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Environmental Monitoring Series

REGIONAL AIR POLLUTION STUDY: QUALITY ASSURANCE AUDITS

Environmental Sciences Research Laboratory
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REGIONAL AIR POLLUTION STUDY:

QUALITY ASSURANCE AUDITS

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ABSTRACT

Aerometric data is being collected by the Regional Air Pollution Study (RAPS) for use in developing and evaluating air quality simulation models. In addition to the Regional Air Monitoring System (RAMS), data is also collected by research teams in periodic expeditions to the St. Louis study area. Data from all sources are made available for integration through the RAPS Data Bank. A quality assurance audit of instrument systems employed in the Summer 1975 RAPS Expeditionary Research Program was conducted to check the various systems for accuracy. Additionally such checks provide a basis for determining the extent to which data from different instrument systems may be integrated. This report describes the audit equipment and standards used and problems encountered. Quantitative audit results from individual instrument systems are presented. The audits included analyzers for NO, NO_x, O_3, SO_2, CO, CH_4 and THC measurements.

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1.0 INTRODUCTION

This report summarizes the preparation and use of a mobile calibration system for the RAPS 1975 Summer Study Quality Assurance Audits. The purpose of these audits was to check the analyzers of the RAPS field investigations and RAMS stations for accuracy. A mobile laboratory van was used to carry a controlled environment to the field. A brief description of the methods used to acquire the data and a listing of the pertinent data is included.

2.0 TASK ORDER REQUIREMENTS

2.1 TECHNICAL REQUIREMENTS

Under this task order, the contractor was to:

A) Prepare the EPA mobile laboratory for quality assurance audits.

B) Drive the van to various sites and perform calibration checks of various air monitoring systems including the following:

1) Operate and maintain chemiluminescent oxone analyzers, chemiluminescent NO-NO_x analyzers, total sulfur analyzers, sulfur chromatographs, Beckman Model 6800 gas chromatographs, integrating nephelometers, and strip-chart recorders.

2) Prepare and operate the gas dilution systems, gas sampling systems, and air purification systems.

3) Compute the concentrations of standard gas mixes, preparation of calibration curves, and compile and record data.

2.2 EQUIPMENT

The Winnebago laboratory van, instruments, and calibration gases were to be supplied by the EPA Task Order Project Officer.

2.3 PERIOD OF PERFORMANCE

Task order duration - the task order was estimated to require 11 weeks ending September 5, 1975.

2.4 REPORTS

Monthly progress reports, draft final reports, and an approved final report were to be furnished in accordance with provisions of the EPA contract 68-02-1081.

3.0 WORK PERFORMED

The work performed consisted of preparing the van for mobile calibration use, calibrating the transfer standards using National Bureau of Standards (NBS) reference materials, and performing audits on the measurement systems of independent investigators and selected RAMS stations.

During the performance of this task the Air Monitoring Center provided the services of a senior engineer and a technician to perform the required tasks. The specific calibration procedures employed and the schedule of sites and analyzers were received from the EPA Task Coordinator, S.L. Kopczynski, in the form of technical direction on a daily basis.

3.1 VAN PREPARATION

The van preparation included modifications to the physical support system and installation of the instrumentation system.

3.1.1 Physical Support System

The Winnebago van originally had a single generator for the entire vehicle when it was not using line power. In order not to overload this generator and to prevent surges in the instruments when the air conditioner started, another generator was installed by EPA. This generator was only used on the air conditioner with the other handling the instruments. The second generator was wired into the system to allow either A.C. line power or the generator to power the air conditioner (See Figure 1).

3.1.2 Instrumentation

The government supplied instruments consisted of a Bendix NO-NO_X analyzer, a Bendix Ozone analyzer, a Tracor sulfur chromatograph and a Bendix dynamic calibration system. These instruments were calibrated and installed in the van with the appropriate auxiliary gases necessary for operation. The plans for using the mobile laboratory instruments for cross-checking analyses was dropped in favor of more thorough multipoint calibration checks which utilized all budgeted manpower.

3.2 CALIBRATION METHODS

The gas sources used in calibration were directly traceable to NBS where possible. These concentrated gases were diluted to several values and a corresponding multipoint calibration performed on the analyzers.

