WEEKLY AVERAGE SULFUR DIOXIDE EMISSIONS AT THE TAMPA ELECTRIC COMPANY GANNON UNIT 3: A COMPARISON OF EMISSION MONITORING AND COAL SAMPLING/ANALYSIS

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Prepared for

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1. INTRODUCTION

In 1980, Tampa Electric Company (TEC) initiated reconversion of the Francis J. Gannon Units 1-4 from oil to coal-fired. The reconversion was approved by the Florida Environmental Regulation Commission (ERC) at a public hearing in Tampa, Florida on October 23, 1980. As part of that ruling, TEC was required to conduct a six-month emissions test program at one unit following conversion, comparing sulfur dioxide (SO_2) emission estimates based on coal sampling and analysis (CSA) with measured SO_2 emissions derived from continuous stack monitoring. In compliance with this provision, a six-month test program was conducted at Gannon Unit 3 from October 28, 1985 through May 4, 1986. Coal samples were obtained and analyzed during the same period for comparison purposes. Kilkelly Environmental Associates (KEA) was retained to monitor stack emissions and for data analysis. The objective of this report is to present a comparative analysis of the data gathered by continuous emissions monitoring and CSA.

SO_2 emissions were monitored using test equipment specified by the U.S. Environmental Protection Agency (EPA), Reference Method 6B. Results are expressed as 24-hour average SO_2 emission rates in lb SO_2/MMBtu. Triplicate samples, from three separate sampling trains, were analyzed to improve the precision of the reported 24-hour average SO_2 emission rate. QA audits were performed using both calibration gases of known concentration and independent, third-party audits.

Two sets of coal samples were taken: (1) weekly average composite samples, normally used in reporting seven-day average SO_2 emissions to the Florida

Department of Environmental Regulation (DER), and (2) daily coal samples, for the specific purpose of this study, and are included as Appendix A.

The following data analyses were completed:

- Characterization of weekly average SO_2 emissions for Gannon Unit 3 in terms of the mean, variability, and autocorrelation.
- Comparison, on a weekly basis, of the two SO_2 emission estimates.
- For each measurement technique, estimation of the probability of exceeding the seven-day average emission standard of 2.4 lb SO_2/MMBtu, dictated by the Gannon Station Sulfur Dioxide Regulatory Compliance Plan.

2. EMISSION TESTING

2.1 TEST PROCEDURES

The out-of-stack SO_2 emission rate in lb SO_2/MMBtu was determined using EPA Reference Method 6B (RM6B). This method has also been adopted by the Florida Department of Environmental Regulation for SO_2 continuous emissions monitoring.

The equipment, shown in Figure 1, consisted of three commercially sold RM6B systems, a heated manifold, and a heated stainless steel probe. Gas was continuously extracted from the stack at a single point (six feet into the stack, along the radius from the stack wall), through the probe and into the manifold. The manifold separated this "extracted" stack gas into three streams, and directed each gas stream to a separate RM6B system.

Each RM6B system was comprised of a timer, heated umbilical, a heated filter, the sample collection train, a rotometer, a needle-valve, a shut-off valve, a pump, and all the associated electrical equipment. The timer measures the elapsed time of operation of the train during the 24-hour period. The umbilical transports the gas from the manifold to the three filter housings. The filters remove sulfates and particulates from the gas stream. The gas then enters the sample collection train, consisting of one empty impinger followed by two impingers [each containing 75 ml of 10 percent hydrogen peroxide (H_2O_2)], a drierite column, and finally an ascarite column. The first impinger serves as a condenser, allowing the gas stream to cool down before entering the second and third impingers. In the second and third impingers, the SO_2 is absorbed in the H_2O_2 solution. The drierite

RM6B Flow Diagram

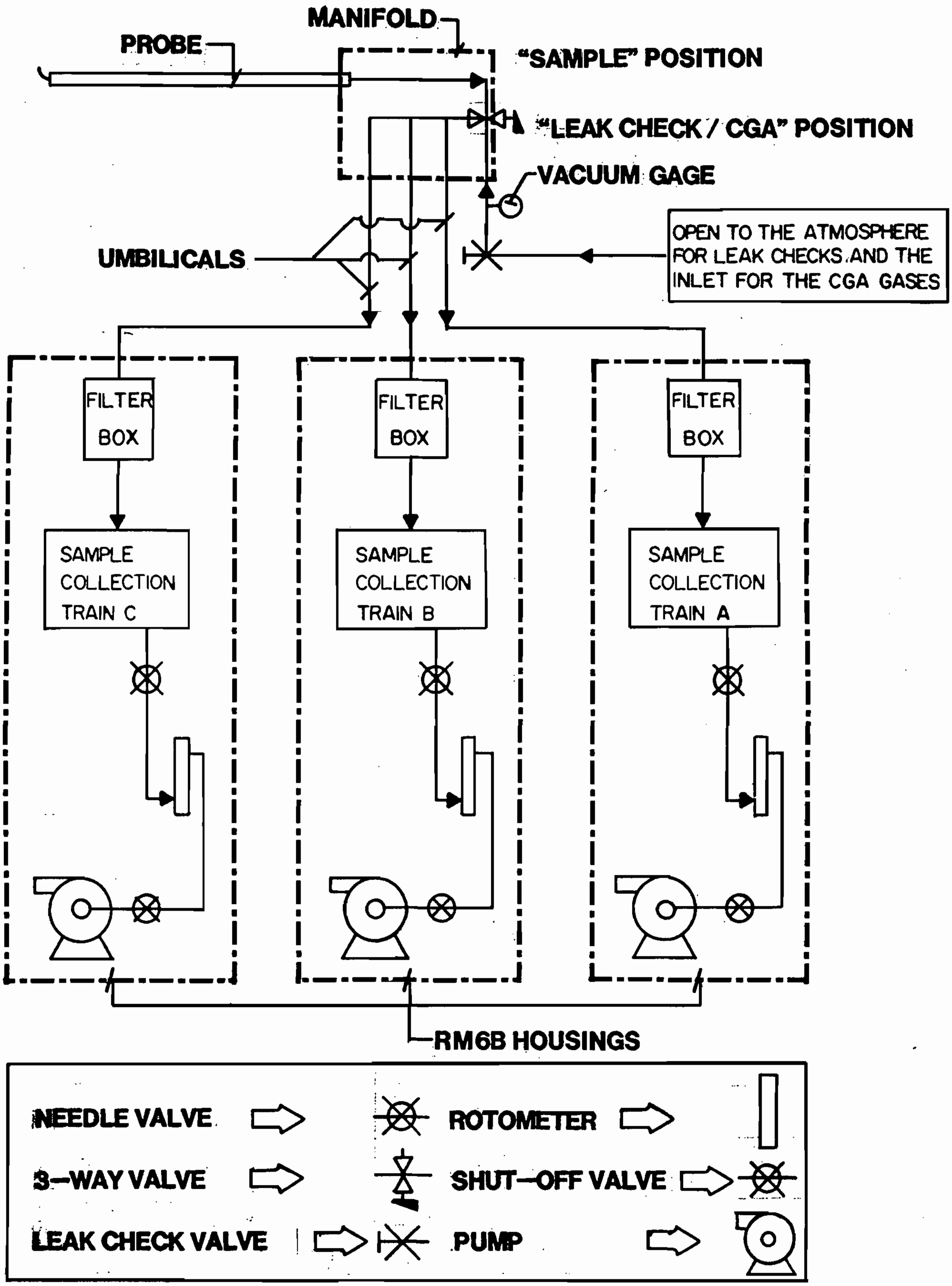

FIGURE 1

column removes water; the ascarite column quantitatively absorbs carbon dioxide (CO_2).

The RM6B equipment was operated in full accordance with all requirements as outlined for EPA Reference Method 6B except for the following minor modifications. First, a small plug of drierite was inserted at the discharge end of the ascarite column, as illustrated in Figure 2. Water, which is one of the products from the CO_2-ascarite reaction, must be quantitatively retained in order for the RM6B system to produce accurate results. Although the active ingredient in ascarite, sodium hydroxide, is hydroscopic, use of a drierite plug would guard against any water loss. The drierite moisture-indicator demonstrated that no water break-through occurred during the test period.

Secondly, Mae West impingers were used instead of the midget impingers specified in the EPA method. Mae West impingers are mentioned in Section 2 of the Reference Method 6, but their use is "subject to the approval of the Administrator". This requisite approval was obtained.

The final modification relates to the leak check procedure. The leak check procedure specified for RM6B is that outlined for Reference Method 6 (RM6). The RM6 leak check procedure requires that a rotometer -- capable of measuring flows less than two percent of the sampling flow rate -- be attached to the dry gas meter exhaust. The RM6B systems, however, were not equipped with dry gas meters. Furthermore, the RM6B 24-hour sampling flow rates were extremely low (40 cc/min). As a result, the RM6 leak check procedures could not be performed on the RM6B systems. Consequently, pre- and

Ascarite Column

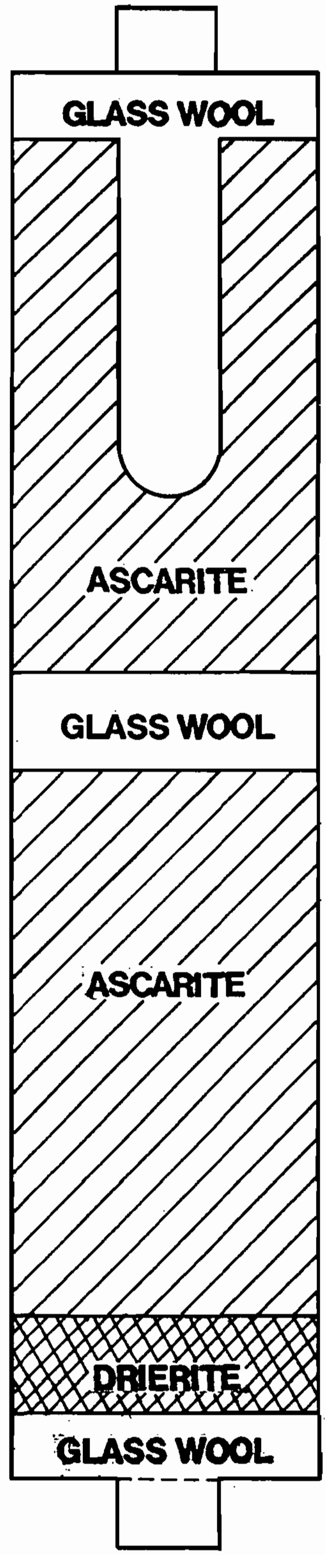

FIGURE 2

post-test leak checks were conducted in the following manner. The three-way valve on the manifold was placed in the "Leak Check/Cylinder Gas Audit" position. The leak check valve, also located on the manifold, was closed, and all three RM6B systems were operated until the manifold vacuum gauge indicated a vacuum of 5 inches of Hg or greater. At this point, the RM6B system shut-off valves were closed, and the pumps were turned off. If none of the impinger solutions bubbled (bubbles indicate a leak upstream of the impinger) or flowed into the preceeding impinger (i.e., "backed up", an indication of a leak downstream of that impinger) during a three-minute period, the RM6B system passed the leak check. Essentially, this leak check procedure is a modified version of the RM6 leak check procedure used prior to promulgation of the current RM6 procedure.

Daily and weekly routines were established to facilitate data acquisition. At 6:00 a.m. each day in a laboratory environment, the field engineer prepared (or charged) three sample collection trains (Trains A, B and C) for operation during the up-coming 24-hour test period. After being charged with fresh reagents, the collection trains were assembled (i.e., all the impingers and columns were connected in proper series) and carried to the Gannon Unit No. 3 sampling location. All scheduled quality control checks (discussed in Section 2.2) were performed, and then the three collection trains that had been operating for the previous 24-hours (trains A^1, B^1 and C^1) were replaced with collection trains A, B and C. Each 24-hour sampling period began and ended at 7:00 a.m. Trains A^1, B^1 and C^1 were returned to the laboratory, and recovered for later analysis. Each day's activities and associated information were recorded in the daily log. Analyses and calculations were performed three times weekly (i.e., Monday, Wednesday and Friday).

Every other day, the heated filters in each RM6B system were replaced. These heated filters "condition" the gas sample and remove any sulfates that may be present in the stack gas. Heated filters are required only for RM6B tests conducted downstream of a wet scrubber. They were included in the RM6B systems at Gannon Unit 3, however, to ensure that measured values reflect only SO_2 emissions. A brief test at the start of the six-month monitoring program confirmed that replacement of the filters every other day was adequate. After a 48-hour operating period, all filters from each RM6B system were recovered and analyzed for sulfate content. The highest measured sulfate level for any filter was 0.34 mg, a negligible amount.

During an extended testing program, unit outages and equipment failures were inevitable. Since the RM6B systems were being used to measure daily average SO_2 emissions, it was decided that any RM6B sample representative of less than 18 hours of boiler operation during a 24-hour period would be excluded from the data base. If the Unit No. 3 boiler or the RM6B systems failed to meet the minimum data capture requirements for a given 24-hour period (7:00 a.m. to 7:00 a.m.), the RM6B samples were discarded. Boiler operating periods established by TEC began and ended at midnight. The RM6B systems were operated from 7:00 a.m. to 7:00 a.m. the following day, to account for the time lag between the bunkering of the coal and burning that same coal in the boiler. If the boiler did not operate for at least 18 hours over the 24-hour boiler operating period (midnight to midnight), then the day was excluded from the data base and the sample was also discarded.

Ultimately, the measured RM6B 24-hour SO_2 emission rates were reduced to weekly averages, for comparison with weekly coal sampling data. To insure that each weekly emission average was representative of actual operating conditions, criteria were developed for weekly data capture requirements analogous to the minimum daily data capture requirements. These criteria required that a valid weekly average SO_2 emission rate consist of at least five valid 24-hour emission averages.

