EPA/AA/EOD/90-01

Technical Report

CO/CO2 NDIR Analyzer Replacement

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April, 1990

NOTICE

U. S. Environmental Protection Agency
Office of Air and Radiation
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Engineering Operations Division
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Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

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I. Abstract

The EPA Motor Vehicle Emissions Laboratory (MVEL) makes extensive use of gas analyzers employing nondispersive infrared (NDIR) technology for the determination of carbon monoxide (CO) and carbon dioxide (CO2) concentrations. The analyzers, primarily used for measurements of CO and CO2 in automotive emissions, are also used for ambient level measurements and gas standards procedures.

The MVEL has replaced all vehicle emission measurement system Bendix 8501-5C CO and MSA 202 CO and CO2 analyzers with Horiba Instruments, Inc., AIA-23 CO and CO2 analyzers. A total of 30 analyzers were purchased to upgrade the Light Duty, Heavy Duty, Evaluation & Development, and Master Sites.

This report summarizes the various evaluation and comparison testing performed as part of the analyzer procurement and the Equipment/Procedure Change Notice (EPCN #70) process. Included in this report is information that has already been released in EPCN #70, as well as additional information needed to completely document the project.

The Horiba CO analyzers were approved for MVEL use based on the pre-purchase test data supplied by Horiba and on the results of a preliminary in-house investigation of CO measurement differences between old and new analyzers.

The Horiba CO2 analyzers were approved for MVEL use based on the pre-purchase test data supplied by Horiba and on the results of an in-house CO2 measurement comparison study between old and new analyzers. The significant finding of the CO2 comparison testing indicated an average shift in CO2 measurements of -0.53% between Horiba and the MSA analyzers (average percent-of-point difference between corrected concentrations, Horiba reading lower). This result was obtained from statistical analyses of simultaneous measurements made on vehicle exhaust. Investigative testing indicated that water vapor interference occurring on the MSA analyzer was contributing to the observed CO2 measurement shift.

The results of the evaluation and comparison testing documented in this report and in EPCN #70 show that the Horiba NDIR analyzers meet the functional requirements and produce measurements comparable to the old analyzers.

II. Executive Summary

As early as 1984, the Engineering Operations Division had plans for a large scale NDIR analyzer replacement. Problems with the Bendix and MSA CO and CO2 analyzers, such as out-of-tolerance water vapor interference, electrical output noise, and other performance deficiencies, required an increasing amount of minor repairs. This situation, coupled with a decreasing amount of manufacturer support (e.g., some spare parts were no longer available) underscored the need for new analyzers. Funding for the new analyzers was obtained in 1986.

The analyzer procurement documented in this report resulted in the purchase of Horiba AIA-23 CO and CO2 analyzers. These analyzers were designed specifically for automotive emission applications and are used extensively by automotive manufacturers. This was not true of the MSA and Bendix analyzers which were designed for nonautomotive process control applications and ambient monitoring of hazardous locations, such as mineshafts.

The process of approving the new analyzers for MVEL use began with a review of results from performance testing required by the EPA procurement contract. The manufacturer was required to perform and document valid calibrations, water vapor interference checks (CO analyzers only), and determinations of repeatability, electrical output noise, curve nonlinearities, zero/span drift, and response times for each analyzer. The test results showed that all the analyzers demonstrated compliance with the pre-purchase test criteria.

The EPA internal approval process called for preparation of an Equipment/Procedure Change Notice (EPCN) which documented significant effects on MVEL testing resulting from the analyzer replacement. A series of comparison tests was performed on the old and new analyzers to detect and quantify measurement differences. The final tests compared CO2 measurements very precisely on Range 23 (0-2.5%) only. CO analyzer comparisons were found to be acceptable during the preliminary investigation.

The results of the comparisons indicated that the Horiba analyzers used in the study exhibited better precision during calibration curve generation, decreased sensitivity to known interferants and changes in barometric pressure, reduced electrical output noise, and less zero/span drift than their comparison study counterparts.

The Horiba NDIR CO and CO2 analyzers were approved for use at MVEL based on the information contained in EPCN #70. This information was part of, but did not completely document, the overall project work. This report documents the entire NDIR CO and CO2 analyzer project. The EPCN #70 cover page is shown in Attachment A.

III. Introduction

The Laboratory Projects Group was assigned the task of coordinating the procurement of new NDIR CO/CO2 analyzers in June of 1986. All MVEL CO and CO2 analyzers used for bag analysis (bench mounted) were to be replaced. The primary reason for the procurement was that the MSA and Bendix NDIR analyzers were obsolete and some spare parts were no longer available. A total of 30 analyzers, including spares, were to be ordered. This included analyzers for Light Duty, Heavy Duty, E&D, and the Master Site. A table listing the number of CO and CO2 analyzers to be replaced, their locations, and ranges is shown in Attachment B.

Analyzers employing NDIR technology were researched from several manufacturers. A list of performance specifications and required salient features was compiled for the procurement documentation (see Attachment C). This list not only included specifications and desirable features resulting from the research of new analyzers, but also from CFR requirements and other EPA performance specifications. We wished to obtain documented verification of these parameters, so the performance specifications were defined and written in the form of test criteria to be met. More elaborate descriptions of the required performance tests (see Attachment C) were included in the procurement package to ensure valid measurements.

Beckman Industrial Corp., Horiba Instruments, Inc., Westinghouse/Maihak Div., and Combustion Engineering, Inc., were listed as suggested sources. These manufacturers were sent "Request for Quotation" documents which included our specifications. An advertisement was also listed for 30 days in The Commerce Business Daily to solicit additional bids. Horiba submitted the low bid of $101,377.86 and was awarded the contract in August of 1986.

The process of approving the Horiba NDIR CO/CO2 analyzers for MVEL use began with a review of results from performance testing required by the EPA contract. Each analyzer had undergone three sets of performance tests, one for each range setting. The manufacturer was required to perform and document valid calibrations, water vapor interference checks (CO analyzers only), and determinations of repeatability, electrical output noise, curve nonlinearities, zero/span drift, and response times. The actual test specifications and results for the analyzers are listed in Attachment D. The test results showed that all the analyzers demonstrated compliance with the pre-purchase test criteria. Horiba was authorized to deliver the analyzers in March of 1987.

IV. Preliminary Investigation

Summary

Once the analyzers had been delivered, a preliminary investigation was performed to detect possible measurement differences between the Horiba analyzers and the MSA and Bendix analyzers being replaced. This investigation did not constitute a full measurement comparison, but did indicate where further study was warranted. The testing for this investigation took place in June of 1987.

Analyzer agreement on vehicle exhaust bag sets was studied as well as agreement on bags generated for the Sample Analysis Correlation (SAC) process (a mixture of cylinder gases blended together in a sample bag and then analyzed on all MVEL vehicle test sites as a diagnostic test). The data consisted of simultaneous measurements taken on old and new analyzers. Comparisons were performed on all ranges that were to be calibrated and actively used.

CO and CO2 measurement differences calculated from the SAC bag comparison data were used to generate means and confidence intervals on the means. In three of the five range comparisons, a statistically valid bias could not be discerned.

The data obtained from vehicle exhaust bag readings showed statistically valid biases. Both positive and negative biases were observed. The following two tables summarize the results of the preliminary investigation.

SAC Bag Comparison Results
Statistics Computed For % Diff.
% Diff = [(H.R. - O.A.R.)/O.A.R.] x 100
H.R. = Horiba Reading
O.A.R. = Old Analyzer Reading

CO Range Comparisons	N	MIN	MAX	MEAN	SDEV	95% Conf. Interval
Horiba R18 vs. Bendix R17	9	-2.21	1.01	-1.03	0.98	$-1.79 \leq \mu \leq -0.28$
Horiba R18 vs. Bendix R19	4	-0.96	-0.04	-0.29	0.45	$-1.00 \leq \mu \leq 0.42$
Horiba R20 vs. MSA R20	1	-2.43	-2.43	-2.43		
CO2 Range Comparisons						
Horiba R22 vs. MSA R22	9	-1.6	0.25	-0.23	0.59	$-0.69 \leq \mu \leq 0.22$
Horiba R23 vs. MSA R23	5	-1.15	0.62	0.035	0.72	$-0.87 \leq \mu \leq 0.93$

Vehicle Exhaust Bag Comparison Results

Statistics Computed For % Diff.

% Diff = [(H.C.C. - O.A.C.C.)/O.A.C.C.] x 100

H.C.C. = Horiba Corrected Concentration

O.A.C.C. = Old Analyzer Corrected Concentration

CO Range Comparisons	N	MIN	MAX	MEAN	SDEV	95% Conf. Interval
Horiba R16 vs. Bendix R17	6	-4.36	-1.86	-2.75	0.93	$-3.72 \leq \mu \leq -1.78$
Horiba R18 vs. Bendix R19	6	-1.75	-0.53	-0.97	0.47	$-1.47 \leq \mu \leq -0.48$
Horiba R20 vs. MSA R20	6	-5.08	-3.68	-4.4	0.56	$-4.99 \leq \mu \leq -3.81$
CO2 Range Comparisons						
Horiba R22 vs. MSA R22	6	0.042	1.05	0.4	0.36	$0.02 \leq \mu \leq 0.78$
Horiba R23 vs. MSA R23	9	-0.09	1.55	0.61	0.56	$0.18 \leq \mu \leq 1.05$
Horiba R24 vs. MSA R24	6	-1.32	-0.52	-1.03	0.32	$-1.36 \leq \mu \leq -0.69$

R16 = 0 - 100 ppm
R17 = 0 - 250 ppm
R18 = 0 - 500 ppm
R19 = 0 - 1000 ppm
R20 = 0 - 2500 ppm
R22 = 0 - 1.0%
R23 = 0 - 2.5%
R24 = 0 - 5.0%

Test Description

A special bench was constructed, containing a set of three Horiba NDIR analyzers (LCO, HCO, CO2). These analyzers were identical to those which would be installed in the certification test sites. The bench was tied into Site A202 so that simultaneous measurements could be made on the old and new analyzer pairs. The sample flow rate supplied to the Horiba instruments was adjusted to 3.0 SCFH, versus the 6.0 SCFH flow rate supplied to the old NDIR analyzers. The ranges used on the Horiba Low CO analyzer were R16 (0-100 ppm) and R18 (0-500 ppm), and were being compared to the Bendix analyzer's R17 (0-250 ppm) and R19 (0-1000 ppm) ranges, respectively. These changes were planned as part of the NDIR replacement, and therefore became a constraint on any comparison testing. Hardware provisions (voltmeter, strip/chart) were made to record analyzer output, and the Horiba analyzers were then calibrated.

Vehicle exhaust samples were generated using MVEL vehicles and standard driving schedules. The samples were measured simultaneously on corresponding analyzer pairs. To quickly check agreement at other portions of the analyzer ranges, the exhaust samples were repeatedly diluted and remeasured. The initial background reading was used to correct the initial and subsequently diluted sample readings. In general, agreement on corresponding ranges of each analyzer pair was measured at six different points, the only exception being CO2 Range 23 (0-2.5%), where nine points along the range were compared.

Simultaneous SAC bag readings were taken on the old and new analyzers during the normal SAC schedule rounds. Readings from the Horiba analyzers were compared to those from the old analyzers but were not included in the calculated SAC statistics.

Results/Observations/Conclusions

The preliminary investigation data indicated that small but statistically valid measurement differences existed between the old and new NDIR analyzers. The measurement biases were observed primarily on analyses of vehicle exhaust. One valid bias was observed in the SAC bag analyses. The measurement differences are documented in the tables shown in the summary.

The CO measurement comparisons performed on vehicle exhaust during the preliminary investigation documented mean differences that ranged from approximately -1.0% to -4.0% of point. However, the CO comparison data set needs some further qualifying.

Two of the three range comparisons were interrange, meaning that the comparisons were between different ranges. This reflected the proposed CO range changes.

The largest mean difference was observed in the CO (Range 20) comparison. The MSA high CO analyzer was found to exhibit an unacceptable amount of water vapor interference during a follow-up test. This meant that the instrument was giving abnormally high responses to humid samples. Since in the high CO comparison the MSA was reading higher than the Horiba, we concluded that we could expect somewhat better analyzer agreement between the two MVEL high CO analyzer populations.

The primary goal of the preliminary investigation and the subsequent comparison studies was to document measurement differences between MSA/Bendix and Horiba NDIR analyzers. More specifically, we were interested in the possible impact on fuel economy determination. Since fuel economy calculations are relatively insensitive to changes in CO measurement, it was concluded that the results of the preliminary investigation were fully adequate for operational approval of the Horiba CO analyzers.

Conversely, because of the "large role" of CO2 in fuel economy determination, we felt that the CO2 data were insufficient to completely quantify the possible impact. We decided that a more tightly controlled CO2 comparison study was warranted.

V. First CO2 Comparison Study

Summary

A comparison study of CO2 analyzer agreement was designed, and the Calibration and Maintenance Group began taking data in December of 1987. The study focused on a comparison of several vehicle exhaust bag sets. Procedures and precautions used for the control of the study included taking simultaneous readings (calibrations, zero/span, sampling) on both analyzers, daily curve checks at mid-span, and analyzer plumbing dimensions and components as similar to production test benches as possible.

Statistically valid measurement biases between the analyzers were again observed while measuring vehicle exhaust. This contrasted with very good agreement observed during calibration curve generation. We began to suspect that water vapor interference was contributing to the change in agreement between the two situations.

Data was taken in an attempt to discern and characterize any water vapor interference. Water vapor interference data was taken not only on the study analyzers, but also on several other MVEL MSA and Horiba NDIR CO2 analyzers (total: 5 MSA and 4 Horiba analyzers). The data indicated that the MSA analyzer used in the first study had an abnormally high and unrepresentative response to water vapor. This finding compromised the validity of the vehicle exhaust data by implying that the measurement bias observed was larger than, and unrepresentative of, the true bias. However, an attempt was made to correct the vehicle exhaust comparison data based on the water vapor interference data. Correction factors were developed for each CO2 range and applied to the vehicle exhaust data.

The data from the study were incorporated into a first draft package for the EPCN process. The draft EPCN was then circulated for comments. After reviewing the returned comments, we decided that a second comparison study would have to be performed using an MSA analyzer more representative of the MSA analyzer "population." Portions of the study remained valid, however, and for that reason we felt a description of the study was warranted here.

Test Description

The setup consisted of a pair of Horiba and MSA CO2 analyzers in a special module (19" rack) tied into the analyzer bench located on Site A002. The two CO2 analyzers were plumbed in parallel to make simultaneous measurement possible. Care was taken to ensure that line lengths and related components (valves, etc.) were as similar to the production testing benches as possible. The supplied flow rates were, as before, 6.0 SCFH to

the MSA and 3.0 SCFH to the Horiba. All calibration gas and sample readings were taken with calibrated digital voltmeters. All readings (calibration gases, zero/span gases, sample/background gases) were taken simultaneously on both analyzers. Curves were generated on all three ranges of each analyzer.

The study compared several vehicle exhaust bag sets. Repeated readings of the bag sets were taken on each analyzer to estimate the precision of the instruments when measuring vehicle exhaust. A mid-span CO2 cylinder was read daily, following zero/span procedures, to detect curve shifts. The curve shift data was later used to provide comparisons of accuracy and sensitivity to changes in barometric pressure.

Data was also generated on all bench-mounted NDIR CO2 analyzers to discern and characterize any water vapor interference. A total of five MSA and four Horiba CO2 analyzers were included in the water vapor interference investigation. The data was generated by routing CO2 calibration gases through a bubbler apparatus and into the analyzers. This allowed us to make observations over the entire curve instead of only around zero as in the standard CFR interference check.

Results/Observations/Conclusions

Vehicle Exhaust Comparison

The data from the vehicle exhaust comparisons indicated that the Horiba CO2 analyzer was giving consistently lower measurements. Because of the results of the water vapor interference investigation, the validity of the vehicle exhaust comparison was suspect. However, an attempt was made to correct the vehicle exhaust data using correction factors developed from the water vapor interference data. The correction factors were ratios of the water vapor responses of the "abnormal" MSA analyzer and the average water vapor responses of the "normal" MSA analyzers. The results (correction factors applied) of the comparison are summarized below. This data was superseded by later exhaust comparisons.

Vehicle Exhaust Bag CO2 Comparison

%Diff. = [(Horiba Corr.Conc. - MSA Corr.Conc.)/MSA Corr.Conc.] x 100

CO2 Range Comparisons	N	Avg % Diff.
Horiba R22 vs. MSA R22	16	0.67
Horiba R23 vs. MSA R23	18	0.04
Horiba R24 vs. MSA R24	12	-0.18

R22 = 0 - 1.0%
R23 = 0 - 2.5%
R24 = 0 - 5.0%

Water Vapor Interference Investigation

Data was generated to investigate the possibility of water vapor interference occurring during the vehicle exhaust measurements. Each analyzer's response to a given "dry" calibration gas was compared to its response to the same gas passed through a bubbler. The sample was assumed to be in a saturated state after it had been bubbled.

An interference-free analyzer, when measuring a bubbled calibration gas, will return a measured concentration slightly less than the calibration gas's "named" concentration. This is due to the addition of water to the sample stream by the bubbler. Therefore, if an analyzer returns a measured concentration greater than the original "named" concentration, it is likely that water vapor interference is occurring. The magnitude of this interference is at least as great as the difference between the erroneously high reading and the true "named" concentration.

The results of the water vapor interference investigation are shown graphically in Attachment E. The graphs show the difference between the analyzer-measured concentration (bubbled) and original cylinder "name" (units = %CO2) versus cylinder concentration (units = %CO2). The following observations/conclusions were made on the basis of these data:

1. The responses of the Horiba CO2 analyzers, including the study analyzer, were tightly grouped. Water vapor interference, if it was occurring with the Horiba analyzers, was difficult to discern.

2. The responses of the MSA CO2 analyzers were tightly grouped, with the exception of the comparison study analyzer, which returned abnormally high responses. The positive offset of the MSA responses indicated a small amount of water vapor interference.

3. The negative slope of the plots was due to the concentration-lowering effect of the bubbler. The bubbler replaced a certain, consistent percentage of each sample with water. This percentage equated to a larger and larger absolute CO2 reduction as higher concentration gases were used.

4. The average offset between Horiba and MSA grouped responses was consistent and was not concentration- (or range-) dependent.

5. The MSA CO2 analyzer used in the first study gave unrepresentative responses when compared to the other MSA responses.

Analyzer Sensitivity to Barometric Changes

The effect of changes in barometric pressure on analyzer readings was studied to see if any correlation existed. A mid-span secondary cylinder was repeatedly read on each range of each CO2 analyzer over the 21-day study period. Readings were obtained over a barometric pressure range of 28.5 to 29.25 "Hg. The analyzer readings from each range were regressed against barometer readings. In this way, we planned to see if analyzer readings changed as the barometer changed.

The Horiba CO2 analyzer showed a very low correlation coefficient between reading changes and barometric changes, and we concluded that no correlation existed at the 95% confidence level. A correlation may have existed at lower confidence levels, but this was not investigated.

The MSA CO2 analyzer studied did show a valid correlation, at the 95% confidence level, between reading changes and barometric changes. The results are shown in Attachment F.

Wet Precision

The vehicle exhaust samples were also used to estimate analyzer precision. Duplicate measurements were made on each vehicle exhaust bag. Standard deviations were calculated on the duplicates. The standard deviations were then pooled together.[1] The results are shown in Attachment G.

One other useful operational statistic was computed, and that was relative range.[2] This statistic was calculated only for sample bag measurements generated on the Horiba CO2 analyzer and serves as a benchmark for future reference. The relative range data and calculations are shown in Attachment G. The average relative range of duplicates for Horiba CO2 Ranges 22, 23, and 24 turned out to be very consistent with values between 0.21% and 0.24% (of point). This meant that we could expect the Horiba CO2 analyzer used in the study to be capable of repeating measurements of vehicle exhaust to within 0.24%.

Curve Check Summary Statistics

A mid-span calibration gas was measured twice daily to flag possible curve shifts. No out-of-tolerance curve shifts were observed. The mid-span data was also used to check for analyzer sensitivity to changes in barometric pressure. The summary statistics and raw data are listed in Attachment H.

1. Formula from EPA QAMS (3/30/84), Chapter 5, page 8.
2. Formula from EPA QAMS (3/30/84), Chapter 5, page 1.

VI. Second CO2 Comparison Study

Summary

The effort to document measurement differences between old and new NDIR analyzers was, at this point, focused on the comparison of CO2 analyzers. A good portion of the comparison data from the previous study could not be relied upon due to the findings of the water vapor interference investigation. A second comparison study was designed and underwent a panel review by members of Facility Support Branch, Quality Control, Quality Assurance, Certification Branch, and Correlation & Engineering Services. The review group met several times and, as a consequence, several revisions to the design of the study were performed. It should be noted that the input from the interdivisional panel was an invaluable tool in clarifying what was needed for the EPCN process.

The Calibration and Maintenance Group began taking data for the second comparison study in August of 1988. The study again focused on a comparison of vehicle exhaust samples. Water vapor interference data was again taken, with several refinements added to the procedure. A controlled CO2 measurement comparison at background level concentrations was also performed.

Procedures and precautions used for the control of the study included representative analyzer selections, daily calibration curve generation, and water vapor mass measurement as well as all of the controls used in the previous study.

The second comparison study showed that the Horiba and MSA CO2 analyzers agreed very closely when measuring dry calibration gases. The Horiba demonstrated better precision than the MSA on dry (water vapor free) calibration gas readings.

A small bias was observed between Horiba and MSA CO2 analyzer readings taken from vehicle exhaust bags. The Horiba analyzer gave consistently lower readings than the MSA. The mean difference in analyzer readings was -0.53% (of the MSA corrected concentration).

The negative shift in the CO2 measurement produced a positive shift in calculated fuel economy. The magnitude of the positive shift was virtually equal to the magnitude of the CO2 shift (corrected concentration).

The water vapor interference data showed a similar negative bias (Horiba read lower), but the magnitude of this single effect would have only accounted for one-third of the bias in vehicle exhaust measurements. The interference data also displayed greater variability than the vehicle exhaust data.

We concluded that water vapor interference was contributing to the bias in vehicle exhaust CO2 measurements but that there were other factors involved. In addition, the nature of the interference data suggests that the MSA analyzer, not the Horiba, was exhibiting the water vapor interference. It should also be noted that the measured interference effects did not cause the analyzers to exceed the manufacturer's stated accuracy limits or CFR interference criteria, and both the MSA and Horiba analyzer groups could be termed "free" of water vapor interference.

The impact of the measurement shift documented in our controlled comparison may not be detectable in future production test results. The fact that a fuel economy determination may require eight CO2 measurements (four sample and four background for full confirmatory), combined with the normal variability experienced across the certification sites, will tend to mask a small measurement shift.

The study data underwent another review by QC/QA as part of the EPCN process. Most of the study data was incorporated into the final EPCN #70 package. Only minor questions and comments on the EPCN have been received at this time.

Discussion of Analyzer Selections for Study

The CO2 measurement comparison study involved two individual analyzers chosen to represent their respective analyzer groups. This section presents data that show each of the study analyzers is representative of its "population." Completely similar data on both analyzer groups did not exist; however, we felt the data presented here were sufficient to make the selections.

The information on the MSA analyzer group contains a SAC summary of MVEL MSA CO2 analyzers over a 7-month period leading up to the CO2 study, and the water vapor interference data for CO2 Range 23 (0-2.5%) generated during a preliminary water vapor sensitivity study (see Attachment I). The water vapor interference data was generated by reading secondary standards which had been flowed through a bubbler at room temperature.

The information on the Horiba CO2 analyzer group contains the water vapor interference data for CO2 Range 23 (0-2.5%) generated during the preliminary water vapor sensitivity study and the Horiba-supplied performance test results from pre-purchase compliance testing (see Attachment I).

The SAC data indicated that the MSA analyzer used in the comparison study (Site A002 CO2 analyzer) was representative of the other MSA analyzers. The mean deviations (from average) for the three MSA analyzers screened for the study were closely grouped over the 7-month SAC analysis period.

The water vapor interference data showed that the responses of the MSA analyzer used in the comparison study were closely grouped with the responses of the other MSA analyzers.

The performance test data and the water vapor interference data indicated that the responses of the Horiba analyzer used in the comparison study were closely grouped with the responses of the other Horiba analyzers.

Water Vapor Interference Investigation

Background

Previous studies on NDIR instruments, primarily CO instruments, showed that analyzer readings could be affected by the presence of water vapor in the sample. We suspected water vapor as the cause of CO2 measurement differences between Horiba and MSA analyzers observed during the previous study.

We wanted to quantify any possible water vapor interference effect by running a controlled experiment. Because we wished to use this information to help quantify a possible fuel economy measurement shift, the optimum data for such an investigation would come from actual vehicle exhaust samples; however, using actual exhaust samples was not practically feasible. CO2 and water vapor content are highly correlated in vehicle exhaust, which means high CO2 levels are generally observed in conjunction with high water vapor levels. This makes the water vapor interference statistically difficult to separate out. Also, actual exhaust data does not contain the low-to-moderate levels of water vapor needed to really quantify the interference effect.

CO2 measurements for the water vapor interference study were obtained by using calibration gases, and water vapor was added to the samples by using a "variable" bubbler apparatus. This consisted of a standard bubbler with a valve-controlled bypass added to vary the amount of water vapor added to the samples. This made it possible to cover much larger ranges of water vapor and CO2 content faster and more efficiently than with actual exhaust samples. This strategy produced a controlled, isolated measure of the water vapor influence.

Test Description

The test involved running the study calibration gases through a variable bubbler and into the Horiba and MSA CO2 analyzers simultaneously. A dew-point meter was put in line to measure the humidity content. A schematic of the setup is shown in Attachment J. The analyzers were simultaneously calibrated on a daily basis.

The study measured the analyzers' agreement on samples that had humidities ranging from essentially 0 grains/pound to more than 90 grains/pound. Gas concentrations were also controlled, and ranged from zero gas up to 2.4% CO2.

Data Handling

The matrix of data generated contained CO2 analyzer agreement at various levels of water vapor content and CO2 concentration. Multiple linear regressions were performed to see if either water vapor content, CO2 concentration, or the cross-product of the two could account for the variations in analyzer agreement. A raw data table and analyzer agreement plot are shown in Attachment J.

Observations

Of all the regressions performed, a simple linear regression of analyzer agreement versus water vapor content, with a zero intercept, showed the best fit. Although the correlation coefficient squared (r^2) was still quite low, this regression was used later in the study to try and account for CO2 analyzer output differences observed on vehicle exhaust bag measurements.

Vehicle Exhaust Bag CO2 Comparison

Summary

Exhaust samples were collected from vehicles using standard driving cycles (2-Bag LA-4's, Highways). A total of 11 tests were run (see Attachment K). Sample and background bags were read simultaneously on both analyzers. The humidity of the bag sets was measured for possible correlation with the water vapor interference investigation data. The comparison results are shown in the table below and graphically in Attachment K. A raw data table is also shown in Attachment K.

VEHICLE EXHAUST CO2 COMPARISON RESULTS

Sample and Background Bag Comparison Results
CO2 Analyzer Agreement (% of MSA Sample Pt.Diff.)
$[((H - M)/M_S) * 100]$

	Min	Max	Mean	95% Confidence Interval
Background	0.0072	-0.52	-0.20	$-0.33 \leq \mu \leq -0.07$
Sample	-0.2045	-1.27	-0.69	$-0.88 \leq \mu \leq -0.50$

Corrected Concentration Comparison Results
CO2 Analyzer Agreement (% of Pt.Diff.)
$[((H_{CC} - M_{CC})/M_{CC}) * 100]$

	Min	Max	Mean	95% Confidence Interval
Corr. Conc.	-0.0226	-0.98	-0.5302	$-0.73 \leq \mu \leq -0.33$

A small bias was observed between Horiba and MSA CO2 analyzer readings taken from vehicle exhaust bags. The Horiba analyzer gave consistently lower readings than the MSA. The mean difference in analyzer readings was -0.53% (of the MSA corrected concentration).

The negative shift in the CO2 measurement produced a positive shift in calculated fuel economy. The magnitude of the positive shift was virtually equal to the magnitude of the CO2 shift (corrected concentration).

Test Description

The study required a special setup in which a Horiba CO2 analyzer was connected in parallel with the MSA analyzer located on Site A002 (see Attachment K). The analyzers were calibrated simultaneously each day that study data was taken to randomize the effect of the calibration curve generation process. A special set of gases was used for the daily calibrations; however, the initial and final set of curves were generated with secondary standards for curve comparison purposes.

The supplied flow rate to the Horiba analyzer was 3.0 SCFH, 6.0 SCFH to the MSA analyzer. Digital voltmeters were used to measure the analyzers' output.

The vehicle exhaust CO2 comparison was limited to standard lab range 23 (0-2.5% CO2) only. We felt this was acceptable because of data indicating that Range 23 is used approximately 96% of the time on FTP and Highway analyses.[4]

Other Data Handling

The analyzer agreement (CO2 corrected concentration differences) and CO2 concentration values were regressed against each other to see if a correlation existed. This was done to determine if changes in analyzer agreement were concentration dependent.

4. Actual CO2 Range use data compiled by D. Garter. Analysis of 385 FTP and 366 Highway tests performed between 1/1/87 and 6/5/87 showed CO2 Range 23 (0-2.5%) used 99.5% on Bag 1, 89.3% on Bag 2, 99.5% on Bag 3 of FTP tests and 95.6% on Highway tests. (See memo dated 5/13/88 from D. Garter to J.T.White.)

Observations

The data showed a negative bias (Horiba read lower) of mean magnitude equal to -0.53% (of the MSA corrected concentration) between the Horiba and MSA CO2 analyzers. The observed bias was statistically valid (the 95% confidence interval on the mean did not include zero).

The humidity content of the sample bags was grouped between 60 and 75 grains/pound and the background bag humidities were grouped between 40 and 55 grains/pound (agreeing closely with the test cell measured humidity).

The variations in analyzer agreement could not be explained by variations in CO2 concentration. In each case the correlation coefficient was below the minimum level needed to establish that correlation exists at 95% confidence level (r_{min} = 0.602). Analyzer agreement is simply reported in means and confidence intervals as a result. The calculated correlation coefficients were as follows:

Regressed Variables	Correlation Coeff.(r)
Corr.Conc. % F.S.Diff.s vs. MSA Corr.Conc.(%CO2)	0.11
Corr.Conc. % pt.Diff.s vs. MSA Corr.Conc.(%CO2)	0.48

Analysis of Vehicle Exhaust Bag CO2 Measurement Differences

Analysis Description

An attempt was made to account for the differences observed on vehicle exhaust bag CO2 measurements by calculating and removing the effect of water vapor interference. The calculations were based on what we had observed in the interference investigation.

The specific humidity raw data from the vehicle exhaust bag comparison were used with a regression equation developed from the water vapor interference investigation to calculate a concentration difference "K" (see Attachment L). The "K" values were then subtracted from the Horiba analyzer readings. New dilution factors, bag differences, and corrected concentration differences were then calculated.

Once the analyzer differences were "corrected" in this manner, new confidence intervals on the mean differences could be computed to see if they included zero.

Observations

The calculated water vapor effect only accounted for approximately one-third of the difference observed between Horiba and MSA CO2 readings on vehicle exhaust bags. The data still showed a statistically valid negative bias (Horiba read lower) of mean magnitude equal to -0.36% (of the MSA corrected concentration). This remaining difference could not be explained.

Description of Calibration Gases Used in the Study

At the Gas Lab's request, a separate set of calibration gases, as opposed to the Gas Lab's secondary standards, were used for the daily curve generation. Secondary standards were not depleted, and overlap of cylinder usage between the Gas Lab and the study was thus avoided. Cylinders for the study were procured by the Gas Lab and named off curves generated from secondary standards, making them equivalent to working gases,i.e., span gases.

Printouts documenting the daily calibration curve generation are listed in Attachment M. The printouts contain some notation in the operator comment section that needs clarifying:

BLINE = Initial curves generated with sec. standards
WORK = Curves generated with "working" standards
ENDSEC = Final curves generated with sec. standards
ENDWORK = Final curves generated with "working" standards

Calibration Curve Variability

Test Description

Daily calibration curves were generated simultaneously on both the study analyzers to measure response shifts and the resulting curve shifts (see Attachment M). The same curve fit parameters were used on both analyzers' curves. This process measured the individual variabilities of the two CO2 measurement systems as well as the variability of their agreement to each other. Response shifts and resulting curve shifts due to barometric pressure changes were, in effect, compensated for by the daily curve generation and therefore were not considered a factor during this study. A total of 10 curves were generated on

Range 23 (0-2.5%) of each analyzer. In addition, Range 22 (0-1.0%) on both analyzers was calibrated during two of the test days as part of the background level CO2 measurement comparison. The calibrations were generated with a special set of gases obtained for the study.

Data Handling

For each test day, the curve-generated CO2 concentrations for each calibration gas were compared back to the calibration gas "named" concentration. The results are shown in the following table and graphically in Attachment N. In addition, since the curve generation was performed simultaneously on both analyzers, the curve-generated concentrations for each cylinder were paired and differences calculated. The results are shown in the following table and graphically in Attachment N.

Calibration Curve Statistics
No. of Curves = 10

Cal. Cyl. Conc(%CO2)	Horiba Avg Conc(%CO2)	HOR - Cyl. Avg.%FS Diff	MSA Avg Conc(%CO2)	MSA - Cyl. Avg.%FS Diff	HOR - MSA Avg.%FS Diff
2.3803	2.3800	-0.012	2.3807	0.016	-0.030
1.9123	1.9125	0.008	1.9120	-0.012	0.020
1.6013	1.6013	-0.004	1.6003	-0.040	0.036
1.2088	1.2100	0.048	1.2100	0.048	-0.001
0.9515	0.9504	-0.044	0.9514	-0.004	-0.040
0.7991	0.7984	-0.028	0.7986	-0.020	-0.007
0.4959	0.4962	0.012	0.4973	0.056	-0.045
0.4060	0.4063	0.012	0.4049	-0.044	0.056

Observations/Conclusions

Agreement of the Horiba and MSA calibration curve concentrations with the calibration gas "names" averaged to within ±0.05% of Full Scale and ±0.06% of Full Scale, respectively, at each calibrated point.

The overall variabilities (as expressed by ±3 Standard Deviations) of the differences between the Horiba and MSA curve concentrations and the calibration gas "names" were within ±0.11% of Full Scale and ±0.26% of Full Scale, respectively, at each calibrated point.