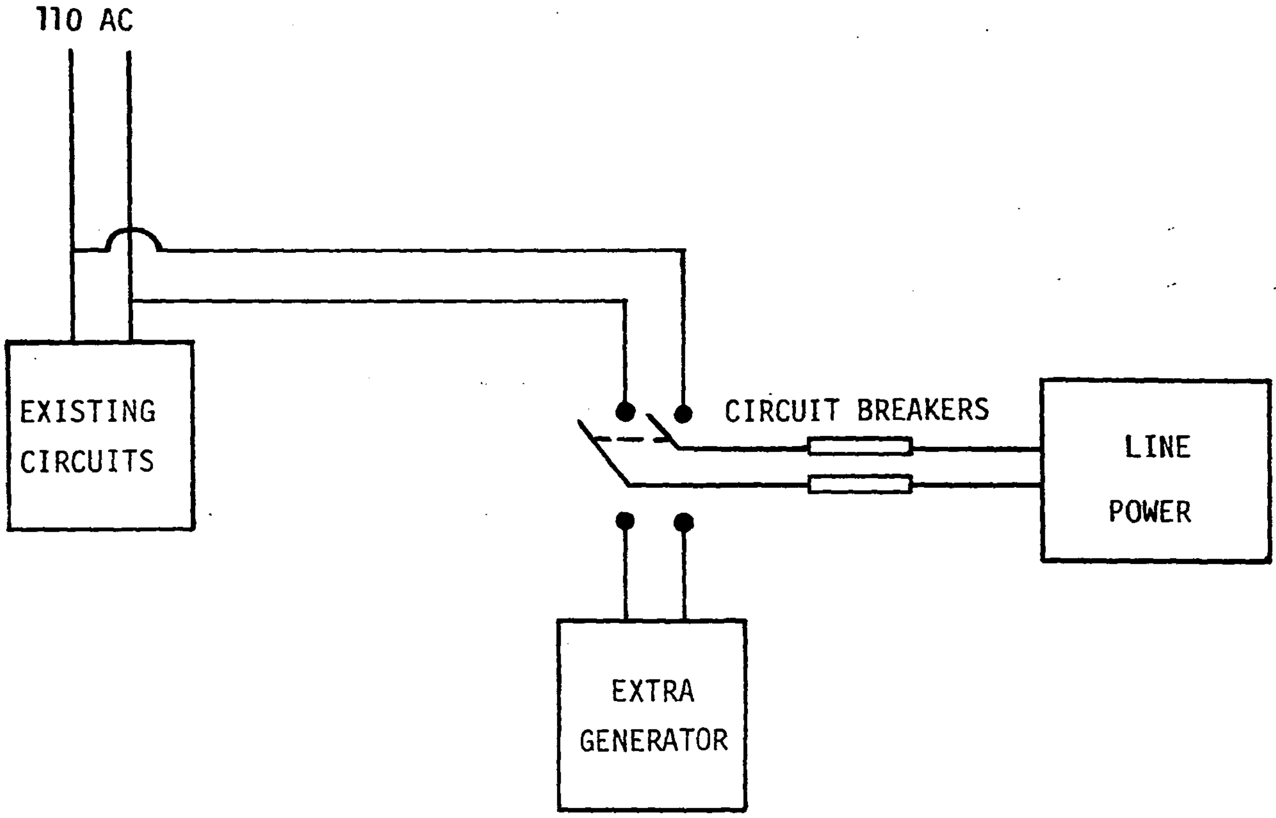

FIGURE 1

POWER CIRCUIT MODIFICATION

3.2.1 $NO-NO_X$ Source Calibration

The mobile lab contained a tank of approximately 100 ppm of NO, which was used as the standard for $NO-NO_X$ calibrations. This tank was initially calibrated using a NBS NO cylinder #RSG-30-7963 which contained 93.4 ppm as the standard reference. This calibration was done in the GC lab using a Bendix $NO-NO_X$ analyzer (which was calibrated with the NBS tank) to measure several known mixtures of the unknown tank. Efforts were made to have the same concentrations as those used in the initial calibration of the instrument.

3.2.2 SO_2 Source Calibration

Two NBS SO_2 permeation tubes were used as the standard for all audits. Since the permeation rate of the tube is highly temperature dependent, it was placed in an oven in the Bendix Dynamic Calibrator which had provisions for both heating as well as cooling in order to maintain a temperature of $25^{o}C$, $\pm$ $0.1^{o}C$. The output of the Bendix Dynamic Calibrator was cross-checked at the RAMS station 120 with an NBS permeation tube installed in the station calibration system.

3.2.3 CO and CH_4 Source Calibration

An NBS CO tank containing 9.82 ppm CO was used in conjunction with the GC laboratory's 6800 to certify three Scott tanks, one containing a 21.2 ppm of CO (#L1722), one containing 2.01 ppm CH_4 and 5.24 ppm CO (#1749) and one containing 2.04 ppm CH_4 and 5.20 ppm CO (#2359). These tanks were either used directly to give a single point or dynamically diluted with either Matheson zero air or Scott ultrapure air to give a multipoint calibration. The zero air was also checked for residue CO and was found to be within acceptable tolerances.

