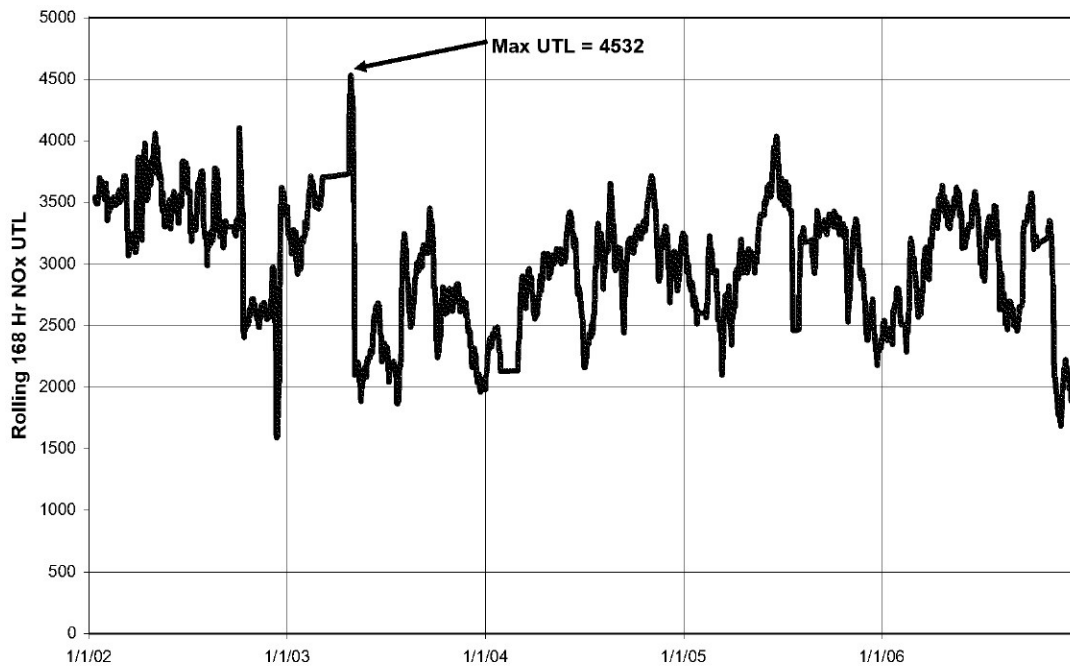
Unit C 168 Hour NOx UTL Results



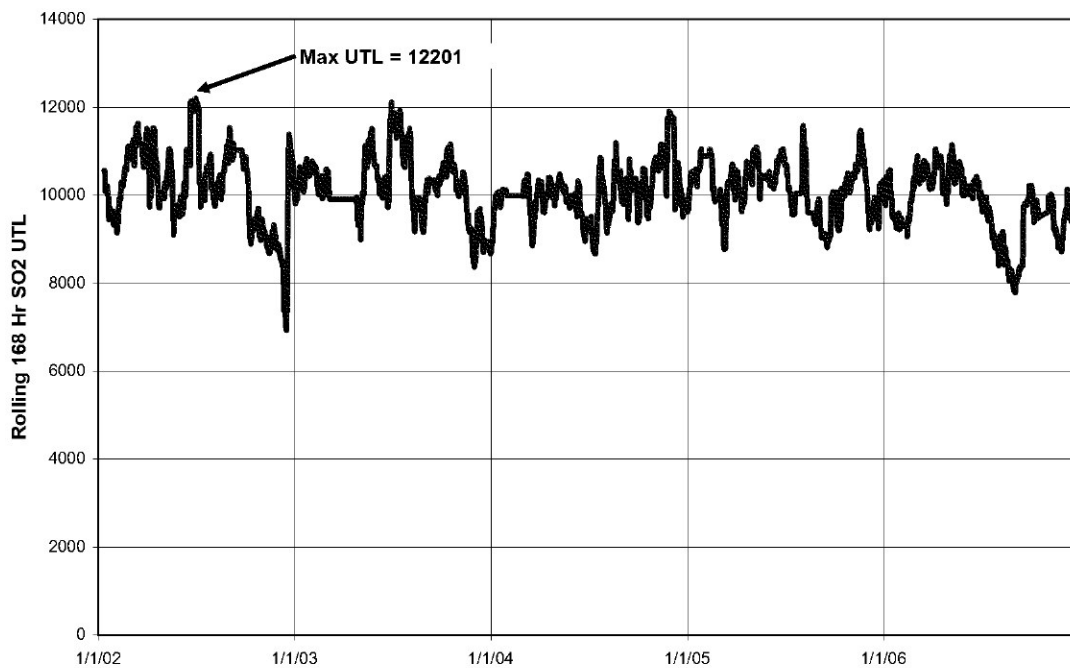
Unit C 168 Hour SO2 UTL Results