2.2 QUALITY CONTROL

The importance of carefully monitoring equipment functions and data quality cannot be overemphasized when using manual testing equipment continuously for extended periods (e.g., six months). The timely detection and correction of equipment failures, contamination problems, or unacceptable sampling conditions are crucial to project success. Quality control procedures included daily and periodic checks, periodic equipment maintenance, and laboratory audits.

The RM6B equipment was checked daily to assure that the equipment was operating properly. These checks included verification of the following:

- sample flow rates
- elapsed time of operation
- condition of heat traced lines
- proper heating of sample lines, manifold, and filter boxes.

The daily flow rates are included in Appendix B.

The following periodic equipment checks and maintenance procedures were also performed. The heated manifold 3-way valve was removed and cleaned approximately once a month. Twice during the project, each RM6B system pump was dismantled and inspected for badly worn parts. Sample gas temperatures were checked weekly with a hand-held thermocouple meter.

The most important periodic maintenance and equipment check involved the thorough cleaning of all sample handling equipment, including the probe, manifold, umbilicals, filter housings, and all interconnnecting tubing. The RM6B sample handling equipment was cleaned with deionized water approximately every two weeks during normal test periods. The equipment was also cleaned during each Gannon Unit 3 outage, and on an as-needed basis.

In addition to these quality control procedures designed to insure proper sampling techniques and continued equipment operation, analytical audits were performed to provide an internal check to insure the quality of the RM6B analyses. One EPA performance audit sample was prepared and analyzed each time a set of RM6B samples was analyzed. Furthermore, the RM6B samples were not analyzed until the analytically determined EPA audit value was calculated and found to agree within five percent of the "known" audit value. If the "calculated" and "known" audit values did not agree within five percent, corrective actions were taken, and more EPA audits were analyzed until one pair of "calculated" and "known" values did agree within five percent. The results of these audits are reported in Appendix B.

2.3 QUALITY ASSURANCE

Quality assurance audits were conducted to evaluate the accuracy and precision of the RM6B tests over the six-month period, and to verify that all equipment was operating properly. Cylinder Gas Audits (CGA) and reference method audits were performed on several occasions during the project. The continuous emission monitoring and coal sampling and analysis were conducted independently. Results were not compared until completion of all measurements and calculations.

Over the six-month period Clean Air Engineering (CAE) conducted two external reference method audits. Each of these audits consisted of a series of RM6 and RM3 tests, as specified in EPA 40 CFR 60 Appendix A, completed over the duration of one 24-hour RM6B test. Each CAE audit involved 24 duplicate determinations of stack SO_2, CO_2, and O_2 concentrations. One set of duplicate measurements was conducted each hour. The sampling duration for each test was approximately thirty minutes.

In order for each hour's audit test results to be considered valid, the duplicate SO_2, CO_2, and O_2 results were required to meet the precision criteria noted in Table 1. These criteria, derived from the within laboratory precision values for RM3 and RM6 appearing in "The EPA Program for the Standardization of Stationary Source Emission Test Methodology" (EPA-600/4-76-044), reflect a 95 percent confidence interval on the difference between duplicate determinations. Differences between CAE duplicate measurements could not exceed the specified maximum allowable difference. If any of the criteria were exceeded, then all of the determinations for that hour were considered invalid. Furthermore, the overall acceptability of the audit required that a minimum of twenty-one valid hours be obtained.

TABLE 1. Precision Criteria for External Audits.

Component	Within Lab Precision	Between Duplicate Determinations
CO_2	0.20%	0.55%
O_2	0.32%	0.90%
SO_2 (RM6)	4% of the mean value	0.111 x (mean of duplicate runs) (e.g., approximately 66 ppm for source level of 600 ppm SO_2).

The results of the CAE audits are presented in Table 2. The CAE test reports are included in Appendix B. Audit values were within 7.5 and 8.9 percent of the 24-hour SO_2 emission rates determined using RM6B on the two dates, respectively. Since RM6B uses CO_2 as the diluent, the CAE audit results are reported using CO_2 as the diluent.

TABLE 2. External Audit Results.

CAE TEST			REFERENCE METHOD 6B
Test Date	Number of Valid Hours	SO_2 Emission Rate	Results SO_2 Emission Rate
12/3-4/86	22	1.855 lb SO_2/MMBtu	1.726 lb/MMBtu
3/25-26/86	21	1.834 lb SO_2/MMBtu	1.684 lb/MMBtu

During the second audit, CAE was also requested to determine the SO_2 and CO_2 concentrations of a calibration gas prepared using EPA Protocol 1. These results are summarized in Table 3. The known concentrations were 10 percent CO_2 and 511 ppm SO_2. Values measured by CAE ranged between 9.2-10.0 percent CO_2 and 493-573 ppm SO_2.

TABLE 3. Clean Air Engineering
SO_2 and CO_2 Tank Gas Audit.

Train A			Train B		
Run No	%CO_2	SO_2 (ppm dry)	Run No	%CO_2	SO_2 (ppm dry)
Cal 1A*	9.2	466*	Cal 1B	9.2	573
Cal 2A	9.65	520	Cal 2B	9.75	526
Cal 3A*	10.0	470*	Cal 3B*	10.0	465*
Cal 4A**	NA	210**	Cal 4B	NA	503
Cal 5A	NA	493	Cal 5B	NA	503
Cal 6A	10.0	500	Cal 6B	10.0	532

* Cal 1A, Cal 3A, Cal 3B - missing manifold not purged with SO_2 tank gas; sampling ambient air first minutes of test - runs voided.

** Cal 4A sample solution spilled - run voided.

In addition to the external audits, internal quality assurance audits were conducted using cylinder gases with known concentrations of SO_2 and CO_2. These audit gases were prepared in accordance with EPA Protocol 1. The SO_2 and CO_2 concentrations were not known by the field engineer at the time of the audit. During several unit outages, the field engineer analyzed these cylinder gases with each RM6B system using a cylinder gas audit (CGA) manifold, illustrated in Figure 3. During each CGA, one of the two cylinder gases was sampled over a 24-hour period. Afterwards, the collection train samples were analyzed using procedures identical to those for daily stack gas samples. The results of these cylinder gas audits for SO_2 are given in Table 4. Measured values of SO_2 were always within four percent of the known concentration.

Cylinder Gas Audit Equipment

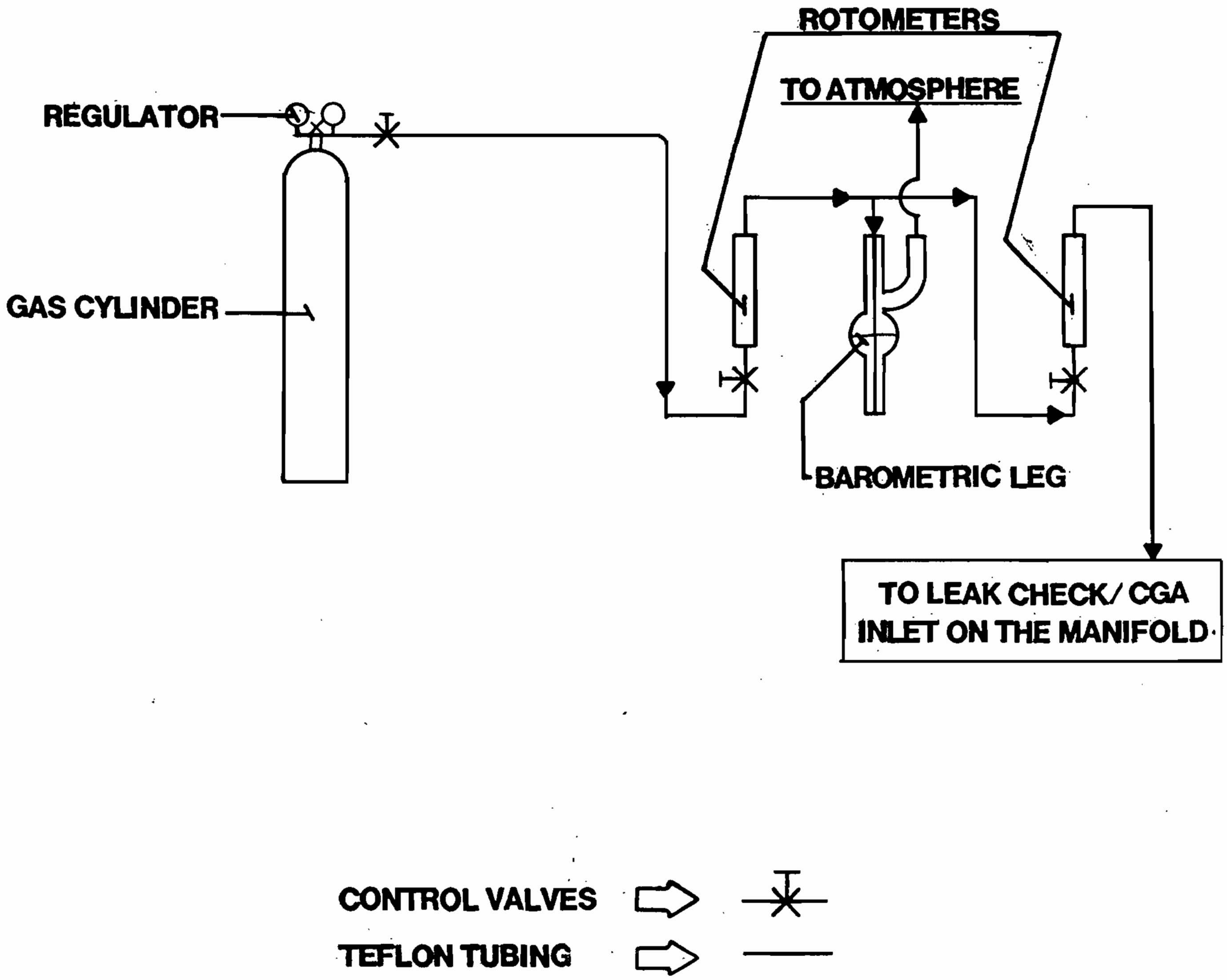

FIGURE 3

TABLE 4. RM6B Audit Results Using Calibration Gases Prepared in Accordance with EPA Traceability Protocol 1.

	Cylinder Used	Known Concentration SO_2 lb/MMBtu	Results of RM6B Tests A	B	C	D
1-16-86	CC49506	1.679	1.625	1.672	1.636	1.644
1-17-86	CC49506	1.679	lost	1.708	1.711	1.710
1-19-86	CC49521	1.533	1.550	1.524	1.508	1.527
1-22-86	CC49521	1.533	1.511	1.512	1.505	1.509
3-28-86	CC49521	1.533	1.526	1.520	1.512	1.519

3. TEST RESULTS

3.1 DATA DESCRIPTION

The field test program was begun on October 28, 1985 and concluded on May 4, 1986. The overall duration of the test program was 27 weeks or 189 days. During the test period, 32 days were lost because of unit outage. Of the remaining days, six were lost because of RM6B system failure. Four of these six days occurred early in the six-month period, and were related to problems with equipment start-up; two resulted from sample line pluggage. The usable data, subject to the data capture requirements specified in Section 2 and the precision criteria outlined below, were used to compute 20 weekly average SO_2 emission rates.

Prior to calculation of weekly averages, the precision of the triplicate 24-hour average values (from Trains A, B, and C) was evaluated for each day. The maximum allowable difference criteria for duplicate and triplicate RM6B test results are presented in Table 5. If the differences among all three values were less than the specified precision criteria, the daily average was computed as the triplicate mean. In some situations, only one pair (e.g., Train A and Train C, or Train A and Train B, etc.) passed the precision requirement. If so, the daily average was computed using only results for the pair that passed. On one day, the three trains failed the precision check, but all pair-wise comparisons passed, indicating uniform scatter in the data. In this case, the daily mean was computed using all three test values.

TABLE 5. Acceptance Criteria for Duplicate and Triplicate RM6B Test Results.

	Maximum Allowable Difference*
Duplicate measurements	(2.77) x (0.043) x (Duplicate Average)
Triplicate measurements	(3.31) x (0.043) x (Triplicate Average)

* The maximum allowable difference is based on a within laboratory precision of 4.3 percent of the mean value. 2.77 and 3.31 are critical values, representing 95 percent confidence levels for differences in duplicate and triplicate readings, respectively. Source: W.J. Dixon and F.J. Massey, Introduction to Statistical Analyses, McGraw Hill, Second Edition, 1957, Table A-8.

Once the daily averages were computed, weeks with at least five valid days were identified. Daily test results for weeks not meeting this criterion were discarded. The daily averages for the 20 valid weeks are included as Appendix C. The following parameters are also noted in Appendix C for each day:

- Number of hours of generation at Gannon Unit 3.
- Measured 24-hour SO_2 values for each train for the 20 valid weeks.
- An explanation for any missing daily values, i.e., unit outage (hours), RM6B sampling equipment problems (leak or plug), or insufficient days of data for calculation of a valid weekly average (days).
- The mean of all measured 24-hour SO_2 values, ignoring the precision criteria (i.e., the raw mean).
- The high (Max) and low (Min) values for each day, and the absolute value of their difference (Delta).
- The maximum allowable difference (Max Delta), calculated from the raw mean as described in Appendix D.
- The maximum allowable delta (Max Delta) minus the observed delta. Negative values for this quantity indicate potential precision problems.

- The computed daily mean, based on the defined precision criteria.
- Trains (A, B, and/or C) used to compute the daily mean.

The weekly average SO_2 emissions for the 20 valid weeks are given in Table 6. The weekly average SO_2 emissions based on coal sampling and analysis (CSA) are also included. These coal analysis results, which are reported by TEC to the Florida DER, reflect a 95 percent fuel sulfur conversion factor.

Variations in weekly average SO_2 emissions during the study are illustrated in Figure 4. Note that, with few exceptions, the coal analysis values are consistently higher than the corresponding RM6B values. A detailed comparison of results is provided in Section 3.2.