The Horiba and MSA analyzers cal curve agreement was within ±0.06% of Full Scale, on the average, at each calibrated point.

The overall variability (±3 Standard Deviations) of the difference between the two analyzers calibration curves was within ±0.26% of Full Scale at each calibrated point.

We concluded that analyzer agreement during the calibration process was excellent, and we could assume that the analyzers gave equivalent calibration results.

These data also demonstrated that the Horiba CO2 analyzer is quite capable of meeting CFR requirements and is much more precise than the MSA unit.

Background Level CO2 Measurement Comparison

Background

The first CO2 comparison study showed greater disagreement (on a percentage basis) of background bag measurements than on sample bag measurements taken between Horiba and MSA analyzers. It was not known if the disagreement was a characteristic of the background bag measurements or if it was a calibration curve disagreement. For this reason, an agreement check of the analyzers on background level, dry CO2 gases was included in this study.

Test Description

The test involved measuring the analyzers' responses to low level CO2 cylinder gases. Three cylinders were obtained from the Gas Lab for the study. On the first and last testing days of the study, two curves were generated on Range 22 (0-1.0%) and Range 23 (0-2.5%) of both analyzers, one using secondary standards, the second using the study calibration gases. Responses to the low level CO2 gases were taken and concentrations calculated from the various curves. In addition, responses to cylinders were taken daily on Range 23 (0-2.5%) and concentrations calculated from the daily curves. Since the responses were taken simultaneously on both analyzers, the readings were paired and differences were calculated. The results are shown Attachment O.

Observations

The differences in measured concentrations between the analyzers had an average of -0.011% of Full Scale (Range 23 or 2.5% CO2 FS).

The large percent differences on background bag measurements that were observed in the previous study were not observed in the background agreement data or the background bag comparison data of this study.

VII. EPCN Process Coordination/Implementation

Equipment replacements within the EOD production testing environment are subject to the Equipment/Procedure Change Notice, or EPCN, process. The work documented in this report, for the most part, was performed to address the objectives of that process.

Initially, the first investigations and comparisons were performed and the results, along with Horiba supplied performance data and other details of the procurement, were incorporated into an EPCN draft package. The package was released for comments in April of 1988. The comments received indicated that further comparison tests would have to be performed and, in addition, some consensus would have to be reached among the "customers" as to exactly what data would satisfy everyone.

In order to address this issue, an interdivisional panel was formed. The panel was made up of members of Facility Support Branch (FSB), Quality Control (QC), Quality Assurance (QA), Correlation & Engineering Services (C&ES), and Certification Branch. The panel's review of the test plan proposed by LPG helped optimize the plan's specific details. The second set of comparison tests were performed and the results underwent a follow-up review by the panel. No further testing was requested, and a second EPCN package was drafted and released for comments in October of 1988. Once the comments had been received, the EPCN package underwent a final review/revision process by members of FSB, QA and QC. The finalized version of EPCN #70 was signed off and released in February of 1989.

VIII. Installation Chronology

Gas Lab

The Gas Lab began using Horiba high CO and CO2 analyzers as of 7-16-87. The low CO analyzer will be replaced with a Horiba unit at a later date.

Light Duty

Site A001 was released for production testing on 1-19-89.
Site A002 was released for production testing on 4-11-89.
Site A003 was released for production testing on 6-15-89.
Site A004 is slated for NDIR replacement in June of 1990.

E&D

Sites A202 and A203 had Horiba analyzers installed in early 1988.

Heavy Duty

Site A009 had a new Horiba low CO analyzer installed in early 1988.

Other Changes

Several incidental and/or related changes were made to the analyzer benches as part of the NDIR replacement. These changes were included within the measurement comparisons, i.e., Horiba analyzers were operated under changed conditions, and therefore their combined impact on testing was observed and documented. The following sections discuss the changes.

Flow Rate

The normal flow rate to the CO and CO2 NDIR analyzers was changed from 6.0 SCFH to 3.0 SCFH. The change was made to relieve demand on the sample bench pump. This will allow easier flow balancing of the bench, allow the flow rate to another analyzer to be increased if needed, and lengthen the the life of the pump.

Bench Plumbing

Although no changes were made to the fundamental schematic of the sample bench, the actual placement of the plumbing was modified in a "housekeeping" effort. Valves and sample lines were moved to help standardize the layouts of the light duty benches. An updated schematic of the light duty benches is contained in Calibration and Maintenance Group files.

Sample Analysis Correlation (SAC) Revision

The CO range changes required a corresponding change in the CO concentrations generated for SAC. The lowest CO range is now R16 (0 - 100 ppm); this means that a larger range of CO concentrations must be generated by the SAC blender. Several changes were made to the SAC schedule in order to accomplish this, as follows:

1. The CO cylinder concentration was lowered from 1700 ppm to 800 ppm to obtain the low blended CO concentrations needed for Range 16 while maintaining the minimum blend time of 15 seconds.

2. The SAC schedule sequence for HC and NOX was rearranged to obtain blend time needed to generate CO concentrations for Range 20 (0-2500 ppm).

3. The previous SAC schedule checked CO Ranges 17, 19, and 20, a total of five, two, and one time(s), respectively. The new SAC schedule will check CO Ranges 16, 18, and 20, a total of four, three, and one time(s), respectively, during the 2-week SAC period. This is in response to a request by QC for more appropriate coverage of the CO ranges.

IX. Overall Discussion of Study Results

CO

The CO measurement comparisons performed on vehicle exhaust during the preliminary investigations documented mean differences that ranged from approximately -1.0% to -4.0% of point. However, the CO comparison data set needs some further qualifying.

Two of the three range comparisons were interrange, meaning that the comparisons were between different ranges. This reflected the proposed CO range changes.

The largest mean difference was observed in the high CO (Range 20) comparison. The MSA high CO analyzer was found to exhibit an unacceptable amount of water vapor interference during a follow-up test. This meant that the instrument was giving abnormally high responses to humid samples. Since in the high CO comparison, the MSA was reading higher than the Horiba, we concluded that we could expect somewhat better analyzer agreement between the two high CO analyzer populations.

For these reasons, it was decided that further CO comparisons were not warranted and the Horiba NDIR CO analyzers were approved for use at MVEL based on the preliminary investigation and the pre-purchase performance test results.

CO2

During the course of the project, the focus of the CO2 investigation was narrowed to a comparison of CO2 measurements taken on Range 23 (0-2.5%) only.

The comparison study showed that the Horiba and MSA CO2 analyzers agreed very closely when measuring dry calibration gases. The Horiba demonstrated better precision than the MSA on dry (water vapor free) calibration gas readings.

Good agreement was observed between the Horiba and MSA CO2 analyzers when measuring background level CO2 concentrations generated from cylinders.

A small bias was observed between the Horiba and MSA CO2 analyzer readings taken from vehicle exhaust bags. The Horiba analyzer gave consistently lower readings than the MSA. The mean difference in analyzer readings was -0.53% (of the MSA corrected concentration), with the Horiba giving lower results.

The negative shift in the CO2 measurement produced a positive shift in calculated fuel economy. The magnitude of the positive shift was virtually equal to the magnitude of the CO2 shift (corrected concentration).

The water vapor interference data showed a similar negative bias (Horiba read lower), but the magnitude of this single effect would have only accounted for one-third of the bias in vehicle exhaust measurements. The interference data also displayed greater variability than the vehicle exhaust data.

We concluded that water vapor interference was contributing to the bias in vehicle exhaust CO2 measurements, but that other factors were involved. In addition, the nature of the interference data suggested that the MSA analyzer, not the Horiba, was exhibiting the water vapor interference. It should also be noted that the measured interference effects were within the manufacturer's stated accuracy limits, and both the MSA and Horiba analyzer groups could be termed "free" of water vapor interference.

The impact of the measurement shift documented in our controlled comparison may not be detectable in future production test results. The fact that a fuel economy determination may require eight CO2 measurements (four sample and four background for full confirmatory), combined with the normal variability experienced across the certification sites, will tend to mask a small measurement shift.

XI. List of Attachments

A	EPCN #70 Cover Page
B	Analyzer Location Table
C	Procurement Documentation
D	Pre-purchase Test Result slots
F	Barometer Sensitivity Table
G	Wet Precision Tables
H	Curve Check Summary Statistics/Raw Data
I	Analyzer Selections for Study
J	Water Vapor Interference Plots/Data
K	CO2 Comparison Plots/Data
L	CO2 Comparison Analysis Plots/Data
M	Comparison Study Calibration Curves
N	Calibration Curve Statistics Plots
O	Background Level CO2 Comparison Data

ATTACHMENT A

EQUIPMENT/PROCEDURE CHANGE NOTICE

EPCN NO. 70 | DATE ENTERED 3 / 24 / 87 | PAGE ___ OF ___

1. ORIGINATOR Aaron McCarthy | 2. PHONE EXT. 215 | 3. REVIEW DUE DATE: none | ENTER "FYI" AS APPLICABLE

4. DIVISION CLEARANCE

5. TYPE OF CHANGE: ☐ FED. REGISTER ☒ EQUIPMENT ☐ A/C ☐ MSAPC PROCEDURE ☐ FORM ☐ OTHER

6. REFERENCE DOCUMENTS (List Attachments, Forms, Procedures, FR#s, etc.)

SEE ATTACHED PAGE

7. DESCRIPTION OF CHANGE (Attach details, specifications, drawings, and implementation plan).

All Bendix 8501-5C CO analyzers and MSA 202 CO and CO_2 analyzers are to be replaced with Horiba AIA-23 CO and CO_2 analyzers. (AIA - 23AS for LCO).

The ranges normally used on the low CO analyzers will be changed from R17 (0-250ppm) and R19 (0-1000ppm) to R16 (0-100ppm) and R18 (0-500ppm), respectively.

The CO blend concentrations used in the sample analysis cross check will be revised to accommodate the range changes.

The normally supplied flow rate to the CO and CO_2 analyzers will be changed from 6.0 SCFH to 3.0 SCFH.

Installation will begin mid-December 1988 and EOD Sites 1-4 will be complete by mid-March 1989, one site at a time.

8. PURPOSE OF CHANGE (Why is this change being proposed?)

The Bendix and MSA analyzers are obsolete and some replacements parts are no longer available. The new analyzers will provide improvements in performance and maintenance as well as standardize the NDIR modules to one manufacturer type.

9. PROPOSED EFFECTIVITY (Date, MY, etc.) December 1988

10. DURATION OR EXTENT OF USE ☒ PERMANENT ☐ TEMPORARY

11. AREAS OF MSAPC AFFECTED BY THIS CHANGE

☒ LDT ☒ E & D ☒ INST. SERV. ☐ CHEM LAB. ☒ QC/QA ☐ ECTD
☒ HDT ☒ C & M ☐ RTS HDWR. ☐ TEST VALID. ☐ DATA BR. ☐ CSD
☐ OTHER

12. REVIEWS AND APPROVALS

REVIEWED BY	INIT.	DATE	CONCURRENCE	COMMENTS
A. James D. Carpenter, Chief Facility Support Branch		12/15/88	☒ YES ☐ NO	
B.			☐ YES ☐ NO	
C.			☐ YES ☐ NO	

13. DIVISION RESPONSE (QC)	DATE	RECOMMENDED ACTION
Signature Donald D. Danyko, Mgr, QC	12/15/88	APPROVE ☐ DISAPPROVE ☐ CONDITIONAL APPROVAL ☐ (Comments) REQUEST TO REVIEW REDRAFTS ☐
THE REVIEWS AND RESPONSES NOTED HAVE BEEN RECEIVED AND DOCUMENTED.	DATE	14. EPCN CONTROLLER QC — REDRAFT REQUIRED ☐ RELEASED FOR IMPLEMENTATION ☐

THE PROVISIONS OF THIS EPCN ARE HEREBY AUTHORIZED FOR IMPLEMENTATION.

15. AUTHORIZED BY: Richard B. Lawrence, Director EOD | DATE 12-15-88

MSAPC FORM 7.5 REVISED: 7/1/75

DISTRIBUTION: ORIGINAL (White) - EPCN LOG; COPY 1 (Yellow) - DIVISION LOG; COPY 2 (Blue) - EPCN INTERIM LOG; COPY 3 (Pink) - RETAINED BY ORIGINATOR

ANALYZER LOCATIONS

ANALYZER: MODEL P/N* CELL LENGTH / DETECTOR TYPE (choppers are all 10 Hz)	RANGES:	decimal for pct.	decimal for ppm	RANGE	TOTAL	A001	A002	A003	A004	A202	A203	A009	A251	SPARE
	CO													
AIA - 23AS			100	16										
363053	LOW		250	17	9	1	1	1	1	1	1	1	1	1
500mm / DUAL			500	18										
AIA - 23			2500	20										
360448	HIGH		5000	21	8	1	1	1	1	1	1	1	1	1
30mm / SINGLE		1	0000	22										
AIA - 23		2	5000	23										
360421		5	0000	24	1								1	
3mm / SINGLE		10	0000											
	CO2													
AIA - 23			2500	20										
360439			5000	21	1								1	
30mm / SINGLE		1	0000	22										
AIA - 23		1	0000	22										
360442		2	5000	23	10	1	1	1	1	1	1		1	3
6mm / SINGLE		5	0000	24										
AIA - 23		5	0000	24										
360449		10	0000		1								1	
1mm / SINGLE		15	0000											
				TOTAL	30	3	3	3	3	3	3	1	6	5

*Each P/N includes one "AIA" (detector) and one "OPE" (amplifier).

ATTACHMENT B

(Shaded areas are for use of procurement office only) ATTACHMENT C Page of

US Environmental Protection Agency
Washington, DC 20460

EPA Procurement Request/Order

1. Name of Originator: Aaron D. McCarthy		2. Date of Requisition: 06-16-86
3. Mail Code: EOD-15	4. Telephone Number: 313-668-4215	5. Date Item Required:
6. Signature of Originator: Aaron D. McCarthy	7. Recommended Procurement Method: ☒ Competitive ☐ Other than full and open competition ☐ Sole source small purchase	
8. Deliver To (Project Manager): Carl J. Ryan	9. Address: 2565 Plymouth Rd EPA Ann Arbor, Mich. 48105	10. Mail Code: EOD-15
11. Telephone Number: 313-668-4251		

12. Financial Data

(a) Appropriation

NOTE: Item 12 (c) Document Type—Contract = "C," Purchase Order = "P," IGA = "A," Other (Misc.) = "X"

FMO Use (b) (13 digits)	DT (c)	Document Control Number (d) (6 digits)	Account Number (e) (10 digits)	Object Class (f) (4 digits)	Amount (g) Dollars	Cents

13. Suggested Source (Name, Address, ZIP Code, Phone/Contact)

See Attachment A

14. Amount of money committed is:
☒ Original
☐ Increase
☐ Decrease

15. Contracting office is authorized to exceed amount shown by 10%
☐ Yes ☐ No

16. Servicing Finance Office Number

17. Approvals

a. Branch Office: [signature]	Date: 6/27/86	d. Property Management Officer/Designee	Date
b. Division Office: [signature] for RDL	Date: 6/27/86	e. Other (Specify): Carl Ryan	Date: 6-27-86
c. Funds listed above are available and reserved	Date	f. Other (Specify)	Date

18. Date of Order	19. Order Number	20. Contract Number (if any)	21. Discount Terms

22. FOB Point	23. Delivery to FOB Point by On or before (Date)	24. Person Taking Order/Quote and Phone No.

25. Contractor (Name, address, ZIP Code)

26. Type of Order
☒ a. Purchase

Reference your quote (See block 24)

Please furnish the above on the terms specified on both sides of this order and or the attached sheets, if any, including delivery as indicated.

☐ b. Delivery provisions on the reverse are deleted. The delivery order is subject to the terms and conditions of the contract. (See Block 20)

c. ☐ Oral ☐ Written ☐ Confirming

27. Schedule

Item Number (a)	Supplies or Services (b)	Quantity Ordered (c)	Unit (d)	Estimated Unit Price (e)	Unit Price (f)	Amount (g)	Quantity Accepted (h)
	CO Analyzer (Horiba Model AIA-23 or equivalent)	19					
	CO_2 Analyzer (Horiba Model AIA-23 or equivalent)	11					
	Required Analyzer Ranges, Specifications and Features See Attachments B & C JUSTIFICATION: Needed to replace obsolete equipment.						
				$120,000.00	Total $		

28. United States of America
By (Signature)

29. Typed Name and Title of Contracting Officer

SUGGESTED SOURCES

Beckman Industrial Corporation
41365 Vincenti Court
Novi, MI 48050

Horiba Instruments
3901 Varsity Drive
Ann Arbor, MI 48104

Westinghouse Electric Corporation
Maihak AG Subsidiary
1201 N. Main
P.O. Box 901
Orville, OH 44667-0901

Combustion Engineering Inc.
Process Analytical Division
P.O. Drawer 831
Lewisburg, W. Virginia 24901

SPECIFICATIONS

Horiba Model AIA-23 or equivalent. The following salient features of the Horiba Model AIA-23 will be used to determine equivalency:

TYPE:	Non-Dispersive Infrared Analyzer, with optical filter, and at least three switch-selectable analysis ranges.
RANGES:	Required ranges listed in Attachment C.
OUTPUT:	0 to +10 volts DC output.
RANGE IDENTIFICATION:	Isolated contact closure; contact rating; 100 ma.
GAS CONNECTIONS:	1/4 NPT
SIZE:	Amplifier/control module 19" rackmount or smaller, separate zero, span and range controls must be provided if amplifier/control module is larger than 3.6" wide by 9.2" tall.
POWER	115 VAC, 60 Hz
CALIBRATION & INTERFERENCE:*	As per CFR 40, Ch. 1, Pts. 86.114-79, 86.122-78 & 86.124-78.
REPEATABILITY:*	12 repeated readings shall not deviate more than 0.5% FS (Full Scale) from each other.
NOISE:*	Short term variations in analyzer output shall not deviate more than 0.5% FS on a 90% FS continuous sample over a 1-minute period.
NON-LINEARITY:*	Shall be less than 10%.
DRIFT:*	Long term directional variations in analyzer output shall not deviate more than 1.0% FS on continuous zero and span samples over a 4-hour period.
RESPONSE TIME:*	Response time to 90% final reading shall be less than 4.0 seconds.

* The manufacturer is required to show proof that each analyzer meets these specifications. The manufacturer shall complete the performance tests described by Attachment C. The manufacturer shall submit acceptable performance test results for each analyzer within 120 days after receipt of order. The manufacturer will be authorized to ship the analyzers only after the Facility Support Branch has approved the performance test results in writing. The EPA may choose to observe performance testing at the manufacturer's facility. The manufacturer shall give the EPA ten days notice prior to the start of the performance testing.

RANGE SPECIFICATIONS*

CO Analyzer Ranges	Quantity (Analyzers)
100 PPM (.01%) 250 PPM (.025%) 1000 PPM (.10%)	9
2500 PPM (.25%) 5000 PPM (.50%) 10000 PPM (1.0%)	8
25000 PPM (2.5%) 50000 PPM (5.0%) 100000 PPM (10.0%)	1

CO_2 Analyzer Ranges	
2500 PPM (.25%) 5000 PPM (.50%) 10000 PPM (1.0%)	1
10000 PPM (1.0%) 25000 PPM (2.5%) 50000 PPM (5.0%)	10
50000 PPM (5.0%) 100000 PPM (10.0%) 150000 PPM (15.0%)	1

* 3 Switch Selectable Ranges Per Analyzer

01.06e

PERFORMANCE TESTS

A. Proof of Acceptability:

Prior to specific performance testing the manufacturer must show proof that the analyzers have general acceptance in the market place. The manufacturer shall provide three or more references, (with at least one related to the automobile industry) of companies currently using these specific analyzers.

B. After the contract is awarded, the manufacturer must submit documentation to demonstrate their analyzers' performance. The manufacturer will not be paid or authorized to ship the analyzers until the documentation is approved by the Facility Support Branch.

The documentation which the manufacturer is required to submit is strip chart recordings of analyzer output as well as tabulated data obtained from the strip chart recordings. The documentation must show that each analyzer has been calibrated and tested (as defined below), and that each analyzer's performance is in accordance with the criteria defined below. The tabulated data must list the relevant readings from the strip chart recordings that show compliance with the performance tests. The analyzers will not be accepted if the documentation does not show that the analyzers meet these acceptance criteria.

The manufacturer shall submit acceptable performance test results for each analyzer within 120 days after receipt of order. The manufacturer will be authorized to ship the analyzers only after the Facility Support Branch has approved the test results. The manufacturer will not be paid for equipment, supplies or materials shipped prior to approval. The EPA may choose to observe performance testing at the manufacturer's facility. The manufacturer shall give the EPA 10 days notice prior to the start of the performance testing.

Each range of each analyzer shall be calibrated as defined in the Code of Federal Regulations, Title 40, Chapter I, Parts 86.114-79, 86.122-78 and 86.124-78, as appropriate (see page 4). Each range of each analyzer shall be tested as defined below.

For each calibration or test the analyzer output shall be adjusted to produce 10.0 volts if a full-scale concentration gas were sampled and 0.0 volts if nitrogen gas were sampled. The full-scale gas concentrations for each range are defined above under "RANGES". The strip chart recorder shall be adjusted to record its full-scale output for a 10.0 volt input, and zero for a 0.0 volt input. The speed of the strip chart recorder paper shall be written on the paper. Use of linearizing circuitry in the analyzer is not allowed. The analyzer sample gas flow rate for these tests shall be 4.0 standard cubic feet per hour (standard conditions of 70.0 degrees Farenheit and 14.696 psia).

1. INTERFERENCE: Each carbon monoxide analyzer shall meet interference criteria as defined in the Code of Federal Regulations, Title 40, Chapter I, Part 86.122-78 (see page 4). The use of conditioning columns is not allowed.

2. Repeatability: The following sequence shall be repeated 12 times; sample nitrogen gas until analyzer output is stable, sample a nominal 90% of full-scale sample gas until analyzer output is stable, record analyzer output. Each reading shall not deviate more than 0.5% of full-scale output, from the average of the 12 readings.

3. Noise: A nominal 90% of full-scale sample gas shall be sampled continuously for one minute. The analyzer output shall not deviate more than 0.5% of full-scale analyzer output, from minimum to maximum.

4. Non-Linearity: The percent non-linearity of the calibration curve is defined as the deviation at mid-scale of the curve concentration from the straight line connecting zero and full-scale concentration. The deviation is expressed as a percentage of full-scale concentration and shall be determined as follows: find the curve concentration at half of the full-scale analyzer output using the calibration curve found above, subtract this from half of the full-scale concentration, divide the result by the full-scale concentration, multiply this result by 100. The percent non-linearity shall be less than 10%. The use of linearizing circuitry is not allowed. NOTE: This test is not required if the calibration curve is a single calibration factor, as defined in the CFR references listed above.

5. Drift: This test shall be performed on the lowest range of each analyzer only. Zero: Nitrogen gas shall be sampled continuously for 4-hours. The analyzer output shall not deviate more than 1.0% of full-scale analyzer output, from minimum to maximum. Span: A nominal 90% of full-scale sample gas shall be sampled continuously for 4-hours. The analyzer output shall not deviate more than 1.0% of full-scale analyzer output, from minimum to maximum.

6. Response Time: A strip chart recording of transitory analyzer output, which occurs when the analyzer samples a step change in gas concentration, shall be obtained as follows: sample nitrogen gas until the analyzer output is stable, sample a nominal 90% of full-scale sample gas until the analyzer output is stable. The time duration from the start of analyzer output transition, to 90% of the final stable analyzer output, shall be less than 4.0 seconds.

#0106e

§ 86.114-79 Analytical gases.

(a) Analyzer gases.

(1) Gases for the CO and CO_2 analyzers shall be single blends of CO and CO_2 respectively using nitrogen as the diluent.

(2) Gases for the hydrocarbon analyzer shall be single blends of propane using air as the diluent.

(3) Gases for NO_x analyzer shall be single blends of NO named as NO_x, with a maximum NO_2 concentration of 5 percent of the nominal value, using nitrogen as the diluent.

(4) Fuel for the evaporative emission enclosure FID shall be a blend of 40±2% hydrogen with the balance being helium. The mixture shall contain less than 1 ppm equivalent carbon response. 98 to 100 percent hydrogen fuel may be used with advance approval by the Administrator.

(5) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04 percent (400 ppm) carbon dioxide and 0.1 ppm nitric oxide.

(6) "Zero grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(7) The use of proportioning and precision blending devices to obtain the required analyzer gas concentration is allowable provided their use has been approved in advance by the Administrator.

(b) Calibration gases shall be traceable to within 1 percent of NBS gas standards, or other gas standards which have been approved by the Administrator.

(c) Span gases shall be accurate to within 2 percent of true concentration, where true concentration refers to NBS gas standards, or other gas standards which have been approved by the Administrator.

[42 FR 32954, June 28, 1977, as amended at 43 FR 52920, Nov. 14, 1978]

§ 86.122-78 Carbon monoxide analyzer calibration.

The NDIR carbon monoxide analyzer shall receive the following initial and periodic calibrations:

(a) *Initial and periodic interference check.* Prior to its introduction into service and annually thereafter the NDIR carbon monoxide analyzer shall be checked for response to water vapor and CO_2.

(1) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance on the most sensitive range to be used.

(2) Zero the carbon monoxide analyzer with either zero-grade air or zero-grade nitrogen.

(3) Bubble a mixture of 3 percent CO_2 in N_2 through water at room temperature and record analyzer response.

(4) An analyzer response of more than 1 percent of full scale for ranges above 300 ppm full scale or of more than 3 ppm on ranges below 300 ppm full scale will require corrective action. (Use of conditioning columns is one form of corrective action which may be taken.)

(b) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter the NDIR carbon monoxide analyzer shall be calibrated.

(1) Adjust the analyzer to optimize performance.

(2) Zero the carbon monoxide analyzer with either zero-grade air or zero-grade nitrogen.

(3) Calibrate on each normally used operating range with carbon monoxide in N_2 calibration gases having nominal concentrations of 15, 30, 45, 60, 75, and 90 percent of that range. Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

§ 86.124-78 Carbon dioxide analyzer c bration.

Prior to its introduction into serv and monthly thereafter the NI carbon dioxide analyzer shall be c brated:

(a) Follow the manufacturer's structions for instrument startup operation. Adjust the analyzer to o mize performance.

(b) Zero the carbon dioxide anal with either zero-grade air or z grade nitrogen.

(c) Calibrate on each normally u operating range with carbon dioxid N_2 calibration gases with nominal centrations of 15, 30, 45, 60, 75, an percent of that range. Additional bration points may be generated. each range calibrated, if the devia from a least-squares best-fit stra line is 2 percent or less of the valu each data point, concentration va may be calculated by use of a si calibration factor for that rang the deviation exceeds 2 percent at point, the best-fit non-linear equa which represents the data to with percent of each test point shal used to determine concentration.

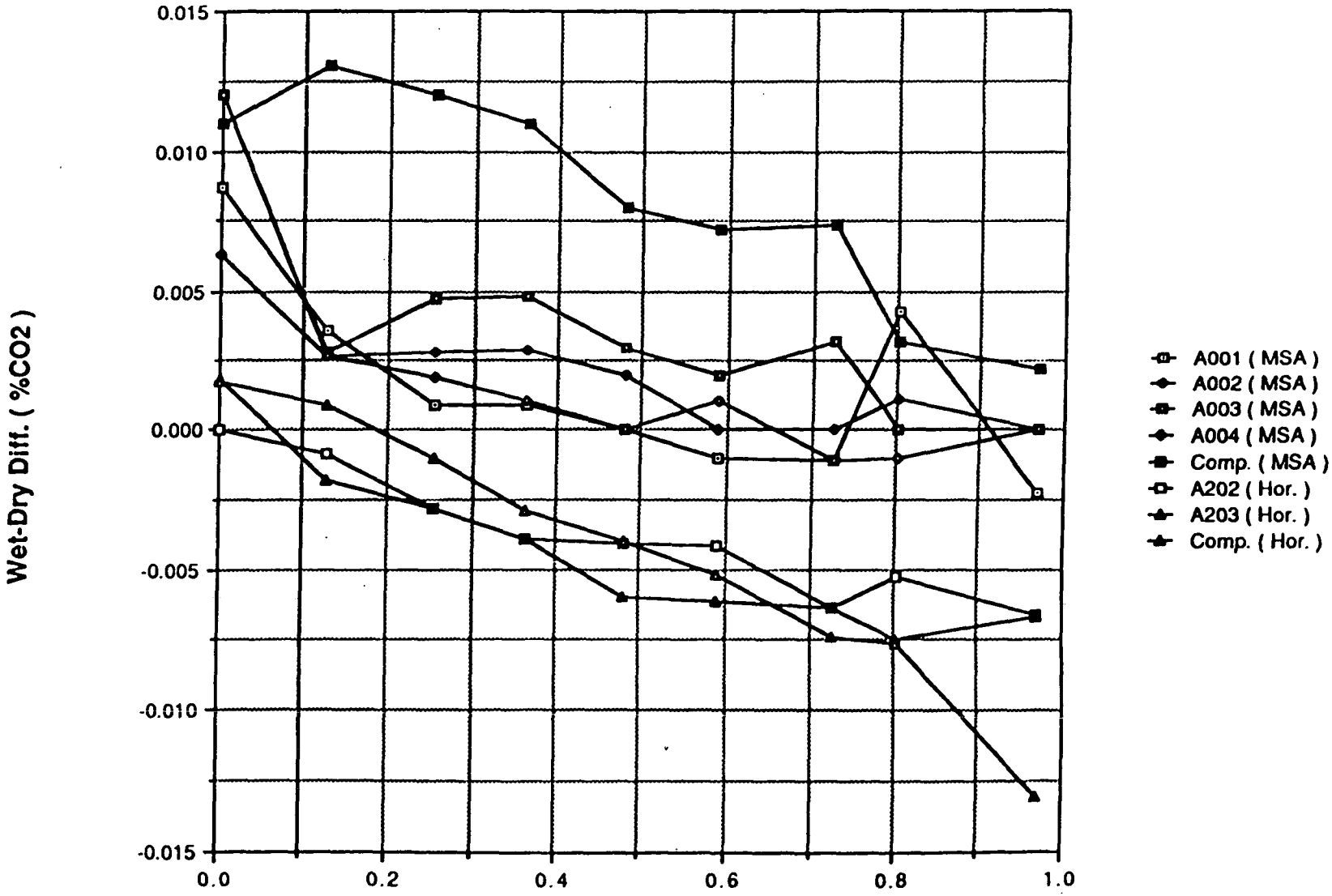
Serial No.	Type	Range	Range Conc.s	H2O Interference	Repeatability		Noise	Non-Linearity	Response Time	Drift (%F.S.)					
					Avg.	Max. Dev.				Zero			Span		
				(%F.S.)	(%F.S.)	(%F.S.)	(%F.S.)	(%)	(sec.s)	Min.	Max.	Dev.	Min.	Max.	Dev.
561661011	CO	1	0 - 100 ppm	1.00	90.01	0.09	0.20	0.80	5.40	-0.30	-0.30	0.00	84.00	84.00	0.00
		2	0 - 250 ppm	-	94.01	0.09	0.20	3.00	5.40	-	-	-	-	-	-
		3	0 - 500 ppm	-	89.20	0.00	0.20	6.63	5.30	-	-	-	-	-	-
561661012	CO	1	0 - 100 ppm	-0.10	89.91	-0.21	0.40	0.61	5.35	-0.50	-0.50	0.00	84.56	84.50	0.00
		2	0 - 250 ppm	-	94.04	0.16	0.20	2.80	5.50	-	-	-	-	-	-
		3	0 - 500 ppm	-	89.90	-0.20	0.20	6.58	5.30	-	-	-	-	-	-
561661013	CO	1	0 - 100 ppm	1.00	91.00	0.00	0.40	0.60	5.35	0.40	-0.40	0.80	87.70	87.20	0.50
		2	0 - 250 ppm	-	94.17	0.13	0.20	2.80	5.35	-	-	-	-	-	-
		3	0 - 500 ppm	-	91.00	0.00	0.50	6.69	5.40	-	-	-	-	-	-
561661014	CO	1	0 - 100 ppm	0.70	95.00	0.10	0.20	-	5.30	0.20	0.00	0.20	-	-	0.40
		2	0 - 250 ppm	-	94.01	0.19	0.20	3.00	-	-	-	-	-	-	-
		3	0 - 500 ppm	-	94.91	-0.09	0.20	6.96	-	-	-	-	-	-	-
561661015	CO	1	0 - 100 ppm	1.2(<3ppm)	96.02	0.08	0.40	-	5.20	0.30	0.30	0.00	-	-	0.30
		2	0 - 250 ppm	-	94.10	0.10	0.20	-	-	-	-	-	-	-	-
		3	0 - 500 ppm	-	96.00	0.00	0.10	6.48	-	-	-	-	-	-	-
561661016	CO	1	0 - 100 ppm	-0.10	97.02	-0.12	0.20	-	5.00	0.20	0.10	0.10	-	-	0.30
		2	0 - 250 ppm	-	94.05	0.15	0.20	3.00	-	-	-	-	-	-	-
		3	0 - 500 ppm	-	97.05	0.05	0.00	6.78	-	-	-	-	-	-	-
561661017	CO	1	0 - 100 ppm	1.10	94.84	-0.14	0.50	-	5.20	0.00	0.00	0.00	-	-	0.10
		2	0 - 250 ppm	-	94.77	-0.07	0.20	-	-	-	-	-	-	-	-
		3	0 - 500 ppm	-	95.00	0.00	0.10	7.06	-	-	-	-	-	-	-
561661018	CO	1	0 - 100 ppm	0.50	95.97	-0.17	0.70	-	5.10	0.70	0.50	0.20	-	-	0.00
		2	0 - 250 ppm	-	96.06	-0.06	0.10	-	-	-	-	-	-	-	-
		3	0 - 500 ppm	-	96.00	0.00	0.10	6.79	-	-	-	-	-	-	-
561661019	CO	1	0 - 100 ppm	1.40	97.01	-0.11	0.50	-	5.20	0.70	0.70	0.00	-	-	0.10
		2	0 - 250 ppm	-	96.99	-0.09	0.20	-	-	-	-	-	-	-	-
		3	0 - 500 ppm	-	97.08	0.12	0.20	7.10	-	-	-	-	-	-	-
561661021	CO	1	0 - 2500 ppm	0.90	95.05	0.15	0.20	-	3.90	0.00	0.00	0.00	-	-	0.10
		2	0 - 5000 ppm	-	92.00	0.00	0.30	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	94.10	0.00	0.10	7.80	-	-	-	-	-	-	-
561661022	CO	1	0 - 2500 ppm	0.80	96.03	0.07	0.20	-	3.80	0.00	0.00	0.00	-	-	0.20
		2	0 - 5000 ppm	-	92.91	0.09	0.10	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	94.90	0.00	0.20	7.80	-	-	-	-	-	-	-
561661023	CO	1	0 - 2500 ppm	0.70	97.06	0.14	0.40	-	4.00	0.20	0.10	0.10	-	-	0.10
		2	0 - 5000 ppm	-	94.00	0.00	0.30	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	95.80	0.00	0.10	7.80	-	-	-	-	-	-	-