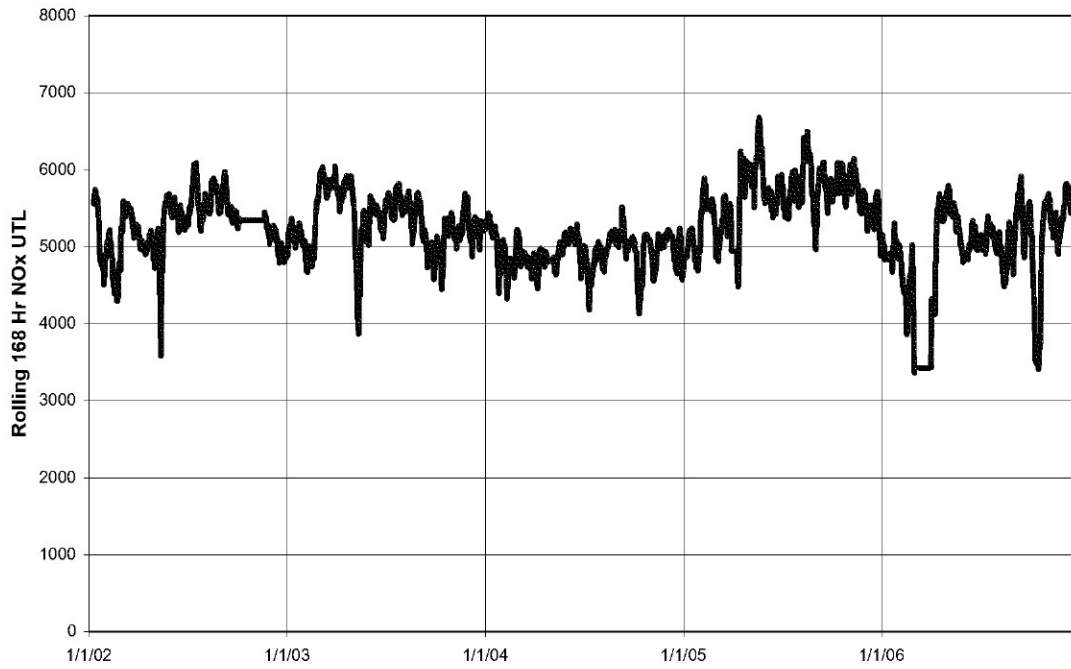
Unit A 168 Hour NOx UTL Results



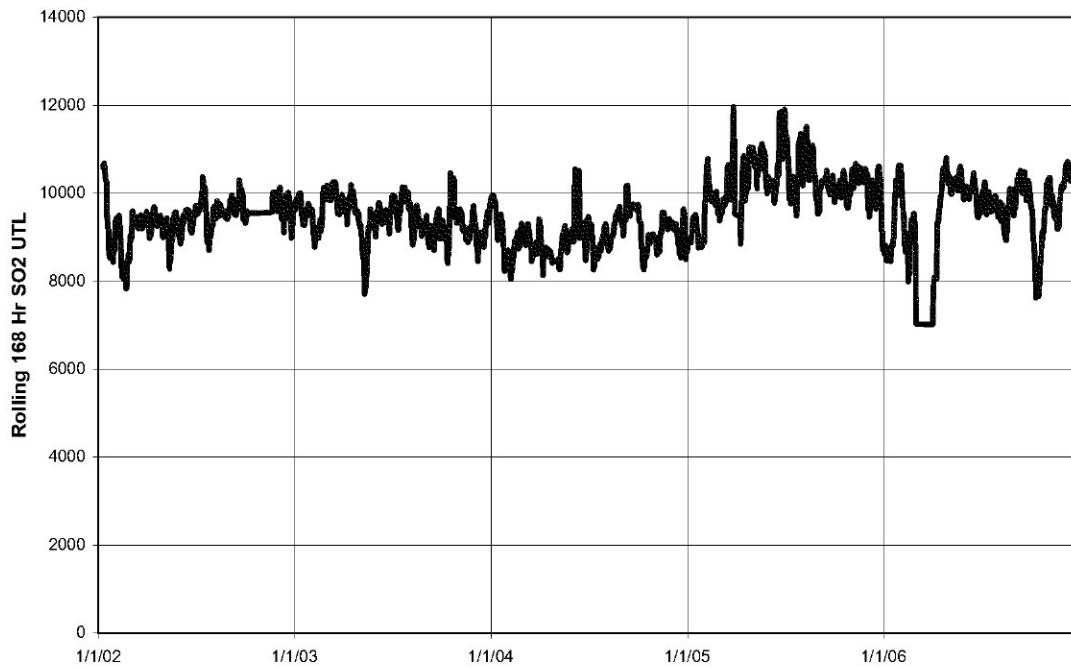