3.2 STATISTICAL ANALYSIS OF DATA

The comparison of the weekly average SO_2 emissions was conducted using several statistical techniques. These techniques were focused at addressing the following questions:

1. What are the general statistical characteristics of the RM6B and CSA data?
2. Are the statistical characteristics of the two data sets similar or different.
3. How well does CSA predict out-of-stack (RM6B) emissions?
4. Using either measurement technique, what can be said regarding the reported level of compliance to a 2.4 lb SO_2/MMBtu emission standard?

In interpreting the answers to these questions, however, some consideration must be given to several general characteristics of the data. The relatively

TABLE 6. Weekly Average SO_2 Emission Rates, lb SO_2/MMBtu

WEEK	RM6B	CSA	Difference[1/] Between CSA and RM6B
1			
2			
3	1.65	1.64	-0.01
4	1.58	1.76	0.18
5	1.67	1.75	0.08
6	1.63	1.78	0.15
7	1.60	1.76	0.16
8	1.62	1.74	0.12
9	1.70	1.82	0.12
10			
11	1.63	1.85	0.22
12			
13			
14	1.68	1.72	0.04
15	1.56	1.85	0.29
16	1.68	1.82	0.14
17	1.67	1.68	0.01
18	1.77	1.90	0.13
19	1.77	1.86	0.09
20	1.72	1.91	0.19
21	1.75	1.70	-0.05
22			
23	1.78	1.74	-0.04
24			
25	1.67	1.72	0.05
26	1.68	1.74	0.06
27	1.74	1.84	0.10
Average:	1.68	1.78	0.10

1/ CSA-RM6B

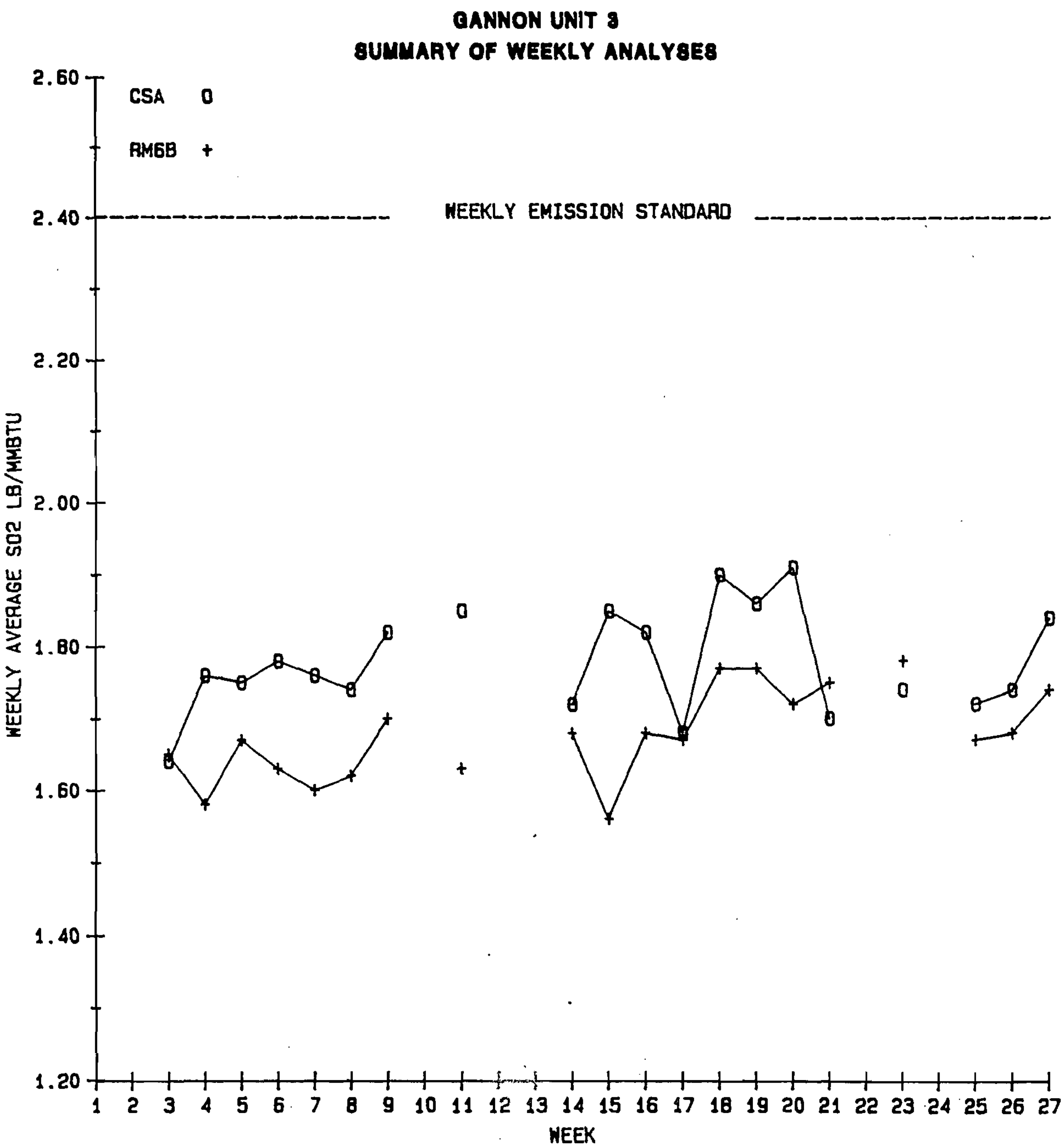

Figure 4. Variations in weekly average SO_2 emission rates over the six-month test period.

small sample size (n=20 weeks) limits the types and effectiveness of the various statistical tests employed. Measured weekly SO_2 emissions varied over a fairly small range, making it difficult to detect correlations between the CSA and continuous monitoring data, and to evaluate the use of CSA for predicting out-of-stack emissions. In addition, the fuel conversion factor, while assumed to be constant at 0.95, may, in fact, be subject to variation below this value. Finally, both the RM6B and CSA values are subject to variations that are implicit in any measurement technique. The effects of these factors on data analyses and results are discussed in the following subsections.

3.2.1 Statistical Characterization of RM6B and CSA Data

The first step in the analysis was to process the RM6B and CSA data in Table 6 using the SAS Univariate Procedure.[1/] This procedure furnishes a complete statistical characterization of a single observed variable (e.g., RM6B). Useful outputs from this procedure include (1) the mean, (2) standard deviation, and (3) standard error of the mean.

The Univariate Procedure will also perform a statistical test that evaluates the distribution properties of the observed data relative to the normal distribution. For small sample sizes, the Shapiro-Wilk statistic[2/] ("W" value) is used. The Univariate Procedure determines the probability that a true normal distribution will produce a "W" value smaller than the one com-

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1/ SAS is a computer software system for statistical data analysis. It is available from SAS Institute, P.O. Box 8000, Cary, NC 27511.

2/ Shapiro, S.S. and Wilk, M.B. (1965), "An Analysis of Variance Test for Normality (Complete Samples)," Biometrika, 52, 591-611.

puted from the observed data. If the probability is high that data sampled from a normal distribution could yield "W" values even smaller than the observed "W" value, then it must be concluded that the observed data are normally distributed. Generally speaking, a probability of 0.05 or smaller is considered to be significant evidence of non-normality.

The results of the Univariate analysis of the RM6B and CSA data are presented in Table 7. Note that the probabilities for the "W" test statistic for both the RM6B and CSA data are high, indicating that both data sets are normally distributed.

TABLE 7. The Mean, Variability and Distribution Properties for the Weekly Average SO_2 Emissions.

	RM6B lb SO_2/MMBtu	Coal Analysis
Mean	1.68	1.78
Standard deviation	0.064	0.074
"W" Test Statistic	0.964	0.966
Probability of smaller "W"	0.60	0.64
Distribution	Normal	Normal

The time series properties (autocorrelation) of the weekly averages were computed using the SAS Autoreg Procedure. This procedure can estimate autoregressive properties in the presence of missing data. It is generally agreed that accurate estimation of time series parameters requires 50 or more observations per data set. Nevertheless, the Autoreg Procedure can provide the best available estimates of the autocorrelation properties for the 20 measurements of weekly average SO_2 emissions rates.

In evaluating the autocorrelation structure of the weekly averages, the back step option in the Autoreg Procedure was used. Basically, this forces the procedure to start with a specified autocorrelation model (in this case using 2 lags), and then eliminate nonsignificant lags. The results of the Autoreg analysis of the weekly average SO_2 emisison rates are given in Table 8. The signs for the autocorrelation estimates are the opposite of those usually reported. This is simply a matter of the convention adopted by SAS. The T ratio and prob $> |T|$ were used to determine whether or not the estimates of the lag 1 and lag 2 autocorrelations are statistically different from zero. Generally speaking, prob $> |T|$ values greater than 0.05 indicate that the estimates are not significantly different from zero. There was no indication of a significant second-order lag in either of the two data sets. Furthermore, the first-order term is clearly not significant for the coal analysis data. For the RM6B data, the first-order autocorrelation is not significant at the 0.05 level, but is significant at the 0.10 level. Because of the small number of observations (n=20), results from the autocorrelation analysis must be interpreted with caution. The absence of a statistically significant autocorrelation does not necessarily mean that, in fact, autocorrelation is lacking.

TABLE 8. Results of Autocorrelation Analysis of Weekly Data.

	RM 6B Analysis			Coal Analysis		
	Estimate	T-Ratio	Prob	Estimate	T-Ratio	Prob
Lag 2	-0.216	-0.910	0.375	-0.061	-0.259	0.799
Lag 1	-0.405	-1.881	0.076	0.057	0.236	0.816

3.2.2 Comparison of the Mean and Variability for RM6B and CSA

A paired t-test was used to determine whether or not the RM6B and CSA data had significantly different mean values. This test is based on the paired differences between the observed weekly CSA and RM6B values. In performing this test, the mean difference and the standard error of the estimate for the mean difference are computed. This standard error is then used to compute a 95 percent confidence interval about the mean difference. If zero is included within this interval, then the means are assumed to be the same. If zero is not within the interval, then the means are said to be significantly different.

The information required to conduct the paired t-test was obtained from a Univariate analysis of the paired differences. The Univariate analysis is summarized in Table 9. Note that the high probability for the Shapiro-Wilk "W" statistic indicates that the paired differences are normally distributed.

TABLE 9. Univariate Analysis of Difference Between Weekly Average CSA and RM6B Results

Mean Difference (CSA-RM6B)	0.102 lb SO_2/MMBtu
Standard Error of Means	0.0195 lb SO_2/MMBtu
Shapiro-Wilk "W"	0.986
Probability of a smaller W	0.99
Distribution	Normal

The 95 percent confidence interval is constructed using a t value of 2.09 (based on 19 degrees of freedom). The 95 percent confidence interval about the true mean difference is given by:

$$0.102 \pm t \text{ (standard error of mean), or}$$

$$0.102 \pm 2.09(0.0195) = 0.102 \pm 0.041.$$

The 95 percent confidence interval extends from 0.061 to 0.143 lb SO_2/MMBtu. Since zero is not contained within this confidence interval, it is concluded that there is a significant difference between the two means.

The variability in weekly emission averages for the two methods was also compared. The estimated variability for the RM6B was 0.064 lb SO_2/MMBtu and 0.074 for CSA. Numerically speaking, the CSA variability appears to be slightly higher that the RM6B variability.

The F-ratio test was used to determine whether the variances of the two methods were the same. This test compares the ratios of the variances for the two measurement techniques against a standard value. If the ratio is less than or equal to this value, then the variances are accepted as being equal. This test was conducted using the Univariate statistic results found in Table 7. Recall that the variance is the square of the standard deviation. The F-ratio is given by $F = (0.074/0.064)^2 = 1.34$. The critical F, at the 95 percentile and based on 19 degrees of freedom, is 2.17. Since the observed F-ratio, 1.34, is less than the critical value, it is concluded that variations in weekly SO_2 emissions measured using CSA and RM6B are not significantly different. This test assumes independence of the two samples, which may not be true when both CSA and RM6B are measuring simultaneously and for the same coal.

3.2.3 Regression Analysis of RM6B vs CSA

A regression analysis of the RM6B vs CSA values, using the SAS Regression Procedure, was also conducted. Before discussing the results, it should be noted that a regression analysis on small data sets with low overall variability should be viewed with some caution. The model used was RM6B = A + B(CSA). The results indicate essentially no correlation between the CSA and RM6B values. The squared correlation (R^2) between the two methods was 0.04. The estimate for the slope of the regression line (B) was not significantly different from zero. Furthermore, the model F value, which can be used to test whether or not the regression model is significant, also showed a lack of significance. The summary statistics for the regression analysis are given in Table 10.

TABLE 10. Results of Regression Analysis of RM6B on CSA

Parameter	Estimate	Standard Error	Significant
Intercept	1.367	0.354	Yes
Slope	0.175	0.199	No
Model F = 0.771		Prob > F = 0.3916 (not significant)	
Model R^2 = 0.041			

Results from the regression analysis should be interpreted with caution, however. First of all, the range of the observed data is extremely small. The RM6B varied from 1.58 to 1.78 lb SO_2/MMBtu, and the CSA from 1.64 to 1.91 lb SO_2/MMBtu. This represents a variation, in terms of percent difference from the mean, of 12 percent for the RM6B [100(1.78-1.58/1.68)]; and 15 percent for the CSA [100(1.91-1.64/1.98)]. Some portion of this variation can be attributed to sampling and analytical variation, essentially a "white noise" component. For data-sets spanning a limited range in values, even a small sampling and analytical variation term may mask a true relationship between variables. In addition, one of the fundamental assumptions in regression analysis is that the independent variable (in this case the weekly average CSA data) is measured without error. It has been shown by Johnston[3/] that measurement error (variation) in the independent variable (i.e., the "white noise" component for the CSA variable) will downwardly bias the slope of the regression line. It is possible that this effect is having a major impact on the regression analysis.