ATTACHMENT D

Serial No.	Type	Range	Range Conc.s	H2O Interference	Repeatability		Noise	Non-Linearity	Response Time	Drift (%F.S.)					
					Avg.	Max. Dev.				Zero			Span		
				(%F.S.)	(%F.S.)	(%F.S.)	(%F.S.)	(%)	(sec.s)	Min.	Max.	Dev.	Min.	Max.	Dev.
561661024	CO	1	0 - 2500 ppm	0.80	95.07	-0.07	0.30	-	3.80	0.00	0.20	0.20	-	-	0.10
		2	0 - 5000 ppm	-	92.78	0.08	0.30	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	94.00	0.00	0.10	8.14	-	-	-	-	-	-	-
561661025	CO	1	0 - 2500 ppm	0.80	96.00	0.00	0.10	-	3.60	-0.10	-0.30	0.20	-	-	0.00
		2	0 - 5000 ppm	-	93.70	0.00	0.10	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	95.00	0.00	0.00	8.14	-	-	-	-	-	-	-
561661026	CO	1	0 - 2500 ppm	0.70	97.02	0.08	0.20	-	3.60	0.00	-0.10	0.10	-	-	0.20
		2	0 - 5000 ppm	-	94.90	0.00	0.10	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	96.00	0.00	0.10	7.77	-	-	-	-	-	-	-
561661027	CO	1	0 - 2500 ppm	0.80	93.28	-0.08	0.20	-	3.60	-0.40	-0.60	0.20	-	-	0.00
		2	0 - 5000 ppm	-	92.60	0.00	0.10	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	93.60	0.00	0.10	8.38	-	-	-	-	-	-	-
561661028	CO	1	0 - 2500 ppm	0.60	94.36	-0.06	0.40	-	3.60	0.30	0.10	0.20	-	-	0.10
		2	0 - 5000 ppm	-	93.60	0.00	0.30	-	-	-	-	-	-	-	-
		3	0 - 10000 ppm	-	94.60	0.00	0.20	9.63	-	-	-	-	-	-	-
5616610502	CO2	1	0 - 1.0 %	-	92.83	-0.07	0.40	-	3.30	0.30	0.40	0.10	-	-	0.50
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	93.08	-0.08	0.10	7.73	-	-	-	-	-	-	-
5616610503	CO2	1	0 - 1.0 %	-	94.90	0.10	0.20	-	3.30	-0.50	-0.90	0.40	-	-	0.10
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	95.08	-0.08	0.10	7.91	-	-	-	-	-	-	-
5616610504	CO2	1	0 - 1.0 %	-	93.08	-0.08	0.30	-	3.40	0.00	-0.10	0.10	-	-	0.30
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	94.00	0.00	0.10	7.82	-	-	-	-	-	-	-
5616610505	CO2	1	0 - 1.0 %	-	94.11	-0.11	0.20	-	3.40	0.70	-0.10	0.80	-	-	0.60
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	95.00	0.00	0.10	7.82	-	-	-	-	-	-	-
5616610506	CO2	1	0 - 1.0 %	-	95.08	-0.08	0.20	-	3.50	-0.10	-0.50	0.40	-	-	0.10
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	96.00	0.00	0.10	7.82	-	-	-	-	-	-	-
5616610507	CO2	1	0 - 1.0 %	-	94.00	0.00	0.30	-	3.50	0.00	0.00	0.00	-	-	0.00
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	94.00	0.00	0.10	7.88	-	-	-	-	-	-	-
5616610508	CO2	1	0 - 1.0 %	-	92.94	0.06	0.20	-	3.50	0.20	0.10	0.10	-	-	0.70
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	95.00	0.00	0.10	7.88	-	-	-	-	-	-	-
5616610509	CO2	1	0 - 1.0 %	-	95.95	-0.05	0.20	-	3.60	0.60	0.40	0.20	-	-	0.60
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	96.00	0.00	0.00	7.88	-	-	-	-	-	-	-

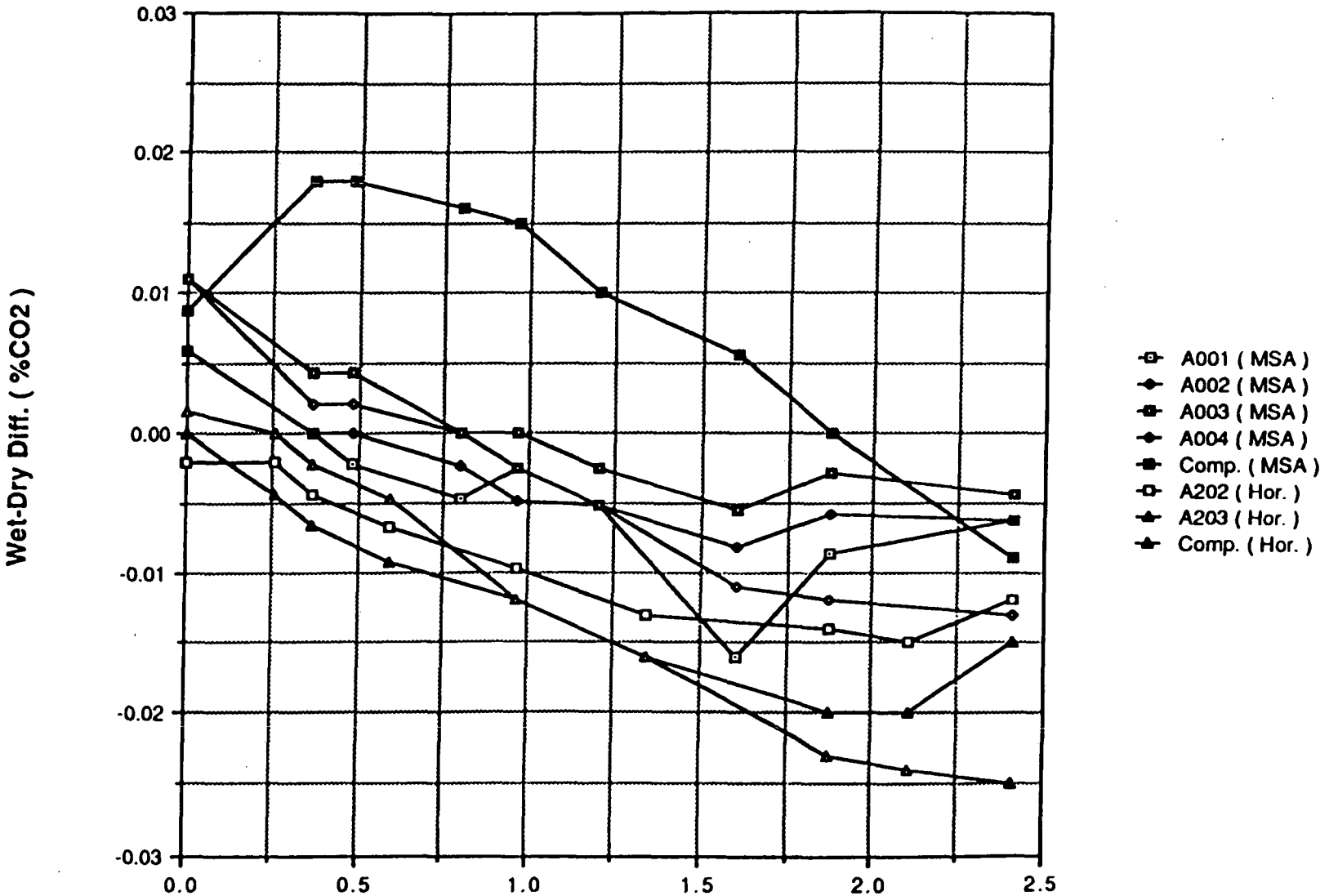
Serial No.	Type	Range	Range Conc.s	H2O Interference	Repeatability		Noise	Non-Linearity	Response Time	Drift (%F.S.)					
											Zero			Span	
				(%F.S.)	Avg. (%F.S.)	Max. Dev. (%F.S.)	(%F.S.)	(%)	(sec.s)	Min.	Max.	Dev.	Min.	Max.	Dev.
5616610510	CO2	1	0 - 1.0 %	-	93.86	-0.06	0.20	-	3.60	0.10	0.00	0.10	-	-	0.20
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	93.00	0.00	0.00	7.88	-	-	-	-	-	-	-
5616610501	CO2	1	0 - 1.0 %	-	92.90	0.00	0.30	-	3.60	0.00	-0.30	0.30	-	-	0.20
		2	0 - 2.5%	-	-	-	-	-	-	-	-	-	-	-	-
		3	0 - 5.0%	-	93.00	0.00	0.20	8.37	-	-	-	-	-	-	-
56166103	CO2	1	0 - 5.0%	-	95.00	0.00	0.20	-	3.20	0.20	-0.30	0.50	-	-	0.00
		2	0 - 10.0%	-	90.96	-0.06	0.20	-	3.20	-	-	-	-	-	-
		3	0 - 15.0%	-	92.00	0.00	-	6.43	3.20	-	-	-	-	-	-
56166104	CO2	1	0 - 2500 ppm	-	90.00	0.00	0.10	-	3.70	-0.10	-0.50	0.40	-	-	0.30
		2	0 - 5000 ppm	-	91.00	0.00	0.20	-	3.60	-	-	-	-	-	-
		3	0 - 10000 ppm	-	94.00	0.00	0.10	8.89	3.60	-	-	-	-	-	-
56166106	CO2	1	0 - 2500 ppm	-	90.50	0.00	0.40	-	3.40	0.00	0.00	0.00	-	-	0.60
		2	0 - 5000 ppm	-	90.90	0.00	0.10	-	3.20	-	-	-	-	-	-
		3	0 - 10000 ppm	-	91.90	0.00	0.10	7.79	3.20	-	-	-	-	-	-

Range 22 Water Response (CO2 Analyzers)

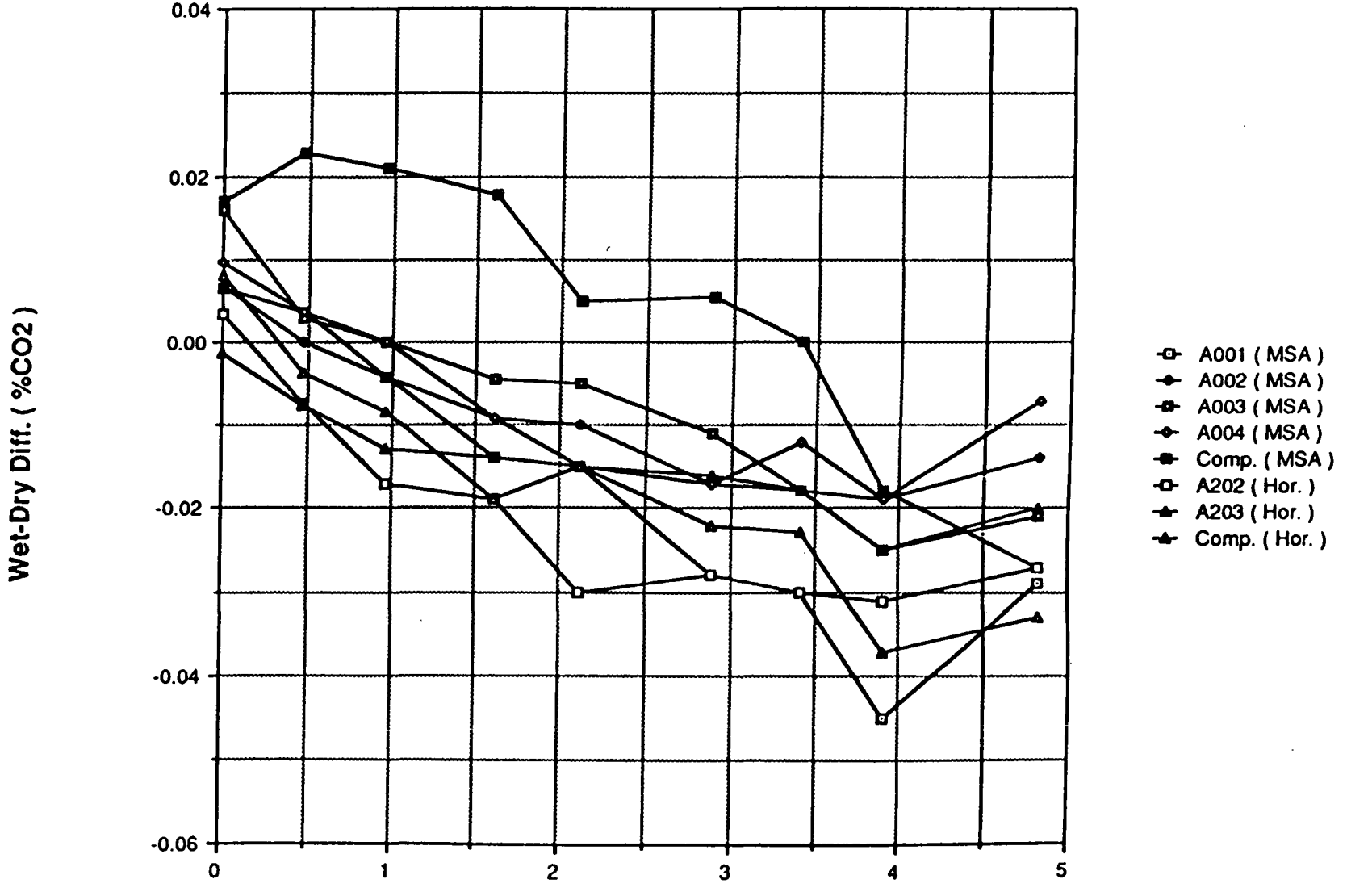


ATTACHMENT E

Range 23 Water Response (CO2 Analyzers)



Range 24 Water Response (CO2 Analyzers)



ATTACHMENT F

CO_2 Analyzer Reading Changes
Over Range of Barometer Change (28.5-29.25" Hg)

	N	(%CO2) Sec. Std. T	Regression: Rdg(%CO2)= m Baro("Hg)+b m / b	Corr. Coef. R	min. R for 95% Conf. of correlation Rmin	Does Correlation Exist?	Analyzer Reading Change (%Δ) over range of Barometer change (from regression) %Δ = (max-min)x100 / max	Analyzer Reading Change (%Δ) over +1"Hg Barometer change (from regression) %Δ = (max-min)x100 / max
R22 Horiba	15	.4812	.86675E-3 .45694	0.339	0.514	no	+0.13	+0.18
MSA	15	.4812	.32712E-2 .38534	0.631	0.514	yes	+0.51	+0.68
R23 Horiba	15	1.3480	.19490E-2 1.2915	0.337	0.514	no	+0.11	+0.14
MSA	15	1.3480	.46397E-2 1.2199	0.518	0.514	yes	+0.26	+0.34
R24 Horiba	10	2.1100	.18248E-2 2.0476	0.108	0.632	no	+0.07	+0.09
MSA	10	2.1100	.24822E-1 1.3919	0.668	0.632	yes	+0.88	+1.17

ATTACHMENT G

CO2 Analyzer
Vehicle Bag Sample Data
Two repeated readings on each bag
No Barometer Changes between readings

Range	1 N	Analyzer Readings (%CO2) (from all readings) Mean X	2 ---Range ------		Bag Sample Std. Dev. %CO2 S pooled	%CV S·100 / X
R22 (0-1%)						
Horiba	8 prs	.6520	.4984	.7577	.002332	0.36
MSA	8 prs	.6551	.5015	.7599	.001157	0.18
R23 (0-2.5%)						
Horiba	9 prs	1.1537	.4981	2.1924	.001796	0.16
MSA	9 prs	1.1679	.5138	2.1995	.001383	0.12
R24 (0-5%)						
Horiba	6 prs	1.6348	.8615	2.2448	.002625	0.16
MSA	6 prs	1.6545	.8878	2.2621	.005965	0.36

1 N = Number of Sample Bags, each bag contained a different CO2 concentration, and was read twice.

2 These values represent approximate lowest and highest bag concentrations in the bag set.

*Formula from EPA QAMS (3/30/84), Chapter 5, page 8

CO2 Analyzer
Background Bag Data
Two repeated readings on each bag
No Barometer Changes between readings

	N	Analyzer Readings (% CO2) (from all readings) Mean x	----Range----		Background Bag Std. Dev. % CO2 S pooled
R22 (0-1%)					
Horiba	8 prs	.04085	.03680	.04850	.0007115
MSA	8 prs	.04673	.04180	.05390	.001521
R23 (0-2.5%)					
Horiba	9 prs	.04122	.03830	.04520	.0006916
MSA	9 prs	.04864	.04270	.05770	.002256
R24 (0-5%)					
Horiba	6 prs	.04123	.03650	.04320	.0009815
MSA	6 prs	.04798	.04400	.05500	.001834

CO2 Analyzer
Corrected Concentration (Sample - Background) Bag Data
Two repeated readings on each bag
No Barometer Changes between readings

		Analyzer Readings (% CO2) (from all readings)			Corrected Concentration Std. Dev.	% CV
	N	Mean X	--- Range ---		S pooled	S·100 / X
R22 (0-1%)						
Horiba	8 prs	.6111	.4598	.7164	.002271	0.37
MSA	8 prs	.6084	.4588	.7135	.001905	0.31
R23 (0-2.5%)						
Horiba	9 prs	1.1125	.4588	2.1531	.001697	0.15
MSA	9 prs	1.1192	.4668	2.1547	.003466	0.31
R24 (0-5%)						
Horiba	6 prs	1.5936	.8250	2.2016	.002802	0.17
MSA	6 prs	1.6065	.8438	2.2108	.005442	0.34

0924e

Horiba CO2 NDIR Analyzer Wet Precision

RANGE 2 2

Duplicates X1, X2 (%CO2)	Average Xa = [X1+X2]/2 (%CO2)	Range R = |X1-X2| (%CO2)	Relative Range RR = [R/Xa] x 100 (% of pt.)
0.6209 0.6119	0.6164	0.009	1.460
0.7567 0.7577	0.7572	0.001	0.132
0.7492 0.7492	0.7492	0.000	0.000
0.6209 0.6209	0.6209	0.000	0.000
0.6375 0.6355	0.6365	0.002	0.314
0.6720 0.6720	0.6720	0.000	0.000
0.4984 0.4984	0.4984	0.000	0.000
0.6657 0.6647	0.6652	0.001	0.150 Average RR 0.237

RANGE 2 3

Duplicates X1, X2 (%CO2)	Average Xa = [X1+X2]/2 (%CO2)	Range R = |X1-X2| (%CO2)	Relative Range RR = [R/Xa] x 100 (% of pt.)
1.2451 1.2503	1.2477	0.005	0.417
1.1431 1.1431	1.1431	0.000	0.000
1.3490 1.3517	1.3504	0.000	0.000
0.6104 0.6081	0.6093	0.002	0.378
0.9714 0.9714	0.9714	0.000	0.000
0.8124 0.8100	0.8112	0.002	0.296
0.5003 0.4981	0.4992	0.002	0.441
2.1924 2.1924	2.1924	0.000	0.000
1.5571 1.5599	1.5585	0.003	0.180 Average RR 0.212

RANGE 2 4

Duplicates X1, X2 (%CO2)	Average Xa = [X1+X2]/2 (%CO2)	Range R = |X1-X2| (%CO2)	Relative Range RR = [R/Xa] x 100 (% of pt.)
0.9106 0.9147	0.9127	0.004	0.449
1.8190 1.8190	1.8190	0.000	0.000
2.2397 2.2448	2.2423	0.005	0.227
0.8656 0.8615	0.8636	0.004	0.475
1.7902 1.7854	1.7878	0.005	0.268
2.1838 2.1838	2.1838	0.000	0.000 Average RR 0.240

ATTACHMENT H

CO2 Analyzer
Mid - Span Data - Dry Gas
From Different Days
with Barometer Changes Between Readings

Range	N	Average Analyzer Reading X (%CO2)	Sec. Std. T (%CO2)	Bias X-T (%CO2)	Bias Percent $\frac{(X-T)x100}{T}$ (%)	Std. Dev. S (%CO2)	%CV $\frac{S \cdot 100}{X}$ (%)
22							
Horiba	15	.48203	.4812	.00083	0.17	.00070	0.15
MSA	15	.48006	.4812	-.00114	-0.24	.00143	0.30
23							
Horiba	15	1.3480	1.3480	0.0	0.0	.00132	0.10
MSA	15	1.3544	1.3480	.00640	0.47	.00204	0.15
24							
Horiba	10	2.1003	2.1100	-.00970	-0.46	.00258	0.12
MSA	10	2.1081	2.1100	-.00190	0.09	.00565	0.27

RANGE 22

MID-SPAN CHECK DATA

DATE	NOM. CONC.	HOR. CALC CONC.	MSA CALC CONC.	HORIBA DEFL.	HORIBA CONC.	MSA DEFL.	MSA CONC.	BARO "HG	DIFF. FROM CAL. BARO. "HG
12/3/87	0.9812	0.9813	0.9815	50.9	0.9813	50.1	0.4795	28.70	-0.14
—				—	—	50.8	0.4805	—	—
12/9/87				—	—	50.1	0.4795	29.03	0.19
—				—	—	50.3	0.4815	—	—
12/11/87				—	—	50.2	0.4805	28.5	-0.34
—				—	—	49.9	0.4775	—	—
12/16/87				51.1	0.4833	50.0	0.4786	28.78	-0.06
—				—	—	—	—	—	—
12/23/87				51.0	0.4823	50.3	0.4815	29.25	0.41
—				—	—	—	—	—	—
—				—	—	—	—	—	—
—				—	—	—	—	—	—
—				—	—	—	—	—	—
12/24/87				—	—	50.0	0.4786	29.03	0.19
—				—	—	—	—	—	—

HORIBA S/N # 5616610 — 506

MSA SITE # A002

H-1

RANGE 23

MID-SPAN CHECK DATA

DATE	NOM CONC.	HOR. CALC. CONC.	MSA CALC CONC.	HORIBA DEFL.	HORIBA CONC.	MSA DEFL.	MSA CONC.	BARO. "HG.	DIFF. FROM CAL BARO "HG
									28.84
12/3/87	1.3480	1.3491	1.3495	59.0	1.3464	58.2	1.3520	28.70	-0.14
—				—	—	—	—	—	—
12/4/87				59.1	1.3490	58.3	1.3546	29.03	0.19
—				—	—	58.2	1.3520	—	—
12/9/87				59.0	1.3464	—	—	28.74	-0.10
—				—	—	58.3	1.3546	—	—
12/16/87				59.1	1.3490	58.4	1.3571	28.78	-0.06
—				—	—	58.3	1.3546	—	—
12/23/87				—	—	58.4	1.3571	29.25	0.41
—				—	—	—	—	—	—
—				—	—	—	—	—	—
—				59.0	1.3464	58.3	1.3546	—	—
—				—	—	—	—	—	—
12/24/87				59.1	1.3490	—	—	29.03	0.19
—				—	—	58.2	1.3520	—	—

HORIBA S/N# 561610-506
MSA SITE # A002

RANGE 24

MID-SPAN CHECK DATA

DATE	NOM. CONC.	HOR. CALC. CONC.	MSA CALC. CONC.	HORIBA DEFL.	HORIBA CONC.	MSA DEFL.	MSA CONC.	BARO. "HG	DIFF. FROM CAL. BARO. "HG
12/3/87	2.1100	2.1033	2.1096	50.7	2.0983	50.9	2.1096	28.70	-0.14
—				50.8	2.1033	—	—	—	—
12/4/87				—	—	50.5	2.1145	29.03	0.19
—				—	—	50.9	2.1096	—	—
12/9/87				—	—	50.3	2.1047	28.71	-0.10
—				50.7	2.0983	—	—	—	—
12/16/87				—	—	50.2	2.0999	28.78	-0.06
—				—	—	—	—	—	—
12/24/87				—	—	50.5	2.1195	29.03	0.19
—				—	—	50.5	2.1195	—	—

HORIBA S/N # 5616610-506

MSA SITE # A002

****
* SAC SUMMARY STATISTICS *
* ANALYSIS OF DEVIATIONS *
* FROM LAB AVERAGE FOR CO2 *
****

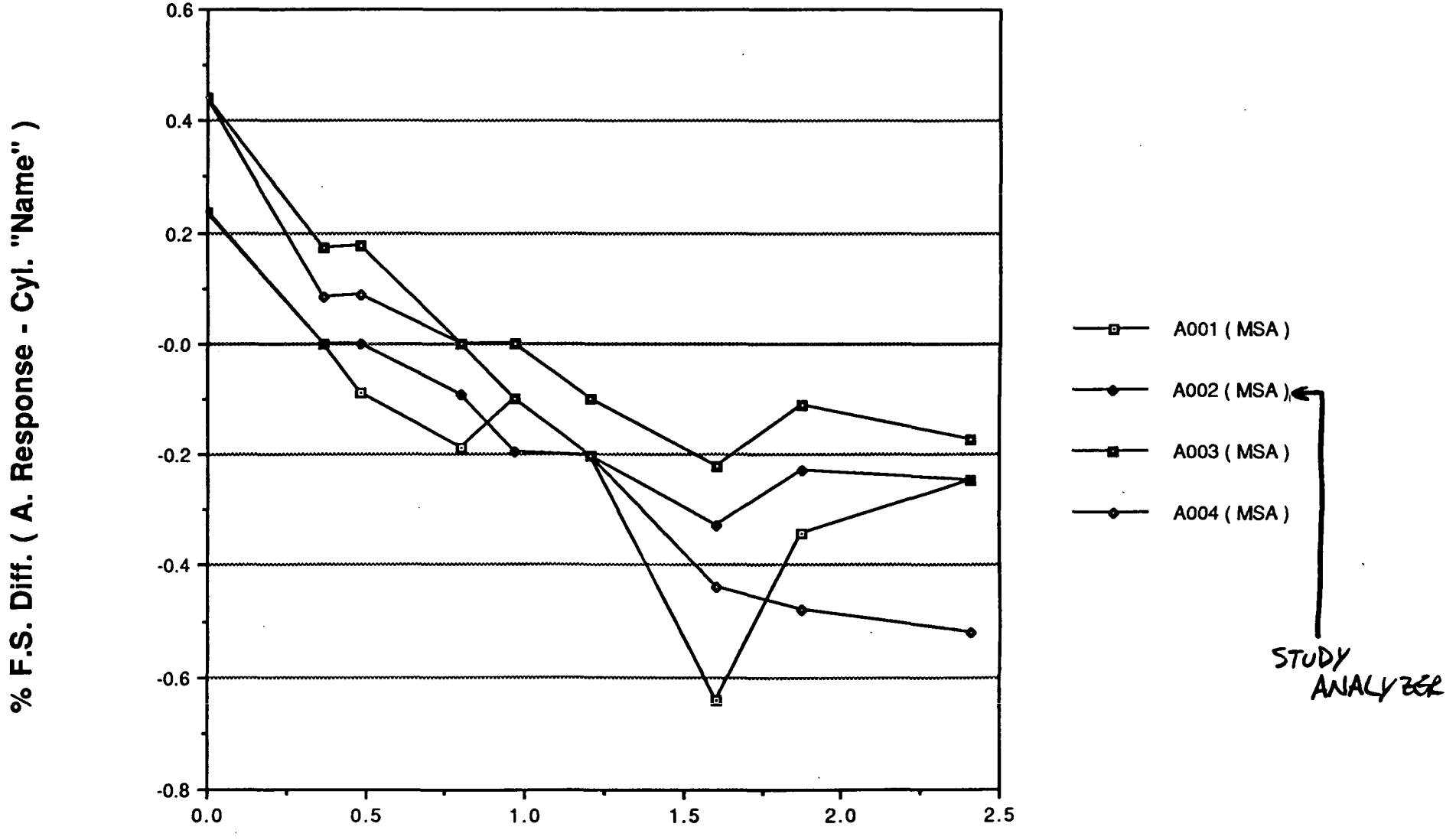
PERIOD OF ANALYSIS: 1- 1-88 TO 8-10-88 PROCESSED: 10:32:53 NOV 3, 1988

SITE NO	RANGE 21 5000 PPM			RANGE 22 1 PCT			RANGE 23 3 PCT			RANGE 24 5 PCT			ALL RANGES		
****	N	MEAN	SIGMA	N	MEAN	SIGMA	N	MEAN	SIGMA	N	MEAN	SIGMA	N	MEAN	SIGMA
A001	0	0.0	0.0	91	-0.16	0.579	48	0.04	0.471	0	0.0	0.0	139	-0.09	0.551
A002	0	0.0	0.0	73	0.11	0.779	65	0.08	0.379	0	0.0	0.0	138	0.09	0.622
A003	0	0.0	0.0	96	0.69	0.653	51	0.22	0.398	0	0.0	0.0	147	0.53	0.617
A004	0	0.0	0.0	57	-0.24	0.764	54	0.18	0.614	0	0.0	0.0	111	-0.04	0.724
A009	0	0.0	0.0	72	0.58	0.607	61	0.70	0.398	0	0.0	0.0	133	0.64	0.523
A202	0	0.0	0.0	90	-0.42	0.659	46	-0.56	0.624	0	0.0	0.0	136	-0.47	0.649
A203	0	0.0	0.0	89	-0.54	0.665	47	-1.02	0.591	0	0.0	0.0	136	-0.71	0.678
ALL	0	0.0	0.0	568	0.00	0.807	372	-0.01	0.713	0	0.0	0.0	940	-0.00	0.771
							SIGMA VALUE AS OF 3-28-81								0.750
ANALYSIS OF ALL SITES AND RANGES AVERAGE VS THEORETICAL % DIFFERENCE													125	-1.22	2.142

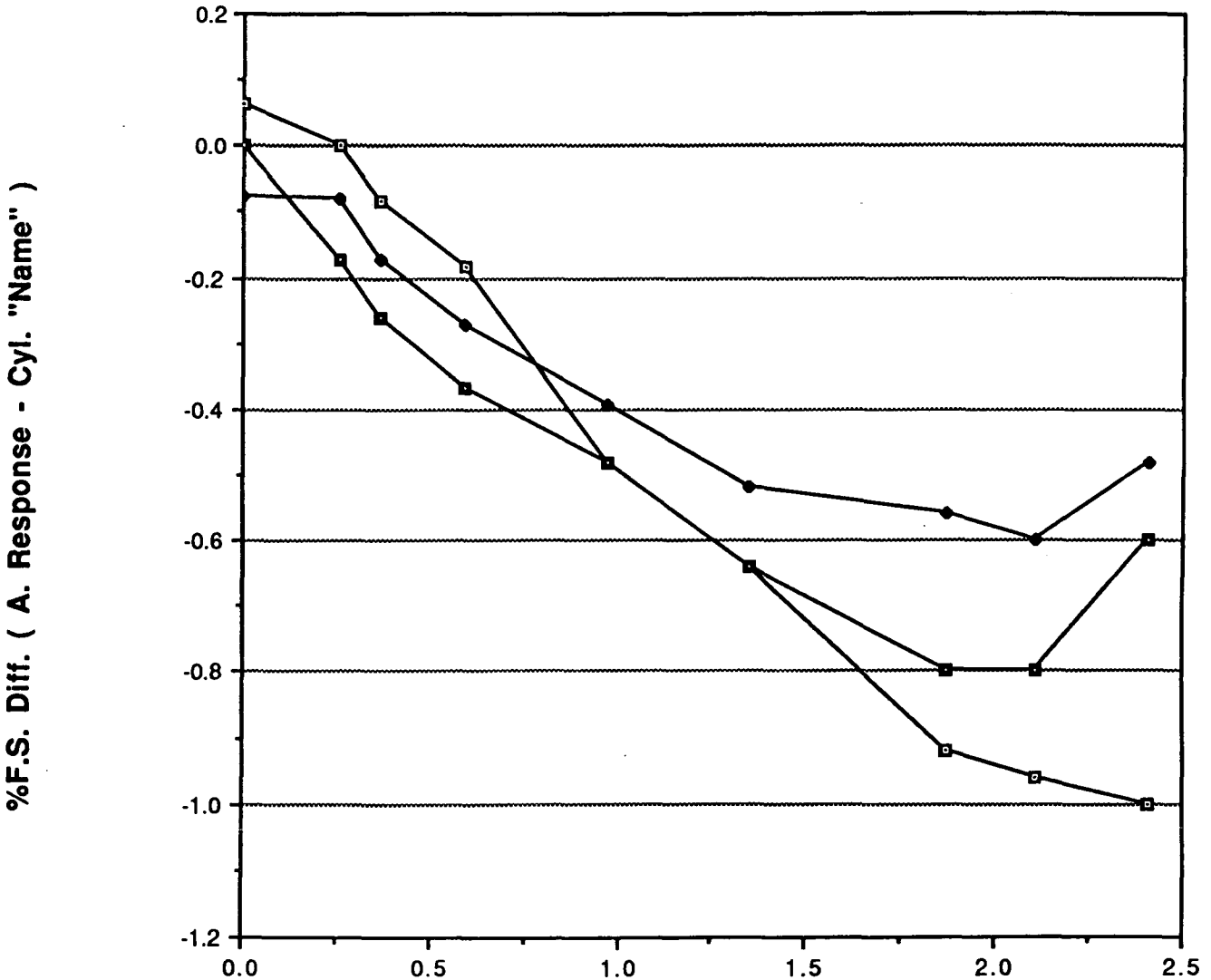
MSA CO_2 ANALYZER USED IN COMPARISON STUDY

ATTACHMENT I

Comparison of MSA CO2 Analyzers' Response to H2O (R23 Only)



Comparison of HORIBA CO2 Analyzers' Response to H2O (R23 Only)



HORIBA S/N's

COMPARATOR - 56166105O6
A202 - 56166105O5
A203 - 56166105O2

A004 Wet Data (R23)