3.2.4 O_3 Source Calibration

The O_3 used for the audits was generated on site through use of a uv tube which was assumed to have adequate short term stability but would vary from day to day. For this reason the O_3 output was calibrated each time the O_3 was used by means of an O_3 - NO titration immediately after calibration of an $NO-NO_X$ analyzer. Since the instrument's calibration could be traced to a NBS NO tank, the drop in NO when the O_3 was turned on gave a calibrated O_3 value at that flow setting. Others were obtained by varying the dilution flow for a multipoint calibration.

3.3 INSTRUMENT CALIBRATION METHOD

The calibration system employed was a Bendix Dynamic Calibrator which used precision pressure regulators to maintain a given pressure differential across sets of capillaries which in turn would give a constant flow. These flows were calibrated for various pressure settings using a bubble meter at the beginning of the study. Near the end of the study, a bubble meter and mass flow meters #FM-302 and FM-300 were used to recalibrate Input C capillary #4 and check the others.

There are three pressure regulators; one controls the flow across the permeation oven which has two flow levels - a high flow and a low flow. The second controls the flow of concentrated calibrating gas to be diluted by the zero air from the third regulator. The third regulator has four capillaries associated with it for generating a wide range of dilutions. Air from one of these capillaries flows through an ozone generator and is used for NO_2 checks via gas phase titration and to calibrate the ozone analyzer (Figure 2).

The gas mixture produced by this method was introduced into a glass manifold to produce a demand system operating at atmospheric pressure. Before the arrival of the manifold, a simple Tee was used, this was found to effect the sample flow rate of some instruments at the lower concentration levels. A complex Tee arrangement removed this bias, no data was taken under the simple Tee arrangement. The RAMS stations internal calibration manifold was used when auditing stations. In all cases, the inter-connections were made with Teflon tubing and fittings.

3.4 PREPARATION OF CALIBRATION CURVES

The same procedure was used on all instruments to prepare calibration curves. This procedure consisted of generating various gas concentrations and allowing the instrument to sample them until the instrument equilibrated before a reading was taken. This reading along with the known concentration was tabulated and a least squares linear fit was used to find an intercept and a slope. All instruments were done this way including the $NO-NO_x$ instrument used in finding the ozone concentration. This procedure assumes all of the flows are correct as well as the concentration of the tank gases and the zero air was pure. The dilution or zero air used was bottled zero air for areas other than RAMS stations with the station