3/ J. Johnston, Econometric Methods, Second ed. pp. 281-291.

Another possible contributing element is variability in the fuel sulfur retention factor. CSA values were calculated assuming a constant fuel sulfur retention factor of 0.95. In reality, however, the fuel sulfur retention factor may be subject to variation below this value. This variation would inflate the standard deviation for the estimate of the slope and also may negatively bias the slope estimate (B).

In summary, results from the regression analysis are inconclusive. There appear to be several mitigating factors that, when taken as a whole, result in an apparent lack of agreement between the RM6B and CSA test methods.

3.2.4 Achievability of 2.4 lb SO_2/MMBtu Emission Standard

Gannon Unit 3 is subject to a 2.4 lb SO_2/MMBtu emission standard. Compliance with this standard is based on weekly average SO_2 emission rates. The following exercise shows that both RM6B and CSA are suitable methods for demonstrating compliance with this standard. It should be noted that (1) the mean SO_2 emission level as determined by CSA is higher than that for RM6B, and (2) the variability of the weekly CSA values may be higher than the weekly RM6B values. Thus, CSA will tend to over predict SO_2 emissions relative to RM6B.

The probability of exceeding the SO_2 emission standard can be computed using the Univariate statistics found in Table 7. First, the Z statistic is calculated. For a normal distribution (as in this case) this statistic is computed by $Z = (X_c - \overline{X})/\sigma$. X_c is the critical value, i.e., the 2.4 lb SO_2/MMBtu standard; $\overline{X}$ and σ are the mean and standard deviation, respectively, of the weekly averages.

Basically, the Z statistic represents the distance, in number of standard deviations, between the critical value and the observed mean. If, for example, Z is 1.96, the associated probability value indicates that 97.5 percent of the weekly averages would be below the critical value of 2.4 lb SO_2/MMBtu. Conversely, the critical value would be exceeded, on the average, only 2.5 percent of the time.

The application of this procedure to the weekly RM6B and CSA data is summarized in Table 11. The Z statistics for both methods (CSA and RM6B) are extremely high, and beyond the values found in statistical tables. Therefore, the reported probabilities of exceeding the 2.4 lb SO_2/MMBtu emission standard are conservative. The estimated probabilities indicate that an exceedence of the standard would occur, on average, at a frequency much less than one week per every 10,000 weeks of unit operation.

Table 11. Probability of Exceeding the 2.4 lb SO_2/MMBtu Weekly Average SO_2 Emission Standard.

Measurement	Mean	Standard Deviation	Z	Probability of Exceeding 2.4
RM6B	1.68	0.064	11.25	< 0.00001
Coal Analysis	1.78	0.074	8.38	< 0.00001

4. CONCLUSION

In conclusion, results from this study indicate that the use of CSA as a monitoring method provides a conservative estimate of the actual out-of-stack emissions. Since the CSA method has a mean that is approximately 0.10 lb SO_2/MMBtu higher than the RM6B method, the CSA method tends to overpredict the actual SO_2 emissions. The ability to meet the 2.4 lb SO_2/MMBtu emission standard was also estimated using both the CSA and RM6B data sets and results for both data sets indicate that the 2.4 lb SO_2/MMBtu emission standard would be exceeded less than 1 week out 10,000 weeks, or approximately 1 exceedance per 190 years. Therefore, irrespective of the measurement technique, the probability of exceeding the 2.4 lb SO_2/MMBtu emission standard is extremely remote.

APPENDIX A

Daily Fuel Analysis Values

Gannon Unit 3

COMBINED RM6B AND CSA (CTL) DATA

MO	DAY	YEAR	WEEK		CSA SO2 LB/MMBTU	HEAT RATE	MWH	GENERATION HOURS	CSA TONS SO2	RM6B SO2 LB/MMBTU	RM6B TONS SO2
10	28	85	1	M	1.59	10886	2393	24	20.71		
10	29	85	1	T	1.61	10886	2377	24	20.83		
10	30	85	1	W	1.68	10886	2450	24	22.40		
10	31	85	1	T	1.70	10886	2100	24	19.43		
11	1	85	1	F	1.58	11442	1938	24	17.52	1.331	14.76
11	2	85	1	S	1.72	11442	1657	24	16.31	1.553	14.72
11	3	85	1	S		11442	2215	24		1.381	17.50
11	4	85	2	M	1.57	11442	2105	24	18.91	1.646	19.82
11	5	85	2	T		11442	145	4			
11	6	85	2	W		11442	618	9			
11	7	85	2	T	1.58	11442	2018	24	18.24	1.458	16.83
11	8	85	2	F		11442	1000	15			
11	9	85	2	S	1.59	11442	1702	24	15.48	1.676	16.32
11	10	85	2	S	1.54	11442	1777	24	15.66	1.645	16.72
11	11	85	3	M	1.61	11442	2023	24	18.63	1.595	18.46
11	12	85	3	T	1.59	11442	1516	20	13.70	1.704	14.78
11	13	85	3	W		11442	299	5			
11	14	85	3	T	1.84	11442	1860	23	19.58	1.648	17.54
11	15	85	3	F	1.68	11442	2038	24	19.59	1.630	19.00
11	16	85	3	S	1.70	11442	1500	21	14.59	1.654	14.19
11	17	85	3	S		11442	453	7			
11	18	85	4	M	1.62	11442	1961	24	18.17	1.601	17.96
11	19	85	4	T	1.64	11442	2058	24	19.31	1.598	18.81
11	20	85	4	W	1.64	11442	2096	24	19.67	1.568	18.80
11	21	85	4	T	1.62	11442	1982	24	18.37	1.422	16.12
11	22	85	4	F	1.66	11442	2089	24	19.84	1.550	18.52
11	23	85	4	S	1.57	11442	1732	24	15.56	1.660	16.45
11	24	85	4	S	1.67	11442	1828	24	17.46	1.646	17.21
11	25	85	5	M	1.65	11442	1958	24	18.48	1.714	19.20
11	26	85	5	T	1.81	11442	1797	24	18.61	1.774	18.24
11	27	85	5	W	1.76	11442	1821	24	18.34	1.689	17.60
11	28	85	5	T	1.78	11442	1964	24	20.00	1.633	18.35
11	29	85	5	F	1.75	11442	1778	24	17.80	1.674	17.03
11	30	85	5	S	1.72	11442	1780	24	17.52	1.584	16.13

Gannon Unit 3

COMBINED RM6B AND CSA (CTL) DATA

MO	DAY	YEAR	WEEK		CSA SO2 LB/MMBTU	HEAT RATE	MWH	GENERATION HOURS	CSA TONS SO2	RM6B SO2 LB/MMBTU	RM6B TONS SO2
12	1	85	5	S	1.71	11157	1910	24	18.22	1.634	17.41
12	2	85	6	M	1.88	11157	1885	24	19.77	1.729	18.18
12	3	85	6	T		11157	1740	24		1.726	16.75
12	4	85	6	W	1.80	11157	1710	24	17.17	1.688	16.10
12	5	85	6	T	1.75	11157	1675	24	16.35	1.593	14.88
12	6	85	6	F	1.71	11157	1916	24	18.28	1.569	16.77
12	7	85	6	S	1.64	11157	1955	24	17.89	1.558	16.99
12	8	85	6	S	1.73	11157	1689	24	16.30	1.578	14.87
12	9	85	7	M	1.65	11157	2473	24	22.76	1.595	22.00
12	10	85	7	T	1.62	11157	2139	24	19.33	1.603	19.13
12	11	85	7	W	1.64	11157	2096	24	19.18	1.628	19.04
12	12	85	7	T	1.78	11157	2465	24	24.48	1.602	22.03
12	13	85	7	F	1.67	11157	2234	24	20.81	1.573	19.60
12	14	85	7	S	1.68	11157	2023	24	18.96	1.594	17.99
12	15	85	7	S	1.68	11157	2043	24	19.15	1.607	18.31
12	16	85	8	M	1.61	11157	2274	24	20.42	1.738	22.05
12	17	85	8	T	1.81	11157	1973	24	19.92	1.609	17.71
12	18	85	8	W	1.69	11157	1755	24	16.55	1.538	15.06
12	19	85	8	T	1.71	11157	1900	24	18.12	1.399	14.83
12	20	85	8	F	1.66	11157	2271	24	21.03	1.762	22.32
12	21	85	8	S	1.93	11157	2056	24	22.14	1.730	19.84
12	22	85	8	S	1.71	11157	2494	24	23.79	1.594	22.18
12	23	85	9	M	1.65	11157	2117	24	19.49	1.538	18.16
12	24	85	9	T	1.65	11157	1577	22	14.52	1.579	13.89
12	25	85	9	W		11157	1092	17			
12	26	85	9	T	1.63	11157	2673	24	24.31	1.868	27.85
12	27	85	9	F	2.17	11157	2472	24	29.92	1.771	24.42
12	28	85	9	S	1.76	11157	2733	24	26.83	1.748	26.65
12	29	85	9	S	1.75	11157	2140	24	20.89	1.664	19.86
12	30	85	10	M	1.71	11157	2371	24	22.62	1.836	24.31
12	31	85	10	T		11157	1326	17			

Gannon Unit 3

COMBINED RM6B AND CSA (CTL) DATA

MO	DAY	YEAR	WEEK		CSA SO2 LB/MMBTU	HEAT RATE	MWH	GENERATION HOURS	CSA TONS SO2	RM6B SO2 LB/MMBTU	RM6B TONS SO2
1	1	86	10	W	.	11623		0			
1	2	86	10	T		11623	1447	19		1.741	14.64
1	3	86	10	F	1.70	11623	2310	24	22.82	1.743	23.40
1	4	86	10	S	1.74	11623	1879	22	19.00		
1	5	86	10	S	.	11623		0			
1	6	86	11	M	.	11623	1690	21		1.603	15.74
1	7	86	11	T		11623	2162	24		1.644	20.66
1	8	86	11	W	1.70	11623	2052	24	20.27	1.633	19.47
1	9	86	11	T	1.73	11623	2311	24	23.23	1.805	24.24
1	10	86	11	F	1.82	11623	2237	24	23.66	1.556	20.23
1	11	86	11	S	1.75	11623	2430	24	24.71	1.639	23.15
1	12	86	11	S	.	11623	2200	24	0.00	1.536	19.64
1	13	86	12	M	1.67	11623	2710	24	26.30	1.622	25.55
1	14	86	12	T	1.71	11623	2330	24	23.15	1.657	22.44
1	15	86	12	W		11623	1019	12			
1	16	86	12	T	.	11623		0			
1	17	86	12	F	.	11623		0			
1	18	86	12	S		11623		0			
1	19	86	12	S		11623		0			
1	20	86	13	M		11623	376	10			
1	21	86	13	T		11623	348	6			
1	22	86	13	W		11623		0			
1	23	86	13	T		11623		0			
1	24	86	13	F		11623	1607	20		1.635	15.27
1	25	86	13	S	.	11623	2166	24			
1	26	86	13	S		11623	14	1			
1	27	86	14	M	1.69	11623	1950	21	19.15		
1	28	86	14	T		11623	2640	24		1.658	25.44
1	29	86	14	W	1.73	11623	2520	24	25.34	1.606	23.52
1	30	86	14	T	1.61	11623	2260	24	21.15	1.676	22.01
1	31	86	14	F	1.67	11623	2040	24	19.80	1.696	20.11

Gannon Unit 3

COMBINED RM6B AND CSA (CTL) DATA

MO	DAY	YEAR	WEEK		CSA SO2 LB/MMBTU	HEAT RATE	MWH	GENERATION HOURS	CSA TONS SO2	RM6B SO2 LB/MMBTU	RM6B TONS SO2
2	1	86	14	S	1.68	11363	1871	24	17.86	1.722	18.31
2	2	86	14	S	1.76	11363	2313	24	23.13	1.737	22.83
2	3	86	15	M	1.71	11363	1844	24	17.92	1.711	17.93
2	4	86	15	T	1.70	11363	2117	24	20.45	1.653	19.88
2	5	86	15	W	1.74	11363	1860	24	18.39	1.346	14.22
2	6	86	15	T	1.76	11363	2145	24	21.45	1.238	15.09
2	7	86	15	F	1.72	11363	2325	24	22.72	1.601	21.15
2	8	86	15	S	1.72	11363	2235	24	21.84	1.657	21.04
2	9	86	15	S	1.77	11363	2107	24	21.19	1.687	20.19
2	10	86	16	M		11363	2558	24		1.604	23.31
2	11	86	16	T	1.76	11363	2045	20	20.45	1.654	19.22
2	12	86	16	W	1.76	11363	2033	24	20.33	1.653	19.09
2	13	86	16	T	1.76	11363	1700	24	17.00	1.703	16.45
2	14	86	16	F	1.75	11363	1760	24	17.50	1.721	17.21
2	15	86	16	S	1.75	11363	1755	24	17.45	1.708	17.03
2	16	86	16	S	1.69	11363	1802	24	17.30	1.713	17.54
2	17	86	17	M	1.67	11363	1641	24	15.57	1.604	14.95
2	18	86	17	T	1.68	11363	1658	24	15.83	1.595	15.02
2	19	86	17	W	1.66	11363	1852	21	17.47		
2	20	86	17	T		11363	1376	15			
2	21	86	17	F	1.84	11363	1913	24	20.00	1.694	18.41
2	22	86	17	S	1.68	11363	2390	24	22.81	1.699	23.07
2	23	86	17	S	1.77	11363	1590	24	15.99	1.738	15.70
2	24	86	18	M	1.78	11363	2026	24	20.49	1.688	19.43
2	25	86	18	T	1.69	11363	2572	24	24.70	1.810	26.45
2	26	86	18	W	1.72	11363	2260	24	22.09	1.758	22.57
2	27	86	18	T	1.87	11363	2037	24	21.64	1.793	20.75
2	28	86	18	F	1.90	11363	2412	24	26.04	1.846	25.30