	Cyl. Conc. R23	Dry (%CO2)	Wet (%CO2)	W-D Diff.	W-D %fs Diff.	W-D %pt Diff.
1	2.4120	2.4174	2.4048	-0.013	-0.520	-0.538
2	1.8730	1.8809	1.8693	-0.012	-0.480	-0.638
3	1.6050	1.6119	1.6008	-0.011	-0.440	-0.682
4	1.2060	1.2087	1.2036	-5.100e-3	-0.204	-0.422
5	0.9696	0.9702	0.9677	-2.500e-3	-0.100	-0.258
6	0.8017	0.8017	0.8017	0.000	0.000	0.000
7	0.4812	0.4809	0.4831	2.200e-3	0.088	0.458
8	0.3647	0.3645	0.3666	2.100e-3	0.084	0.576
9	0.0000	0.0019	0.0134	0.011	0.440	578.900

A202 Wet Data (R23)

	Cyl. Conc. R23	Dry (%CO2)	Wet (%CO2)	W-D Diff.	W-D %fs Diff.	W-D %pt Diff.
1	2.4120	2.4165	2.4042	-0.012	-0.480	-0.497
2	2.1100	2.1078	2.0930	-0.015	-0.600	-0.712
3	1.8730	1.8714	1.8571	-0.014	-0.560	-0.748
4	1.3480	1.3426	1.3294	-0.013	-0.520	-0.968
5	0.9696	0.9606	0.9508	-9.800e-3	-0.392	-1.000
6	0.5900	0.5812	0.5744	-6.800e-3	-0.272	-1.200
7	0.3647	0.3596	0.3553	-4.300e-3	-0.172	-1.200
8	0.2550	0.2504	0.2484	-2.000e-3	-0.080	-0.799
9	0.0000	0.0076	0.0057	-1.900e-3	-0.076	-25.000

A203 Wet Data (R23)

	Cyl. Conc. R23	Dry (%CO2)	Wet (%CO2)	W-D Diff.	W-D %fs Diff.	W-D %pt Diff.
1	2.4120	2.4139	2.3988	-0.015	-0.600	-0.621
2	2.1100	2.1117	2.0914	-0.020	-0.800	-0.947
3	1.8730	1.8769	1.8572	-0.020	-0.800	-1.100
4	1.3480	1.3529	1.3373	-0.016	-0.640	-1.200
5	0.9696	0.9707	0.9585	-0.012	-0.480	-1.200
6	0.5900	0.5921	0.5829	-9.200e-3	-0.368	-1.600
7	0.3647	0.3669	0.3604	-6.500e-3	-0.260	-1.800
8	0.2550	0.2573	0.2530	-4.300e-3	-0.172	-1.700
9	0.0000	0.0060	0.0060	0.000	0.000	0.000

A001 Wet Data (R23)

	Cyl. Conc. R23	Dry (%CO2)	Wet (%CO2)	W-D Diff.	W-D %fs Diff.	W-D %pt Diff.
1	2.4120	2.4102	2.4040	-6.200e-3	-0.248	-0.257
2	1.8730	1.8823	1.8737	-8.600e-3	-0.344	-0.457
3	1.6050	1.6131	1.5966	-0.016	-0.640	-0.992
4	1.2060	1.2131	1.2080	-5.100e-3	-0.204	-0.420
5	0.9696	0.9733	0.9708	-2.500e-3	-0.100	-0.257
6	0.8017	0.8077	0.8030	-4.700e-3	-0.188	-0.582
7	0.4812	0.4842	0.4820	-2.200e-3	-0.088	-0.454
8	0.3647	0.3672	0.3672	0.000	0.000	0.000
9	0.0000	0.0019	0.0078	5.900e-3	0.236	310.500

A002 Wet Data (R23)

	Cyl Conc. R23	Dry (%CO2)	Wet (%CO2)	W-D Diff.	W-D %fs Diff.	W-D %pt Diff.
1	2.4120	2.4105	2.4043	-6.200e-3	-0.248	-0.257
2	1.8730	1.8691	1.8634	-5.700e-3	-0.228	-0.305
3	1.6050	1.6012	1.5930	-8.200e-3	-0.328	-0.512
4	1.2060	1.2020	1.1969	-5.100e-3	-0.204	-0.424
5	0.9696	0.9670	0.9621	-4.900e-3	-0.196	-0.507
6	0.8017	0.7981	0.7958	-2.300e-3	-0.092	-0.288
7	0.4812	0.4809	0.4809	0.000	0.000	0.000
8	0.3647	0.3637	0.3637	0.000	0.000	0.000
9	0.0000	0.0020	0.0080	6.000e-3	0.240	300.000

A003 Wet Data (R23)

	Cyl. Conc. R23	Dry (%CO2)	Wet (%CO2)	W-D Diff.	W-D %fs Diff.	W-D %pt Diff.
1	2.4120	2.4102	2.4059	-4.300e-3	-0.172	-0.178
2	1.8730	1.8697	1.8669	-2.800e-3	-0.112	-0.150
3	1.6050	1.5997	1.5942	-5.500e-3	-0.220	-0.344
4	1.2060	1.1958	1.1933	-2.500e-3	-0.100	-0.209
5	0.9696	0.9587	0.9587	0.000	0.000	0.000
6	0.8017	0.7910	0.7910	0.000	0.000	0.000
7	0.4812	0.4731	0.4775	4.400e-3	0.176	0.930
8	0.3647	0.3595	0.3638	4.300e-3	0.172	1.200
9	0.0000	0.0019	0.0134	0.011	0.440	578.900

R23 1-14-04

-B7-

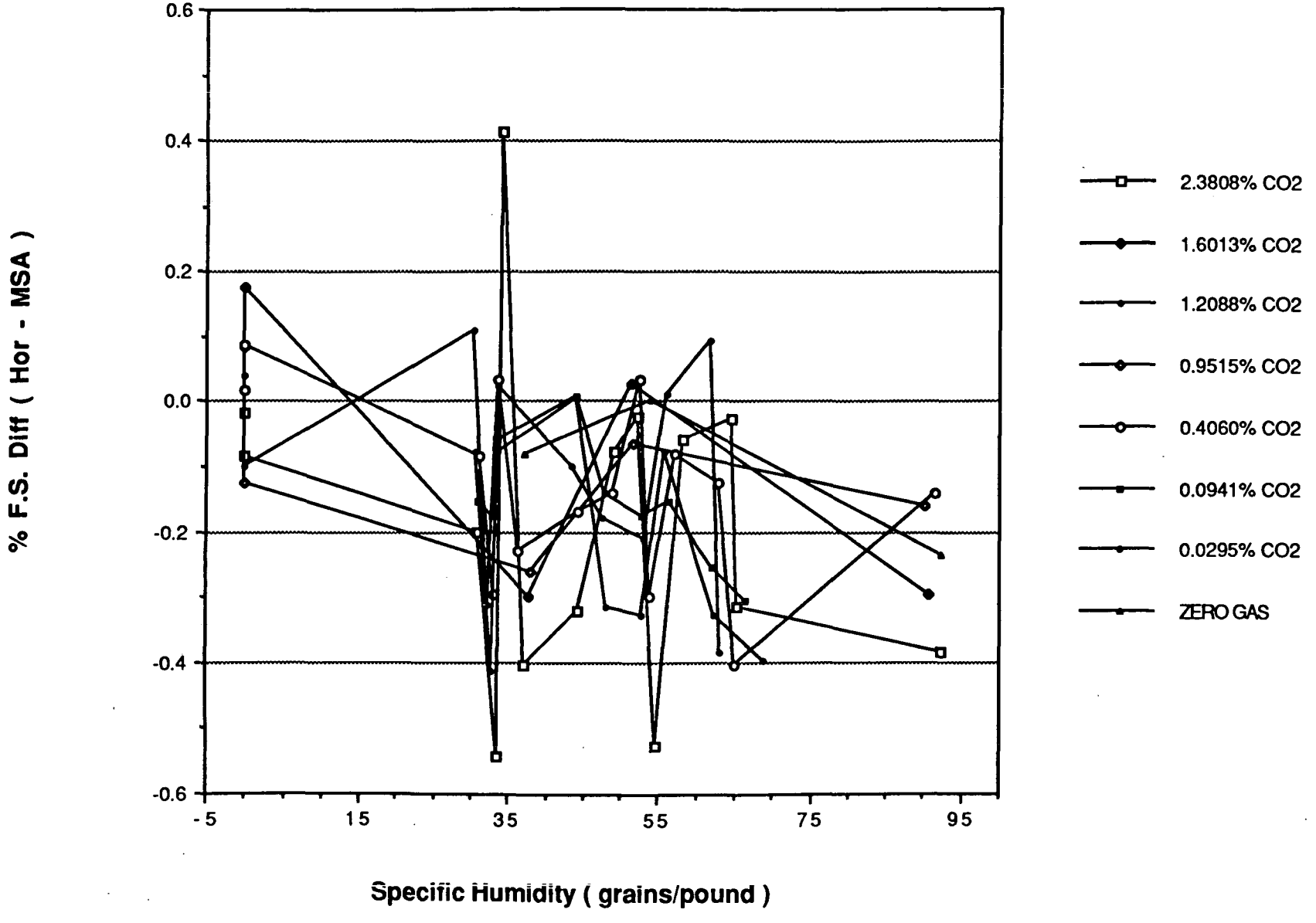
HORIBA S/N# 5616610506

COMPARATOR H_2O INTERFERENCE	CONC	CO_2 CURVE		$CO_2 + H_2O$ PLOT							
		HOR	MSA	HOR	MSA						
	2.4120	96.5	96.5	95.7	96.2						
	2.1100	86.3	86.0	85.5	86.0						
	1.8730	78.3	77.6	77.5	77.8						
	1.3480	59.1	58.1	58.5	58.5						
	0.9696	44.1	42.9	43.6	43.5						
	0.5900	28.0	26.8	27.8	27.5						
	0.3647	17.8	16.8	17.7	17.6						
	0.2550	12.6	11.7	12.6	12.5						
	0.1282	—	—	6.6	6.5						

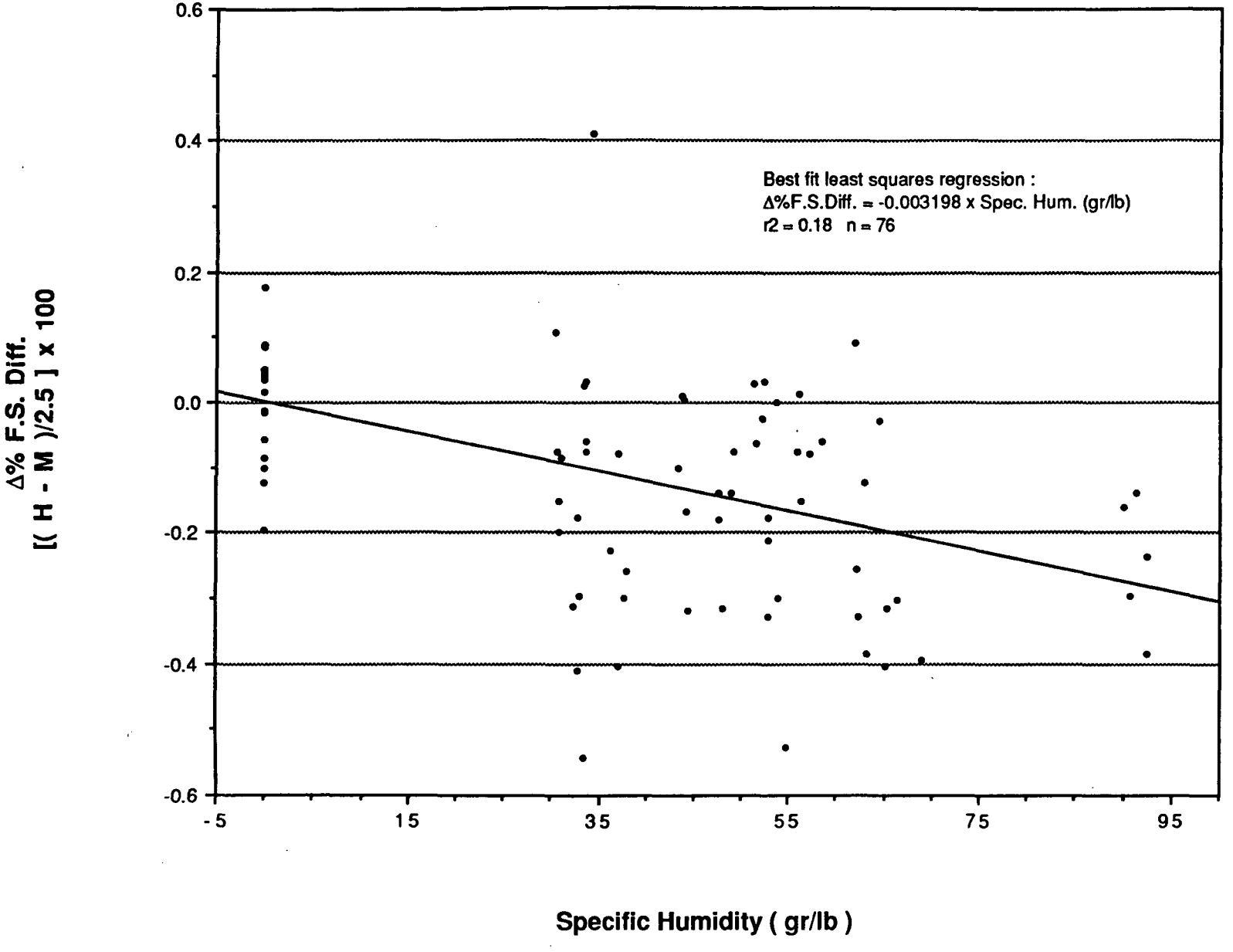
ATTACHMENT J

Bubbled CO2 Differences

Analyzer Agreement vs. Sample Spec. Hum.



Bubbled CO2 Differences

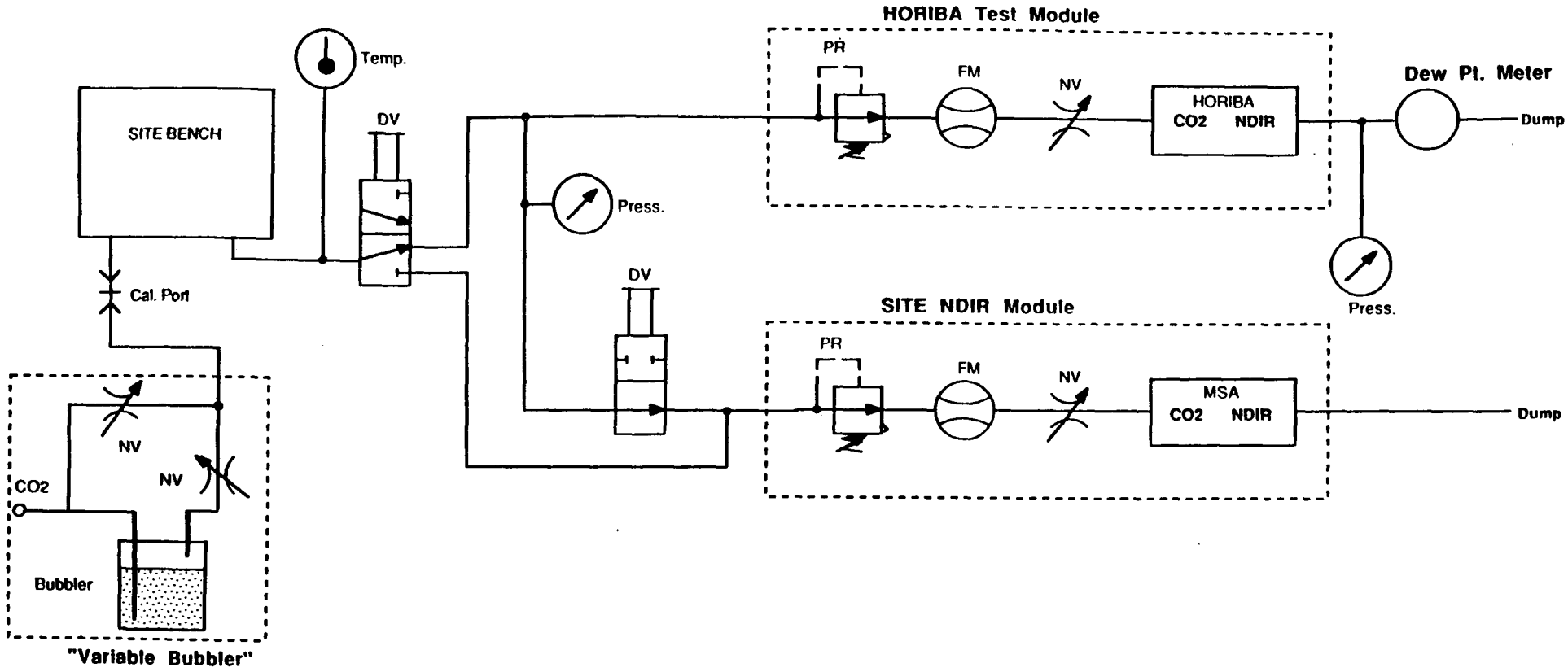


BUBBLED CO2 CYLINDER DATA

Date	Cyl. Conc. (%CO2)	Spec. Hum. SH (gr./lb)	Hor. Response H (%CO2)	MSA Response M (%CO2)	Hor-MSA Diff H - M (%CO2)	% pt. Diff. see below (% M pt.)	% F.S. Diff. see below (% R23)
8/18/88	2.3803	30.88	2.3733	2.3783	-0.0050	-0.210	-0.200
	1.2088	30.26	1.2075	1.2048	0.0027	0.224	0.108
	0.4060	31.00	0.4039	0.4060	-0.0021	-0.517	-0.084
	0.0941	30.88	0.0961	0.0999	-0.0038	-3.804	-0.152
	0.0295	30.51	0.0298	0.0317	-0.0019	-5.994	-0.076
	2.3803	44.33	2.3673	2.3753	-0.0080	-0.337	-0.320
	1.2088	43.32	1.2049	1.2074	-0.0025	-0.207	-0 100
	0.4060	44.16	0.4039	0.4081	-0.0042	-1.029	-0.168
	0.0941	43.82	0.0961	0.0959	0.0002	0.209	0.008
	0.0295	43.99	0.0318	0.0317	0.0001	0.315	0.004
	2.3803	58.29	2.3583	2.3598	-0.0015	-0.064	-0.060
	1.2088	55.93	1.1975	1.1972	0.0003	0.025	0.012
	0.4060	56.99	0.4018	0.4038	-0.0020	-0.495	-0.080
	0.0941	56.14	0.0961	0.0999	-0.0038	-3.804	-0.152
	0.0295	55.72	0.0318	0.0337	-0.0019	-5.638	-0.076
8/24/88	2.3808	34.23	2.3738	2.3635	0.0103	0.436	0.412
	1.2088	33.42	1.2047	1.2041	0.0006	0.050	0.024
	0.4060	33.69	0.4061	0.4053	0.0008	0.197	0.032
	0.0941	33.69	0.0971	0.0986	-0.0015	-1.521	-0.060
	0.0295	33.69	0.0321	0.0340	-0.0019	-5.588	-0.076
	2.3808	49.19	2.3647	2.3666	-0.0019	-0.080	-0.076
	1.2088	47.52	1.1996	1.2041	-0.0045	-0.374	-0.180
	0.4060	48.81	0.4018	0.4053	-0.0035	-0.864	-0.140
	0.0941	47.71	0.0951	0.0986	-0.0035	-3.550	-0.140
	0.0295	48.07	0.0301	0.0380	-0.0079	-20.789	-0.316
	2.3808	65.22	2.3556	2.3635	-0.0079	-0.334	-0.316
	1.2088	63.08	1.1945	1.2041	-0.0096	-0.797	-0.384
	0.4060	64.98	0.4018	0.4119	-0.0101	-2.452	-0.404
	0.0941	66.44	0.0951	0.1027	-0.0076	-7.400	-0.304
	0.0295	68.94	0.0301	0.0400	-0.0099	-24.750	-0.396
8/25/88	2.3808	33.44	2.3680	2.3816	-0.0136	-0.571	-0.544
	1.2088	32.26	1.2021	1.2099*	-0.0078	-0.645	-0.312
	0.4060	32.91	0.4037	0.4111	-0.0074	-1.800	-0.296
	0.0941	32.78	0.0948	0.0992	-0.0044	-4.435	-0.176
	0.0295	32.65	0.0300	0.0403	-0.0103	-25.558	-0.412
	2.3808	54.71	2.3559	2.3691	-0.0132	-0.557	-0.528
	1.2088	52.88	1.1970	1.2023	-0.0053	-0.441	-0.212
	0.4060	53.89	0.4015	0.4090	-0.0075	-1.834	-0.300
	0.0941	52.68	0.0968	0.1012	-0.0044	-4.348	-0.176
	0.0295	52.68	0.0300	0.0382	-0.0082	-21.466	-0.328
	2.3808	64.36	2.3529	2.3536	-0.0007	-0.030	-0.028
	1.2088	61.77	1.1970	1.1947	0.0023	0.193	0.092
	0.4060	62.94	0.4015	0.4046	-0.0031	-0.766	-0.124
	0.0941	62.01	0.0948	0.1012	-0.0064	-6.324	-0.256
	0.0295	62.24	0.0300	0.0382	-0.0082	-21.466	-0.328
8/31/88	2.3808	36.98	2.3706	2.3807	-0.0101	-0.424	-0.404
	1.6013	37.71	1.5936	1.6011	-0.0075	-0.468	-0.300
	0.9515	38.01	0.9453	0.9518	-0.0065	-0.683	-0.260
	0.4060	36.26	0.4048	0.4105	-0.0057	-1.389	-0.228
	0.0000	37.12	0.0020	0.0040	-0.0020	-50.000	-0.080
	2.3808	52.09	2.3615	2.3621	-0.0006	-0.025	-0.024
	1.6013	51.30	1.5882	1.5875	0.0007	0.044	0.028
	0.9515	51.50	0.9429	0.9445	-0.0016	-0.169	-0.064
	0.4060	52.29	0.4004	0.3996	0.0008	0.200	0.032
	0.0000	53.69	0.0000	0.0000	0.0000	0.000	0.000
	2.3808	92.42	2.3494	2.3590	-0.0096	-0.407	-0.384
	1.6013	90.78	1.5801	1.5875	-0.0074	-0.466	-0.296
	0.9516	90.14	0.9356	0.9396	-0.0040	-0.426	-0.160
	0.4060	91.44	0.3983	0.4018	-0.0035	-0.871	-0.140
	0.0000	92.42	0.0020	0.0079	-0.0059	-74.684	-0.236
8/12/88 Calibration Data	2.3803	0.00	2.3798	2.3802	-0.0004	-0.017	-0.016
	1.9123	0.00	1.9125	1.9128	-0.0003	-0.016	-0.012
	1.6013	0.00	1.6014	1.6010	0.0004	0.025	0.016
	1.2088	0.00	1.2098	1.2088	0.0010	0.083	0.040
	0.9515	0.00	0.9510	0.9489	0.0021	0.221	0.084
	0.7991	0.00	0.7975	0.8024	-0.0049	-0.611	-0.196
	0.4959	0.00	0.4967	0.4955	0.0012	0.242	0.048
	0.4060	0.00	0.4061	0.4057	0.0004	0.099	0.016
8/18/88 Calibration Data	2.3803	0.00	2.3793	2.3814	-0.0021	-0.088	-0.084
	1.9123	0.00	1.9141	1.9128	0.0013	0.068	0.052
	1.6013	0.00	1.6002	1.5958	0.0044	0.276	0.176
	1.2088	0.00	1.2100	1.2125	-0.0025	-0.206	-0.100
	0.9515	0.00	0.9501	0.9532	-0.0031	-0.325	-0.124
	0.7991	0.00	0.7984	0.7975	0.0009	0.113	0.036
	0.4959	0.00	0.4967	0.4981	-0.0014	-0.281	-0.056
	0.4060	0.00	0.4060	0.4038	0.0022	0.545	0.088

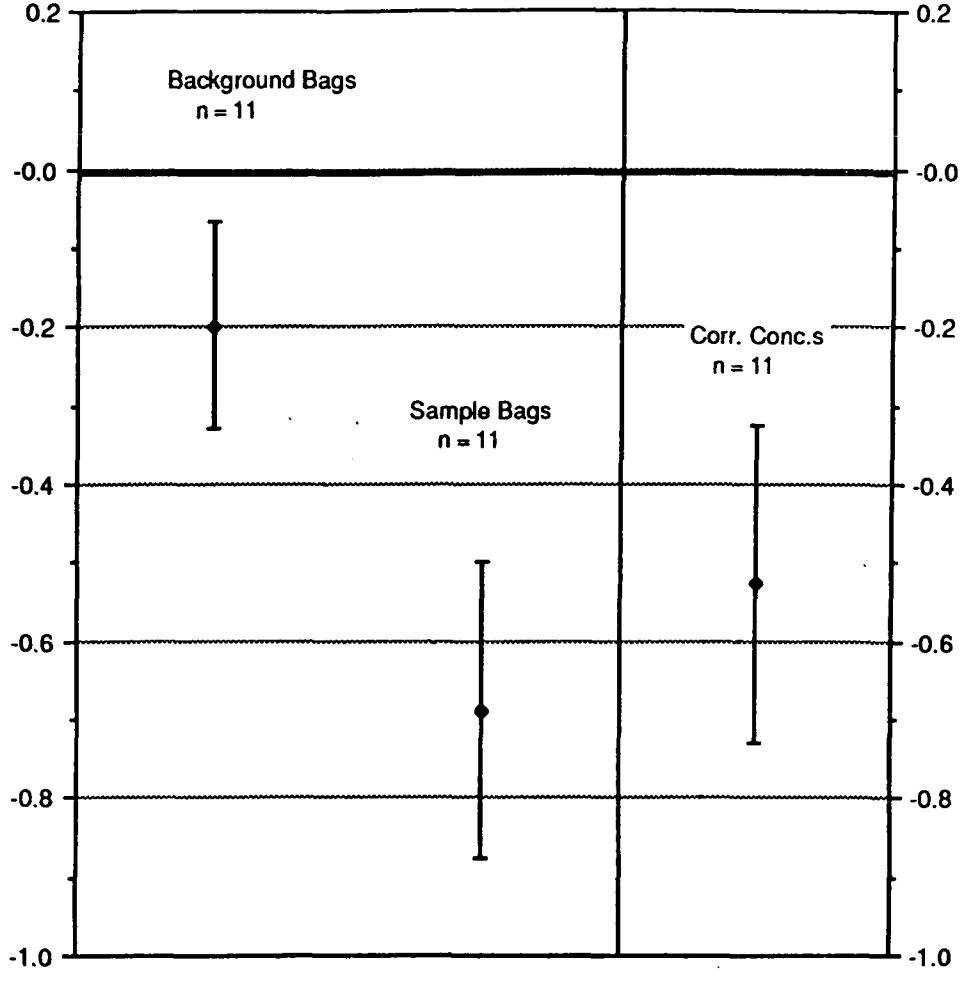
% pt. Diff. = [(H - M) / M] x 100
%F.S. Diff. = [(H - M) / 2.5] x 100

CO2 Comparison Equipment Set-Up



Means & 95% C.I.s for Vehicle Bag CO2 Diff.s

% (of sample pt.) Diff. (see below)



% pt. Difference (see below)

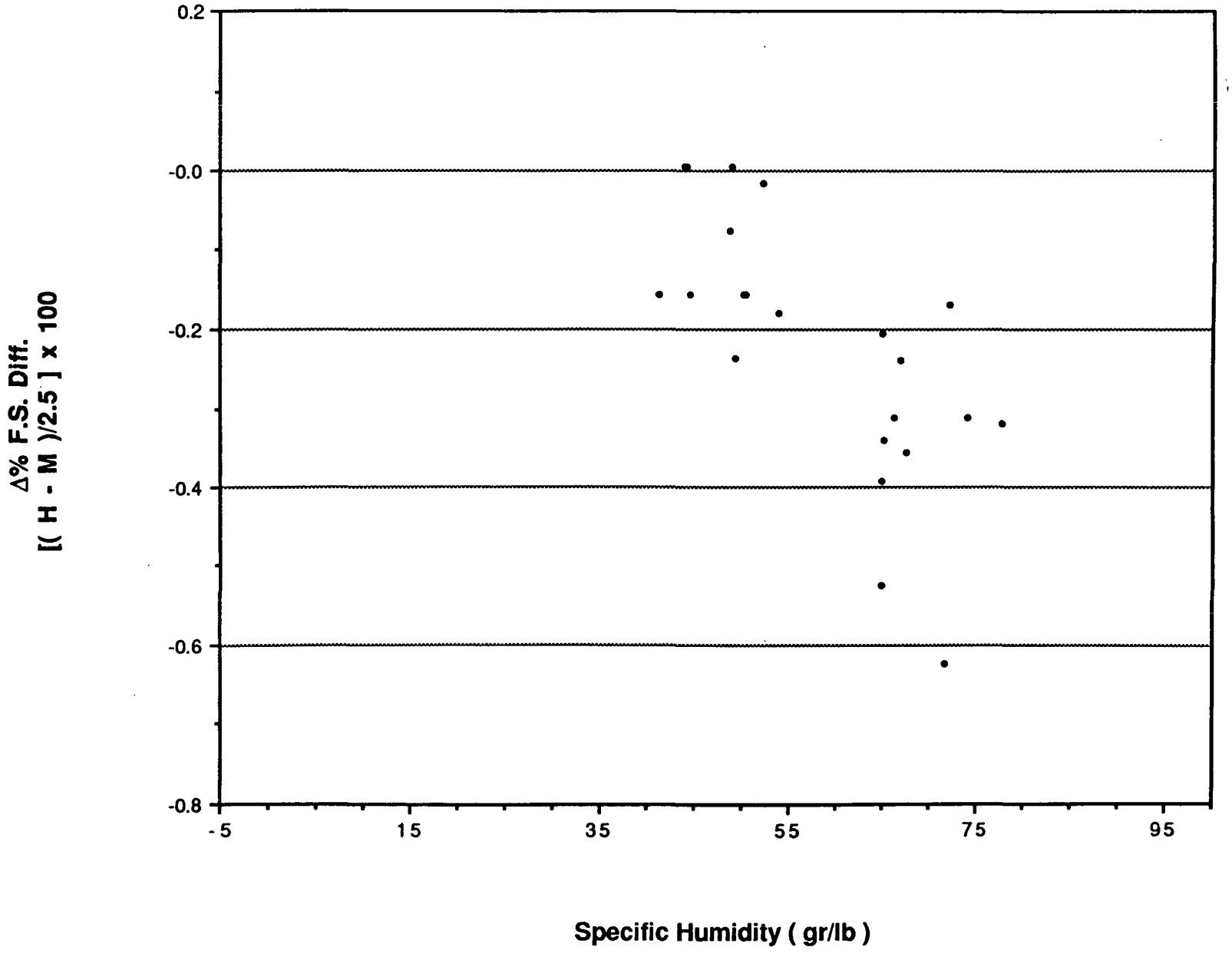
ATTACHMENT K

Background %Sam Diff. = [(H_D - M_D) / M_S] x 100

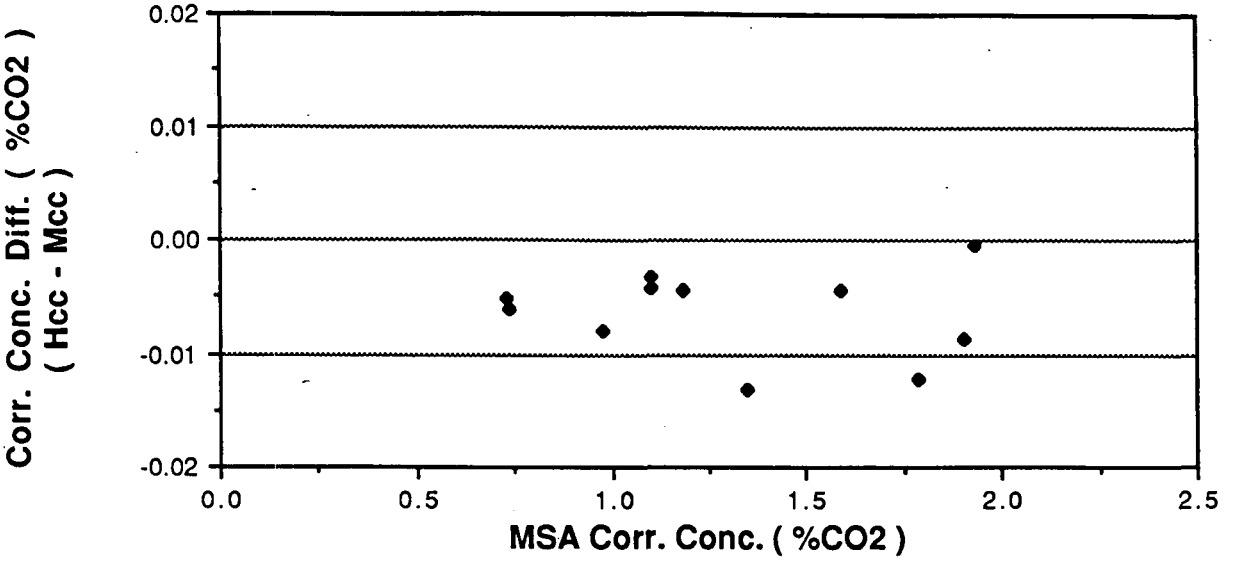
Sample %Sam Diff. = [(H_S - M_S) / M_S] x 100

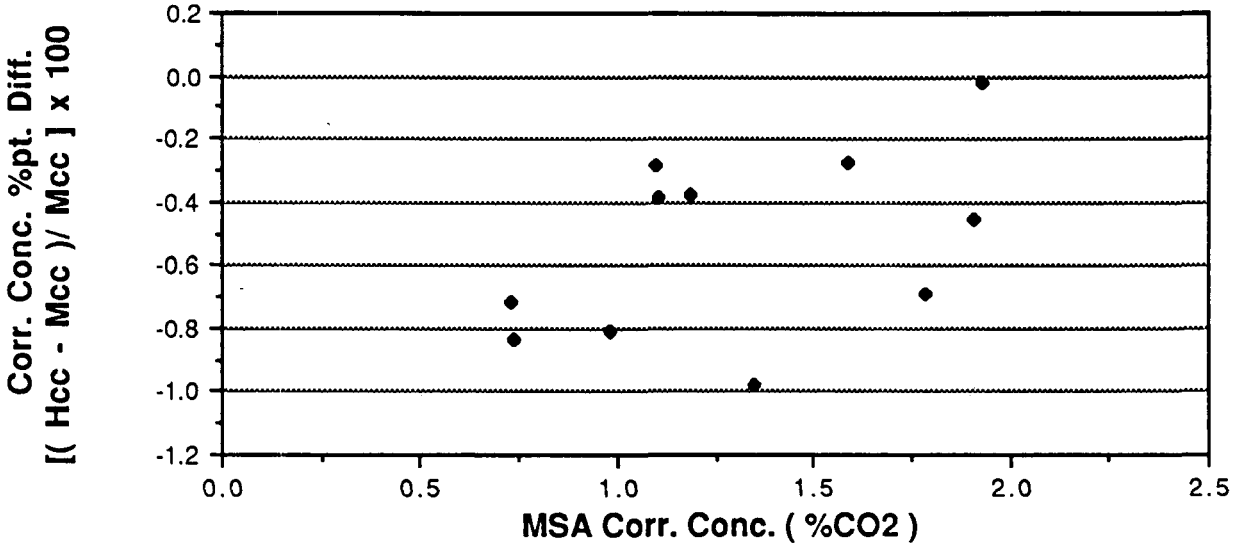
Corr. Conc. %pt. Diff. = [(H_{CC} - M_{CC}) / M_{CC}] x 100