Dynamic Calibration System

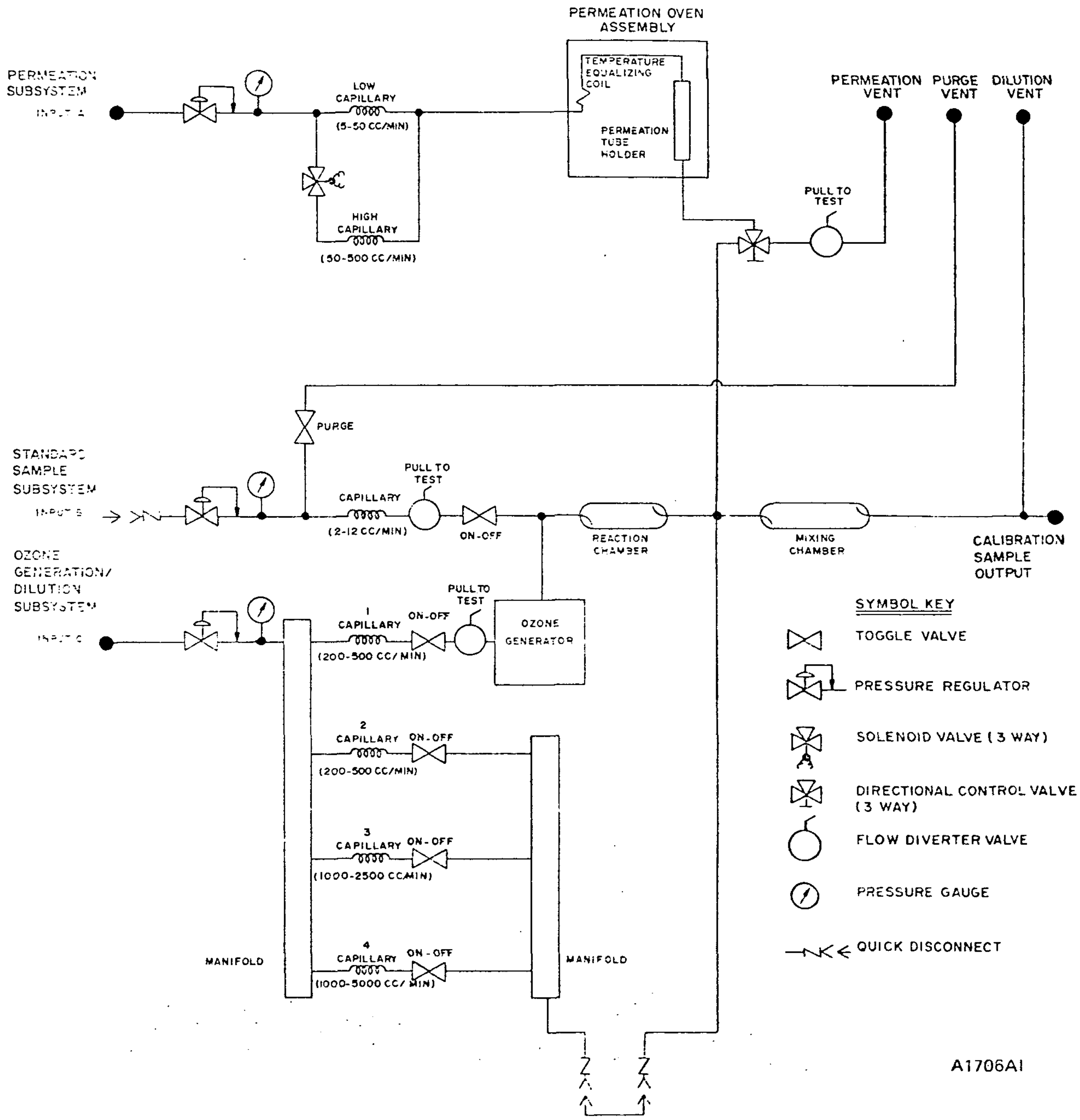

FIGURE 2

zero air used in the station except for CO and HC.

3.5 AUDIT SITES

The main thrust of the quality assurance audits were to check analyzers of RAPS field investigations and RAMS for accuracy. Several RAMS stations were checked. In particular, stations 113 and 122 were selected because unusually high ozone concentrations were consistently obtained there.

The data from each of the sites are presented in a standard format in Tables 1-22. For each case the column "data reading" contains the observed instrument response in volts; "Calibrator Value" is the known concentration (ppm) which was supplied to the instrument; "Station Value" is the concentration (ppm) calculated from the voltage response and the calibration constants in use for that instrument at that time.

A summary of results is presented in Table 23. The percent error was calculated by subtracting the calibration value from the station value (at the highest point), dividing by the calibrator value and multiplying by 100. The significance of the table is in that it demonstrates a rough confidence factor in measurements of this type.

3.5.1 RAPS Helicopters

The RAPS helicopter site was audited three times. There was only enough time to audit one of the three helicopters each visit. The first visit was not successful due to malfunction of the calibration instruments. The Bendix calibrator has several pull-to-test gas line diverters for calibration purposes, one of which had worked loose and shut off a main capillary flow. With this flow shut off, it was impossible to calibrate all instruments. The results are in Tables 1-3.

3.5.2 Meteorology Research Incorporated Plane (MRI)

The MRI plane was audited twice in the Thunderbird hangar at Spirit of St. Louis Air Field. The temperature of the permeation bath was not performing correctly during the first audit. The temperature of the Bendix permeation oven is adjusted by a multi turn pot. In the process of moving, a wire was dislodged from this pot resulting in a much higher temperature than indicated by the setting of the pot. This wire was repaired and the setting was returned to 25^{o}C.

There was some question of this setting by MRI on the second visit since their value did not agree to the standard. The system was rechecked in station 120 and the setting was still found to be 25^{o}C with a thermometer traceable to NBS. The results are in Tables 4-6. (NO, SO_2 data for first visit).

3.5.3 Aerosol Trailer

The aerosol trailer located west of Glasgow, Illinois was visited twice. The first time the aerosol trailer had some grounding problems on the inputs which affected many of the readings, in particular the O_3 reading gave a very poor linear fit. Since there wasn't any way to decide which values were valid, all values were reported. The results are in Tables 7-9.

3.5.4 Research Triangle Institute Van

The 6800 on the RTI was audited once for CO values. The values are in Table 10.

3.5.5 Environmental Measurements Incorporated Van (EMI)

The EMI van associated with the MRI plane was audited during the second visit to the plane. The van was located outside the Thunderbird hangar and the calibration took place outdoors since the air conditioner of the mobile laboratory was not operational. The sulfur reading was high; however, upon checking the Bendix System later in Station 120 the temperature was still found to be 25^{o}C. During the audit of the van the indicator for heating or cooling was steady on the cooling side; this may have represented an inability of the cooling unit to keep the permtube at the proper temperatures.

The EMI calibrator was checked and found to give proper readings; however, the van was not available for further checking. The results are in Tables 11-12.

3.5.6 RAMS Stations

The stations checked were 120, 105, 113 and 122. The permeation tubes were found to be off in 105, 113 and 120. In order to check the station permtube with a NBS standard, the NBS tube had to be placed in the station approximately 24 hours before the audit to equilibrate. Due to the large distance and time factor for station 122, this could not be done in time to check the station tube. Station #113 and 122 were checked mainly for O_3 values. The values are found in Tables 13-19.