Gannon Unit 3

COMBINED RM6B AND CSA (CTL) DATA

MO	DAY	YEAR	WEEK		CSA SO2 LB/MMBTU	HEAT RATE	MWH	GENERATION HOURS	CSA TONS SO2	RM6B SO2 LB/MMBTU	RM6B TONS SO2
3	1	86	18	S	1.88	11128	2029	24	21.22	1.695	19.14
3	2	86	18	S	1.86	11128	1969	24	20.38	1.780	19.50
3	3	86	19	M	1.70	11128	1690	24	15.99	1.585	14.90
3	4	86	19	T	1.71	11128	1925	24	18.32	1.753	18.78
3	5	86	19	W	1.87	11128	2045	24	21.28	1.899	21.61
3	6	86	19	T	1.84	11128	2905	24	29.74	1.824	29.48
3	7	86	19	F	1.81	11128	2730	24	27.49	1.753	26.63
3	8	86	19	S	1.81	11128	2490	24	25.08	1.739	24.09
3	9	86	19	S	1.82	11128	1786	24	18.09	1.841	18.29
3	10	86	20	M	1.98	11128	2346	24	25.85	1.764	23.03
3	11	86	20	T	1.96	11128	2480	24	27.05	1.814	25.03
3	12	86	20	W	1.87	11128	2474	24	25.74	1.863	25.64
3	13	86	20	T	1.87	11128	2190	24	22.79	1.808	22.03
3	14	86	20	F	1.79	11128	1973	24	19.65	1.535	16.85
3	15	86	20	S		11128	1905	24			
3	16	86	20	S	1.68	11128	1799	24	16.82	1.541	15.42
3	17	86	21	M		11128	1622	17			
3	18	86	21	T		11128	2127	24		1.843	21.81
3	19	86	21	W	1.85	11128	2229	24	22.94	1.762	21.85
3	20	86	21	T	1.77	11128	2567	24	25.28	1.723	24.61
3	21	86	21	F	1.74	11128	2555	24	24.74	1.717	24.41
3	22	86	21	S	1.69	11128	2559	24	24.06	1.728	24.60
3	23	86	21	S	1.68	11128	2404	24	22.47	1.740	23.27
3	24	86	22	M	1.70	11128	2859	24	27.04	1.632	25.96
3	25	86	22	T	1.66	11128	2437	24	22.51	1.683	22.82
3	26	86	22	W	1.62	11128	2573	24	23.19	1.669	23.89
3	27	86	22	T	1.63	11128	2642	23	23.96		
3	28	86	22	F		11128	0	0			
3	29	86	22	S		11128	1383	16			
3	30	86	22	S	1.61	11128	1810	24	16.21	1.639	16.51
3	31	86	23	M	1.68	11128	2495	24	23.32	1.739	24.14

Gannon Unit 3

COMBINED RM6B AND CSA (CTL) DATA

MO	DAY	YEAR	WEEK		CSA SO2 LB/MMBTU	HEAT RATE	MWH	GENERATION HOURS	CSA TONS SO2	RM6B SO2 LB/MMBTU	RM6B TONS SO2
4	1	86	23	T	1.81	11084	2443	24	24.51	1.715	23.22
4	2	86	23	W	1.84	11084	2572	24	26.23	1.819	25.93
4	3	86	23	T	1.92	11084	2670	24	28.41	1.835	27.15
4	4	86	23	F	1.76	11084	2900	24	28.29	1.794	28.83
4	5	86	23	S	1.78	11084	2455	24	24.22	1.790	24.35
4	6	86	23	S	1.80	11084	1905	24	19.00	1.737	18.34
4	7	86	24	M	1.70	11084	2497	24	23.53	1.718	23.77
4	8	86	24	T	1.74	11084	2578	24	24.86	1.647	23.53
4	9	86	24	W	1.82	11084	2070	24	20.88		
4	10	86	24	T	1.78	11084	1221	20	12.04		
4	11	86	24	F		11084		0			
4	12	86	24	S		11084		0			
4	13	86	24	S		11084	50	1			
4	14	86	25	M		11084	2276	24		1.803	22.74
4	15	86	25	T	1.94	11084	1973	24	21.21	1.646	18.00
4	16	86	25	W	1.74	11084	2027	24	19.55	1.693	19.02
4	17	86	25	T	1.88	11084	2126	24	22.15	1.689	19.90
4	18	86	25	F	1.67	11084	1816	24	16.81	1.640	16.51
4	19	86	25	S	1.63	11084	1837	24	16.59	1.640	16.70
4	20	86	25	S	1.56	11084	1859	24	16.07	1.600	16.48
4	21	86	26	M	1.71	11084	2200	24	20.85	1.579	19.25
4	22	86	26	T	1.67	11084	2449	24	22.67	1.562	21.20
4	23	86	26	W	1.57	11084	1971	24	17.15	1.734	18.94
4	24	86	26	T	1.80	11084	1950	24	19.45	1.753	18.94
4	25	86	26	F	1.71	11084	2375	24	22.51	1.669	21.97
4	26	86	26	S	1.72	11084	2125	24	20.26	1.718	20.23
4	27	86	26	S	1.82	11084	2452	24	24.73	1.738	23.62
4	28	86	27	M	1.80	11084	2421	24	24.15	1.766	23.69
4	29	86	27	T	1.76	11084	2165	24	21.12	1.744	20.93
4	30	86	27	W	1.61	11084	2467	24	22.01	1.725	23.58
5	1	86	27	T	1.70	11218	2696	24	25.71	1.780	26.92
5	2	86	27	F	1.81	11218	2774	24	28.16	1.743	27.12
5	3	86	27	S	1.79	11218	1620	24	16.26	1.703	15.47
5	4	86	27	S	1.73	11218	2340	24	22.71	1.742	22.86

APPENDIX B

Quality Assurance Checks

RM6B EPA AUDIT SAMPLE RESULTS - GANNON UNIT 3

Sample Period From	To	QC #	Known (mg/dscm)	Reported (mg/dscm)	Difference %
10/28	11/1	9438	1197.3	1187.9	-0.8
11/2	11/4	2131	297.4	310.7	+4.4
11/5	11/7	7495	899.9	892.8	-0.8
11/8	11/12	3436	282.2	296.0	+4.9
11/13	11/14	9489	1197.3	1175.6	-1.8
11/15	11/17	7131	899.9	879.7	-2.2
11/18	11/19	5250	968.5	967.2	-0.1
11/20	11/21	9151	1197.3	1184.4	-1.1
11/22	11/24	7454	899.9	894.6	-0.6
11/25	11/26	5537	968.5	955.1	-1.4
11/27	11/28	5527	968.5	954.2	-1.5
11/29	12/2	7516	899.9	883.8	-1.8
12/3		9457	1197.3	1188.4	-0.7
12/4	12/5	7523	899.9	876.4	-2.6
12/6	12/8	9448	1197.3	1182.9	-1.2
12/9	12/10	5544	968.5	958.5	-1.0
12/11	12/12	9283	1197.3	1184.7	-1.1
12/13	12/15	7389	899.9	892.1	-0.9
12/16	12/17	5066	968.5	956.9	-1.2
12/18	12/19	7250	1326.9	1305.0	-1.6
12/20	12/22	8346	1250.7	1229.7	-1.7
12/23	12/26	8337	1250.7	1230.3	-1.6
12/27	12/29	7329	1326.9	1312.8	-1.1
12/30	1/2	8137	1250.7	1225.5	-2.0
1/3	1/7	7195	1326.9	1310.5	-1.2
1/8	1/9	8147	1250.7	1244.7	-0.5
1/10	1/12	8246	1250.7	1236.0	-1.2
1/13	1/16	7190	1326.9	1320.6	-0.5
1/17	1/19	7241	1326.9	1308.2	-1.4
1/20	1/22	8145	1250.7	1242.9	-0.6
1/24	1/28	8124	1250.7	1252.6	+0.1
1/29	1/30	7316	1326.9	1318.8	-0.6
1/31	2/2	7193	1326.9	1324.1	-0.2
2/3	2/4	2289	701.6	706.8	+0.7
2/5	2/9	7293	1326.9	1302.6	-1.8
2/10	2/13	8101	1250.7	1236.6	-1.1
2/14	2/16	2053	701.6	694.7	-1.0
2/17	2/18	7198	1326.9	1316.3	-0.8
2/19	2/23	8150	1250.7	1237.9	-1.0
2/24	2/25	7369	1326.9	1316.1	-0.8
2/26	2/27	8261	1250.7	1221.8	-2.3
2/28	3/3	2260	701.6	717.8	+2.3
3/4		7219	1326.9	1307.9	-1.4
3/5		8182	1250.7	1242.2	-0.7
3/6	3/9	8184	1250.7	1222.3	-2.3
3/10	3/11	2328	701.6	727.2	-3.6
3/12	3/13	2079	701.6	702.6	+0.1

RM6B EPA AUDIT SAMPLE RESULTS - GANNON UNIT 3
(continued)

Sample Period From	To	QC #	Known (mg/dscm)	Reported (mg/dscm)	Difference %
3/14	3/16	7319	1326.9	1291.3	-2.7
3/17	3/18	7300	1326.9	1294.7	-2.4
3/19	3/20	8108	1250.7	1231.7	-1.5
3/21	3/24	2060	701.6	699.1	-0.4
3/25		8127	1250.7	1235.5	-1.2
3/26	3/30	2014	701.6	702.7	+0.2
3/31	4/1	9116	1197.3	1191.3	-0.5
4/2	4/3	7313	899.9	896.7	-0.4
4/4	4/6	5559	968.5	961.3	-0.7
4/7	4/8	9102	1197.3	1179.3	-1.5
4/14	4/15	7296	899.9	893.9	-0.7
4/16	4/17	5034	968.5	961.3	-0.7
4/18	4/20	5438	968.5	954.2	-1.5
4/21	4/22	7442	899.9	888.8	-1.2
4/23	4/24	9154	1197.3	1188.6	-0.7
4/25	4/27	5305	968.5	967.7	-0.1
4/28	4/29	9087	1197.3	1192.8	-0.4
4/30	5/1	7237	899.9	868.5	-1.5
5/2	5/3	5477	968.5	961.1	-0.8
5/4		9260	1197.3	1192.5	-0.4

GANNON UNIT 3

RM6B FLOW RATE SUMMARY

Date	A-Initial cc/min	B-Initial cc/min	C-Initial cc/min	A-Final cc/min	B-Final cc/min	C-Final cc/min
11/08	40	40	40	40	40	40
11/09	40	40	40	35	35	35
11/10	40	40	40	20	20	25
11/11	40	40	40	40	40	40
11/12	40	40	40	25	25	20
11/13	40	40	40	35	30	35
11/14	40	40	40	40	40	40
11/15	40	40	40	40	40	40
11/16	40	40	40	35	35	30
11/17	40	40	40	30	30	30
11/18	40	40	40	35	35	35
11/19	40	40	40	35	35	40
11/20	40	40	40	30	35	35
11/21	40	40	40	30	30	40
11/22	40	40	40	35	30	35
11/23	40	40	40	30	30	40
11/24	40	40	40	40	35	35
11/25	40	40	40	30	35	20
11/26	40	40	40	35	40	35
11/27	40	40	40	40	35	30
11/28	40	40	40	40	30	20
11/29	40	40	40	35	35	35
11/30	40	40	40	40	35	25
12/01	40	40	40	35	35	35
12/02	40	40	40	35	35	40
12/03	40	40	40	35	30	40
12/04	40	40	40	35	35	35
12/05	40	40	40	40	35	30
12/06	40	40	40	35	30	40
12/07	40	40	40	35	35	30
12/08	40	40	40	30	30	30
12/09	40	40	40	35	35	35
12/10	40	40	40	35	40	30
12/11	40	40	40	30	35	35
12/12	40	40	40	25	0	20
12/13	40	40	40	30	30	40
12/14	40	40	40	40	40	40
12/15	40	40	40	40	40	40
12/16	40	40	40	40	40	40
12/17	40	40	40	40	35	35
12/18	40	40	40	35	35	35
12/19	40	40	40	40	30	40
12/20	40	40	40	40	35	35
12/21	40	40	40	35	40	30
12/22	40	40	40	40	40	40

GANNON UNIT 3

RM6B FLOW RATE SUMMARY
(continued)

Date	A-Initial cc/min	B-Initial cc/min	C-Initial cc/min	A-Final cc/min	B-Final cc/min	C-Final cc/min
12/23	40	40	40	30	30	40
12/24	40	40	40	40	35	35
12/25	40	40	40	40	35	35
12/26	40	40	40	40	35	40
12/27	40	40	40	35	30	35
12/28	40	40	40	40	40	40
12/29	40	40	40	40	40	40
12/30	40	40	40	40	40	40
12/31	40	40	40	--	--	Unit Down
01/01	--	--	--	--	--	Unit Down
01/02	40	40	40	40	35	35
01/03	40	40	40	35	35	35
01/04	40	40	40	--	--	Unit Down
01/05	--	--	--	--	--	Unit Down
01/06	40	40	40	40	40	40
01/07	40	40	40	30	40	30
01/08	40	40	40	40	40	40
01/09	40	40	40	30	40	30
01/10	40	40	40	35	35	35
01/11	40	40	40	35	40	30
01/12	40	40	40	40	40	30
01/13	40	40	40	40	40	40
01/14	40	40	40	35	35	30
01/15	40	40	40	--	--	Unit Down
01/16	40	40	40	40	40	40
01/17	40	40	40	Loss of Train	40	40
01/18	Equipment	Repair	--	--	--	--
01/19	40	40	40	40	40	40
01/20	40	40	40	--	--	Unit Down
01/21	40	40	40	--	--	Unit Down
01/22	40	40	40	30	35	40
01/23	--	--	--	--	--	--
01/24	40	40	40	35	35	35
01/25	40	40	40	--	--	Unit Down
01/26	--	--	--	--	--	Unit Down
01/27	40	40	40	35	40	30
01/28	40	40	40	40	40	40
01/29	40	40	40	40	40	40
01/30	40	40	40	40	40	40
01/31	40	40	40	40	40	40
02/01	40	40	40	35	35	30
02/02	40	40	40	40	40	40
02/03	40	40	40	35	40	40
02/04	40	40	40	40	35	30