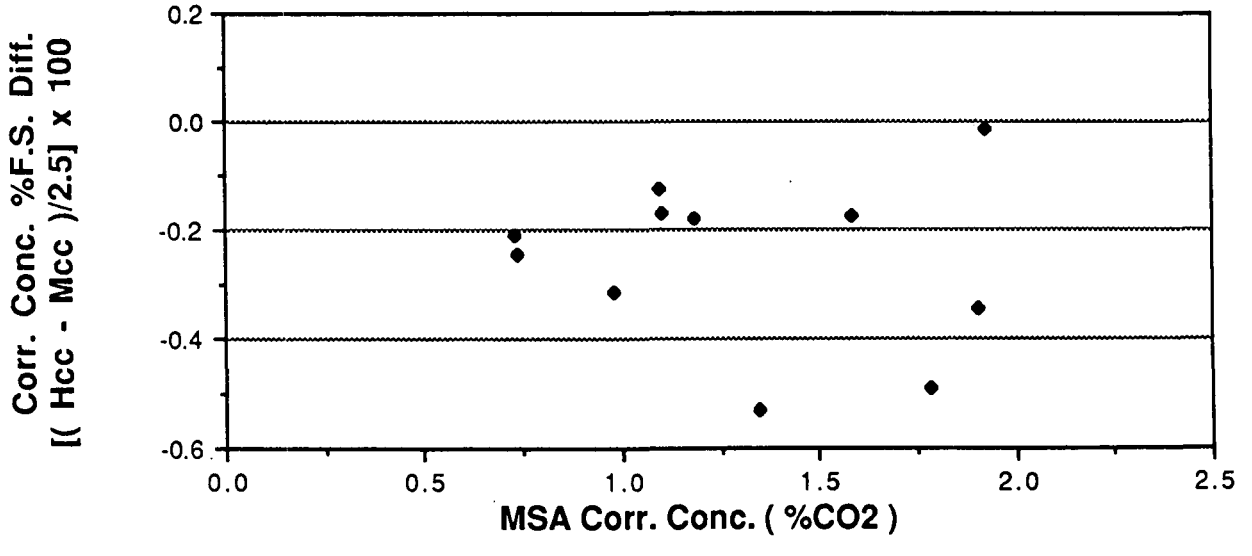
Vehicle Bag CO2 Differences



Corrected Concentration Differences
HORIBA - MSA







Test Date	Test Type	Bag	HORIBA Conc. H (%CO2)	MSA Conc. M (%CO2)	Specific Humidity SH (gr/lb)	HORIBA Dilution Factor DFh (see below)	MSA Dilution Factor DFm	Hor-MSA Difference H - M (%CO2)	Hor-MSA Difference H - M (ppm)	Backgrnd %F.S. Diff see below (%FS R23)	Backgrnd %Sam Diff see below (%MSA Sam)	Sample %FS Diff see below (%FS R23)	Sample %Sam Diff see below (%MSA Sam)	HORIBA Corr.Conc. Hcc see below (%CO2)	MSA Corr.Conc. Mcc see below (%CO2)	Corr. Conc. %FS Diff see below (%FS R23)	Corr. Conc. %pt. Diff see below (%MSA CC)
8/16/88	2-bag LA-4	B1	0.0378	0.0377	43.985	9.80	9.70	0.0001	1.00	0.0040	0.0072			1.3341	1.3473	-0.5291	-0.9817
	Van	S1	1.3680	1.3811	64.928			-0.0131	-131.00			-0.5240	-0.9485				
		B2	0.0398	0.0397	44.160	13.31	13.21	0.0001	1.00	0.0040	0.0099			0.9698	0.9777	-0.3166	-0.8096
		S2	1.0066	1.0144	66.386			-0.0078	-78.00			-0.3120	-0.7689				
8/25/88	2-bag LA-4	B1	0.1440	0.1485	53.963	6.54	6.52	-0.0045	-45.00	-0.1800	-0.2191			1.9277	1.9282	-0.0174	-0.0226
	REPCA	S1	2.0497	2.0539	72.163			-0.0042	-42.00			-0.1680	-0.2045				
		B2	0.1152	0.1156	52.154	6.72	6.69	-0.0004	-4.00	-0.0160	-0.0200			1.8970	1.9056	-0.3455	-0.4532
		S2	1.9950	2.0039	67.534			-0.0089	-89.00			-0.3560	-0.4441				
8/31/88	2-bag LA-4	B1	0.0339	0.0358	48.710	11.88	11.81	-0.0019	-19.00	-0.0760	-0.1675			1.0974	1.1016	-0.1710	-0.3882
	REPCA	S1	1.1284	1.1344	67.008			-0.0060	-60.00			-0.2400	-0.5289				
		B2	0.0359	0.0358	48.896	17.66	17.54	0.0001	1.00	0.0040	0.0131			0.7248	0.7300	-0.2083	-0.7134
		S2	0.7587	0.7638	65.099			-0.0051	-51.00			-0.2040	-0.6677				
	2-bag LA-4	B1	0.0339	0.0398	49.287	11.90	11.81	-0.0059	-59.00	-0.2360	-0.5201			1.0948	1.0980	-0.1248	-0.2843
	REPCA	S1	1.1259	1.1344	65.320			-0.0085	-85.00			-0.3400	-0.7493				
		B2	0.0339	0.0378	50.426	17.61	17.38	-0.0039	-39.00	-0.1560	-0.5060			0.7290	0.7352	-0.2460	-0.8364
		S2	0.7610	0.7708	65.078			-0.0098	-98.00			-0.3920	-1.2714				
	Hwy	B3	0.0339	0.0378	50.218	7.44	7.38	-0.0039	-39.00	-0.1560	-0.2148			1.7709	1.7831	-0.4907	-0.6880
	REPCA	S3	1.8002	1.8158	71.831			-0.0156	-156.00			-0.6240	-0.8591				
9/23/88	2-bag LA-4	B1	0.0359	0.0398	44.532	8.30	8.26	-0.0039	-39.00	-0.1560	-0.2403			1.5837	1.5881	-0.1757	-0.2766
	W. Nova	S1	1.6153	1.6231	74.199			-0.0078	-78.00			-0.3120	-0.4806				
		B2	0.0359	0.0398	41.212	11.06	10.98	-0.0039	-39.00	-0.1560	-0.3197			1.1793	1.1838	-0.1791	-0.3781
		S2	1.2120	1.2200	77.801			-0.0080	-80.00			-0.3200	-0.6557				
										STD DEV 0.0880	STD DEV 0.1945	STD DEV 0.1331	STD DEV 0.2848			STD DEV 0.1541	STD DEV 0.2943
										AVERAGE -0.1018	AVERAGE -0.1979	AVERAGE -0.3447	AVERAGE -0.6890			AVERAGE -0.2549	AVERAGE -0.5302
										95% C.I. (-.04,-.16)	95% C.I. (-.07,-.33)	95% C.I. (-.26,-.43)	95% C.I. (-.50,-.88)			95% C.I. (-.15,-.36)	95% C.I. (-.33,-.73)

Background %F.S. Diff. = $[(H_b - M_b) / 2.5] \times 100$

Background %Sam Diff. = $[(H_b - M_b) / M_s] \times 100$

Sample %F.S. Diff. = $[(H_s - M_s) / 2.5] \times 100$

Sample %Sam Diff. = $[(H_s - M_s) / M_s] \times 100$

Horiba Corr. Conc. (H_{cc}) = $H_s - H_b(1 - 1/DF)$

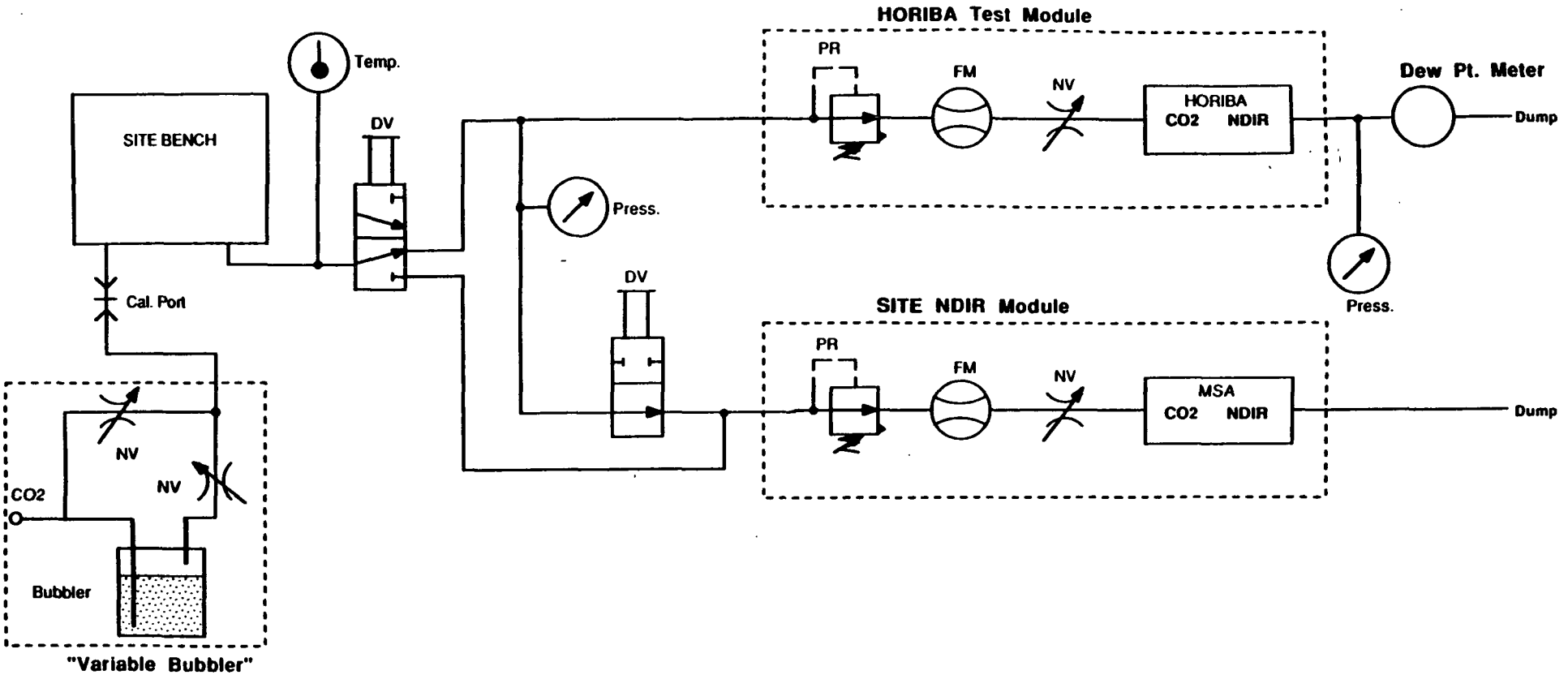
MSA Corr. Conc. (M_{cc}) = $M_s - M_b(1 - 1/DF)$

Corr. Conc. %F.S. Diff. = $[(H_{cc} - M_{cc}) / 2.5] \times 100$

Corr. Conc. %pt. Diff. = $[(H_{cc} - M_{cc}) / M_{cc}] \times 100$

Dilution Factor (for study) = 13.4 / %CO2

CO_2 Comparison Equipment Set-Up



Test Date	Test Type	Bag	HORIBA Conc. H (%CO2)	MSA Conc. M (%CO2)	Specific Humidity SH (gr/lb)	X-T calc from Regr. Formula K (Δ %CO2)	HORIBA Corr. for "K" Hc = H-K (%CO2)	Corr.for K HORIBA Dilution Factor DFh	MSA Dilution Factor DFm	Corr. for K Hor-MSA Difference Hc - M (%CO2)	Corr.for K Hor-MSA Difference Hc - M (ppm)	Corr.for K Backgrnd %F.S. Diff see below (%FS R23)	Corr.for K Backgrnd %Sam Diff see below (%MSA Samp)	Corr.for K Sample %FS Diff see below (%FS R23)	Corr.for K Sample %Sam Diff see below (%MSA Samp)	Corr.for K HORIBA Corr.Conc. Hcc see below (%CO2)	Corr.for K MSA Corr.Conc. Mcc see below (%CO2)	Corr.for K Corr. Conc. %FS Diff see below (%FS R23)	Corr.for K Corr. Conc. %pt. Diff see below (%MSA CC)
8/18/88	2-bag LA-4	B1	0.0378	0.0377	43.985	-0.00351660	0.04131660	9.76	9.70	0.0036	36.17	0.1447	0.2619			1.3361	1.3473	-0.4471	-0.8296
	Van	S1	1.3680	1.3811	64.928	-0.00519099	1.37319099			-0.0079	-79.09			-0.3164	-0.5727				
		B2	0.0398	0.0397	44.160	-0.00353059	0.04333059	13.24	13.21	0.0036	36.31	0.1452	0.3579			0.9718	0.9777	-0.2342	-0.5990
		S2	1.0066	1.0144	66.386	-0.00530756	1.01190756			-0.0025	-24.92			-0.0997	-0.2457				
8/25/88	2-bag LA-4	B1	0.1440	0.1485	53.963	-0.00431434	0.14831434	6.52	6.52	-0.0002	-1.86	-0.0074	-0.0090			1.9299	1.9282	0.0698	0.0904
	REPCA	S1	2.0497	2.0539	72.163	-0.00576943	2.05546943			0.0016	15.69			0.0628	0.0764				
		B2	0.1152	0.1158	52.154	-0.00416971	0.11936971	6.70	6.69	0.0038	37.70	0.1508	0.1881			1.8988	1.9056	-0.2695	-0.3536
		S2	1.9950	2.0039	67.534	-0.00539934	2.00039934			-0.0035	-35.01			-0.1400	-0.1747				
8/31/88	2-bag LA-4	B1	0.0339	0.0358	48.710	-0.00389436	0.03779436	11.82	11.81	0.0020	19.94	0.0798	0.1758			1.0992	1.1016	-0.0988	-0.2242
	REPCA	S1	1.1284	1.1344	67.008	-0.00535729	1.13375729			-0.0006	-6.43			-0.0257	-0.0567				
		B2	0.0359	0.0358	48.896	-0.00390924	0.03980924	17.54	17.54	0.0040	40.09	0.1604	0.5249			0.7264	0.7300	-0.1470	-0.5035
		S2	0.7587	0.7638	65.099	-0.00520467	0.76390467			0.0001	1.05			0.0042	0.0137				
	2-bag LA-4	B1	0.0339	0.0398	49.287	-0.00394050	0.03784050	11.85	11.81	-0.0020	-19.60	-0.0784	-0.1727			1.0965	1.0980	-0.0597	-0.1360
	REPCA	S1	1.1259	1.1344	65.320	-0.00522233	1.13112233			-0.0033	-32.78			-0.1311	-0.2889				
		B2	0.0339	0.0378	50.426	-0.00403156	0.03793156	17.49	17.38	0.0001	1.32	0.0053	0.0171			0.7304	0.7352	-0.1894	-0.6439
		S2	0.7610	0.7708	65.078	-0.00520299	0.76620299			-0.0046	-45.97			-0.1839	-0.5964				
	Hwy	B3	0.0339	0.0378	50.218	-0.00401493	0.03791493	7.42	7.38	0.0001	1.15	0.0046	0.0063			1.7731	1.7831	-0.3994	-0.5599
	REPCA	S3	1.8002	1.8158	71.831	-0.00574289	1.80594289			-0.0099	-98.57			-0.3943	-0.5429				
9/23/88	2-bag LA-4	B1	0.0359	0.0398	44.532	-0.00356033	0.03946033	8.27	8.26	-0.0003	-3.40	-0.0136	-0.0209			1.5865	1.5881	-0.0630	-0.0992
	W. Nova	S1	1.6153	1.6231	74.199	-0.00593221	1.62123221			-0.0019	-18.68			-0.0747	-0.1151				
		B2	0.0359	0.0398	41.212	-0.00329490	0.03919490	11.00	10.98	-0.0006	-6.05	-0.0242	-0.0496			1.1826	1.1838	-0.0494	-0.1043
		S2	1.2120	1.2200	77.801	-0.00622019	1.21822019			-0.0018	-17.80			-0.0712	-0.1459				
												STD DEV 0.0864	STD DEV 0.2056	STD DEV 0.1344	STD DEV 0.2364			STD DEV 0.1565	STD DEV 0.2870
												AVERAGE 0.0516	AVERAGE 0.1163	AVERAGE -0.1245	AVERAGE -0.2408			AVERAGE -0.1716	AVERAGE -0.3603
												95% C.I. (.11,-.01)	95% C.I. (.25,-.04)	95% C.I. (-.03,-.22)	95% C.I. (-.07,-.41)			95% C.I. (-.06,-.28)	95% C.I. (-.15,-.55)

ATTACHMENT L

Background %F.S. Diff. = $[(H_b - M_b) / 2.5] \times 100$

Background %Sam Diff. = $[(H_b - M_b) / M_s] \times 100$

Sample %F.S. Diff. = $[(H_s - M_s) / 2.5] \times 100$

Sample %Sam Diff. = $[(H_s - M_s) / M_s] \times 100$

Horiba Corr. Conc. (H_{cc}) = $H_s - H_b(1 - 1/DF)$

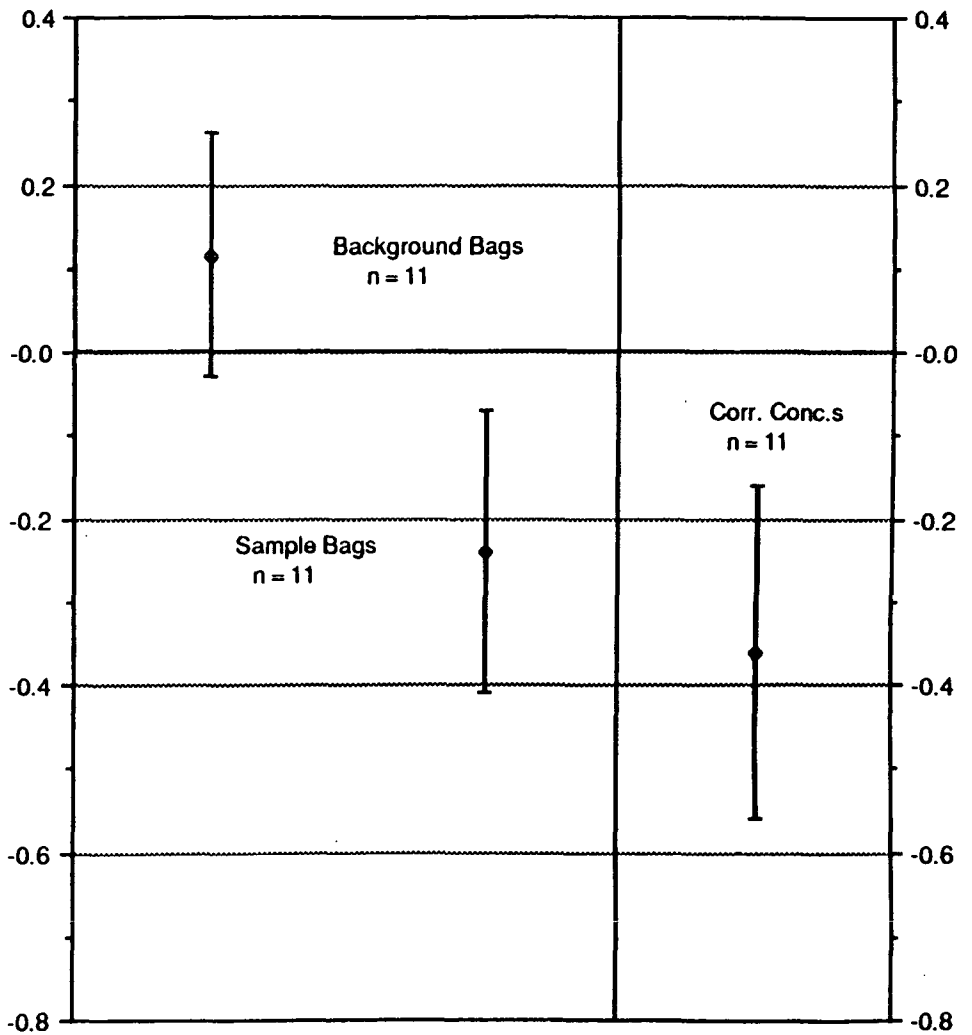
MSA Corr. Conc. (M_{cc}) = $M_s - M_b(1 - 1/DF)$

Corr. Conc. %F.S. Diff. = $[(H_{cc} - M_{cc}) / 2.5] \times 100$

Corr. Conc. %pt. Diff. = $[(H_{cc} - M_{cc}) / M_{cc}] \times 100$

Dilution Factor (for study) = 13.4 / %CO2

Means & 95% C.I.s for Vehicle Bag CO2 Diff.s (corr. for H2O vapor)



% (of sample pt.) Diff. (see below)

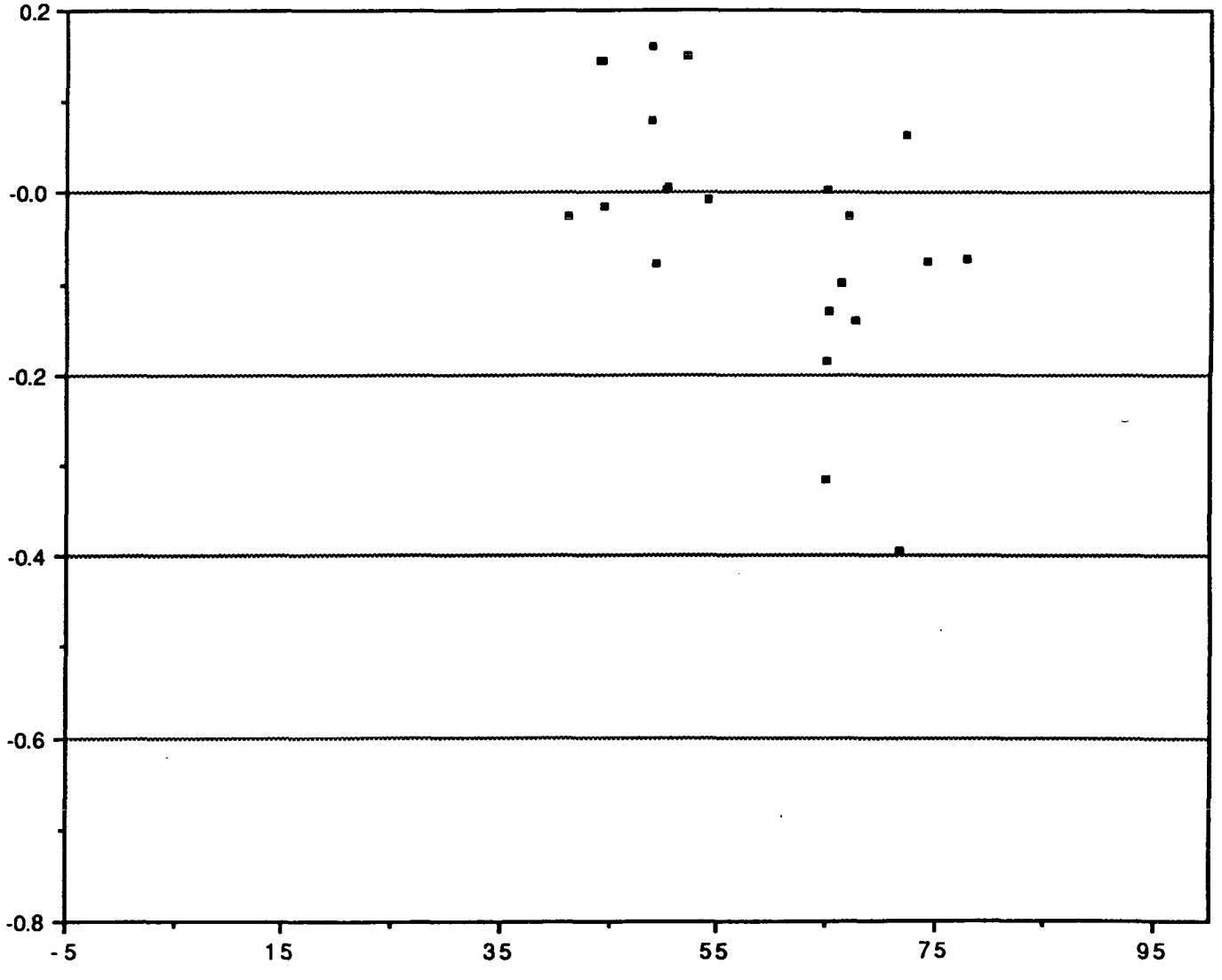
% pt. Difference (see below)

Background %Sam Diff. = $[(H_b - M_b) / M_s] \times 100$

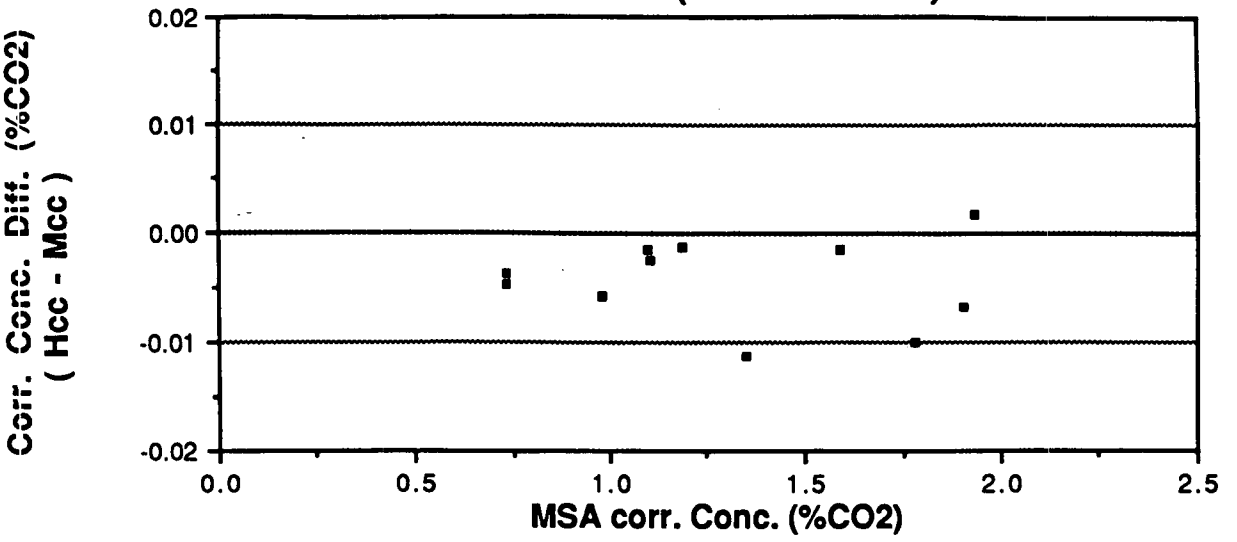
Sample %Sam Diff. = $[(H_s - M_s) / M_s] \times 100$

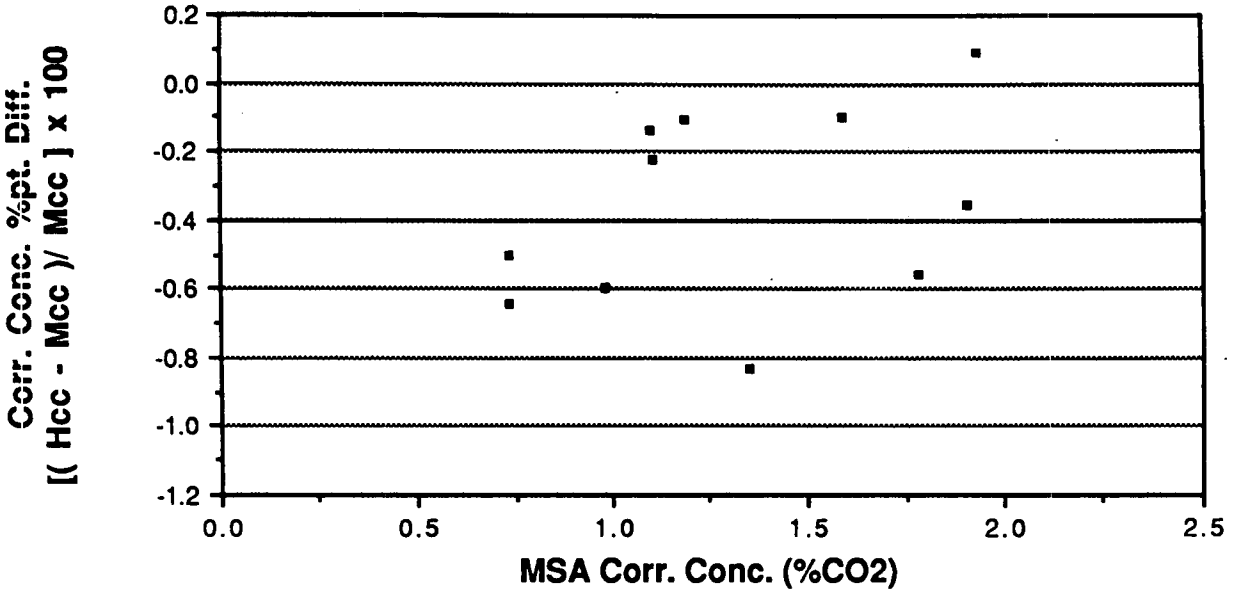
Corr. Conc. %pt. Diff. = $[(H_{cc} - M_{cc}) / M_{cc}] \times 100$

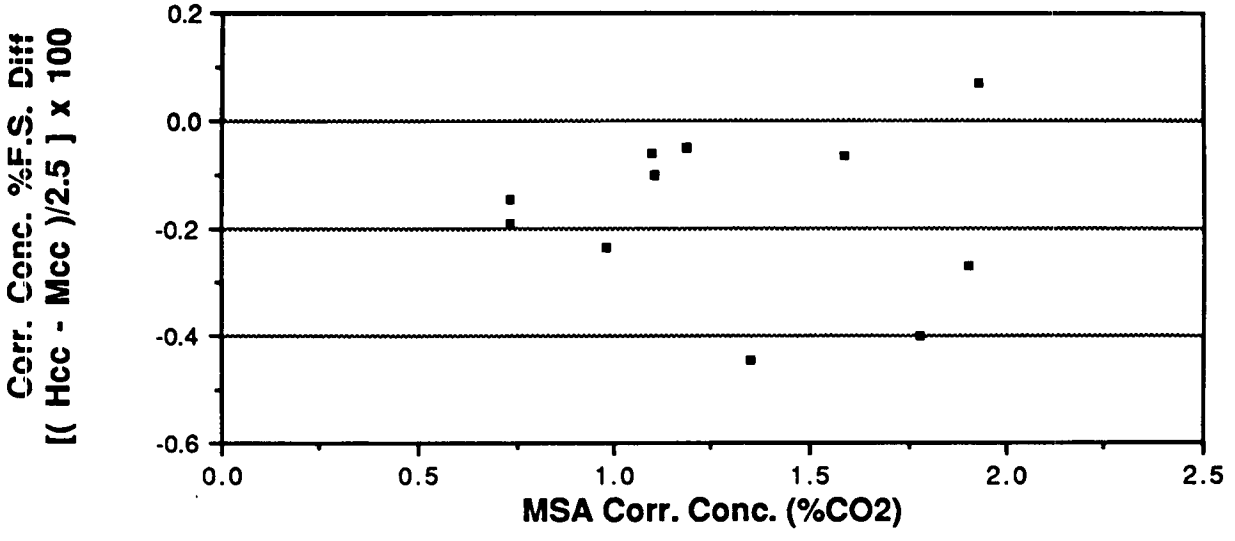
Vehicle Exhaust Bag
CO2 Differences
Corrected for H2O Vapor



Corrected Concentration CO2 Differences
HORIBA - MSA (Corr. for "K")







EQUIPMENT ID #	789463	***	***
CALIBRATION NAME	CO2A-CR22	***	ANALYZER CALIBRATION CURVE ANALYSIS ***
CALIBRATION #	880811-104630	***	***
TEST SITE	A251	**********	**********
CALIB DONE AT	14:12 08-10-88		
OPERATOR COMMENT	EPA-MSA-R22-BLINE		

AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
155139	#1	#1	CURVE	95.40	0.9515	#1
33470	#1	#1	CURVE	81.40	0.7991	#1
163287	#1	#1	CURVE	71.40	0.6925	#1
B1103	#1	#1	CURVE	61.90	0.5947	#1
B442	#1	#1	CURVE	52.10	0.4959	#1
B1575	#1	#1	CURVE	43.00	0.4060	#1
B916	#1	#1	CURVE	25.30	0.2344	#1
337743	#1	#1	CURVE	15.10	0.1396	#1
B2386	#1	#1	NAMED	97.00	0.9696	#1
B2211	#1	#1	NAMED	81.70	0.8017	#1
B1454	#1	#1	NAMED	74.40	0.7260	#1
A-221	#1	#1	NAMED	61.30	0.5900	#1
B1184	#1	#1	NAMED	50.60	0.4812	#1
157656	#1	#1	NAMED	38.90	0.3647	#1
286591	#1	#1	NAMED	27.30	0.2550	#1
065369	#1	#1	NAMED	13.80	0.1282	#1
244214	#1	#1	NAMED	10.60	0.0941	#1
391539	#1	#1	NAMED	6.60	0.0606	#1
66207	#1	#1	NAMED	3.20	0.0295	#1