3.5.7 Lou Chaney's O_3 and CO Monitors

Two portable O_3 monitors were used in a series of experiments. These were compared twice with O_3 analyzers at RAMS station 105. A CO monitor was also used in this experiment. Several bag samples as well as dynamic diluted samples were tested on this instrument. The results of the first audit are presented in the Tables. During the second audit, there appeared to be a problem with the 6800 in station 105 which gave conflicting results. This was later found to be caused by the automatic range switching program. A test in the G.C. laboratory cleared this up. The O_3 monitors during the second audit were off by as much as 30%. Questions arose as to the reliability of the NO NBS tank, Central's NBS tank and the working standard NO tank. A Bendix NO-NO_X instrument was connected to the Bendix dynamic calibrator and the various tanks were then compared by means of the NO-NO_X instrument. A difference in the working standard tank was found from the original calibration, then a difference between the two NBS tanks was found. Upon further retesting the values were not found to be repeatable since the NO-NO_X instrument was drifting. Readings taken a day apart or even morning versus afternoon gave a different value. The NO-NO_X instrument had been on previously without the vacuum but with oxygen connected. In the past this condition has been found to give erroneous results on some instruments for as long as 2-3 days after the vacuum has been reconnected. This may have been the problem; however, it was not resolved in the time frame available. This is not believed to have affected the readings of the Tables. The results are in Tables 20-22.

3.5.8 Environmental Quality Research (EQR) Theta Sensor

As a service to EQR a Theta sulfur sensor was calibrated using the stations calibration system with a NBS permeation tube. EQR inadvertantly readjusted the settings and the instrument was recalibrated in a similar fashion.

3.5.9 Battelle Northwest DC-3

Battelle Northwest employed a portable sulfur gas chromatograph (AID) (model #513) for the Metromex study. As a courtesy the gas chromatograph was calibrated for SO_2 on a visit to the Battelle plane at the Alton City Airport.

3.5.10 Gas Chromatography Laboratory

The Gas Chromatography Laboratory was not audited. However, cylinder no. 1749 (Section 3.2.3) with its certified analysis, was used as the daily calibration standard for the Beckman 6800 gas chromatograph.

3.6 RAW DATA

The raw data was placed in two laboratory notebooks with carbon copies. They were turned over to the EPA Task Coordinator.

4.0 PROBLEMS AND RECOMMENDATIONS

Most of the problems encountered during the audits were caused by lack of feedback from the calibrator. There was no flow indicator or temperature indicator. A pressure was set on the regulator and it was assumed the flow was correct.

The lack of a temperature indicator required the entire permeation oven to be taken apart in order to place a thermometer in the cavity to register the temperature. The permeation tube in the meantime would change temperature and require a settling time on the order of hours before it would register correctly. A higher setting of the temperature to 30^{o}C would give a temperature which would be easier to maintain in a high temperature ambient environment such as was encountered in the study.

The calibrator did not have a calibration manifold attached to it, this required an additional manifold to be carried each time there was a non-RAMS station field use. The problem from a lack of a calibrator manifold was encountered early in the program when high dilution flows caused a pressure build-up in the sampling line which caused the instrument sample flow to increase.

A portable calibrator with direct reading mass flow meters, or even rotameters along with an actual temperature indicator instead of a null detector, would solve many of these problems.

TABLE 1

QUALITY ASSURANCE AUDIT

RAPS Helicopter #1 Date: July 22, 1975

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.88	.800	.94
1.06	.450	.53
.0002	0	0
.353	.170	.176
1.85	.800[a]	.93

a. Replicate at end of audit

NO_X

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.86	.800	.93
1.05	.450	.525
.002	0	.001
.345	.170	.173
1.84	.800[a]	.92

a. Replicate at end of audit

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.03	0[a]	.3
-.10	Instrument Zero	-1.0
1.633	21.2	16.33
.391	5.24	3.91
.89	9.82	8.9

a. Matheson zero air-uncertified purity

Convertor Efficiency ______

NO	NO_X	CO
A = -.0100	A = -.0097	A = -.0579
B = 1.1873	B = 1.1744	B = .7938
r^2= .9993	r^2= .9991	r^2= .9862

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 2

QUALITY ASSURANCE REPORT
RAPS Helicopter #3

Date: July 26, 1975

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.578	.790	.789
1.010	.505	.505
.657	.340	.329
.324	.170	.162
.000	0	.000

Convertor Efficiency 98.5%

A = -.0053
B = 1.004
r^2 = .9997

NO_x

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.588	.790	.794
1.003	.505	.502
.661	.340	.331
.324	.170	.162
.006	0	.003