GANNON UNIT 3

RM6B FLOW RATE SUMMARY
(continued)

Date	A-Initial cc/min	B-Initial cc/min	C-Initial cc/min	A-Final cc/min	B-Final cc/min	C-Final cc/min
02/05	40	40	40	30	30	35
02/06	40	40	40	35	35	35
02/07	40	40	40	40	40	40
02/08	40	40	40	40	40	40
02/09	40	40	40	40	40	40
02/10	40	40	40	40	40	40
02/11	40	40	40	40	40	40
02/12	40	40	40	40	40	40
02/13	40	40	40	40	40	40
02/14	40	40	40	35	35	40
02/15	40	40	40	35	30	30
02/16	40	40	40	30	30	30
02/17	40	40	40	35	30	35
02/18	40	40	40	35	40	30
02/19	40	40	40	--	--	Unit Down
02/20	--	--	--	--	--	Unit Down
02/21	40	40	40	40	40	40
02/22	40	40	40	40	40	40
02/23	40	40	40	40	40	40
02/24	40	40	40	40	40	40
02/25	40	40	40	40	40	40
02/26	40	40	40	40	40	40
02/27	40	40	40	35	35	40
02/28	40	40	40	40	40	40
03/01	40	40	40	40	40	40
03/02	40	40	40	40	40	40
03/03	40	40	40	35	40	40
03/04	40	40	40	40	40	40
03/05	40	40	40	40	35	40
03/06	40	40	40	40	40	40
03/07	40	40	40	40	40	40
03/08	40	40	40	40	30	25
03/09	40	40	40	40	40	40
03/10	40	40	40	40	40	40
03/11	40	40	40	40	40	40
03/12	40	40	40	40	40	40
03/13	40	40	40	40	40	40
03/14	40	40	40	30	30	30
03/15	40	40	40	25	15	0
03/16	40	40	40	35	35	35
03/17	40	40	40	35	35	40
03/18	40	40	40	40	40	40
03/19	40	40	40	40	40	40
03/20	40	40	40	40	35	40

GANNON UNIT 3

RM6B FLOW RATE SUMMARY
(continued)

Date	A-Initial cc/min	B-Initial cc/min	C-Initial cc/min	A-Final cc/min	B-Final cc/min	C-Final cc/min
03/21	40	40	40	40	35	30
03/22	40	40	40	40	40	40
03/23	40	40	40	40	40	40
03/24	40	40	40	30	30	40
03/25	40	40	40	40	40	40
03/26	40	40	40	40	40	40
03/27	40	40	40	--	--	Unit Down
03/28	--	--	--	--	--	Unit Down
03/29	--	--	--	--	--	Unit Down
03/30	40	40	40	40	30	40
03/31	40	40	40	40	35	35
04/01	40	40	40	40	40	35
04/02	40	40	40	40	40	40
04/03	40	40	40	40	40	40
04/04	40	40	40	40	35	35
04/05	40	40	40	40	40	40
04/06	40	40	40	40	35	35
04/07	40	40	40	40	35	35
04/08	40	40	40	40	40	40
04/09	40	40	40	--	Train Clogged	
04/10	40	40	40	--	Train Clogged	
04/11	--	--	--	--	--	Unit Down
04/12	--	--	--	--	--	Unit Down
04/13	--	--	--	--	--	Unit Down
04/14	40	40	40	40	40	40
04/15	40	40	40	40	40	40
04/16	40	40	40	40	40	40
04/17	40	40	40	35	40	40
04/18	40	40	40	40	40	40
04/19	40	40	40	40	40	40
04/20	40	40	40	40	40	40
04/21	40	40	40	35	40	40
04/22	40	40	40	40	40	40
04/23	40	40	40	40	40	40
04/24	40	40	40	40	40	40
04/25	40	40	40	40	40	40
04/26	40	40	40	40	40	40
04/27	40	40	40	40	40	40
04/28	40	40	40	40	40	40
04/29	40	40	40	40	40	40
04/30	40	40	40	40	40	35
05/01	40	40	40	40	40	40
05/02	40	40	40	40	35	30
05/03	40	40	40	35	35	30
05/04	40	40	40	35	35	40

APPENDIX C

Daily RM6B Data

GANNON UNIT 3 RM6B TEST

MONTH	DAY	YEAR	WEEK #	DAY	GEN HOURS	SO2 LB/MMBTU A TRAIN	B TRAIN	C TRAIN	REASON MISSING	TRIPLICATE AVERAGE (DUPE)	PRECISION CHECKS MAX	MIN	DELTA	MAX DELTA	MAX DELTA MINUS DELTA	MEAN OF ALL PASSING PRECISION	VALUES USED
10	28	85	1	M	24				LEAK								
10	29	85	1	T	24				LEAK								
10	30	85	1	W	24				LEAK								
10	31	85	1	T	24				LEAK								
11	1	85	1	F	24	1.267	1.395	1.661		1.441	1.661	1.267	0.394	0.205	-0.189	1.331	AB
11	2	85	1	S	24	1.090	1.532	1.574		1.399	1.574	1.090	0.484	0.199	-0.285	1.553	BC
11	3	85	1	S	24	1.261	1.490	1.393		1.381	1.490	1.261	0.229	0.196	-0.033	1.381	ABC
11	4	85	2	M	24	1.633	1.596	1.709		1.646	1.709	1.596	0.113	0.234	0.121	1.646	ABC
11	5	85	2	T	4				HOURS								
11	6	85	2	W	9				HOURS								
11	7	85	2	T	24	1.529	1.479	1.366		1.458	1.529	1.366	0.163	0.207	0.044	1.458	ABC
11	8	85	2	F	15				HOURS								
11	9	85	2	S	24	1.688	1.673	1.668		1.676	1.688	1.668	0.020	0.238	0.218	1.676	ABC
11	10	85	2	S	24	1.657	1.686	1.592		1.645	1.686	1.592	0.094	0.234	0.140	1.645	ABC
11	11	85	3	M	24	1.573	1.590	1.622		1.595	1.622	1.573	0.049	0.226	0.177	1.595	ABC
11	12	85	3	T	20	1.691	1.721	1.700		1.704	1.721	1.691	0.030	0.242	0.212	1.704	ABC
11	13	85	3	W	5				HOURS								
11	14	85	3	T	23	1.634	1.659	1.652		1.648	1.659	1.634	0.025	0.234	0.209	1.648	ABC
11	15	85	3	F	24	1.641	1.640	1.609		1.630	1.641	1.609	0.032	0.231	0.199	1.630	ABC
11	16	85	3	S	21	1.645	1.647	1.671		1.654	1.671	1.645	0.026	0.235	0.209	1.654	ABC
11	17	85	3	S	7				HOURS								
11	18	85	4	M	24	1.589	1.582	1.631		1.601	1.631	1.582	0.049	0.227	0.178	1.601	ABC
11	19	85	4	T	24	1.595	1.582	1.618		1.598	1.618	1.582	0.036	0.227	0.191	1.598	ABC
11	20	85	4	W	24	1.591	1.574	1.540		1.568	1.591	1.540	0.051	0.223	0.172	1.568	ABC
11	21	85	4	T	24	1.413	1.389	1.463		1.422	1.463	1.389	0.074	0.202	0.128	1.422	ABC
11	22	85	4	F	24	1.533	1.532	1.584		1.550	1.584	1.532	0.052	0.220	0.168	1.550	ABC
11	23	85	4	S	24	1.661	1.661	1.657		1.660	1.661	1.657	0.004	0.236	0.232	1.660	ABC
11	24	85	4	S	24	1.646	1.658	1.634		1.646	1.658	1.634	0.024	0.234	0.210	1.646	ABC
11	25	85	5	M	24	1.713	1.712	1.716		1.714	1.716	1.712	0.004	0.243	0.239	1.714	ABC
11	26	85	5	T	24	1.785	1.759	1.778		1.774	1.785	1.759	0.026	0.252	0.226	1.774	ABC
11	27	85	5	W	24	1.722	1.648	1.696		1.689	1.722	1.648	0.074	0.240	0.166	1.689	ABC
11	28	85	5	T	24	1.619	1.608	1.671		1.633	1.671	1.608	0.063	0.232	0.169	1.633	ABC
11	29	85	5	F	24	1.694	1.624	1.705		1.674	1.705	1.624	0.081	0.238	0.157	1.674	ABC
11	30	85	5	S	24	1.598	1.523	1.630		1.584	1.630	1.523	0.107	0.225	0.118	1.584	ABC

GANNON UNIT 3 RM6B TEST

PRECISION CHECKS

MONTH	DAY	YEAR	WEEK #	DAY	GEN HOURS	SO2 LB/MMBTU A TRAIN	B TRAIN	C TRAIN	REASON MISSING	TRIPLICATE AVERAGE (DUPE)	MAX	MIN	DELTA	MAX DELTA	MAX DELTA MINUS DELTA	MEAN OF ALL PASSING PRECISION	VALUES USED
12	1	85	5	S	24	1.626	1.567	1.709		1.634	1.709	1.567	0.142	0.232	0.090	1.634	ABC
12	2	85	6	M	24	1.777	1.721	1.688		1.729	1.777	1.688	0.089	0.246	0.157	1.729	ABC
12	3	85	6	T	24	1.739	1.684	1.755		1.726	1.755	1.684	0.071	0.245	0.174	1.726	ABC
12	4	85	6	W	24	1.735	1.613	1.715		1.688	1.735	1.613	0.122	0.240	0.118	1.688	ABC
12	5	85	6	T	24	1.618	1.521	1.640		1.593	1.640	1.521	0.119	0.226	0.107	1.593	ABC
12	6	85	6	F	24	1.600	1.543	1.565		1.569	1.600	1.543	0.057	0.223	0.166	1.569	ABC
12	7	85	6	S	24	1.609	1.463	1.603		1.558	1.609	1.463	0.146	0.221	0.075	1.558	ABC
12	8	85	6	S	24	1.585	1.572	1.576		1.578	1.585	1.572	0.013	0.224	0.211	1.578	ABC
12	9	85	7	M	24	1.598	1.624	1.563		1.595	1.624	1.563	0.061	0.226	0.165	1.595	ABC
12	10	85	7	T	24	1.671	1.557	1.580		1.603	1.671	1.557	0.114	0.228	0.114	1.603	ABC
12	11	85	7	W	24	1.638	1.652	1.594		1.628	1.652	1.594	0.058	0.231	0.173	1.628	ABC
12	12	85	7	T	24	1.540		1.664	LOST	(1.602)	1.664	1.540	0.124	0.191	0.067	1.602	A C
12	13	85	7	F	24	1.594	1.589	1.535		1.573	1.594	1.535	0.059	0.223	0.164	1.573	ABC
12	14	85	7	S	24	1.640	1.595	1.548		1.594	1.640	1.548	0.092	0.226	0.134	1.594	ABC
12	15	85	7	S	24	1.642	1.647	1.532		1.607	1.647	1.532	0.115	0.228	0.113	1.607	ABC
12	16	85	8	M	24	1.722	1.727	1.766		1.738	1.766	1.722	0.044	0.247	0.203	1.738	ABC
12	17	85	8	T	24	1.717	1.624	1.485		1.609	1.717	1.485	0.232	0.228	-0.004	1.609	ABC
12	18	85	8	W	24	1.537		1.538	LOST	(1.538)	1.538	1.537	0.001	0.183	0.182	1.538	A C
12	19	85	8	T	24	1.593	1.412	1.385		1.463	1.593	1.385	0.208	0.208	-0.000	1.399	BC
12	20	85	8	F	24	1.859	1.683	1.744		1.762	1.859	1.683	0.176	0.250	0.074	1.762	ABC
12	21	85	8	S	24	1.708	1.623	1.859		1.730	1.859	1.623	0.236	0.246	0.010	1.730	ABC
12	22	85	8	S	24	1.676	1.503	1.602		1.594	1.676	1.503	0.173	0.226	0.053	1.594	ABC
12	23	85	9	M	24	1.600	1.444	1.570		1.538	1.600	1.444	0.156	0.218	0.062	1.538	ABC
12	24	85	9	T	22	1.607	1.628	1.503		1.579	1.628	1.503	0.125	0.224	0.099	1.579	ABC
12	25	85	9	W	17				HOURS								
12	26	85	9	T	24	1.879	1.911	1.814		1.868	1.911	1.814	0.097	0.265	0.168	1.868	ABC
12	27	85	9	F	24	1.836	2.180	1.705		1.907	2.180	1.705	0.475	0.271	-0.204	1.771	A C
12	28	85	9	S	24	1.805	1.719	1.721		1.748	1.805	1.719	0.086	0.248	0.162	1.748	ABC
12	29	85	9	S	24	1.744	1.709	1.540		1.664	1.744	1.540	0.204	0.236	0.032	1.664	ABC
12	30	85	10	M	24	1.850	1.935	1.730		1.838	1.935	1.730	0.205	0.261	0.056	1.838	ABC
12	31	85	10	T	17				HOURS								