Unit A 168 Hour SO2 UTL Results



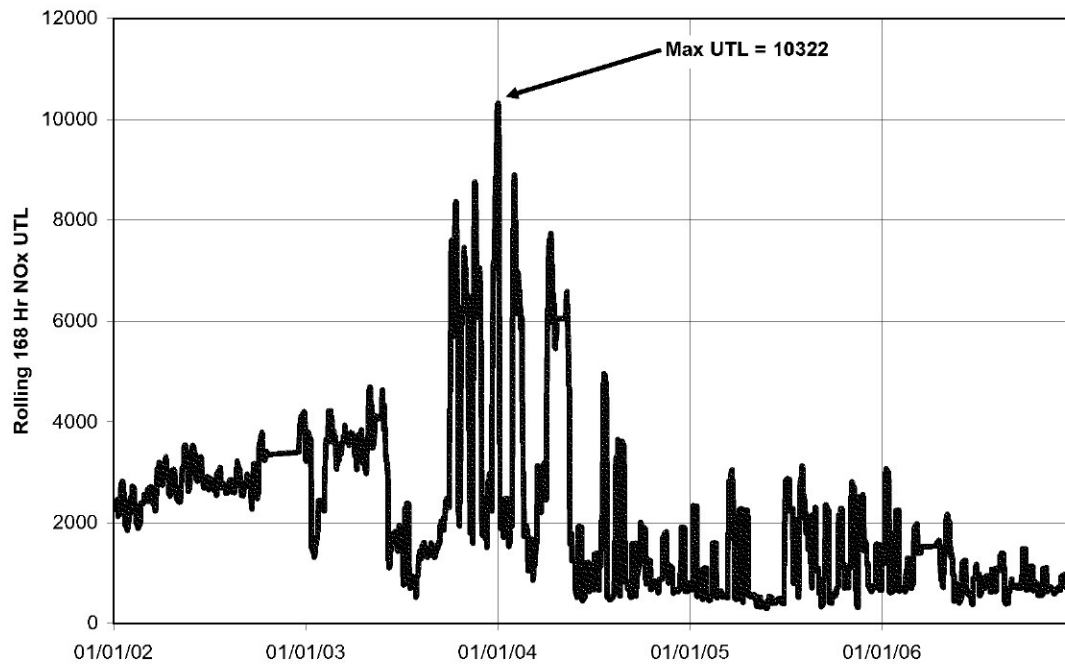
Unit B 168 Hour NOx UTL Results



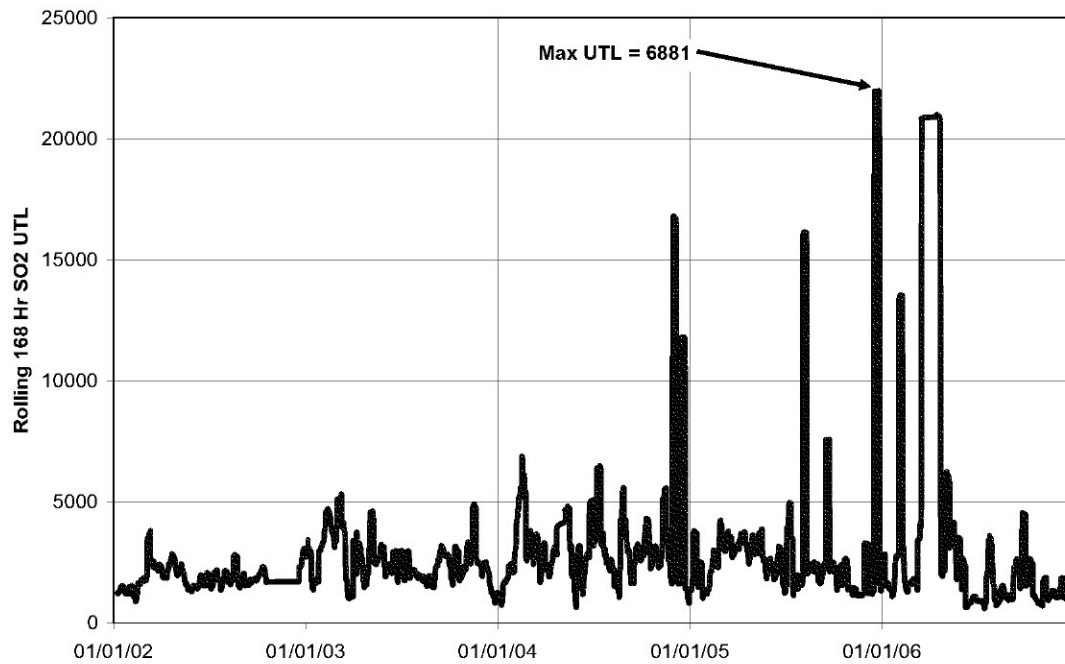