A = -.0044
B = 1.0052
r^2 = .9996

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.737	.198	.174
1.542	.168	.154
.828	.094	.083
.587	.061	.059
.337	.031	.034
.007	0	.001

A = .0039
B = .8726
r^2 = .9979

SO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.073V	.997	1.073
.794	.832	.794
.462	.399	.462
.115	.096	.115
.002	0	.002

A = .0158
B = 1.0186
r^2 = .9898

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.509	5.20	5.09
.060	Instrument Zero	.60
.048	0	.48

A = .4800
B = .8865
r^2 =

DATA READING	CALIBRATOR VALUE	STATION VALUE

A =
B =
r^2 =

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 3

QUALITY ASSURANCE REPORT
RAPS Helicopter #3

Date: August 13, 1975

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.0135	0[a]	.135
.010	Instrument Zero	.10
.444	6.43	4.44
.399	2.97	3.99
.338	2.01	3.38
.260	.870	2.6
.207	.406	2.07
.170	0[b]	1.70

a. At beginning of audit
b. At end of audit

Convertor Efficiency 98.6%

A = 1.6519
B = .5322
r^2 = .6953

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.000	0	.000
.370	.193	.185
.809	.423	.405
1.140	.595	.570
1.529	.812	.765

A = .0026
B = .9452
r^2 = .9998

NO_X

DATA READING	CALIBRATOR VALUE	STATION VALUE
.005	0	.003
.362	.193	.181
.802	.423	.401
1.108	.595	.554
1.505	.812	.753

A = .0042
B = .9248
r^2 = .9999

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
3.15	.390	.315
2.245	.251	.225
1.76	.203	.176
1.246	.131	.125
1.611	.176	.161
.017	0	.002

A = .0133
B = .8029
r^2 = .9918

SO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE
.0006	0	.000
.89	.874	.890
.625	.581	.625
.338	.297	.338
.167	.150	.167
.075	.066	.075
.400	.404	.400

A = .0108
B = 1.0201
r^2 = .9969

DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 4

QUALITY ASSURANCE AUDIT
MRI Plane

Date: July 19, 1975

NO(.5ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
5	0	.005
427	.390	.427
311	.280	.311
211	.190	.211
125	.110	.125

Convertor Efficiency 98%

A = .0055
B = 1.0840
r^2= .9999

NO(1ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
2	0	.004
437	.840	.874
345	.670	.690
211	.390	.420
152	.280	.300
104	.190	.208
61	.110	.120

A = .0097
B = 1.0278
r^2= .9996

NO(2ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
219	.840	.870
170	.670	.680
105	.390	.420
076	.280	.300
050	.190	.210
0	0	.000

A = .0106
B = .1020
r^2= .9990

NO_X(.5 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
20	0	.020
499	.390	.449
325	.280	.325
230	.190	.23
139	.110	.139

A = .0194
B = 1.0990
r^2= .9999

NO_X(1 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
12	0	.024
468	.840	.940
369	.670	.730
224	.390	.450
164	.280	.330
111	.190	.220
68	.110	.140

A = .0217
B = 1.0815
r^2= .9992

NO_X (2 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
8	0	.032
235	.840	.940
184	.670	.740
113	.390	.450
083	.280	.330
056	.190	.220

A = .0253
B = 1.0802
r^2= .9995

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 5

QUALITY ASSURANCE AUDIT
MRI Plane

Date: July 19, 1975

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
260	.214	.260
320	.260	.320
124	.100	.124
91	.070	.091
0	0	.000

Convertor Efficiency ______

A = .0022
B = 1.2175
r^2= .9996

NO (.2 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
312	.110	.156
528	.190	.264

A = .0075
B = 1.3500
r^2= ______

NO (5 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
177	1.71	1.77
129	1.23	1.29
85	.84	.85
66	.67	.66
0	0	.00

A = -.0149
B = 1.0437
r^2= .9992

NO_X (.2 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
335	.110	.168
528	.190	.28

A = .0140
B = 1.4000
r^2= ______

NO_X (5 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
2	0	.02
190	1.71	1.90
140	1.23	1.40
94	.84	.94
74	.67	.72

A = .0079
B = 1.1102
r^2= .9991

DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 6

QUALITY ASSURANCE AUDIT
MRI Plane

Date: July 31, 1975

NO (0.5 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
386	.390	.386
287	.280	.287
189	.190	.189
115	.110	.115
15	0	.015

Convertor Efficiency 97.3%

A = .0119

B = .9613

r^2= .9990

NO_X (0.5 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
369	.390	.369
275	.280	.275
182	.190	.182
115	.110	.115
20	0	.020

A = .01709

B = .9026

r^2= .9989

SO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE
617	.802	.617
462	.602	.462
403	.530	.403
305	.402	.305
150	.199	.150
000	0	.000