GANNON UNIT 3 RM6B TEST

MONTH	DAY	YEAR	WEEK #	DAY	GEN HOURS	SO2 LB/MMBTU A TRAIN	B TRAIN	C TRAIN	REASON MISSING	TRIPLICATE AVERAGE (DUPE)	PRECISION CHECKS MAX	MIN	DELTA	MAX DELTA	MAX DELTA MINUS DELTA	MEAN OF ALL PASSING PRECISION	VALUES USED
1	1	86	10	W	0				HOURS								
1	2	86	10	T	19	1.752	1.715	1.756		1.741	1.756	1.715	0.041	0.247	0.206	1.741	ABC
1	3	86	10	F	24	1.761	1.793	1.676		1.743	1.793	1.676	0.117	0.248	0.131	1.743	ABC
1	4	86	10	S	22				HOURS								
1	5	86	10	S	0				HOURS								
1	6	86	11	M	21	1.686	1.567	1.556		1.603	1.686	1.556	0.130	0.228	0.098	1.603	ABC
1	7	86	11	T	24	1.712	1.613	1.608		1.644	1.712	1.608	0.104	0.233	0.129	1.644	ABC
1	8	86	11	W	24	1.679	1.675	1.546		1.633	1.679	1.546	0.133	0.232	0.099	1.633	ABC
1	9	86	11	T	24	1.855	1.803	1.758		1.805	1.855	1.758	0.097	0.256	0.159	1.805	ABC
1	10	86	11	F	24	1.523	1.589	1.857		1.656	1.857	1.523	0.334	0.235	-0.099	1.556	AB
1	11	86	11	S	24	1.196	1.674	1.604		1.491	1.674	1.196	0.478	0.212	-0.266	1.639	BC
1	12	86	11	S	24	1.460	1.604	1.544		1.536	1.604	1.460	0.144	0.218	0.074	1.536	ABC
1	13	86	12	M	24	1.576	1.705	1.585		1.622	1.705	1.576	0.129	0.230	0.101	1.622	ABC
1	14	86	12	T	24	1.681	1.657	1.632		1.657	1.681	1.632	0.049	0.235	0.186	1.657	ABC
1	15	86	12	W	12				HOURS								
1	16	86	12	T	0				HOURS								
1	17	86	12	F	0				HOURS								
1	18	86	12	S	0				HOURS								
1	19	86	12	S	0				HOURS								
1	20	86	13	M	10				HOURS								
1	21	86	13	T	6				HOURS								
1	22	86	13	W	0				HOURS								
1	23	86	13	T	0				HOURS								
1	24	86	13	F	20	1.669	1.629	1.606		1.635	1.669	1.606	0.063	0.232	0.169	1.635	ABC
1	25	86	13	S	24				HOURS								
1	26	86	13	S	1				HOURS								
1	27	86	14	M	21				HOURS								
1	28	86	14	T	24	1.668	1.651	1.654		1.658	1.668	1.651	0.017	0.235	0.218	1.658	ABC
1	29	86	14	W	24	1.648	1.663	1.506		1.606	1.663	1.506	0.157	0.228	0.071	1.606	ABC
1	30	86	14	T	24	1.714	1.658	1.655		1.676	1.714	1.655	0.059	0.238	0.179	1.676	ABC
1	31	86	14	F	24	1.728	1.655	1.705		1.696	1.728	1.655	0.073	0.241	0.168	1.696	ABC

GANNON UNIT 3 RM6B TEST

PRECISION CHECKS

MONTH	DAY	YEAR	WEEK #	DAY	GEN HOURS	------- SO2 LB/MMBTU--------- A TRAIN	B TRAIN	C TRAIN	REASON MISSING	TRIPLICATE AVERAGE (DUPE)	MAX	MIN	DELTA	MAX DELTA	MAX DELTA MINUS DELTA	MEAN OF ALL PASSING PRECISION	VALUES USED
2	1	86	14	S	24	1.738	1.770	1.657		1.722	1.770	1.657	0.113	0.245	0.132	1.722	ABC
2	2	86	14	S	24	1.728	1.730	1.753		1.737	1.753	1.728	0.025	0.247	0.222	1.737	ABC
2	3	86	15	M	24	1.755	1.722	1.656		1.711	1.755	1.656	0.099	0.243	0.144	1.711	ABC
2	4	86	15	T	24	1.601	1.635	1.724		1.653	1.724	1.601	0.123	0.235	0.112	1.653	ABC
2	5	86	15	W	24	1.327		1.364	LOST	(1.346)	1.364	1.327	0.037	0.160	0.123	1.346	A C
2	6	86	15	T	24	1.212	1.264	1.473		1.316	1.473	1.212	0.261	0.187	-0.074	1.238	AB
2	7	86	15	F	24	1.608	1.573	1.623		1.601	1.623	1.573	0.050	0.227	0.177	1.601	ABC
2	8	86	15	S	24	1.729	1.613	1.630		1.657	1.729	1.613	0.116	0.235	0.119	1.657	ABC
2	9	86	15	S	24	1.727	1.657	1.676		1.687	1.727	1.657	0.070	0.240	0.170	1.687	ABC
2	10	86	16	M	24	1.629	1.587	1.597		1.604	1.629	1.587	0.042	0.228	0.186	1.604	ABC
2	11	86	16	T	20	1.685	1.637	1.641		1.654	1.685	1.637	0.048	0.235	0.187	1.654	ABC
2	12	86	16	W	24	1.633	1.634	1.692		1.653	1.692	1.633	0.059	0.235	0.176	1.653	ABC
2	13	86	16	T	24	1.718	1.675	1.716		1.703	1.718	1.675	0.043	0.242	0.199	1.703	ABC
2	14	86	16	F	24	1.740	1.763	1.659		1.721	1.763	1.659	0.104	0.244	0.140	1.721	ABC
2	15	86	16	S	24	1.800	1.666	1.657		1.708	1.800	1.657	0.143	0.243	0.100	1.708	ABC
2	16	86	16	S	24	1.776	1.703	1.659		1.713	1.776	1.659	0.117	0.243	0.126	1.713	ABC
2	17	86	17	M	24	1.640	1.579	1.592		1.604	1.640	1.579	0.061	0.228	0.167	1.604	ABC
2	18	86	17	T	24	1.553	1.617	1.614		1.595	1.617	1.553	0.064	0.226	0.162	1.595	ABC
2	19	86	17	W	21				HOURS								
2	20	86	17	T	15				HOURS								
2	21	86	17	F	24	1.654	1.677	1.751		1.694	1.751	1.654	0.097	0.241	0.144	1.694	ABC
2	22	86	17	S	24	1.722	1.697	1.678		1.699	1.722	1.678	0.044	0.241	0.197	1.699	ABC
2	23	86	17	S	24	1.747	1.765	1.701		1.738	1.765	1.701	0.064	0.247	0.183	1.738	ABC
2	24	86	18	M	24	1.709	1.743	1.612		1.688	1.743	1.612	0.131	0.240	0.109	1.688	ABC
2	25	86	18	T	24	1.821	1.799	1.559		1.726	1.821	1.559	0.262	0.245	-0.017	1.810	AB
2	26	86	18	W	24	1.695	1.729	1.851		1.758	1.851	1.695	0.156	0.250	0.094	1.758	ABC
2	27	86	18	T	24	1.796	1.800	1.782		1.793	1.800	1.782	0.018	0.255	0.237	1.793	ABC
2	28	86	18	F	24	1.869	1.824	1.846		1.846	1.869	1.824	0.045	0.262	0.217	1.846	ABC

GANNON UNIT 3 RM6B TEST

MONTH	DAY	YEAR	WEEK #	DAY	GEN HOURS	SO2 LB/MMBTU A TRAIN	B TRAIN	C TRAIN	REASON MISSING	TRIPLICATE AVERAGE (DUPE)	PRECISION CHECKS MAX	MIN	DELTA	MAX DELTA	MAX DELTA MINUS DELTA	MEAN OF ALL PASSING PRECISION	VALUES USED
3	1	86	18	S	24	1.724	1.723	1.637		1.695	1.724	1.637	0.087	0.241	0.154	1.695	ABC
3	2	86	18	S	24	1.748	1.797	1.795		1.780	1.797	1.748	0.049	0.253	0.204	1.780	ABC
3	3	86	19	M	24	1.567	1.629	1.558		1.585	1.629	1.558	0.071	0.225	0.154	1.585	ABC
3	4	86	19	T	24	1.730	1.776	1.754		1.753	1.776	1.730	0.046	0.249	0.203	1.753	ABC
3	5	86	19	W	24	1.874	1.825	1.997		1.899	1.997	1.825	0.172	0.270	0.098	1.899	ABC
3	6	86	19	T	24	1.837	1.834	1.801		1.824	1.837	1.801	0.036	0.259	0.223	1.824	ABC
3	7	86	19	F	24	1.777	1.777	1.706		1.753	1.777	1.706	0.071	0.249	0.178	1.753	ABC
3	8	86	19	S	24	1.777	1.785	1.655		1.739	1.785	1.655	0.130	0.247	0.117	1.739	ABC
3	9	86	19	S	24	1.837	1.873	1.813		1.841	1.873	1.813	0.060	0.261	0.201	1.841	ABC
3	10	86	20	M	24	1.708	1.830	1.753		1.764	1.830	1.708	0.122	0.250	0.128	1.764	ABC
3	11	86	20	T	24	1.781	1.858	1.803		1.814	1.858	1.781	0.077	0.258	0.181	1.814	ABC
3	12	86	20	W	24	1.831	1.907	1.852		1.863	1.907	1.831	0.076	0.265	0.189	1.863	ABC
3	13	86	20	T	24	1.787	1.832	1.806		1.808	1.832	1.787	0.045	0.257	0.212	1.808	ABC
3	14	86	20	F	24	1.525	1.635	1.446		1.535	1.635	1.446	0.189	0.218	0.029	1.535	ABC
3	15	86	20	S	24				PLUG								
3	16	86	20	S	24	1.496	1.597	1.529		1.541	1.597	1.496	0.101	0.219	0.118	1.541	ABC
3	17	86	21	M	17				HOURS								
3	18	86	21	T	24	1.839	1.857	1.833		1.843	1.857	1.833	0.024	0.262	0.238	1.843	ABC
3	19	86	21	W	24	1.725	1.802	1.760		1.762	1.802	1.725	0.077	0.250	0.173	1.762	ABC
3	20	86	21	T	24	1.705	1.747	1.717		1.723	1.747	1.705	0.042	0.245	0.203	1.723	ABC
3	21	86	21	F	24	1.722	1.755	1.673		1.717	1.755	1.673	0.082	0.244	0.162	1.717	ABC
3	22	86	21	S	24	1.705	1.758	1.721		1.728	1.758	1.705	0.053	0.245	0.192	1.728	ABC
3	23	86	21	S	24	1.755	1.738	1.726		1.740	1.755	1.726	0.029	0.247	0.218	1.740	ABC
3	24	86	22	M	24	1.576	1.645	1.675		1.632	1.675	1.576	0.099	0.232	0.133	1.632	ABC
3	25	86	22	T	24	1.684	1.684	1.681		1.683	1.684	1.681	0.003	0.239	0.236	1.683	ABC
3	26	86	22	W	24	1.665	1.664	1.678		1.669	1.678	1.664	0.014	0.237	0.223	1.669	ABC
3	27	86	22	T	23				HOURS								
3	28	86	22	F	0				HOURS								
3	29	86	22	S	16				HOURS								
3	30	86	22	S	24	1.614	1.662	1.641		1.639	1.662	1.614	0.048	0.233	0.185	1.639	ABC
3	31	86	23	M	24	1.731	1.745	1.742		1.739	1.745	1.731	0.014	0.247	0.233	1.739	ABC

GANNON UNIT 3 RM6B TEST

MONTH	DAY	YEAR	WEEK #	DAY	GEN HOURS	------- SO2 LB/MMBTU--------- A TRAIN	B TRAIN	C TRAIN	REASON MISSING	TRIPLICATE AVERAGE (DUPE)	PRECISION CHECKS MAX	MIN	DELTA	MAX DELTA	MAX DELTA MINUS DELTA	MEAN OF ALL PASSING PRECISION	VALUES USED
4	1	86	23	T	24	1.704	1.727	1.713		1.715	1.727	1.704	0.023	0.244	0.221	1.715	ABC
4	2	86	23	W	24	1.836	1.829	1.791		1.819	1.836	1.791	0.045	0.258	0.213	1.819	ABC
4	3	86	23	T	24	1.846	1.831	1.827		1.835	1.846	1.827	0.019	0.261	0.242	1.835	ABC
4	4	86	23	F	24	1.817	1.787	1.779		1.794	1.817	1.779	0.038	0.255	0.217	1.794	ABC
4	5	86	23	S	24	1.783	1.802	1.784		1.790	1.802	1.783	0.019	0.254	0.235	1.790	ABC
4	6	86	23	S	24	1.741	1.736	1.735		1.737	1.741	1.735	0.006	0.247	0.241	1.737	ABC
4	7	86	24	M	24	1.740	1.705	1.710		1.718	1.740	1.705	0.035	0.244	0.209	1.718	ABC
4	8	86	24	T	24	1.656	1.657	1.629		1.647	1.657	1.629	0.028	0.234	0.206	1.647	ABC
4	9	86	24	W	24				PLUG								
4	10	86	24	T	20				HOURS								
4	11	86	24	F	0				HOURS								
4	12	86	24	S	0				HOURS								
4	13	86	24	S	1				HOURS								
4	14	86	25	M	24	1.787	1.805	1.817		1.803	1.817	1.787	0.030	0.256	0.226	1.803	ABC
4	15	86	25	T	24		1.620	1.672	LOST	(1.646)	1.672	1.620	0.052	0.196	0.144	1.646	BC
4	16	86	25	W	24	1.684	1.706	1.689		1.693	1.706	1.684	0.022	0.240	0.218	1.693	ABC
4	17	86	25	T	24	1.700	1.688	1.680		1.689	1.700	1.680	0.020	0.240	0.220	1.689	ABC
4	18	86	25	F	24	1.658	1.625	1.637		1.640	1.658	1.625	0.033	0.233	0.200	1.640	ABC
4	19	86	25	S	24	1.666	1.621	1.632		1.640	1.666	1.621	0.045	0.233	0.188	1.640	ABC
4	20	86	25	S	24	1.586	1.584	1.630		1.600	1.630	1.584	0.046	0.227	0.181	1.600	ABC
4	21	86	26	M	24	1.538	1.593	1.606		1.579	1.606	1.538	0.068	0.224	0.156	1.579	ABC
4	22	86	26	T	24	1.572	1.557	1.556		1.562	1.572	1.556	0.016	0.222	0.206	1.562	ABC
4	23	86	26	W	24	1.695	1.758	1.748		1.734	1.758	1.695	0.063	0.246	0.183	1.734	ABC
4	24	86	26	T	24	1.766	1.720	1.773		1.753	1.773	1.720	0.053	0.249	0.196	1.753	ABC
4	25	86	26	F	24	1.687	1.654	1.665		1.669	1.687	1.654	0.033	0.237	0.204	1.669	ABC
4	26	86	26	S	24	1.739	1.710	1.704		1.718	1.739	1.704	0.035	0.244	0.209	1.718	ABC
4	27	86	26	S	24	1.747	1.733	1.735		1.738	1.747	1.733	0.014	0.247	0.233	1.738	ABC
4	28	86	27	M	24	1.778	1.779	1.742		1.766	1.779	1.742	0.037	0.251	0.214	1.766	ABC
4	29	86	27	T	24	1.747	1.729	1.756		1.744	1.756	1.729	0.027	0.248	0.221	1.744	ABC
4	30	86	27	W	24	1.732	1.725	1.717		1.725	1.732	1.717	0.015	0.245	0.230	1.725	ABC
5	1	86	27	T	24	1.779	1.780	1.781		1.780	1.781	1.779	0.002	0.253	0.251	1.780	ABC
5	2	86	27	F	24	1.761	1.742	1.726		1.743	1.761	1.726	0.035	0.248	0.213	1.743	ABC
5	3	86	27	S	24	1.744	1.699	1.667		1.703	1.744	1.667	0.077	0.242	0.165	1.703	ABC
5	4	86	27	S	24	1.749	1.746	1.731		1.742	1.749	1.731	0.018	0.247	0.229	1.742	ABC