Unit B 168 Hour SO2 UTL Results



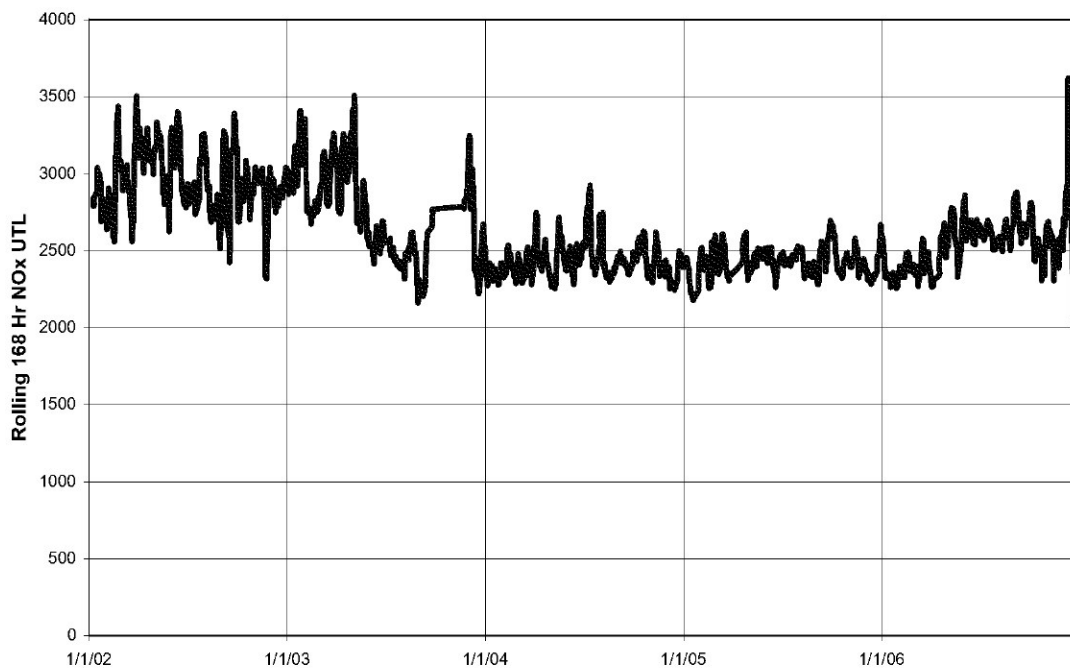
Unit H 168 Hour NOx UTL Results