A = -.0023

B = .7695

r^2= .9999

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
307	.315	.307
197	.205	.197
147	.142	.147
73	.068	.073
3	0	.003

A = .0060

B = .9551

r^2= .9988

DATA READING	CALIBRATOR VALUE	STATION VALUE

DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 7

QUALITY ASSURANCE AUDIT
Aerosol Trailer

Date: July 28, 1975

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
.8404	.091	.120
.4445	.056	.064
.1320	.012	.019
.4480	.056	.064
.001	0	.000
.452	.030	.065[b]

a. Using calibration value of 8/3
b. Outlier point not used

Convertor Efficiency 100%

A = -.0005
B = 1.2537
r^2 = .9855

SO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE
-.0001	0	.000
.089	.167	.157
.055	.097	.096
.042	.066	.073

A = .0046
B = .9324
r^2 = .9937

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.453	3.82	5.23
.749	1.95	2.68
.232	.45	.81
7.425	21.2	26.8
2.020	5.24	7.28
.139	0	.47

A = .4212
B = 1.2475
r^2 = .9997

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 8

QUALITY ASSURANCE AUDIT
Aerosol Trailer

Date: July 28, 1975

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.079	0	.001
4.622	.057	.046
2.308	.027	.023

Convertor Efficiency 125.8%

A = .0012
B = .7891
r^2= .9997

NO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE

A =
B =
r^2=

NO_X

DATA READING	CALIBRATOR VALUE	STATION VALUE
.005	0	0
4.642	.057	.046
2.259	.027	.023

A = .0004
B = .8063
r^2= .9991

THC

DATA READING	CALIBRATOR VALUE	STATION VALUE
.013	0	.06
.655	2.01	2.37

A = .0600
B = 1.1493
r^2=

CH_4

DATA READING	CALIBRATOR VALUE	STATION VALUE
.377	0	.69
3.071	2.01	2.17

A = .690
B = .7363
r^2=

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.139	0	.47
2.020	5.24	7.28

A = .4700
B = 1.3000
r^2=

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 5

QUALITY ASSURANCE AUDIT

Aerosol Trailer

Date: August 13, 1975

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE
-.3288	0	-.003
2.042	.0199	.020
7.909	.0747	.079
10.112	.093	.101
5.175	.0505	.052
8.917	.081	.089

Convertor Efficiency 98.9%

A = -.0030

B = 1.1161

r^2= .9992

NO_X

DATA READING	CALIBRATOR VALUE	STATION VALUE
-.304	0	-.003
2.078	.0199	.021
8.054	.0747	.081
10.384	.093	.104
5.241	.0505	.052
8.920	.081	.089

A = -.0030

B = 1.1352

r^2= .9989

SO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE
-.0006	0	.000
.093	.0914	.164
.198	.193	.349
.354	.427	.626
.085	.0914	.149
.132	.144	.233

A = .0236

B = 1.4571

r^2= .9870

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
.065	.011	.009
.443	.062	.064
.695	.097	.101
1.085	.1566	.157
.033	0	.005

A = .0021

B = .9963

r^2= .9981

CH_4

DATA READING	CALIBRATOR VALUE	STATION VALUE
.428	0	.48
3.381	2.04	2.11

A = .4800

B = .7990

r^2=

THC

DATA READING	CALIBRATOR VALUE	STATION VALUE
.073	0	-.02
.665	2.04	2.52

A = -.0200

B = 1.2451

r^2=

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.794	5.20	12.74
.092	0	.147
1.609	4.76	11.37
.316	1.11	1.804
.577	2.10	3.74
.167	.55	.702

A = -.0651

B = 2.5078

r^2= .9894

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 10

QUALITY ASSURANCE AUDIT
R.T.I. Trailer

Date: August 4, 1975

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
3.252	9.15	9.27
2.217	6.23	6.30
1.426	4.06	4.03
.923	2.46	2.58
1.767	4.65	5.01
3.365	9.82	9.6
.079	0	.17

Convertor Efficiency ________

A = .2135
B = .9751
r^2 = .9979

CH_4

DATA READING	CALIBRATOR VALUE	STATION VALUE
.798	2.04	1.52
.03	0	.04

A = .0400
B = .7255
r^2 = ________

THC

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.035	2.04	1.91
.093	0	.10

A = .1000
B = .8873
r^2 = ________

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE II

QUALITY ASSURANCE AUDIT
EMI Van

Date: July 31, 1975

NO_x DATA READING	NO_x CALIBRATOR VALUE	NO_x STATION VALUE	SO_2 DATA READING	SO_2 CALIBRATOR VALUE	SO_2 STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE
6.95	.840	.695						
7.95	1.060	.795	.92	.602	.92			
3.25	.390	.325	.62	.403	.62			
2.35	.280	.235	.32	.199	.32			
0	0	.000	.01	0	.003			