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y XPOINT (M-C)/C
95.40	0.9516	0.01
81.40	0.7987	-0.05
71.40	0.6929	0.06
61.90	0.5947	0.01
52.10	0.4957	-0.04
43.00	0.4057	-0.08
25.30	0.2351	0.30
15.10	0.1392	0.27
MEAN OF (ABS Z) =		0.10
97.00	0.9694	-0.02
81.70	0.8020	0.03
74.40	0.7244	-0.22
61.30	0.5886	-0.24
50.60	0.4808	-0.09
38.90	0.3656	0.26
27.30	0.2541	-0.36
13.80	0.1271	-0.85
10.60	0.0974	3.41
6.60	0.0605	-0.18
3.20	0.0293	-0.81

SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y XSHIFT (S-C)/C
#4	#4	#4
#4	#4	#4
#4	#4	#4
#4	#4	#4
#4	#4	#4
#4	#4	#4
#4	#4	#4
#4	#4	#4
	#1	#1
	#1	#1
	#1	#1
	#1	#1
	#1	#1
	#1	#1
	#1	#1
	#1	#1
	#1	#1
	#1	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #4: NO PREVIOUS ANALYZER CALIBRATION ON FILE IN THE EFS.
NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

MCAL= 1.0000 BCAL= 0.000 MS = BS =
CFC=1 ZST=1 WFC=2 DGF=3 CFC= ZST= WFC= DGF=
NEW.CALIB.NO= 880811-104630 PRV.CALIB.NO= -
%NL= 2.669 #INF= 0 - -

--- EFF D/T --- INEFF D/T -

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.9126383E-02
A3 = 0.5725509E-05
A4 = 0.3321407E-07
A5 = 0.0000000E 00

C

ATTACHMENT M

PROD PROCESSED : 10:54:51 08-11-88 ******** M A S T E R S I T E ********
Y EQUIPMENT ID # : 789463 ***
CALIBRATION NAME: CO2A-CR22 *** ANALYZER CALIBRATION CURVE ANALYSIS ***
CALIBRATION # : 880811-105451 ***
TEST SITE : A251 **********
CALIB DONE AT : 14:12 08-10-88
OPERATOR COMMENT: EPA-MSA-R22-BLINE

AAAAA 22222 5555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS							CURVE COMPARISONS					
EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE	FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
B2386	#1	#1	CURVE	97.00	0.9696	#1	97.00	0.9700	0.04	#4	#4	#4
B2211	#1	#1	CURVE	81.70	0.8017	#1	81.70	0.8023	0.07	#4	#4	#4
B1454	#1	#1	CURVE	74.40	0.7260	#1	74.40	0.7247	-0.18	#4	#4	#4
A-221	#1	#1	CURVE	61.30	0.5900	#1	61.30	0.5891	-0.15	#4	#4	#4
B1184	#1	#1	CURVE	50.60	0.4812	#1	50.60	0.4814	0.04	#4	#4	#4
157656	#1	#1	CURVE	38.90	0.3647	#1	38.90	0.3664	0.46	#4	#4	#4
286591	#1	#1	CURVE	27.30	0.2550	#1	27.30	0.2548	-0.06	#4	#4	#4
065369	#1	#1	CURVE	13.80	0.1282	#1	13.80	0.1277	-0.41	#4	#4	#4
							MEAN OF (ABS %) :		0.18			
155139	#1	#1	NAMED	95.40	0.9515	#1	95.40	0.9521	0.06		#1	#1
33470	#1	#1	NAMED	81.40	0.7991	#1	81.40	0.7991	-0.00		#1	#1
163287	#1	#1	NAMED	71.40	0.6925	#1	71.40	0.6933	0.11		#1	#1
B1103	#1	#1	NAMED	61.90	0.5947	#1	61.90	0.5952	0.09		#1	#1
B442	#1	#1	NAMED	52.10	0.4959	#1	52.10	0.4963	0.08		#1	#1
B1575	#1	#1	NAMED	43.00	0.4060	#1	43.00	0.4064	0.09		#1	#1
B916	#1	#1	NAMED	25.30	0.2344	#1	25.30	0.2358	0.61		#1	#1
337743	#1	#1	NAMED	15.10	0.1396	#1	15.10	0.1398	0.16		#1	#1
244214	#1	#1	NAMED	10.60	0.0941	#1	10.60	0.0979	3.87		#1	#1
391539	#1	#1	NAMED	6.60	0.0606	#1	6.60	0.0608	0.35		#1	#1
66207	#1	#1	NAMED	3.20	0.0295	#1	3.20	0.0294	-0.23		#1	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #4: NO PREVIOUS ANALYZER CALIBRATION ON FILE IN THE EFS.
NOTE #1: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

MCAL= 1.0000 BCAL= 0.000 | MS = BS =
CFC=1 ZST=1 WFC=2 DGF=3 | CFC= ZST= WFC= DGF=
NEW.CALIB.NO= 880811-105451 | PRV.CALIB.NO= -
%NL= 2.637 #INF= 0 | - -
--- EFF D/T --- INEFF D/T -

MOTOR CODE : 2
DEGREE FIT : 3

EQUATIONS AND COEFFICIENTS
****

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.9182639E-02
A3 = 0.4470880E-05
A4 = 0.4077645E-07

C

PROD					
Y	PROCESSED : 09:05:10 08-11-88	******** MASTER SITE ********		AAAAA 22222 555555 11	
	EQUIPMENT ID # : 789433	***	***	AA AA 22 22 55 111	
	CALIBRATION NAME: CO2A-CR23	*** ANALYZER CALIBRATION CURVE ANALYSIS ***		AA AA 22 55 1111	
	CALIBRATION # : 880811-090510	***	***	AA AA 22 555555 11	
	TEST SITE : A251	**********		AAAAAAA 22 55 11	
	CALIB DONE AT : 09:05 08-10-88			AA AA 222 2 55 55 11	
	OPERATOR COMMENT: EPA-MSA-R23-BLINE			AA AA 2222222 55555 11111	

KNOWN OR MEASURED INPUTS

I	EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE	I
I	B16660	#1	#1	CURVE	95.30	2.3803	#1	I
I	146293	#1	#1	CURVE	79.70	1.9123	#1	I
I	B752	#1	#1	CURVE	68.60	1.6013	#1	I
I	B180	#1	#1	CURVE	53.70	1.2088	#1	I
I	155139	#1	#1	CURVE	43.40	0.9515	#1	I
I	33470	#1	#1	CURVE	36.90	0.7991	#1	I
I	B442	#1	#1	CURVE	23.80	0.4959	#1	I
I	B1575	#1	#1	CURVE	19.40	0.4060	#1	I
I								I
I								I
I	368730	#1	#1	NAMED	96.50	2.4120	#1	I
I	343923	#1	#1	NAMED	78.30	1.8730	#1	I
I	262947	#1	#1	NAMED	68.80	1.6050	#1	I
I	B17780	#1	#1	NAMED	53.60	1.2060	#1	I
I	B2386	#1	#1	NAMED	44.00	0.9696	#1	I
I	B2211	#1	#1	NAMED	37.00	0.8017	#1	I
I	B1184.	#1	#1	NAMED	23.00	0.4812	#1	I
I	157656	#1	#1	NAMED	17.60	0.3647	#1	I
I	244214	#1	#1	NAMED	4.80	0.0941	#1	I
I	391539	#1	#1	NAMED	2.90	0.0606	#1	I
I	66207	#1	#1	NAMED	1.90	0.0295	#1	I

CURVE COMPARISONS

I	FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y %POINT (M-C)/C	I	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
I	95.30	2.3805	0.01	I	95.50	2.3805	-0.00
I	79.70	1.9125	0.01	I	79.72	1.9275	0.79
I	68.60	1.6008	-0.03	I	68.49	1.6207	1.24
I	53.70	1.2081	-0.06	I	53.42	1.2282	1.66
I	43.40	0.9527	0.13	I	43.00	0.9693	1.74
I	36.90	0.7978	-0.16	I	36.42	0.8110	1.65
I	23.80	0.4995	0.72	I	23.17	0.5032	0.75
I	19.40	0.4032	-0.69	I	18.72	0.4032	-0.00
I	MEAN OF (ABS %) =		0.23	I	MEAN OF (ABS %) =		0.98
I				I			
I	96.50	2.4180	0.25	I		#1	#1
I	78.30	1.8723	-0.04	I		#1	#1
I	68.80	1.6063	0.08	I		#1	#1
I	53.60	1.2056	-0.03	I		#1	#1
I	44.00	0.9672	-0.24	I		#1	#1
I	37.00	0.8002	-0.19	I		#1	#1
I	23.00	0.4819	0.14	I		#1	#1
I	17.60	0.3644	-0.09	I		#1	#1
I	4.80	0.0967	2.69	I		#1	#1
I	2.90	0.0582	-4.13	I		#1	#1
I	1.90	0.0381	22.47	I		#1	#1

MCAL= 1.0000	BCAL= 0.000	MS = 1.0116	BS = -0.905
CFC=1 ZST=1	WFC=2 DGF=3	CFC=1 ZST=1	WFC=2 DGF=3
NEW.CALIB.NO= 880811-090510		PRV.CALIB.NO= 880809-165450	
%NL= 5.909	#INF= 0	880809-170322 995 ACTIVE	
		--- EFF D/T ---	INEFF D/T -

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1994883E-01
A3 = 0.4060335E-04
A4 = 0.1277533E-06
A5 = 0.0000000E 00

C

PROD PROCESSED : 09:12:49 08-11-88
Y EQUIPMENT ID # : 789433
CALIBRATION NAME: CO2A-CR23
CALIBRATION # : 880811-091249
TEST SITE : A251
CALIB DONE AT : 09:05 08-10-88
OPERATOR COMMENT: EPA-NSA-R23-BLINE

******** M A S T E R S I T E ********
*** ***
*** ANALYZER CALIBRATION CURVE ANALYSIS ***
*** ***
****

AAAAA 22222 555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
368730	#1	#1	CURVE	96.50	2.4120	#1
343923	#1	#1	CURVE	78.30	1.8730	#1
262947	#1	#1	CURVE	68.80	1.6050	#1
B17780	#1	#1	CURVE	53.60	1.2060	#1
B2386	#1	#1	CURVE	44.00	0.9696	#1
B2211	#1	#1	CURVE	37.00	0.8017	#1
B1184	#1	#1	CURVE	23.00	0.4812	#1
157656	#1	#1	CURVE	17.60	0.3647	#1
B16660	#1	#1	NAMED	95.30	2.3803	#1
146293	#1	#1	NAMED	79.70	1.9123	#1
B752	#1	#1	NAMED	68.60	1.6013	#1
B180	#1	#1	NAMED	53.70	1.2088	#1
155139	#1	#1	NAMED	43.40	0.9515	#1
33470	#1	#1	NAMED	36.90	0.7991	#1
B442	#1	#1	NAMED	23.80	0.4959	#1
B1575	#1	#1	NAMED	19.40	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	2.90	0.0606	#1
66207	#1	#1	NAMED	1.90	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
96.50	2.4122	0.01	96.57	2.4122	0.00
78.30	1.8714	-0.08	78.21	1.8856	0.76
68.80	1.6068	0.11	68.62	1.6244	1.09
53.60	1.2068	0.07	53.29	1.2250	1.51
44.00	0.9684	-0.13	43.61	0.9842	1.63
37.00	0.8011	-0.08	36.54	0.8139	1.60
23.00	0.4821	0.19	22.42	0.4863	0.87
17.60	0.3644	-0.08	16.97	0.3644	-0.00
MEAN OF (ABS %) =		0.09	MEAN OF (ABS %) =		0.93
95.30	2.3751	-0.22		#1	#1
79.70	1.9114	-0.04		#1	#1
68.60	1.6013	0.00		#1	#1
53.70	1.2094	0.05		#1	#1
43.40	0.9538	0.24		#1	#1
36.90	0.7987	-0.05		#1	#1
23.80	0.4998	0.78		#1	#1
19.40	0.4033	-0.66		#1	#1
4.80	0.0966	2.57		#1	#1
2.90	0.0581	-4.28		#1	#1
1.90	0.0380	22.35		#1	#1

MCAL= 1.0000 BCAL= 0.000 | MS = 1.0088 BS = -0.782
CFC=1 ZST=1 WFC=2 DGF=3 | CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880811-091249 | PRV.CALIB.NO= 880809-165450
%NL= 5.733 #INF= 0 | 880809-170322 995 AC-TIVE
--- EFF D/T --- INEFF D/T -

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1991130E-01
A3 = 0.4345426E-04
A4 = 0.9577360E-07

C

```
X   EQUIPMENT ID #   :  789433            ###                                          ###     AA   AA  22   22  55          111
    CALIBRATION NAME :  CO2A-CR23         ### ANALYZER CALIBRATION CURVE ANALYSIS ###      AA   AA      22   55         1111
    CALIBRATION #    :  880816-090155     ###                                          ###     AA   AA     22     555555      11
    TEST SITE        :  A251              ###########################################      AAAAAAA    22          55      11
    CALIB DONE AT    :  09:05  08-11-88                                                        AA   AA  222   2  55   55      11
    OPERATOR COMMENT :  EPA-MSA-R23-WORK                                                       AA   AA  2222222   55555     11111
```

KNOWN OR MEASURED INPUTS							CURVE COMPARISONS: FIT QUALITY OF NEW CURVE			SHIFT FROM PREVIOUS CURVE		
EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE	DEFL XC	CONC YC	Y %POINT (M-C)/C	DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
D16660	#1	#1	CURVE	95.30	2.3803	#1	95.30	2.3788	-0.06	95.44	2.3788	-0.00
146293	#1	#1	CURVE	79.80	1.9123	#1	79.80	1.9140	0.09	79.78	1.9292	0.80
D752	#1	#1	CURVE	68.70	1.6013	#1	68.70	1.6025	0.07	68.56	1.6226	1.26
D180	#1	#1	CURVE	53.80	1.2088	#1	53.80	1.2103	0.12	53.50	1.2304	1.66
155139	#1	#1	CURVE	43.20	0.9515	#1	43.20	0.9479	-0.38	42.79	0.9643	1.73
33470	#1	#1	CURVE	36.90	0.7991	#1	36.90	0.7981	-0.13	36.42	0.8110	1.62
D442	#1	#1	CURVE	23.70	0.4959	#1	23.70	0.4978	0.38	23.08	0.5013	0.70
D1575	#1	#1	CURVE	19.50	0.4060	#1	19.50	0.4059	-0.02	18.84	0.4059	-0.00
							MEAN OF (ABS %) =		0.16	MEAN OF (ABS %) =		0.97
244214	#1	#1	NAMED	4.80	0.0941	#1	4.80	0.0969	2.93		#1	#1
391539	#1	#1	NAMED	3.00	0.0606	#1	3.00	0.0604	-0.38		#1	#1
66207	#1	#1	NAMED	1.60	0.0295	#1	1.60	0.0321	8.13		#1	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

New curve	Previous curve
MCAL= 1.0000 BCAL= 0.000	MS = 1.0105 BS = -0.865
CFC=1 ZST=1 WFC=2 DOF=3	CFC=1 ZST=1 WFC=2 DOF=3
NEW.CALIB.NO= 880816-090155	PRV.CALIB.NO= 880809-165450
%NL= 5.890 #INF= 0	880809-170322 995 AC-TIVE
	--- EFF D/T --- INEFF D/T -

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

EQUATIONS AND COEFFICIENTS
****

... FACTOR CODE : 2
DEGREE FIT : 3

$$X_C = (MCAL * X_M) + BCAL$$

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = \text{PCT } CO_2 / N_2$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

A1 = 0.0000000E 00
A2 = 0.2000664E-01
A3 = 0.3883405E-04
A4 = 0.1380222E-06
A5 = 0.0000000E 00

C

PROD PROCESSED : 09:08:35 08-16-88
X EQUIPMENT ID # : 789433
CALIBRATION NAME: CO2A-CR23
CALIBRATION # : 880816-090835
TEST SITE : A251
CALIB DONE AT : 09:05 08-12-88
OPERATOR COMMENT: EPA-MSA-R23-WORK

```
******** M A S T E R   S I T E ********
***                                  ***
*** ANALYZER CALIBRATION CURVE ANALYSIS ***
***                                  ***
*****************************************
```

```
 AAAAA    22222   5555555    11
AA   AA  22   22  55        111
AA   AA      22   55       1111
AA   AA     22    555555     11
AAAAAAA    22          55    11
AA   AA  222   2  55   55    11
AA   AA  2222222   55555   11111
```

KNOWN OR MEASURED INPUTS						
EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EPS CONC YE
B16660	#1	#1	CURVE	95.30	2.3803	#1
146293	#1	#1	CURVE	79.60	1.9123	#1
B752	#1	#1	CURVE	68.50	1.6013	#1
B180	#1	#1	CURVE	53.70	1.2088	#1
155139	#1	#1	CURVE	43.30	0.9515	#1
33470	#1	#1	CURVE	37.20	0.7991	#1
B442	#1	#1	CURVE	23.80	0.4959	#1
B1575	#1	#1	CURVE	19.70	0.4060	#1
244214	#1	#1	NAMED	4.90	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.60	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EPS CONC (UNSHIFTED).

CURVE COMPARISONS					
FIT QUALITY OF NEW CURVE			SHIFT FROM PREVIOUS CURVE		
DEFL XC	CONC YC	Y %POINT (M-C)/C	DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
95.30	2.3802	-0.00	95.49	2.3802	-0.00
79.60	1.9128	0.02	79.57	1.9234	0.56
68.50	1.6010	-0.02	68.31	1.6161	0.94
53.70	1.2088	-0.00	53.31	1.2254	1.38
43.30	0.9489	-0.28	42.76	0.9635	1.55
37.20	0.8024	0.41	36.58	0.8146	1.53
23.80	0.4955	-0.08	22.99	0.4991	0.73
19.70	0.4057	-0.08	18.83	0.4057	-0.00
MEAN OF (ABS %) =		0.11	MEAN OF (ABS %) =		0.83
4.90	0.0970	2.95		#1	#1
3.00	0.0591	-2.62		#1	#1
1.60	0.0314	5.98		#1	#1
MCAL= 1.0000	BCAL= 0.000		MS = 1.0140	BS = 1.146	
CFC=1 ZST=1	WFC=2 DGF=3		CFC=1 ZST=1	WFC=2 DGF=3	
NEW.CALIB.NO= 880816-090835			PRV.CALIB.NO= 880809-165450		
%NL= 5.871	#INF= 0		880809-170322 995 AC-TIVE		
			--- EFF D/T --- INEFF D/T -		

EQUATIONS AND COEFFICIENTS
****

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1952421E-01
A3 = 0.5351349E-04
A4 = 0.3878552E-07
A5 = 0.0000000E 00

C

```
                                  ********   M A S T E R   S I T E   ********
X   EQUIPMENT ID #  :  789433                ***                             ***
    CALIBRATION NAME:  CO2A-CR23              *** ANALYZER CALIBRATION CURVE ANALYSIS ***
    CALIBRATION #   :  880816-125641           ***                             ***
    TEST SITE       :  A251                   ***********************************************
    CALIB DONE AT   :  09:05  08-16-88
    OPERATOR COMMENT:  EPA-MSA-R23-WORK
```

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.30	2.3803	#1
146293	#1	#1	CURVE	79.50	1.9123	#1
B752	#1	#1	CURVE	68.60	1.6013	#1
B180	#1	#1	CURVE	53.80	1.2088	#1
155139	#1	#1	CURVE	43.30	0.9515	#1
33470	#1	#1	CURVE	36.90	0.7991	#1
B442	#1	#1	CURVE	23.70	0.4959	#1
B1575	#1	#1	CURVE	19.70	0.4060	#1
244214	#1	#1	NAMED	4.90	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
95.30	2.3808	0.02	95.51	2.3808	-0.00
79.50	1.9094	-0.15	79.50	1.9215	0.63
68.60	1.6034	0.13	68.46	1.6199	1.03
53.80	1.2118	0.25	53.46	1.2294	1.45
43.30	0.9501	-0.15	42.82	0.9651	1.58
36.90	0.7968	-0.29	36.34	0.8090	1.53
23.70	0.4952	-0.14	22.97	0.4986	0.69
19.70	0.4076	0.38	18.91	0.4076	-0.00
MEAN OF (ABS %) -	0.19		MEAN OF (ABS %) -		0.87
4.90	0.0977	3.71		#1	#1
3.00	0.0595	1.76		#1	#1
1.50	0.0297	0.56		#1	#1

MCAL= 1.0000	BCAL= 0.000
CFC=1 ZST=1	WFC=2 DGF=3
NEW.CALIB.NO=	880816-125641
%NL= 5.864	#INF= 0

MS = 1.0132	BS = -1.045
CFC=1 ZST=1	WFC=2 DGF=3
PRV.CALIB.NO=	880809-165450
880809-170322 9?5 AC-TIVE	
--- EFF D/T ---	INEFF D/T ---

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1970352E-01
A3 = 0.4860388E-04
A4 = 0.7125615E-07
A5 = 0.0000000E 00

C

```
PROD PROCESSED       :  10:29:34  08-17-88    ********   M A S T E R   S I T E   ********
 X   EQUIPMENT ID #  :  789433                ***                                    ***
     CALIBRATION NAME:  CO2A-CR23             *** ANALYZER CALIBRATION CURVE ANALYSIS ***
     CALIBRATION #   :  880817-102934         ***                                    ***
     TEST SITE       :  A251                  ****************************************
     CALIB DONE AT   :  09:05  08-17-88
     OPERATOR COMMENT:  EPA-MSA-R23-WORK
```

AAAAA 22222 555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.30	2.3803	#1
146293	#1	#1	CURVE	79.60	1.9123	#1
B752	#1	#1	CURVE	68.70	1.6013	#1
B180	#1	#1	CURVE	53.80	1.2088	#1
155139	#1	#1	CURVE	43.50	0.9515	#1
33470	#1	#1	CURVE	36.80	0.7991	#1
B442	#1	#1	CURVE	23.70	0.4959	#1
B1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y ZPOINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS*	Y ZSHIFT (S-C)/C
95.30	2.3815	0.05	95.53	2.3815	-0.00
79.60	1.9091	0.17	79.64	1.9255	0.86
68.70	1.6025	0.08	68.61	1.6241	1.34
53.80	1.2097	0.08	53.53	1.2312	1.78
43.50	0.9545	0.31	43.11	0.9721	1.84
36.80	0.7950	-0.51	36.33	0.8088	1.72
23.70	0.4973	0.28	23.07	0.5010	0.75
19.50	0.4055	-0.13	18.82	0.4055	-0.00
MEAN OF (ABS %) =	0.20		MEAN OF (ABS %) =		1.04
4.80	0.0968	2.83		#1	#1
3.00	0.0603	-0.48		#1	#1
1.50	0.0301	1.88		#1	#1

MCAL= 1.0000	BCAL= 0.000
CFC=1 ZST=1	WFC=2 DGF=3
NEW.CALIB.NO=	880817-102934
%NL= 5.975	#INF= 0

MS = 1.0120	BS = -0.913
CFC=1 ZST=1	WFC=2 DGF=3
PRV.CALIB.NO=	880809-165450
880809-170322 995	ACTIVE

--- EFF D/T --- INEFF D/T

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL \# X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1998616E-01
A3 = 0.3860703E-04
A4 = 0.1458367E-06
A5 = 0.0000000E 00

C

```
X   EQUIPMENT ID #  :  789433                ********  MASTER SITE  ********
    CALIBRATION NAME:  CO2A-CR23             ***  ANALYZER CALIBRATION CURVE ANALYSIS  ***
    CALIBRATION #    :  880818-152113        ***                                  ***
    TEST SITE        :  A251                 ****************************************
    CALIB DONE AT    :  09:05  08-18-88
    OPERATOR COMMENT:  EPA-RSA-R23-WORK
```

AAAAA 22222 555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 555555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.30	2.3803	#1
146293	#1	#1	CURVE	79.60	1.9123	#1
B752	#1	#1	CURVE	68.30	1.6013	#1
B180	#1	#1	CURVE	53.80	1.2088	#1
155139	#1	#1	CURVE	43.40	0.9515	#1
33470	#1	#1	CURVE	36.90	0.7991	#1
B442	#1	#1	CURVE	23.80	0.4959	#1
B1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y ZPOINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y ZSHIFT (S-C)/C
95.30	2.3814	0.05	95.53	2.3814	-0.00
79.60	1.9128	0.03	79.63	1.9250	0.64
68.30	1.5958	-0.35	68.18	1.6125	1.05
53.80	1.2125	0.30	53.49	1.2301	1.45
43.40	0.9532	0.18	42.96	0.9683	1.58
36.90	0.7975	0.20	36.37	0.8097	1.53
23.80	0.4981	0.43	23.10	0.5017	0.73
19.50	0.4038	0.55	18.74	0.4038	-0.00
MEAN OF (ABS %)		0.26	MEAN OF (ABS %)		0.87
4.80	0.0959	1.87		#1	#1
3.00	0.0597	1.56		#1	#1
1.50	0.0297	0.76		#1	#1

```
MCAL= 1.0000   BCAL=  0.000 | MS =  1.0130   BS =  -1.008
CFC=1  ZST=1   WFC=2  DGF=3 | CFC=1  ZST=1   WFC=2  DGF=3
NEW.CALIB.NO= 880818-152113 | PRV.CALIB.NO= 880809-165450
%NL=   5.848   #INF=      0 | 880809-170322 995 ACTIVE
                            |--- EFF  D/T --- INEFF D/T
```

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

EQUATIONS AND COEFFICIENTS
****

$$X_C = (MCAL * X_M) + BCAL$$

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

A1 = 0.0000000E 00
A2 = 0.1974611E-01
A3 = 0.4781195E-04
A4 = 0.7556153E-07
A5 = 0.0000000E 00

C

```
PROD PROCESSED       :  10:28:59  08-24-88    ********   M A S T E R   S I T E   ********
 X   EQUIPMENT ID #  :  789433                ***                                    ***
     CALIBRATION NAME:  CO2A-CR23             *** ANALYZER CALIBRATION CURVE ANALYSIS ***
     CALIBRATION #   :  880824-102859         ***                                    ***
     TEST SITE       :  A251                  ****************************************
     CALIB DONE AT   :  09:05  08-24-88
     OPERATOR COMMENT:  EPA-NSA-R23-WORK
```

```
 AAAAA    22222   5555555      11
AA   AA  22   22  55          111
AA   AA      22  55         1111
AA   AA     22   555555      11
AAAAAAA    22        55      11
AA   AA  222   2  55   55    11
AA   AA 2222222   55555    11111
```

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNKT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.30	2.3803	#1
146293	#1	#1	CURVE	79.80	1.9123	#1
B752	#1	#1	CURVE	68.50	1.6013	#1
B180	#1	#1	CURVE	53.70	1.2088	#1
155139	#1	#1	CURVE	43.30	0.9515	#1
33470	#1	#1	CURVE	36.90	0.7991	#1
B442	#1	#1	CURVE	23.70	0.4959	#1
B1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.10	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
95.30	2.3789	-0.06	95.44	2.3789	-0.00
79.80	1.9158	0.18	79.78	1.9292	0.70
68.50	1.5991	-0.14	68.35	1.6171	1.12
53.70	1.2092	0.03	53.39	1.2275	1.52
43.30	0.9511	-0.05	42.88	0.9663	1.61
36.90	0.7984	0.09	36.40	0.8106	1.53
23.70	0.4974	0.29	23.06	0.5008	0.68
19.50	0.4053	-0.16	18.81	0.4053	-0.00
MEAN OF (ABS %) -		0.13	MEAN OF (ABS %) -		0.89
4.80	0.0966	2.56		#1	#1
3.10	0.0621	2.48		#1	#1
1.50	0.0300	1.55		#1	#1

```
MCAL= 1.0000    BCAL=  0.000 | MS =  1.0110    BS =  -0.899
CFC=1  ZST=1    WFC=2  DGF=3 | CFC=1  ZST=1    WFC=2  DGF=3
NEW.CALIB.NO= 880824-102859  | PRV.CALIB.NO= 880809-165450
%NL=   5.828    #INF=      0 | 880809-170322 995 ACTIVE
                              |--- EFF  D/T --- INEFF D/T ---
```

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1991259E-01
A3 = 0.4271625E-04
A4 = 0.1078268E-06
A5 = 0.0000000E 00

X EQUIPMENT ID # : 789433
CALIBRATION NAME: CO2A-CR23
CALIBRATION # : 880826-105111
TEST SITE : A251
CALIB DONE AT : 09:05 08-25-88
OPERATOR COMMENT: EPA-MSA-R23-WORK

######## M A S T E R S I T E ########
ANALYZER CALIBRATION CURVE ANALYSIS

```
 AAAAA     22222   5555555    11
AA   AA  22    22  55        111
AA   AA       22   55       1111
AA   AA      22    555555     11
AAAAAAA     22          55    11
AA   AA   222   2  55   55    11
AA   AA   2222222   55555   11111
```

KNOWN OR MEASURED INPUTS: EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EPS CONC YE	FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
B16660	#1	#1	CURVE	95.30	2.3803	#1	95.30	2.3816	0.05	95.53	2.3816	-0.00
146293	#1	#1	CURVE	79.60	1.9123	#1	79.60	1.9110	-0.07	79.66	1.9259	0.78
B752	#1	#1	CURVE	68.50	1.6013	#1	68.50	1.5996	-0.10	68.43	1.6193	1.23
B180	#1	#1	CURVE	53.70	1.2088	#1	53.70	1.2099	0.09	53.47	1.2295	1.62
155139	#1	#1	CURVE	43.30	0.9515	#1	43.30	0.9522	0.07	42.95	0.9682	1.68
33470	#1	#1	CURVE	36.90	0.7991	#1	36.90	0.7997	0.07	36.48	0.8123	1.58
B442	#1	#1	CURVE	23.60	0.4959	#1	23.60	0.4967	0.15	23.03	0.5001	0.68
B1575	#1	#1	CURVE	19.40	0.4060	#1	19.40	0.4046	-0.34	18.78	0.4046	-0.00
							MEAN OF (ABS %) -		0.12	MEAN OF (ABS %) =		0.95
244214	#1	#1	NAMED	4.80	0.0941	#1	4.80	0.0972	3.15		#1	#1
391539	#1	#1	NAMED	3.00	0.0606	#1	3.00	0.0405	-0.15		#1	#1
66207	#1	#1	NAMED	1.40	0.0295	#1	1.40	0.0281	-4.80		#1	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EPS CONC (UNSHIFTED).