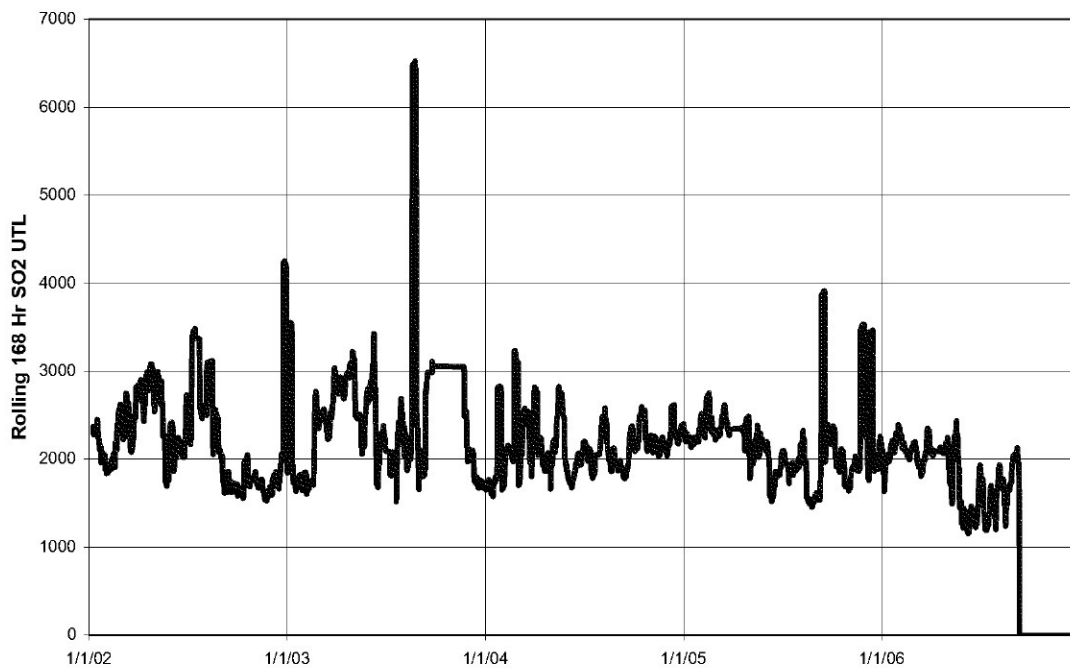
Unit H 168 Hour SO2 UTL Results



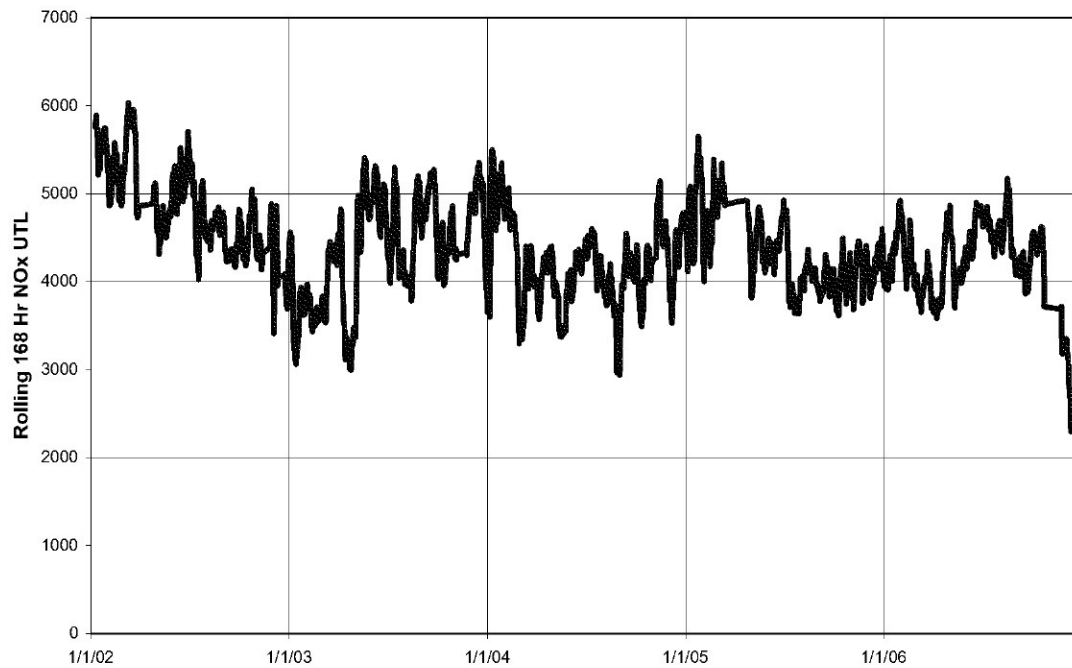
Unit D 168 Hour NOx UTL Results