APPENDIX D

Precision of Reference Method 6B

ESTIMATING A REPEATABILITY STANDARD DEVIATION

C.H. PROCTOR, N.C.S.U., OCTOBER 1985

A collaborative test[1/] yielded duplicate measurements from nine laboratories for five runs. These data were used to furnish an estimate of σ = 0.07 for the repeatability or within laboratory standard deviation. We will review how this estimate was obtained and then discuss how it should be revised.

Certain of the original observations were detected as outliers and appear with underlines in Table III (p. 971). These we have omitted. Twenty-seven (27) pairs of observations remained for the same collaborator and run. We squared the differences for these 27 pairs and viewed each such squared difference as an estimate, with one degree of freedom, of twice the underlying repeatability variance. These squared differences were called "D2" in the SAS program and the attached computer output gives a summary of them by collaborators.

The grand total of all 27 squared differences is .2437. If there is one common variance underlying all 27, it would be estimated as .2437/(27 x 2). Taking a square root gives us σ = .067, in agreement with the article. There is, however, a question concerning the equality of repeatability variances across collaborators.

1/ F.E. Butler, J.E. Knoll, J.C. Suggs, and N.R. Midgett. The collaborative test of Method 6-B: twenty-four-hour analysis of SO_2 and CO_2, Journal of the Air Pollution Control Association, Vol. 33, pp 968-973

As a test for an outlier among variances we will use W.G. Cochran's (1941, of their total, Annals of Eugenics, Vol. 11, pp. 47-52). From the output we see the largest variance among the collaborators is for 8 and the test statistic is g = .0511/.0806 = .634. The table in Cochran's article covers only the cases where there are 8 and where there are 10 collaborators, so we will interpolate for our case of 9. All of our estimated variances do not have exactly 3 degrees of freedom, although that is their average, and it is also the degrees of freedom in the largest. This we judge will not affect in any appreciable degree the applicability of the significance points.

The tabled values at the 5% level are given by Cochran (p. 50) as .6333 for 8 and .6025 for 10 collaborators. Thus our observed value of .634 represents evidence of an outlier. When #8 is removed the estimate becomes σ = .043, while the estimate of repeatability for #8 is σ = .16. The estimate σ = .043 is based on 27 - 3 = 24 degrees of freedom and its uncertainty can be judged accordingly.

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VARIABLE	N	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE	STD ERROR OF MEAN	SUM	VARIANCE	C
CL=1									
D2	3	0.01326667	0.01148927	0.00040000	0.02250000	0.00663333	0.03980000	0.00013200	86.
CL=2									
D2	4	0.00030000	0.00040000	0.00010000	0.00070000	0.00020000	0.00120000	0.00000016	133.
CL=3									
D2	4	0.00757500	0.00868922	0.00010000	0.01960000	0.00434461	0.03030000	0.00007550	114.7
CL=4									
D2	5	0.00134000	0.00282896	0	0.00640000	0.00126515	0.00670000	0.00000800	211.1
CL=5									
D2	2	0.00100000	0.00084853	0.00040000	0.00160000	0.00060000	0.00200000	0.00000072	84.8
CL=6									
D2	0								
CL=7									
D2	5	0.00110000	0.00096695	0.00010000	0.00250000	0.00043243	0.00550000	0.00000094	87.90
CL=8									
D2	3	0.05110000	0.05846153	0.00160000	0.11560000	0.03375278	0.15330000	0.00341775	114.40
CL=9									
D2	1	0.00490000		0.00490000	0.00490000		0.00490000		

Table II. Molecular sieve experiment.

No.[a]	Run No. 1 CO2 (%)	Run No. 1 SO2 (ppm)	Run No. 1 E.R.[b]	Run No. 2 CO2 (%)	Run No. 2 SO2 (ppm)	Run No. 2 E.R.[b]	Run No. 3 CO2 (%)	Run No. 3 SO2 (ppm)	Run No. 3 E.R.[b]	Run No. 4 CO2 (%)	Run No. 4 SO2 (ppm)	Run No. 4 E.R.[b]	Run No. 5 CO2 (%)	Run No. 5 SO2 (ppm)	Run No. 5 E.R.[b]
1I	12.35	387	0.938	11.66	441	1.132	11.87	396	0.998	11.54	456	1.183	13.66	530	1.162
2I	11.97	377	0.942	11.52	435	1.131	12.07	383	0.950	11.77	445	1.132	11.45	449	1.174
3I	11.56	341	0.883	11.78	418	1.062	13.02	389	0.895	11.25	432	1.151	11.69	451	1.156
4I	12.83	337	0.787	7.56	288	1.141	13.53	390	0.862	11.94	435	1.091	11.33	448	1.185
5C	7.92	238	0.898	11.48	387	1.008	11.54	338	0.876	11.40	404	1.060	11.23	426	1.135
6C	11.76	337	0.858	11.73	363	0.926	11.93	348	0.873	12.04	393	0.976	11.61	406	1.046
7C	12.07	343	0.850	15.46	470	0.909	11.96	353	0.883	12.19	402	0.998	11.72	455	1.161
8C	12.40	348	0.840	11.66	381	0.977	12.02	316	0.788	11.90	413	1.040	11.61	418	1.077
Avg.	11.61	339	0.875	11.61	398	1.036	12.24	364	0.891	11.75	423	1.078	11.79	449	1.137

[a] Eight runs each day: I = intermittent; C = continuous.
[b] Emission rate as pounds of SO_2 per 10^6 Btu.

Four different lot numbers of Union Carbide molecular sieves were used in these tests. In addition, approximately six lots of the material were used in prior development work and in subsequent field tests. All of these molecular sieves had sufficient absorptive capacity for CO_2 when used as prescribed in this procedure. The need for regeneration of a new batch of molecular sieves was noted in a private communication. For this reason, the analyst should recognize the possibility that the molecular sieves may require regeneration.

Results of the Collaborators

Results of the nine collaborators obtained during the five 24-h periods are shown in Table III. Of 180 samples, 22 were either not completed or were voided for a number of reasons (these 22 samples are represented by blank spaces in Table III). The most frequent cause was failure to pass the postrun leak test required in the method. Some other reasons were: broken glassware and spilled solution, disconnected sample lines during collection, faulty or uncalibrated dry gas meters, unusually high CO_2 weight gain which the collaborator blamed on weighing errors, and low heat in the flexible connector before the impingers.

An additional 13 sets of results were suspect statistically as outliers according to Grubbs' Test.[6] These results are underlined in Table III although they were not used in precision estimates. If either the CO_2 or SO_2 measurement was an outlier for a given collaborator, then the emission rate, which is dependent on both results, is also underlined. For Collaborator 9, Run No. 2, Train A, both the CO_2 and SO_2 were three times

Table III. Results of collaborators.

Collaborator number	Sampling train I.D.	Type[a] of train	Run No. 1 CO2 (%)	Run No. 1 SO2 (ppm)	Run No. 1 E.R.[b]	Run No. 2 CO2 (%)	Run No. 2 SO2 (ppm)	Run No. 2 E.R.[b]	Run No. 3 CO2 (%)	Run No. 3 SO2 (pm)	Run No. 3 E.R.[b]	Run No. 4 CO2 (%)	Run No. 4 SO2 (ppm)	Run No. 4 E.R.[b]	Run No. 5 CO2 (%)	Run No. 5 SO2 (ppm)	Run No. 5 E.R.[b]
1	A	I	11.79	365	0.93	11.64	403	1.04	11.74	376	0.96	11.48	419	1.09	11.28	423	1.12
	B	I	13.56	372	0.82	11.96	426	1.07	11.98	387	0.97	11.70	428	1.10	11.34	227	0.60
	C	C	12.47	366	0.88	12.13	362	0.89	22.34	368	0.49	12.25	394	0.96	10.76	405	1.13
	D	C	11.88	355	0.90	11.75	400	1.02	11.75	384	0.98	10.53	389	1.11	11.41	106	0.28
2	A	I	12.54	381	0.91	12.48	432	1.04	11.75	372	0.95	11.93	445	1.12	12.05	444	1.10
	B	I	12.69	377	0.89	12.48	432	1.04	11.23	358	0.96	12.07	439	1.09	12.14	436	1.08
	C	C	12.59	384	0.91	11.76	399	1.02	12.63	412	0.98				11.83	443	1.12
	D	C	12.61	380	0.90	11.65	402	1.03	13.11	416	0.95				11.97	452	1.13
3	A	I	17.20	299	0.52	11.12	367	0.99	10.75	359	1.00	9.96	339	1.02	10.77	398	1.10
	B	I				12.06	456	1.13	12.70	381	0.90	12.17	433	1.06	12.21	446	1.09
	C	C				10.87	360	0.99	12.58	397	0.94	12.57	404	0.96	11.35	432	1.14
	D	C				11.37	380	1.00	11.95	340	0.85	11.91	402	1.01	9.59	409	1.28
4	A	I	12.34	349	0.85	10.99	398	1.08	12.28	401	0.93	11.12	405	1.09	10.75	401	1.12
	B	I	12.68	360	0.90	11.12	405	1.09	12.60	403	0.96	11.46	436	1.14	11.65	443	1.14
	C	C	10.43	298	0.85	12.18	431	1.06	12.79	410	0.96	11.51	417	1.09	11.32	425	1.12
	D	C	8.10	234	0.86	13.15	431	0.98	13.77	437	0.95	13.49	490	1.09	13.17	496	1.13
5	A	I	12.31	362	0.88	11.12	428	1.15	11.05	392	1.06	11.65	417	1.05	10.07	343	1.02
	B	I	12.17	365	0.90	11.26	388	1.03	11.96	379	0.95	11.61	403	1.04	10.98	399	1.09
	C	C	11.38	338	0.89	11.83	358	0.98	12.76	370	0.87				11.58	87	0.22
	D	C				12.10	389	0.96	12.23	373	0.91						
6	A	C	30.16	865	0.86	29.47	690	0.70				9.16	226	0.74			
	B	C	21.02	499	0.71	13.29	172	0.39				12.46	74	0.18	13.12	81	0.19
	C	I				15.07	403	0.80	12.08	404	1.00	9.23	414	1.34	10.69	432	1.21
	D	I										8.58	427	1.49	11.43	437	1.14
7	A	I	12.13	354	0.87	12.42	400	0.96	11.74	361	0.92	12.55	449	1.07	16.15	416	0.77
	B	I	12.48	370	0.89	6.11	211	1.03	12.53	383	0.92	12.31	428	1.04	12.23	438	1.07
	C	C	16.47	464	0.84	12.39	409	0.99	12.74	398	0.94	12.43	445	1.07	12.54	464	1.11
	D	C	17.25	504	0.88	5.47	187	1.02	12.61	403	0.96	12.45	450	1.08	12.03	465	1.16
8	A	I	13.12	358	0.82	12.15	413	1.02	12.91	396	0.92	12.49	360	0.86	12.27	369	0.90
	B	I	12.94	354	0.82	12.19	403	0.99	12.71	399	0.94	11.84	353	0.89	12.22	392	0.96
	C	C	11.83	345	0.87	11.99	385	0.96	12.49	375	0.90	12.16	352	0.87	12.04	403	1.00
	D	C	12.98	359	0.83							14.67	332	0.68	14.21	314	0.66
9	A	C	17.21	550	0.96	39.80	1333	1.00	27.07	204	0.23						
	B	C	12.96	446	1.03	12.67	394	0.93	12.88	78	0.18						
	C	I	7.88	387	1.47	12.67	412	0.97	12.44	351	0.84	12.36	430	1.04	11.82	430	1.09
	D	I	7.37	386	1.57	12.38	396	0.96	11.88	358	0.90	11.64	420	1.08	12.08	419	1.04

[a] I = intermittent; C = continuous.
[b] Emission rate as pounds of SO_2 per 10^6 Btu.

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