MCAL= 1.0000 BCAL= 0.000	MS = 1.0112 BS - -0.835
CFC=1 ZST=1 WFC=2 DGF-3	CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880826-105111	PRV.CALIB.NO= 880809-165450
%NL= 5.855 #INF= 0	880809-170322 995 ACTIVE
	--- EFF D/T --- INEFF D/T

EQUATIONS AND COEFFICIENTS
****

DEGREE FIT : 3

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.2005121E-01
A3 = 0.3890154E-04
A4 = 0.1356052E-06
A5 = 0.0000000E 00

PROD PROCESSED : 09:18:27 09-01-88 ******* MASTER SITE *******

X EQUIPMENT ID # : 789433 ***

CALIBRATION NAME: CO2A-CR23 *** ANALYZER CALIBRATION CURVE ANALYSIS ***

CALIBRATION # : 880901-091827 ***

TEST SITE : A251 ***

CALIB DONE AT : 09:05 08-31-88

OPERATOR COMMENT: EPA-MSA-R23-WORK

AAAAA 22222 555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.30	2.3803	#1
146293	#1	#1	CURVE	79.70	1.9123	#1
B752	#1	#1	CURVE	68.50	1.6013	#1
B180	#1	#1	CURVE	53.80	1.2088	#1
155139	#1	#1	CURVE	43.40	0.9515	#1
33470	#1	#1	CURVE	37.00	0.7991	#1
B442	#1	#1	CURVE	23.80	0.4959	#1
B1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	5.10	0.0941	#1
391539	#1	#1	NAMED	2.90	0.0606	#1
66207	#1	#1	NAMED	1.90	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y ZPOINT (M-C)/C	SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS#	Y ZSHIFT (S-C)/C
95.30	2.3807	0.02	95.50	2.3807	0.00
79.70	1.9131	0.04	79.71	1.9273	0.74
68.50	1.5984	-0.18	68.37	1.6175	1.20
53.80	1.2103	0.12	53.48	1.2299	1.62
43.40	0.9518	0.03	42.95	0.9682	1.73
37.00	0.7989	-0.02	36.47	0.8122	1.66
23.80	0.4980	0.43	23.11	0.5018	0.76
19.50	0.4040	0.50	18.75	0.4040	0.00
MEAN OF (ABS %)		0.17	MEAN OF (ABS %)		0.96
5.10	0.1022	7.95		#1	#1
2.90	0.0578	4.77		#1	#1
1.90	0.0378	21.98		#1	#1

MCAL= 1.0000 BCAL= 0.000 | MS = 1.0125 BS = -0.992
CFC=1 ZST=1 WFC=2 DGF=3 | CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880901-091827 | PRV.CALIB.NO= 880809-165450
%NL= 5.931 #INF= 0 | 880809-170322 995 ACTIVE
-- EFF D/T --- INEFF D/T --

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1981583E-01
A3 = 0.4411709E-04
A4 = 0.1058008E-06
A5 = 0.0000000E 00

C

PAGE 2

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PROD PROCESSED       :  09:06:07  09-02-88     ********   M A S T E R   S I T E   ********        AAAAA    22222   555555     11
 X   EQUIPMENT ID #  :  789433                 ***                                      ***       AA   AA  22   22  55         111
     CALIBRATION NAME:  CO2A-CR23              *** ANALYZER CALIBRATION CURVE ANALYSIS ***        AA   AA     22    55        1111
     CALIBRATION #   :  880902-090607          ***                                      ***       AA   AA    22     555555      11
     TEST SITE       :  A251                   ********************************************       AAAAAAA   22          55     11
     CALIB DONE AT   :  09:05  09-01-88                                                           AA   AA  222   2  55  55      11
     OPERATOR COMMENT:  EPA-MSA-R23-SEC                                                           AA   AA  2222222   55555    11111
```

KNOWN OR MEASURED INPUTS							CURVE COMPARISONS					
							FIT QUALITY OF NEW CURVE			SHIFT FROM PREVIOUS CURVE		
EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNKT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EPS CONC YE	DEFL XC	CONC YC	Y %POINT (M-C)/C	DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
N36920	#1	#1	CURVE	95.80	2.3950	#1	95.80	2.3963	0.05	96.03	2.3963	0.00
343923	#1	#1	CURVE	78.20	1.8730	#1	78.20	1.8707	-0.12	78.23	1.8863	0.83
262947	#1	#1	CURVE	68.70	1.6050	#1	68.70	1.6049	-0.01	68.62	1.6244	1.22
B1778	#1	#1	CURVE	53.60	1.2060	#1	53.60	1.2064	0.04	53.35	1.2266	1.67
B2386	#1	#1	CURVE	44.10	0.9696	#1	44.10	0.9701	0.05	43.75	0.9876	1.81
B2211	#1	#1	CURVE	37.10	0.8017	#1	37.10	0.8026	0.11	36.67	0.8168	1.77
B1184	#1	#1	CURVE	23.00	0.4812	#1	23.00	0.4814	0.04	22.41	0.4860	0.96
157656	#1	#1	CURVE	17.60	0.3647	#1	17.60	0.3638	-0.23	16.95	0.3638	-0.00
							MEAN OF (ABS %) =		0.08	MEAN OF (ABS %) =		1.03
B16660	#1	#1	NAMED	95.30	2.3803	#1	95.30	2.3807	0.02		#1	#1
146293	#1	#1	NAMED	79.50	1.9123	#1	79.50	1.9080	-0.22		#1	#1
B752	#1	#1	NAMED	68.50	1.6013	#1	68.50	1.5994	-0.12		#1	#1
B180	#1	#1	NAMED	53.70	1.2088	#1	53.70	1.2090	0.02		#1	#1
155139	#1	#1	NAMED	43.30	0.9515	#1	43.30	0.9506	-0.09		#1	#1
B442	#1	#1	NAMED	23.70	0.4959	#1	23.70	0.4969	0.19		#1	#1
B1575	#1	#1	NAMED	19.40	0.4060	#1	19.40	0.4027	-0.82		#1	#1
244214	#1	#1	NAMED	4.70	0.0941	#1	4.70	0.0944	0.31		#1	#1
391539	#1	#1	NAMED	2.80	0.0606	#1	2.80	0.0560	-8.22		#1	#1
66207	#1	#1	NAMED	1.20	0.0295	#1	1.20	0.0239	-23.35		#1	#1

MCAL= 1.0000 BCAL= 0.000	MS = 1.0113 BS = -0.852
CFC=1 ZST=1 WFC=2 DGF=3	CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880902-090607	PRV.CALIB.NO= 880809-165450
%NL= 5.876 #INF= 0	880809-170322 995 AC-TIVE
	-- EFF D/T -- INEFF D/T

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EPS CONC (UNSHIFTED).

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

EQUATIONS AND COEFFICIENTS
****

$$X_C = (MCAL * X_M) + BCAL$$

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

A1 = 0.0000000E 00
A2 = 0.1987737E-01
A3 = 0.4333516E-04
A4 = 0.1072521E-06
A5 = 0.0000000E 00

C

PROD PROCESSED : 10:24:51 08-11-88 ******** M A S T E R S I T E ********
Y EQUIPMENT ID # : 789463 ***
CALIBRATION NAME: CO2A-CR22 *** ANALYZER CALIBRATION CURVE ANALYSIS ***
CALIBRATION # : 880811-102451 ***
TEST SITE : A251 **********
CALIB DONE AT : 14:12 08-10-88
OPERATOR COMMENT: EPA-HDR-R22-BLINE

AAAAA 22222 5555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B2386	#1	#1	CURVE	97.00	0.9696	#1
B2211	#1	#1	CURVE	81.70	0.8017	#1
B1454	#1	#1	CURVE	74.40	0.7260	#1
A-221	#1	#1	CURVE	61.40	0.5900	#1
B1184	#1	#1	CURVE	50.80	0.4812	#1
157656	#1	#1	CURVE	39.00	0.3647	#1
286591	#1	#1	CURVE	27.60	0.2550	#1
065369	#1	#1	CURVE	14.00	0.1282	#1
155139	#1	#1	NAMED	95.40	0.9515	#1
33470	#1	#1	NAMED	81.50	0.7991	#1
163287	#1	#1	NAMED	71.40	0.6925	#1
B1103	#1	#1	NAMED	62.00	0.5947	#1
B442	#1	#1	NAMED	52.30	0.4959	#1
B1575	#1	#1	NAMED	43.20	0.4060	#1
B916	#1	#1	NAMED	25.40	0.2344	#1
337743	#1	#1	NAMED	15.30	0.1396	#1
244214	#1	#1	NAMED	10.60	0.0941	#1
391539	#1	#1	NAMED	6.60	0.0606	#1
66207	#1	#1	NAMED	3.20	0.0295	#1

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
97.00	0.9699	0.03	#4	#4	#4
81.70	0.8024	0.09	#4	#4	#4
74.40	0.7246	-0.19	#4	#4	#4
61.40	0.5893	-0.12	#4	#4	#4
50.80	0.4819	0.14	#4	#4	#4
39.00	0.3652	0.14	#4	#4	#4
27.60	0.2553	0.14	#4	#4	#4
14.00	0.1277	-0.39	#4	#4	#4
MEAN OF (ABS X) =		0.15			
95.40	0.9521	0.06		#1	#1
81.50	0.8003	0.15		#1	#1
71.40	0.6930	0.08		#1	#1
62.00	0.5955	0.13		#1	#1
52.30	0.4969	0.20		#1	#1
43.20	0.4064	0.10		#1	#1
25.40	0.2344	0.02		#1	#1
15.30	0.1398	0.11		#1	#1
10.60	0.0964	2.34		#1	#1
6.60	0.0598	-1.42		#1	#1
3.20	0.0289	-2.17		#1	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #4: NO PREVIOUS ANALYZER CALIBRATION ON FILE IN THE EFS.
NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

MCAL= 1.0000 BCAL= 0.000 | MS = BS =
CFC=1 ZST=1 WFC=2 DGF=3 | CFC= ZST= WFC= DGF=
NEW.CALIB.NO= 880811-102451 | PRV.CALIB.NO= -
%NL= 2.776 #INF= 0 | - -
--- EFF D/T --- INEFF D/T -

EQUATIONS AND COEFFICIENTS

$X_C = (MCAL * X_M) + BCAL$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$

A1 = 0.0000000E 00
A2 = 0.8994130E-02
A3 = 0.8922260E-05
A4 = 0.1478682E-07
A5 = 0.0000000E 00

C

```
PROD PROCESSED        :  10:32:39  08-11-88    ********   M A S T E R   S I T E   ********
 Y   EQUIPMENT ID #   :  789463                ***                                      ***
     CALIBRATION NAME :  CO2A-CR22             *** ANALYZER CALIBRATION CURVE ANALYSIS ***
     CALIBRATION #    :  880811-103239         ***                                      ***
     TEST SITE        :  A251                  ******************************************
     CALIB DONE AT    :  14:12  08-10-88
     OPERATOR COMMENT :  EPA-HOR-R22-BLINE
```

```
  AAAAA    22222   555555     11
 AA   AA  22   22  55        111
 AA   AA      22  55       1111
 AA   AA     22   555555     11
 AAAAAAA    22        55     11
 AA   AA  222    2  55   55  11
 AA   AA 2222222   55555   11111
```

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNKT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
155139	#1	#1	CURVE	95.40	0.9515	#1
33470	#1	#1	CURVE	81.50	0.7991	#1
163287	#1	#1	CURVE	71.40	0.6925	#1
B1103	#1	#1	CURVE	62.00	0.5947	#1
B442	#1	#1	CURVE	52.30	0.4959	#1
B1575	#1	#1	CURVE	43.20	0.4060	#1
B916	#1	#1	CURVE	25.40	0.2344	#1
337743	#1	#1	CURVE	15.30	0.1396	#1
B2386	#1	#1	NAMED	97.00	0.9696	#1
B2211	#1	#1	NAMED	81.70	0.8017	#1
B1454	#1	#1	NAMED	74.40	0.7260	#1
A-221	#1	#1	NAMED	61.40	0.5900	#1
B1184	#1	#1	NAMED	50.80	0.4812	#1
157656	#1	#1	NAMED	39.00	0.3647	#1
286591	#1	#1	NAMED	27.60	0.2550	#1
065369	#1	#1	NAMED	14.00	0.1282	#1
244214	#1	#1	NAMED	10.60	0.0941	#1
391539	#1	#1	NAMED	6.60	0.0606	#1
66207	#1	#1	NAMED	3.20	0.0295	#1

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y ZPOINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y ZSHIFT (S-C)/C
95.40	0.9514	-0.01	#4	#4	#4
81.50	0.7994	0.04	#4	#4	#4
71.40	0.6922	-0.05	#4	#4	#4
62.00	0.5946	-0.01	#4	#4	#4
52.30	0.4962	0.07	#4	#4	#4
43.20	0.4059	-0.03	#4	#4	#4
25.40	0.2343	-0.06	#4	#4	#4
15.30	0.1397	0.07	#4	#4	#4
MEAN OF (ABS Z) =		0.04			
97.00	0.9693	-0.04		#1	#1
81.70	0.8016	-0.02		#1	#1
74.40	0.7237	-0.31		#1	#1
61.40	0.5885	-0.26		#1	#1
50.80	0.4812	0.00		#1	#1
39.00	0.3648	0.02		#1	#1
27.60	0.2551	0.05		#1	#1
14.00	0.1277	-0.42		#1	#1
10.60	0.0963	2.32		#1	#1
6.60	0.0598	-1.41		#1	#1
3.20	0.0289	-2.15		#1	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #4: NO PREVIOUS ANALYZER CALIBRATION ON FILE IN THE EFS.
NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

```
MCAL= 1.0000    BCAL=  0.000 | MS =              BS =
CFC=1  ZST=1    WFC=2  DGF=3 | CFC=    ZST=     WFC=    DGF=
NEW.CALIB.NO= 880811-103239  | PRV.CALIB.NO=        -
ZNL=    2.814   #INF=     0  |      -               -
                               --- EFF  D/I --- INEFF D/I
```

```
WEIGHTING FACTOR CODE    : 2
DEGREE FIT               : 3
```

EQUATIONS AND COEFFICIENTS
****

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.8997887E-02
A3 = 0.8354270E-05
A4 = 0.1956350E-07
A5 = 0.0000000E 00

C

```
PROD PROCESSED      : 13:44:26  08-10-88   ********   M A S T E R   S I T E   ********
 Y   EQUIPMENT ID #  : 789433               ***                                    ***
     CALIBRATION NAME: CO2A-CR23            *** ANALYZER CALIBRATION CURVE ANALYSIS ***
     CALIBRATION #   : 880810-134426         ***                                    ***
     TEST SITE       : A251                 ****************************************
     CALIB DONE AT   : 09:05  08-10-88
     OPERATOR COMMENT: EPA-HOR-R23-BLINE
```

```
 AAAAA    22222   5555555     11
AA   AA  22   22  55         111
AA   AA      22  55        1111
AA   AA     22   555555     11
AAAAAAA    22        55     11
AA   AA   222    2  55   55  11
AA   AA  2222222   55555   11111
```

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
368730	#1	#1	CURVE	96.50	2.4120	#1
343923	#1	#1	CURVE	78.20	1.8730	#1
262947	#1	#1	CURVE	68.50	1.6050	#1
B17780	#1	#1	CURVE	53.30	1.2060	#1
B2386	#1	#1	CURVE	43.80	0.9696	#1
B2211	#1	#1	CURVE	36.90	0.8017	#1
B1184	#1	#1	CURVE	22.90	0.4812	#1
157656	#1	#1	CURVE	17.60	0.3647	#1
B16660	#1	#1	NAMED	95.40	2.3803	#1
146293	#1	#1	NAMED	79.50	1.9120	#1
B752	#1	#1	NAMED	68.30	1.6013	#1
B180	#1	#1	NAMED	53.40	1.2088	#1
155139	#1	#1	NAMED	43.00	0.9515	#1
33470	#1	#1	NAMED	36.70	0.7991	#1
B442	#1	#1	NAMED	23.50	0.4959	#1
B1575	#1	#1	NAMED	19.40	0.4060	#1
244214	#1	#1	NAMED	4.70	0.0941	#1
391539	#1	#1	NAMED	2.90	0.0606	#1
66207	#1	#1	NAMED	1.40	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEN.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y ZPOINT (M-C)/C	SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS*	Y ZSHIFT (S-C)/C
96.50	2.4112	-0.03	96.54	2.4112	-0.00
78.20	1.8744	0.07	78.09	1.8823	0.42
68.50	1.6054	0.03	68.31	1.6160	0.66
53.30	1.2054	-0.05	52.99	1.2174	0.99
43.80	0.9683	-0.13	43.41	0.9794	1.14
36.90	0.8023	0.08	36.45	0.8117	1.17
22.90	0.4812	-0.01	22.34	0.4845	0.69
17.60	0.3650	0.08	17.00	0.3650	-0.00
MEAN OF (ABS Z) =		0.06	MEAN OF (ABS Z) =		0.63
95.40	2.3779	-0.10		#1	#1
79.50	1.9112	-0.04		#1	#1
68.30	1.6000	-0.08		#1	#1
53.40	1.2079	-0.07		#1	#1
43.00	0.9488	-0.28		#1	#1
36.70	0.7976	-0.19		#1	#1
23.50	0.4945	-0.28		#1	#1
19.40	0.4041	-0.47		#1	#1
4.70	0.0944	0.28		#1	#1
2.90	0.0580	-4.55		#1	#1
1.40	0.0279	-5.83		#1	#1

```
MCAL= 1.0000    BCAL=  0.000 | NS =  1.0081    BS =  -0.744
CFC=1  ZST=1    WFC=2  DGF=3 | CFC=1  ZST=1    WFC=2  DGF=3
NEW.CALIB.NO= 880810-134426  | PRV.CALIB.NO= 880809-165450
XNL=    5.451   #INF=      0 | 880809-170322 995 AC-TIVE
                              |--- EFF  D/T - - INEFF D/T -
```

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1983948E-01
A3 = 0.5050859E-04
A4 = 0.2934626E-07
A5 = 0.0000000E 00

C

PAGE 2

PROD PROCESSED : 08:41:46 08-16-88
X EQUIPMENT ID # : 789433
CALIBRATION NAME: CO2A-CR23
CALIBRATION # : 880816-084146
TEST SITE : A251
CALIB DONE AT : 09:05 08-11-88
OPERATOR COMMENT: EPA-HOR-R23-WORK

******** M A S T E R S I T E ********
*** ***
*** ANALYZER CALIBRATION CURVE ANALYSIS ***
*** ***
****

AAAAA 22222 555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.40	2.3803	#1
146293	#1	#1	CURVE	79.50	1.9120	#1
B752	#1	#1	CURVE	68.30	1.6013	#1
B180	#1	#1	CURVE	53.50	1.2088	#1
155139	#1	#1	CURVE	43.00	0.9515	#1
33470	#1	#1	CURVE	36.70	0.7991	#1
B442	#1	#1	CURVE	23.50	0.4959	#1
B1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y XPOINT (M-C)/C
95.40	2.3800	-0.01
79.50	1.9123	0.02
68.30	1.6008	-0.03
53.50	1.2112	0.20
43.00	0.9496	-0.20
36.70	0.7984	-0.08
23.50	0.4953	0.12
19.50	0.4071	0.26
MEAN OF (ABS X) =		0.11
4.80	0.0967	2.67
3.00	0.0602	-0.73
1.50	0.0300	1.57

SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y XSHIFT (S-C)/C
95.48	2.3800	0.00
79.44	1.9197	0.39
68.13	1.6113	0.65
53.20	1.2227	0.95
42.60	0.9598	1.06
36.25	0.8068	1.05
22.93	0.4978	0.49
18.89	0.4071	-0.00
MEAN OF (ABS X) =		0.57
	#1	#1
	#1	#1
	#1	#1

MCAL= 1.0000 BCAL= 0.000
CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880816-084146
%NL= 5.466 #INF= 0

MS = 1.0091 BS = -0.785
CFC=1 ZST=1 WFC=2 DGF=3
PRV.CALIB.NO= 880809-165450
880809-170322 995 ACTIVE

--- EFF D/T --- INEFF D/T -

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

A1 = 0.0000000E 00
A2 = 0.1990647E-01
A3 = 0.4886654E-04
A4 = 0.4164999E-07
A5 = 0.0000000E 00

C

```
PROG. PROCESSED      :  08:50:23  08-16-88     *******.  M A S T E R   S I T E   ********
 X  EQUIPMENT ID #   :  789433                 ***                                     ***
    CALIBRATION NAME :  CO2A-CR23              *** ANALYZER CALIBRATION CURVE ANALYSIS ***
    CALIBRATION #    :  880816-085023          ***                                     ***
    TEST SITE        :  A251                   ******************************************
    CALIB DONE AT    :  09:05  08-12-88
    OPERATOR COMMENT :  EPA-HOR-R23-WORK
```

```
 AAAAA    22222   5555555    11
AA   AA  22   22  55        111
AA   AA      22   55       1111
AA   AA     22    555555     11
AAAAAAA    22          55    11
AA   AA  222   2  55   55    11
AA   AA  2222222   55555   11111
```

KNOWN OR MEASURED INPUTS							CURVE COMPARISONS: FIT QUALITY OF NEW CURVE			SHIFT FROM PREVIOUS CURVE		
EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE	DEFL XC	CONC YC	Y %POINT (M-C)/C	DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
B16660	#1	#1	CURVE	95.40	2.3803	#1	95.40	2.3798	-0.02	95.47	2.3798	-0.00
146293	#1	#1	CURVE	79.50	1.9120	#1	79.50	1.9125	0.03	79.44	1.9199	0.39
B752	#1	#1	CURVE	68.30	1.6013	#1	68.30	1.6014	0.01	68.15	1.6117	0.64
B180	#1	#1	CURVE	53.40	1.2088	#1	53.40	1.2098	0.08	53.13	1.2210	0.92
155139	#1	#1	CURVE	43.00	0.9515	#1	43.00	0.9510	-0.05	42.64	0.9607	1.02
33470	#1	#1	CURVE	36.60	0.7991	#1	36.60	0.7975	-0.20	36.19	0.8055	1.00
B442	#1	#1	CURVE	23.50	0.4959	#1	23.50	0.4967	0.16	22.98	0.4990	0.47
B1575	#1	#1	CURVE	19.40	0.4060	#1	19.40	0.4061	0.03	18.85	0.4061	-0.00
							MEAN OF (ABS %) =		0.07	MEAN OF (ABS %) =		0.56
244214	#1	#1	NAMED	4.80	0.0941	#1	4.80	0.0971	3.10		#1	#1
391539	#1	#1	NAMED	3.00	0.0606	#1	3.00	0.0604	-0.26		#1	#1
66207	#1	#1	NAMED	1.50	0.0295	#1	1.50	0.0301	2.04		#1	#1

MCAL= 1.0000 BCAL= 0.000	MS = 1.0082 BS = -0.710
CFC=1 ZST=1 WFC=2 DGF=3	CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880816-085023	PRV.CALIB.NO= 880809-165450
%NL= 5.415 #INF= 0	880809-170322 995 AC-TIVE
	--- EFF D/T --- INEFF D/T -

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

OPERATOR COMMENT : I   -WORK

ZERO SPAN FILE COM : 1
WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

EQUIPMENTS AND COEFFICIENTS.

EQUATIONS AND COEFFICIENTS.
****

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2/N2$$

A1 = 0.0000000E 00
A2 = 0.2000604E-01
A3 = 0.4685111E-04
A4 = 0.5164976E-07
A5 = 0.0000000E 00

C

```
PROD PROCESSED       :  12:44:10  08-16-88    ********   M A S T E R   S I T E   ********
 X   EQUIPMENT ID #  :  789433                ***                                    ***
     CALIBRATION NAME:  CO2A-CR23             *** ANALYZER CALIBRATION CURVE ANALYSIS ***
     CALIBRATION #   :  880816-124410         ***                                    ***
     TEST SITE       :  A251                  ****************************************
     CALIB DONE AT   :  09:05  08-16-88
     OPERATOR COMMENT:  EPA-MOR-R23-WORKE
```

```
 AAAAA    22222   5555555     11
AA   AA  22   22  55         111
AA   AA      22  55        1111
AA   AA     22   5555555     11
AAAAAAA    22        55      11
AA   AA  222    2  55   55   11
AA   AA 2222222   55555   11111
```

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.40	2.3803	#1
146293	#1	#1	CURVE	79.50	1.9120	#1
B752	#1	#1	CURVE	68.30	1.6013	#1
B180	#1	#1	CURVE	53.50	1.2088	#1
155139	#1	#1	CURVE	43.00	0.9515	#1
33470	#1	#1	CURVE	36.70	0.7991	#1
B442	#1	#1	CURVE	23.50	0.4959	#1
B1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
95.40	2.3800	-0.01	95.48	2.3800	0.00
79.50	1.9123	0.02	79.44	1.9197	0.39
68.30	1.6008	-0.03	68.13	1.6113	0.65
53.50	1.2112	0.20	53.20	1.2227	0.95
43.00	0.9496	-0.20	42.60	0.9598	1.06
36.70	0.7984	-0.08	36.25	0.8068	1.05
23.50	0.4953	-0.12	22.93	0.4978	0.49
19.50	0.4071	0.26	18.89	0.4071	-0.00
MEAN OF (ABS %) =		0.11	MEAN OF (ABS %) =		0.57
4.80	0.0967	2.67	#1	#1	
3.00	0.0602	-0.73	#1	#1	
1.50	0.0300	1.57	#1	#1	

```
MCAL= 1.0000   BCAL=  0.000 | MS =  1.0091   BS =  -0.785
CFC=1  ZST=1   WFC=2  DGF=3 | CFC=1  ZST=1   WFC=2  DGF=3
NEW.CALIB.NO= 880816-124410 | PRV.CALIB.NO= 880809-165450
ZNL=   5.466   #INF=      0 | 880809-170322 995 ACTIVE
                            |--- EFF  D/T --- INEFF D/T -1
```

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = FCT\ CO2/N2$$

A1 = 0.0000000E 00
A2 = 0.1990647E-01
A3 = 0.4886654E-04
A4 = 0.4164999E-07
A5 = 0.0000000E 00

C

```
PROD PROCESSED       :  10:16:13  08-17-88    ********   M A S T E R   S I T E   ********
 X   EQUIPMENT ID #  :  789433                ***                                    ***
     CALIBRATION NAME:  CO2A-CR23             *** ANALYZER CALIBRATION CURVE ANALYSIS ***
     CALIBRATION #   :  880817-101613         ***                                    ***
     TEST SITE       :  A251                  ****************************************
     CALIB DONE AT   :  09:05  08-17-88
     OPERATOR COMMENT:  EPA-HOR-R23-WORKE
```

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.40	2.3803	#1
146293	#1	#1	CURVE	79.40	1.9120	#1
B752	#1	#1	CURVE	68.30	1.6013	#1
B180	#1	#1	CURVE	53.40	1.2088	#1
155139	#1	#1	CURVE	43.00	0.9515	#1
33470	#1	#1	CURVE	36.60	0.7991	#1
B442	#1	#1	CURVE	23.50	0.4959	#1
B1575	#1	#1	CURVE	19.40	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
95.40	2.3807	0.02	95.50	2.3807	-0.00
79.40	1.9106	-0.08	79.36	1.9177	0.38
68.30	1.6021	0.05	68.17	1.6122	0.63
53.40	1.2102	0.12	53.14	1.2212	0.91
43.00	0.9512	-0.03	42.65	0.9608	1.01
36.60	0.7976	-0.19	36.19	0.8055	0.99
23.50	0.4966	0.13	22.98	0.4989	0.47
19.40	0.4060	-0.00	18.84	0.4060	-0.00
MEAN OF (ABS %)		0.08	MEAN OF (ABS %)		0.55
4.80	0.0970	3.02		#1	#1
3.00	0.0604	0.36		#1	#1
1.50	0.0301	1.94		#1	#1

```
MCAL= 1.0000    BCAL=  0.000 | MS =  1.0087    BS =  -0.725
CFC=1  ZST=1    WFC=2  DGF=3 | CFC=1  ZST=1    WFC=2  DGF=3
NEW.CALIB.NO= 880817-101613  | PRV.CALIB.NO= 880809-165450
%NL=    5.415   #INF=      0 | 880809-170322 995 ACTIVE
                              |--- EFF  D/T ---  INEFF D/T --
```

EQUATIONS AND COEFFICIENTS

```
X    = (MCAL * X ) + BCAL
 C              M

MCAL =      0.1000000E 01
BCAL =      0.0000000E 00
```

DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

```
A1  =      0.0000000E 00
A2  =      0.1998405E-01
A3  =      0.4770664E-04
A4  =      0.4607861E-07
A5  =      0.0000000E 00
```

C

PROD PROCESSED : 15:12:21 08-18-88 ******** MASTER SITE ********
X EQUIPMENT ID # : 789433 ***
CALIBRATION NAME: CO2A-CR23 *** ANALYZER CALIBRATION CURVE ANALYSIS ***
CALIBRATION # : 880818-151221 ***
TEST SITE : A251 **********
CALIB DONE AT : 09:05 08-18-88
OPERATOR COMMENT: EPA-HOR-R23-WORKE

AAAAA 22222 5555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 55555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNKT	DATA POINT TYPES	MEAS REFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
R16660	#1	#1	CURVE	95.40	2.3803	#1
146293	#1	#1	CURVE	79.50	1.9120	#1
R752	#1	#1	CURVE	68.20	1.6013	#1
R180	#1	#1	CURVE	53.40	1.2088	#1
155139	#1	#1	CURVE	43.00	0.9515	#1
33470	#1	#1	CURVE	36.70	0.7991	#1
R442	#1	#1	CURVE	23.60	0.4959	#1
R1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.60	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE REFL XC	CONC YC	Y %POINT (M-C)/C
95.40	2.3793	-0.04
79.50	1.9141	0.11
68.20	1.6002	0.07
53.40	1.2100	0.10
43.00	0.9501	0.14
36.70	0.7984	-0.09
23.60	0.4967	0.15
19.50	0.4060	0.01
MEAN OF (ABS %) -		0.09
4.80	0.0961	2.11
3.00	0.0598	1.36
1.60	0.0318	7.13

SHIFT FROM PREVIOUS CURVE REFL XS	CONC YS*	Y %SHIFT (S-C)/C
95.46	2.3793	0.00
79.41	1.9190	0.25
68.00	1.6078	0.47
53.06	1.2193	0.77
42.57	0.9588	0.91
36.21	0.8059	0.94
22.98	0.4990	0.48
18.85	0.4060	0.00
MEAN OF (ABS %) -		0.48
#1		#1
#1		#1
#1		#1

MCAL= 1.0000 BCAL= 0.000 MS = 1.0094 BS = -0.817
CFC=1 ZST=1 WFC=2 DGF=3 CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880818-151221 PRV.CALIB.NO= 880809 165450
%NL= 5.389 #INF= 0 880809-170322 995 ACTIVE
--- EFF D/T --- INEFF D/T

EQUATIONS AND COEFFICIENTS

X = (MCAL * X) + BCAL
C M

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT : 3

4 3 2
A5*X + A4*X + A3*X + A2*X + A1 = PCT CO2 /N2
C C C C

A1 = 0.0000000E 00
A2 = 0.1976748E-01
A3 = 0.5409156E-04
A4 = 0.1414909E-08
A5 = 0.0000000E 00

CALIBRATION TABLE PERCENT FULL-SCALE CHART DEFLECTION VS PCT CO2 /N2

C

PROD PROCESSED : 10:22:32 08-24-88 ******** M A S T E R S I T E ********
X EQUIPMENT ID # : 789433 ***
CALIBRATION NAME: CO2A-CR23 *** ANALYZER CALIBRATION CURVE ANALYSIS ***
CALIBRATION # : 880824-102232 ***
TEST SITE : A251 **********
CALIB DONE AT : 09:05 08-24-88
OPERATOR COMMENT: EPA-HOR-R23-WORKE

AAAAA 22222 5555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNKT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.40	2.3803	#1
146293	#1	#1	CURVE	79.50	1.9120	#1
B752	#1	#1	CURVE	68.30	1.6013	#1
B180	#1	#1	CURVE	53.40	1.2088	#1
155139	#1	#1	CURVE	43.00	0.9515	#1
33470	#1	#1	CURVE	36.60	0.7991	#1
B442	#1	#1	CURVE	23.50	0.4959	#1
B1575	#1	#1	CURVE	19.40	0.4060	#1
244214	#1	#1	NAMED	4.80	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE *: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
95.40	2.3798	-0.02	95.47	2.3798	-0.00
79.50	1.9125	0.03	79.44	1.9199	0.39
68.30	1.6014	0.01	68.15	1.6117	0.64
53.40	1.2098	0.08	53.13	1.2210	0.92
43.00	0.9510	0.05	42.64	0.9607	1.02
36.60	0.7975	0.20	36.19	0.8055	1.00
23.50	0.4967	0.16	22.98	0.4990	0.47
19.40	0.4061	0.03	18.85	0.4061	-0.00
MEAN OF (ABS %) :		0.07	MEAN OF (ABS %)		0.56
4.80	0.0921	3.10	#1	#1	
3.00	0.0604	-0.26	#1	#1	
1.50	0.0301	2.04	#1	#1	

MCAL= 1.0000 BCAL= 0.000 MS = 1.0082 BS = -0.710
CFC=1 ZST=1 WFC=2 DGF=3 CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880824-102232 PRV.CALIB.NO= 880809-165450
%NL= 5.415 #INF= 0 880809-170322 995 ACTIVE
-- EFF D/T - - INEFF D/T --

EQUATIONS AND COEFFICIENTS
****

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.2000604E-01
A3 = 0.4685111E-04
A4 = 0.5164976E-07
A5 = 0.0000000E 00

CALIBRATION TABLE - PERCENT FULL-SCALE CHART DEFLECTION VS PCT CO2 /N2

C

PROD PROCESSED : 10:45:17 08-26-88 ******** MASTER STILL ******** AAAAA 22222 555555 11

X EQUIPMENT ID # : 789433

CALIBRATION NAME: CO2A-CR23

CALIBRATION # : 880826-104519

TEST SITE : A251

CALIB DONE AT : 09:05 08-25-88

OPERATOR COMMENT: EPA-HDR-R23-WORKE

*** ANALYZER CALIBRATION CURVE ANALYSIS ***

KNOWN OR MEASURED INPUTS							CURVE COMPARISONS					
							FIT QUALITY OF NEW CURVE			SHIFT FROM PREVIOUS CURVE		
EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE	DEFL XC	CONC YC	Y %POINT (M-C)/C	DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
B16660	#1	#1	CURVE	95.40	2.3803	#1	95.40	2.3800	-0.01	95.48	2.3800	-0.00
146293	#1	#1	CURVE	79.40	1.9123	#1	79.40	1.9124	0.00	79.35	1.9172	0.25
B752	#1	#1	CURVE	68.20	1.6013	#1	68.20	1.6018	0.03	68.05	[illegible]	0.45
B180	#1	#1	CURVE	53.30	1.2088	#1	53.30	1.2097	0.07	53.03	1.2163	0.71
155139	#1	#1	CURVE	42.90	0.9515	#1	42.90	0.9502	0.14	42.54	0.9581	0.84
33470	#1	#1	CURVE	36.60	0.7991	#1	36.60	0.7985	0.07	36.18	0.8053	0.85
B442	#1	#1	CURVE	23.50	0.4959	#1	23.50	0.4967	0.16	22.97	0.4988	0.43
B1575	#1	#1	CURVE	19.40	0.4060	#1	19.40	0.4059	-0.02	18.84	0.4059	0.00
							MEAN OF (ABS %)		0.06	MEAN OF (ABS %)		0.44
244214	#1	#1	NAMED	4.85	0.0541	#1	4.86	[illegible]	2.61		#1	#1
391539	#1	#1	NAMED	3.00	0.0606	#1	3.00	0.0602	-0.61		#1	#1
66207	#1	#1	NAMED	1.50	0.0295	#1	1.50	0.0300	1.67		#1	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

MCAL= 1.0000 BCAL= 0.000	MS = 1.0084 BS [illegible]
CFC=1 ZST=1 WFC=2 DGF=3	CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO 880826-104519	PRV.CALIB.NO 880809 165450
%NL= 5.30 #INF= 0	880809-170322 99% AC [illegible]
	[illegible]

EQUATIONS AND COEFFICIENTS
****

$X_C = (MCAL * X_M) + BCAL$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT

$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1$ PCT CO2 /N2

A1 = 0.0000000E 00
A2 = 0.1992400E-01
A3 = 0.5119225E-04
A4 = 0.1536426E-07
A5 = 0.0000000E 00

C

PROD PROCESSED : 09:09:54 09-01-88 ******** M A S T E R S I T E ********
X EQUIPMENT ID # : 789433 ***
CALIBRATION NAME: CO2A-CR23 *** ANALYZER CALIBRATION CURVE ANALYSIS ***
CALIBRATION # : 880901-090954 ***
TEST SITE : A251 **********
CALIB DONE AT : 09:05 08-31-88
OPERATOR COMMENT: EPA-HOR-R23-WORKE

AAAAA 22222 555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 55555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.40	2.3803	#1
146293	#1	#1	CURVE	79.50	1.9123	#1
B752	#1	#1	CURVE	68.30	1.6013	#1
B180	#1	#1	CURVE	53.40	1.2088	#1
155139	#1	#1	CURVE	43.00	0.9515	#1
33470	#1	#1	CURVE	36.70	0.7991	#1
B442	#1	#1	CURVE	23.50	0.4959	#1
B1575	#1	#1	CURVE	19.50	0.4060	#1
244214	#1	#1	NAMED	4.90	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.60	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE: DEFL XC	CONC YC	Y %POINT (M-C)/C
95.40	2.3797	0.03
79.50	1.9130	0.04
68.30	1.6017	0.03
53.40	1.2095	0.06
43.00	0.9502	-0.14
36.70	0.7988	-0.04
23.50	0.4953	-0.11
19.50	0.4070	0.25
MEAN OF (ABS %)		0.09
4.90	0.0986	4.59
3.00	0.0601	0.84
1.60	0.0319	7.63

SHIFT FROM PREVIOUS CURVE: DEFL XS	CONC YS*	Y %SHIFT (S-C)/C
95.47	2.3797	0.00
79.43	1.9195	0.34
68.13	1.6110	0.58
53.09	1.2200	0.87
42.60	0.9596	1.00
36.24	0.8067	0.99
22.92	0.4977	0.47
18.89	0.4070	-0.00
MEAN OF (ABS %)		0.53
#1	#1	#1
#1	#1	#1
#1	#1	#1

MCAL= 1.0000 BCAL= 0.000 | MS = 1.0090 BS -0.786
CFC=1 ZST=1 WFC=2 DGF=3 | CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880901-090954 | PRV.CALIB.NO= 880809-165450
%NL= 5.423 #INF= 0 | 880809-170322 995 ACTIVE
--- EFF D/T --- INEFF D/T

EQUATIONS AND COEFFICIENTS

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

WEIGHTING FACTOR CODE : 2
DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1987993E-01
A3 = 0.5030846E-04
A4 = 0.2907069E-07
A5 = 0.0000000E 00

C

PROD PROCESSED : 13:52:32 09-13-88
Y EQUIPMENT ID # : 789433
CALIBRATION NAME: C02A-CR23
CALIBRATION # : 880913-135232
TEST SITE : A251
CALIB DONE AT : 09:05 09-01-88
OPERATOR COMMENT: EPA-HOR-R23-WORK

******** M A S T E R S I T E ********
*** ***
*** ANALYZER CALIBRATION CURVE ANALYSIS ***
*** ***
****

AAAAA 22222 5555555 11
AA AA 22 22 55 111
AA AA 22 55 1111
AA AA 22 555555 11
AAAAAAA 22 55 11
AA AA 222 2 55 55 11
AA AA 2222222 55555 11111

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
B16660	#1	#1	CURVE	95.40	2.3803	#1
146293	#1	#1	CURVE	79.50	1.9123	#1
B752	#1	#1	CURVE	68.30	1.6013	#1
B180	#1	#1	CURVE	53.40	1.2088	#1
155139	#1	#1	CURVE	43.00	0.9515	#1
33470	#1	#1	CURVE	36.70	0.7991	#1
B442	#1	#1	CURVE	23.50	0.4959	#1
B1575	#1	#1	CURVE	19.40	0.4060	#1
N36920	#1	#1	NAMED	95.90	2.3950	#1
343923	#1	#1	NAMED	78.10	1.8730	#1
262947	#1	#1	NAMED	68.40	1.6050	#1
B1778	#1	#1	NAMED	53.30	1.2060	#1
B2386	#1	#1	NAMED	43.70	0.9696	#1
B2211	#1	#1	NAMED	36.80	0.8017	#1
B1184	#1	#1	NAMED	22.90	0.4812	#1
157656	#1	#1	NAMED	17.60	0.3647	#1
244214	#1	#1	NAMED	4.70	0.0941	#1
391539	#1	#1	NAMED	3.00	0.0606	#1
66207	#1	#1	NAMED	1.50	0.0295	#1

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEN.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

CURVE COMPARISONS

FIT DEFL XC	QUALITY OF NEW CONC YC	CURVE Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
95.40	2.3802	-0.00	95.49	2.3802	-0.00
79.50	1.9125	0.01	79.45	1.9201	0.40
68.30	1.6012	-0.01	68.15	1.6118	0.66
53.40	1.2094	0.05	53.13	1.2209	0.95
43.00	0.9505	0.10	42.64	0.9605	1.05
36.70	0.7954	0.04	36.28	0.8076	1.03
23.50	0.4963	0.08	22.97	0.4987	0.48
19.40	0.4058	-0.06	18.83	0.4058	-0.09
MEAN OF (ABS %) =		0.04	MEAN OF (ABS %) =		0.57
95.90	2.3954	0.02	#1	#1	
78.10	1.8728	-0.01	#1	#1	
68.40	1.6039	-0.07	#1	#1	
53.30	1.2068	0.07	#1	#1	
43.70	0.9676	-0.21	#1	#1	
36.80	0.8018	0.01	#1	#1	
22.90	0.4829	0.36	#1	#1	
17.60	0.3666	0.51	#1	#1	
4.70	0.0950	0.91	#1	#1	
3.00	0.0604	-0.38	#1	#1	
1.50	0.0301	1.93	#1	#1	

MCAL= 1.0000 BCAL= 0.000 | MS = 1.0086 BS = -0.733
CFC=1 ZST=1 WFC=2 DGF=3 | CFC=1 ZST=1 WFC=2 DGF=3
NEW.CALIB.NO= 880913-135232 | PRV.CALIB.NO= 880809-165450
%NL= 5.442 #INF= 0 | 880809-170322 995 AC-TIVE
--- EFF D/T --- INEFF D/T

EQUATIONS AND COEFFICIENTS
****

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

DEGREE FIT : 3

$$A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1 = PCT\ CO2\ /N2$$

A1 = 0.0000000E 00
A2 = 0.1998198E-01
A3 = 0.4715868E-04
A4 = 0.5149988E-07
A5 = 0.0000000E 00

C