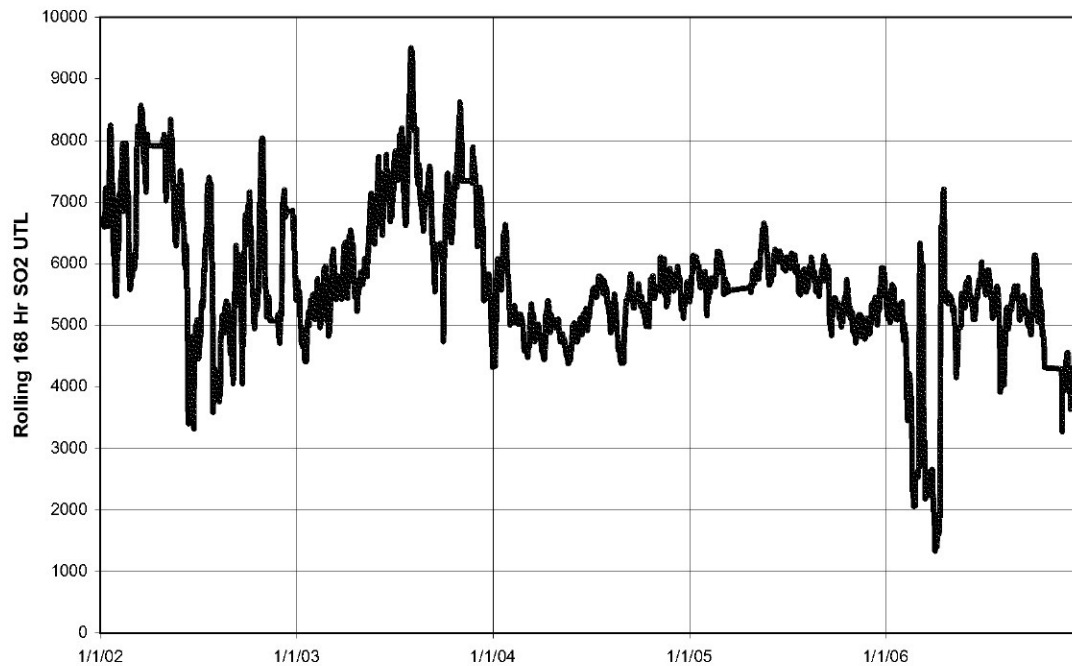
Unit D 168 Hour SO2 UTL Results



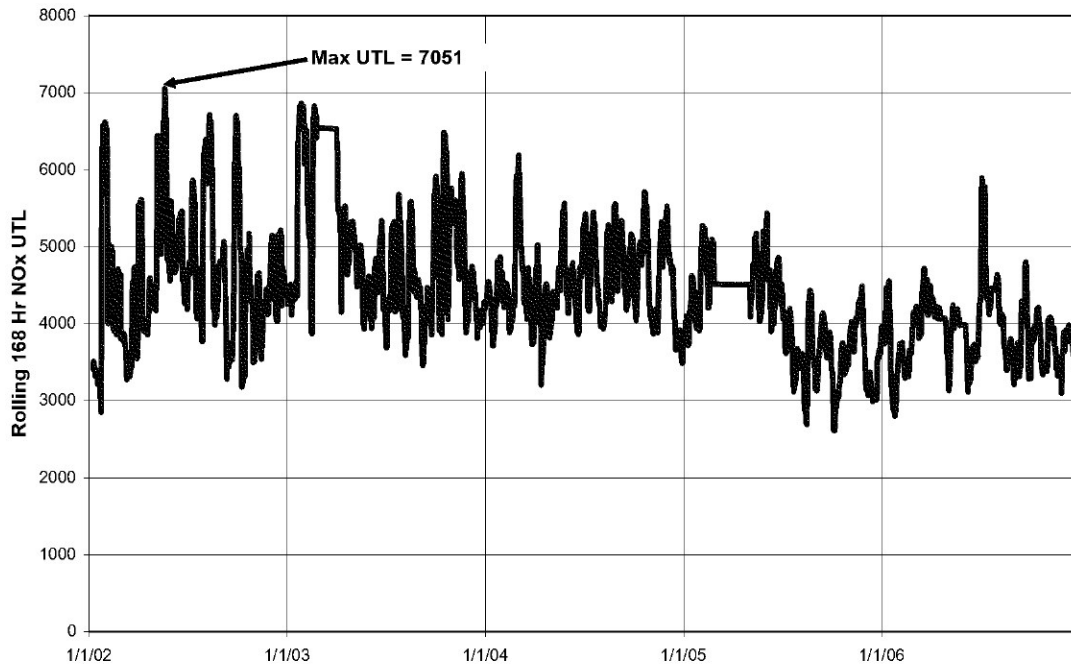
Unit F 168 Hour NOx UTL Results



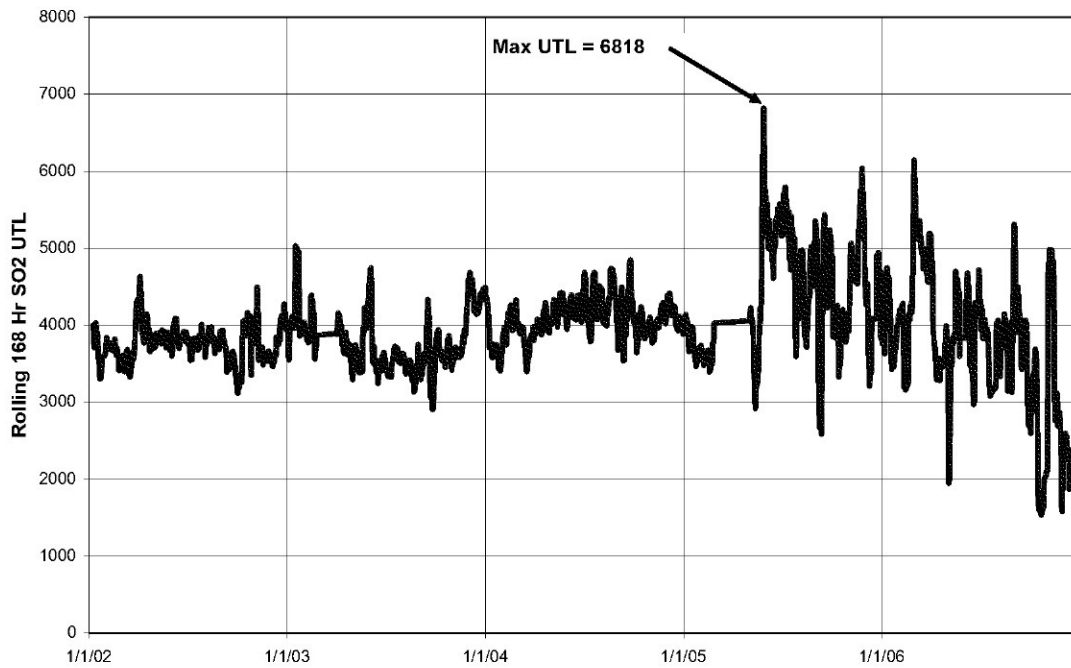
Unit F 168 Hour SO2 UTL Results



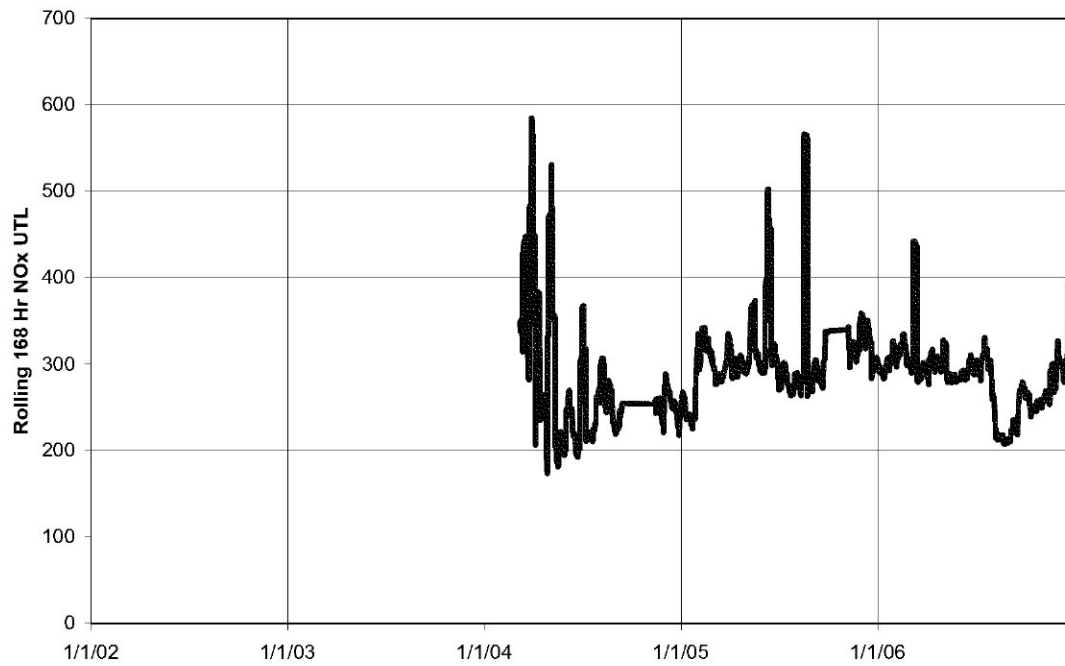
Unit G 168 Hour NOx UTL Results



Unit G 168 Hour SO2 UTL Results



Unit I 168 Hour NOx UTL Results



Unit I 168 Hour SO2 UTL Results