```
PROD PROCESSED       :  13:44:26  08-10-88    ********   M A S T E R   S I T E   ********
 Y   EQUIPMENT ID #  :  789433                ***                                    ***
     CALIBRATION NAME:  CO2A-CR23             *** ANALYZER CALIBRATION CURVE ANALYSIS ***
     CALIBRATION #   :  880810-134426         ***                                    ***
     TEST SITE       :  A251                  ****************************************
     CALIB DONE AT   :  09:05  08-10-88
     OPERATOR COMMENT:  EPA-HOR-R23-BLINE
```

```
 AAAAA    22222   5555555     11
AA   AA  22   22  55         111
AA   AA      22  55        1111
AA   AA     22   555555     11
AAAAAAA    22         55    11
AA   AA  222   2  55   55   11
AA   AA 2222222   55555    11111
```

KNOWN OR MEASURED INPUTS

EPACYL# OR BLNCOD	VENDOR CYLID OR BLENDER RNG	VCODE OR BLNRT	DATA POINT TYPES	MEAS DEFL XM	NOMINAL CONC YM	ACTIVE EFS CONC YE
368730	#1	#1	CURVE	96.50	2.4120	#1
343923	#1	#1	CURVE	78.20	1.8730	#1
262947	#1	#1	CURVE	68.50	1.6050	#1
B17780	#1	#1	CURVE	53.30	1.2060	#1
B2386	#1	#1	CURVE	43.80	0.9696	#1
B2211	#1	#1	CURVE	36.90	0.8017	#1
B1184	#1	#1	CURVE	22.90	0.4812	#1
157656	#1	#1	CURVE	17.60	0.3647	#1
B16660	#1	#1	NAMED	95.40	2.3803	#1
146293	#1	#1	NAMED	79.50	1.9120	#1
B752	#1	#1	NAMED	68.30	1.6013	#1
B180	#1	#1	NAMED	53.40	1.2088	#1
155139	#1	#1	NAMED	43.00	0.9515	#1
33470	#1	#1	NAMED	36.70	0.7991	#1
B442	#1	#1	NAMED	23.50	0.4959	#1
B1575	#1	#1	NAMED	19.40	0.4060	#1
244214	#1	#1	NAMED	4.70	0.0941	#1
391539	#1	#1	NAMED	2.90	0.0606	#1
66207	#1	#1	NAMED	1.40	0.0295	#1

CURVE COMPARISONS

FIT QUALITY OF NEW CURVE DEFL XC	CONC YC	Y %POINT (M-C)/C	SHIFT FROM PREVIOUS CURVE DEFL XS	CONC YS#	Y %SHIFT (S-C)/C
96.50	2.4112	-0.03	96.54	2.4112	-0.00
78.20	1.8744	0.07	78.09	1.8823	0.42
68.50	1.6054	0.03	68.31	1.6160	0.66
53.30	1.2054	-0.05	52.99	1.2174	0.99
43.80	0.9683	-0.13	43.41	0.9794	1.14
36.90	0.8023	0.08	36.45	0.8117	1.17
22.90	0.4812	-0.01	22.34	0.4845	0.69
17.60	0.3650	0.08	17.00	0.3650	-0.00
MEAN OF (ABS %) =	0.06		MEAN OF (ABS %) =		0.63
95.40	2.3779	-0.10	#1	#1	
79.50	1.9112	-0.04	#1	#1	
68.30	1.6000	-0.08	#1	#1	
53.40	1.2079	-0.07	#1	#1	
43.00	0.9488	-0.28	#1	#1	
36.70	0.7976	-0.19	#1	#1	
23.50	0.4945	-0.28	#1	#1	
19.40	0.4041	-0.47	#1	#1	
4.70	0.0944	0.28	#1	#1	
2.90	0.0580	-4.55	#1	#1	
1.40	0.0279	-5.83	#1	#1	

NOTE #1: CYLINDER NOT DEFINED IN THE EQUIPMENT FILE SYSTEM.

NOTE #: YS FOR NAMED CYLS IS PREVIOUS EFS CONC (UNSHIFTED).

```
MCAL= 1.0000    BCAL=  0.000 | MS =  1.0081    BS =  -0.744
CFC=1  ZST=1    WFC=2  DGF=3 | CFC=1  ZST=1    WFC=2  DGF=3
NEW.CALIB.NO= 880810-134426  | PRV.CALIB.NO= 880809-165450
%NL=   5.451    #INF=     0  | 880809-170322 995 AC-TIVE
-----------------------------|--- EFF  D/T --- INEFF D/T -
```

EQUATIONS AND COEFFICIENTS

****

$$X_C = (MCAL * X_M) + BCAL$$

MCAL = 0.1000000E 01
BCAL = 0.0000000E 00

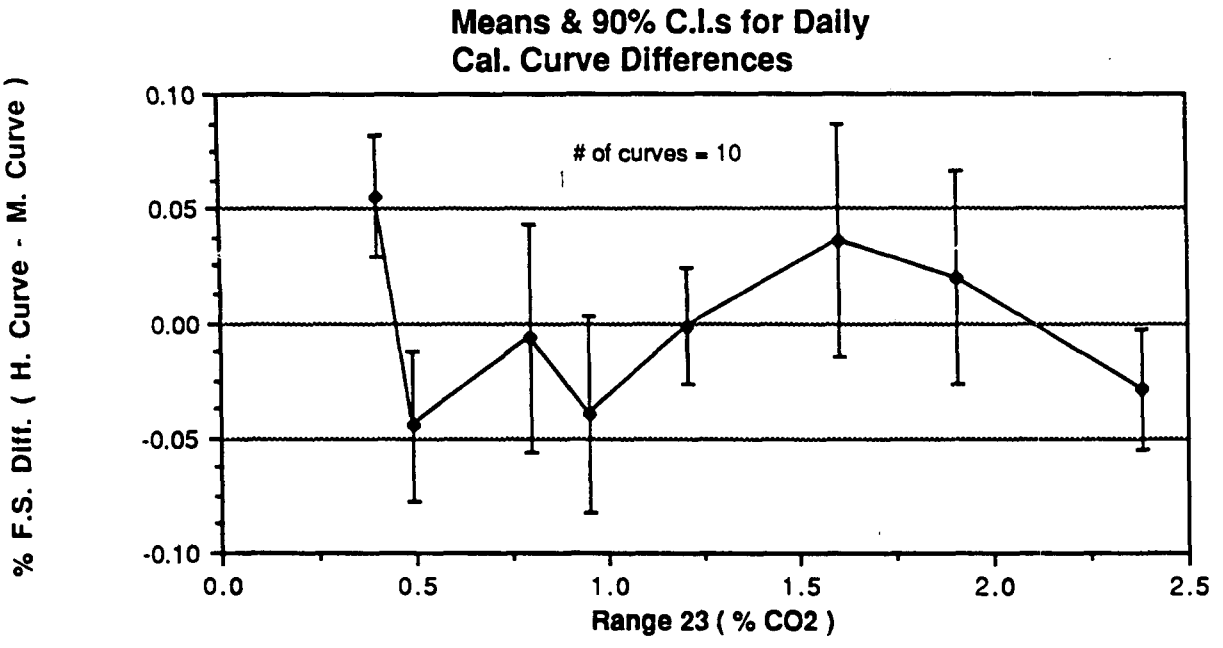
DEGREE FIT : 3

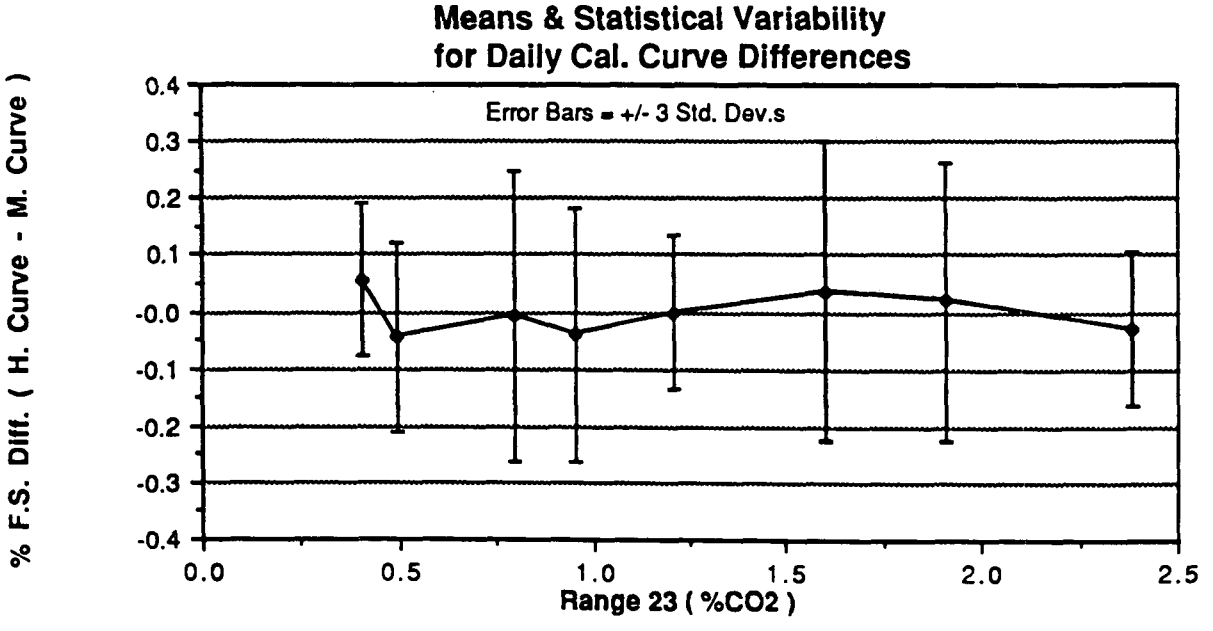
$$A5 * X_C^4 + A4 * X_C^3 + A3 * X_C^2 + A2 * X_C + A1 = PCT\ CO2\ /N2$$

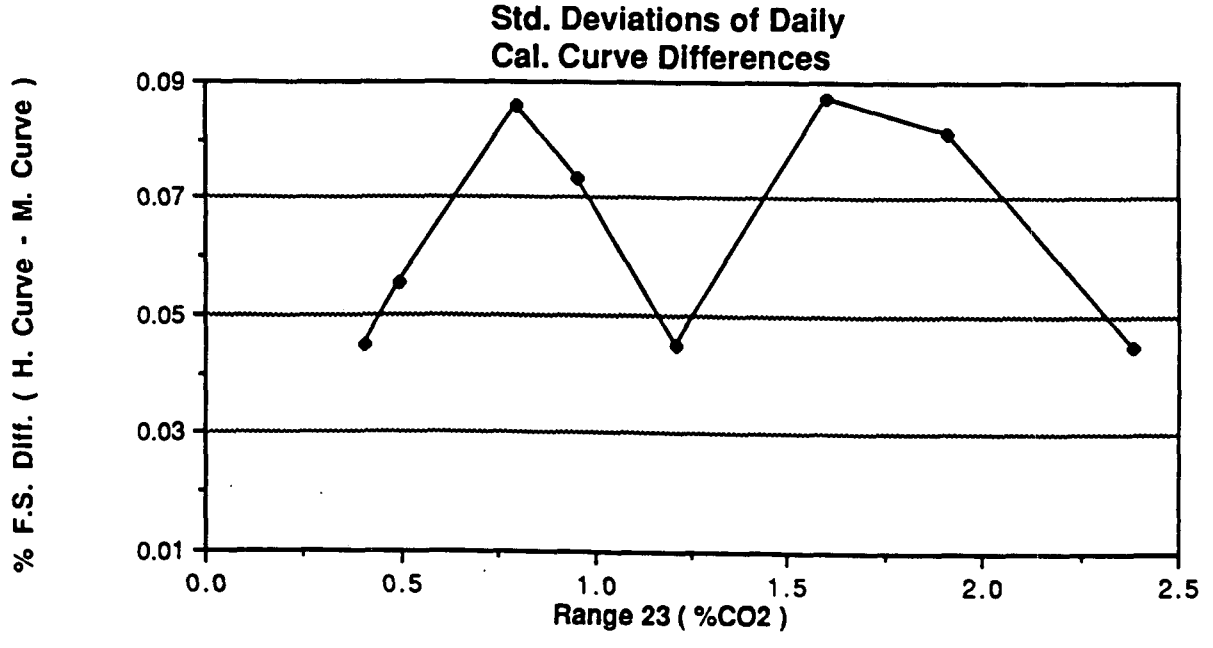
A1 = 0.0000000E 00
A2 = 0.1983948E-01
A3 = 0.5050859E-04
A4 = 0.2934626E-07
A5 = 0.0000000E 00

C

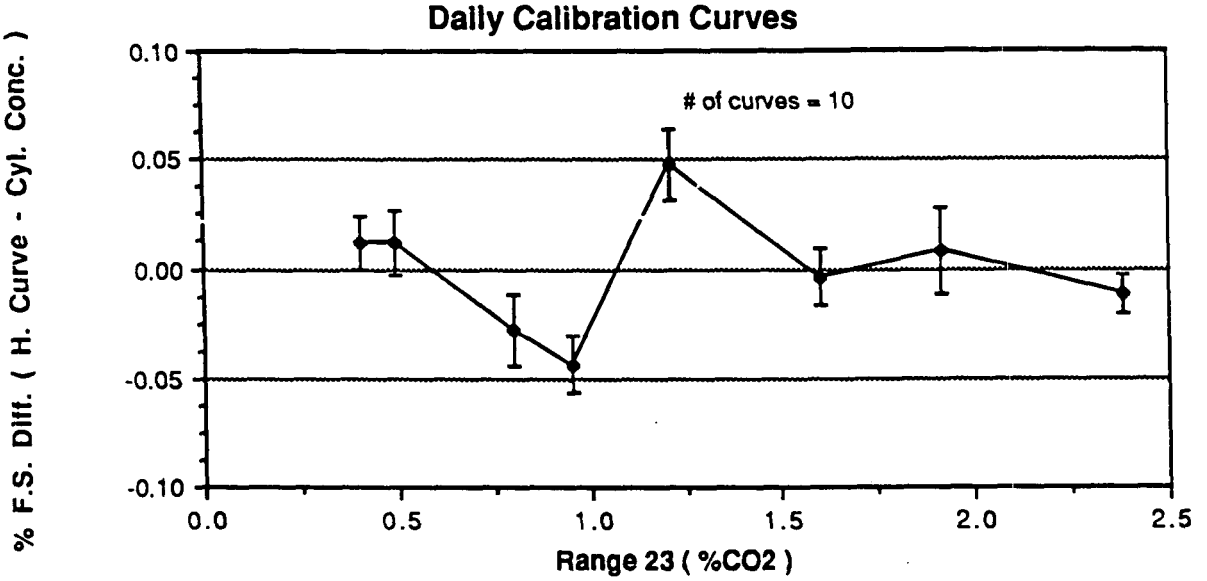
ATTACHMENT N



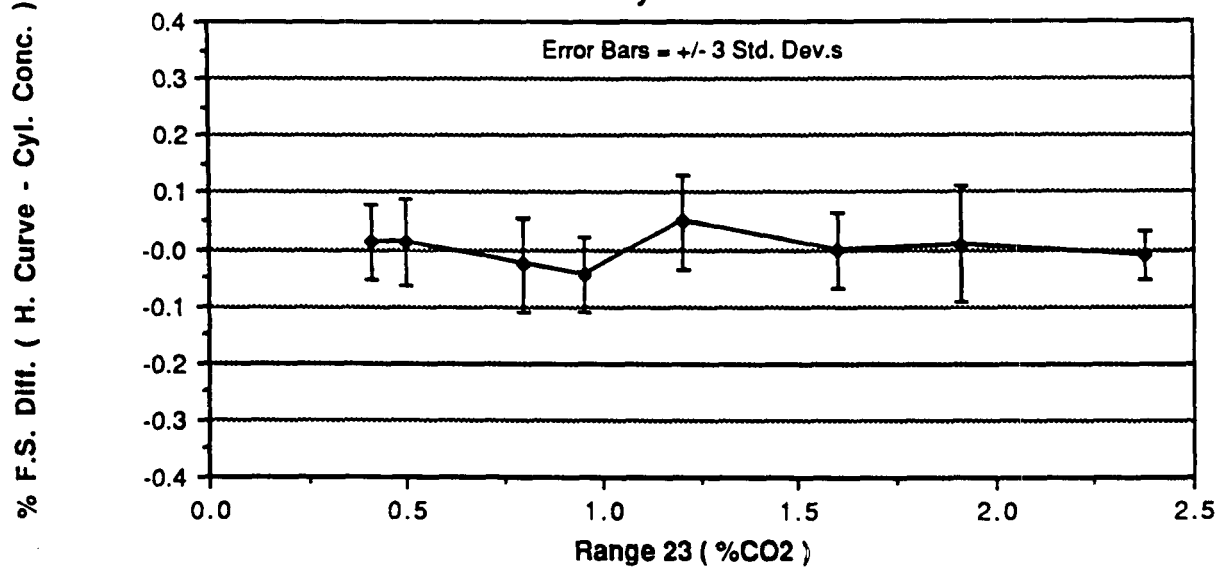




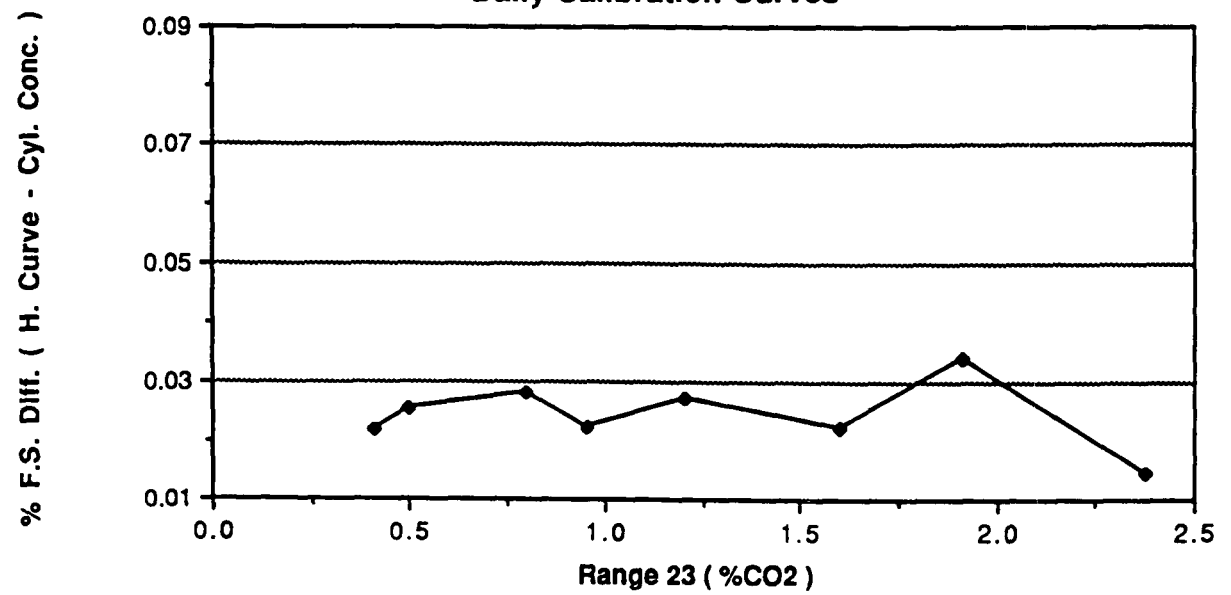
Means & 90% C.I.s of HORIBA Daily Calibration Curves



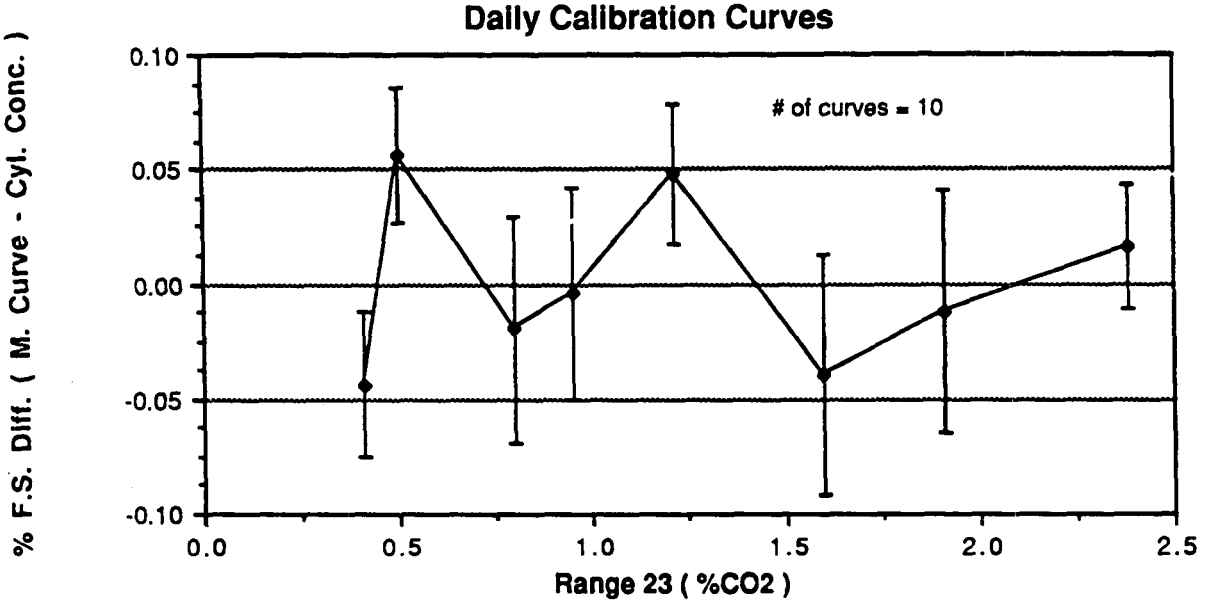
Means & Statistical Variability of HORIBA Daily Calibration Curves



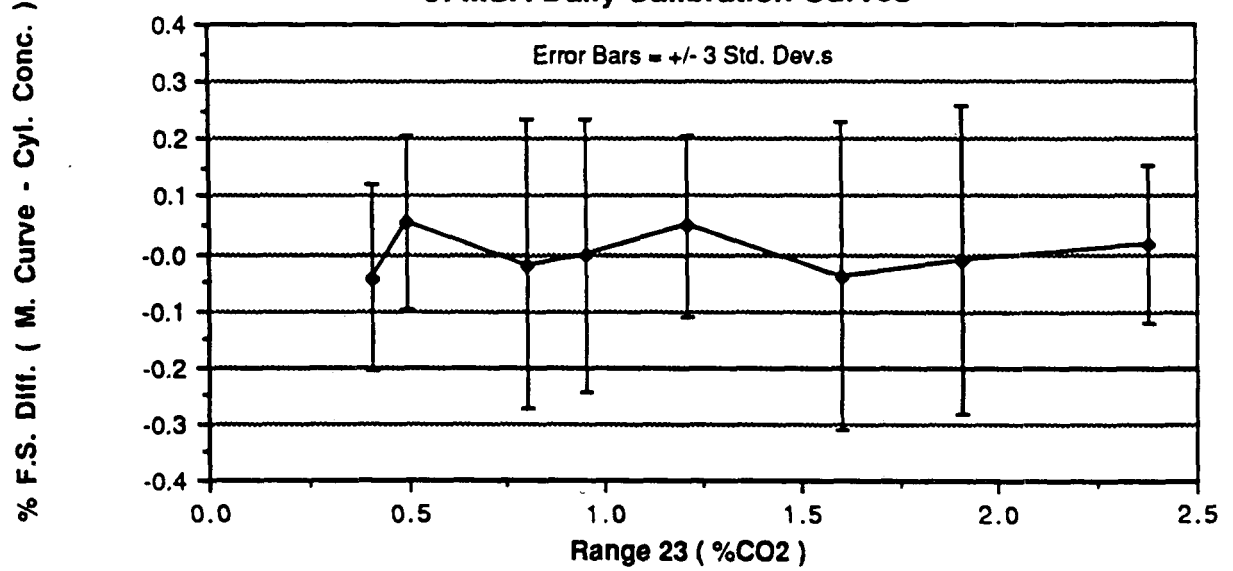
Std. Deviations of HORIBA Daily Calibration Curves



Means & 90% C.I.s of MSA Daily Calibration Curves



Means & Statistical Variability of MSA Daily Calibration Curves



Std. Deviations of MSA Daily Calibration Curves

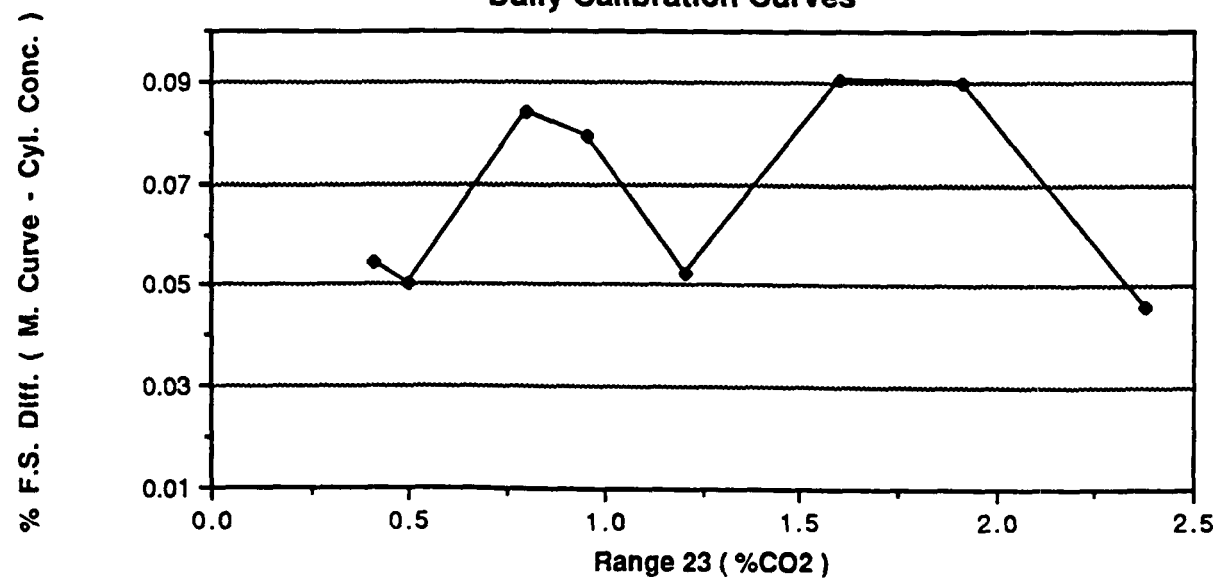


TABLE C

Range 22 Background Level
Agreement Data

Date	Curve Code	Cylinder Conc.	HORIBA Conc.	MSA Conc	HORIBA-MSA %FS Diff
8/10/88	S	0.0941	0.0964	0.0979	-0 1500
	S	0.0606	0.0598	0 0608	-0 1000
	S	0.0295	0.0289	0.0294	-0.0500
	W	0.0941	0.0963	0.0974	-0.1100
	W	0.0606	0.0598	0.0605	-0.0700
	W	0.0295	0.0289	0.0293	-0 0400
9/8/88	W	0.0941	0.0960	0.0955	0.0500
	W	0.0606	0.0592	0.0595	-0.0300
	W	0.0295	0.0300	0.0301	-0.0100
	S	0.0941	0.0960	0.0951	0.0900
	S	0.0606	0.0592	0.0592	0.0000
	S	0.0295	0.0300	0.0300	0 0000
					AVERAGE -0.0350 STD DEV 0.0678

TABLE D

Range 23 Background Level
Agreement Data

Date	Curve Code	Cylinder Conc.	HORIBA Conc.	MSA Conc.	HORIBA-MSA %FS Diff
8/10/88	S	0.0941	0.0944	0.0966	-0.088
	S	0.0606	0.0580	0.0581	-0.004
	S	0.0295	0.0279	0.0380	-0.404
	W	0.0941	0.0950	0.0967	-0.068
	W	0.0606	0.0584	0.0582	0.008
	W	0.0295	0.0281	0.0381	-0.4
8/11/88	W	0.0941	0.0967	0.0969	-0.008
	W	0.0606	0.0602	0.0604	-0.008
	W	0.0295	0.0300	0.0321	-0.084
8/12/88	W	0.0941	0.0971	0.0970	0.004
	W	0.0606	0.0604	0.0591	0.052
	W	0.0295	0.0301	0.0314	-0.052
8/16/88	W	0.0941	0.0967	0.0977	-0.04
	W	0.0606	0.0602	0.0595	0.028
	W	0.0295	0.0300	0.0297	0.012
8/17/88	W	0.0941	0.0970	0.0968	0.008
	W	0.0606	0.0604	0.0603	0.004
	W	0.0295	0.0301	0.0301	0
8/18/88	W	0.0941	0.0961	0.0959	0.008
	W	0.0606	0.0598	0.0597	0.004
	W	0.0295	0.0318	0.0297	0 084
8/24/88	W	0.0941	0.0971	0.0966	0.02
	W	0.0606	0.0604	0.0621	-0.068
	W	0.0295	0.0301	0.0300	0.004
8/25/88	W	0.0941	0.0968	0.0972	-0.016
	W	0.0606	0.0602	0.0605	-0.012
	W	0.0295	0.0300	0.0281	0.076
8/31/88	W	0.0941	0.0986	0.1022	-0.144
	W	0.0606	0.0601	0.0578	0.092
	W	0.0295	0.0319	0.0378	-0.236
9/1/88	W	0.0941	0.0950	0.0946	0.016
	W	0.0606	0.0604	0.0561	0.172
	W	0.0295	0.0301	0.0240	0.244
	S	0.0941	0.0943	0.0944	-0.004
	S	0.0606	0.0599	0.0560	0.156
	S	0.0295	0.0298	0.0239	0.236
					AVERAGE -0.011 STD DEV 0.133

ATTACHMENT O