Convertor Efficiency 84%

NO_x		SO_2	
A =	.0166	A =	.0089
B =	.7653	B =	1.5178
r^2 =	.9937	r^2 =	.9997

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 12

QUALITY ASSURANCE AUDIT
EMI Calibrator

Date: August 7, 1975

SO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE
2.2631	.312	.321*
4.6557	.624	.662
1.1865	.0347	.032
2.3144	.0694	.064
3.2812	.0986	.086

* With pure air dilution

Flow

DATA READING	CALIBRATOR VALUE	STATION VALUE
800cc/min		794cc/min
600		590
		588
400		367
		374
200		202
500		480
300		284

DATA READING	CALIBRATOR VALUE	STATION VALUE

Convertor Efficiency ________

SO_2: A = -.0124, B = 1.0774, r^2 = .9996

Flow: A = -13.2, B = .9997, r^2 = .9975

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 13

QUALITY ASSURANCE AUDIT
Station #120

Date: July 24, 1975

NO(.5 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
2.0922	.17	.160
4.2846	.340	.332
.8764	.070	.065
.0146	0	-.002

Convertor Efficiency ________

A = -.0037
B = .9825
r^2= .9997

NO (1 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.0375	.170	.159
2.1313	.340	.330
3.1860	.505	.495
.4272	.070	.063
.0024	0	-.003

A = -.0028
B = .9810
r^2= .9996

NO_X (.5 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
1.7211	.170	.157
3.0376	.340	.337
.7519	.070	.066
.039	0	.004

A = -.0136
B = .9818
r^2= .9980

NO_X (1 ppm range)

DATA READING	CALIBRATOR VALUE	STATION VALUE
.8618	.170	.157
1.7675	.340	.327
2.6720	.505	.498
4.3041	.790	.803
.3588	.070	.063
.0468	0	.000

A = -.0102
B = 1.0182
r^2= .9993

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
2.7929	.180	.181
4.9633	.323	.323
1.5747	.099	.101
1.0107	.061	.064
.0390	0	.001

A = .0022
B = .9941
r^2= .9999

DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 14

QUALITY ASSURANCE AUDIT
Station #120

Date: July 24, 1975

CO DATA READING	CO CALIBRATOR VALUE	CO STATION VALUE	CH_4 DATA READING	CH_4 CALIBRATOR VALUE	CH_4 STATION VALUE	THC DATA READING	THC CALIBRATOR VALUE	THC STATION VALUE
2.1533	5.20	4.58	.8886	2.03	1.83	.9912	2.03	1.95
2.1923	5.17	4.66	2.1801	5.23	4.60	2.2363	5.23	4.68
1.0937	2.56	2.32	1.1450	2.59	2.38	1.3134	2.59	2.66
.5078	1.19	1.079	.5737	1.20	1.15	.7958	1.20	1.52
.2832	.634	.601	.3564	.64	.688	.5859	.64	1.06
.1611	.314	.342	.2563	.318	.472	.4687	.318	.804
0.000	0	-.001	.0244	0	-.025	.1342	0	.069

Convertor Efficiency ______

	CO	CH_4	THC
A =	.0345	.1031	.3958
B =	.8853	.8639	.8305
r^2=	.9996	.9980	.9857

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 15

QUALITY ASSURANCE AUDIT
Station #120
SO_2

Date: July 29, 1975

TS

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE
2.3364	.0961	.121	2.5073	.0961	.126			
3.5107	.150	.182	3.8183	.150	.192			

Convertor Efficiency ________

A = .0122 A = .0083

B = 1.1317 B = 1.2245

r^2= ________ r^2= ________

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 16

QUALITY ASSURANCE AUDIT
Station #113

Date: August 8, 1975

NO			NO_x			O_3		
DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE
-.0488	0	-.008	-.0073	0	.000	2.299	.245	.226
1.6381	.193	.161	1.7480	.193	.176	3.7597	.412	.376
2.7612	.313	.275	2.8540	.313	.287	2.8002	.302	.276
3.8281	.433	.383	3.9746	.433	.399	1.5014	.158	.144
4.3505	.486	.435	4.8239	.486	.454	.00439	0	-.004

Convertor Efficiency 86.6%

NO	NO_x	O_3
A = -.0106	A = -.0020	A = -.0026
B = .9117	B = .9304	B = .9229
r^2 = .9997	r^2 = .9998	r^2 = .9999

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 17

QUALITY ASSURANCE AUDIT
Station #113

Date: August 8, 1975

SO_2

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE
.0976	0	-.002						
2.1972	.082	.097						
2.0166	.075	.088						
2.7690	.103	.124						
4.1113	.155	.187						
1.6064	.060	.069						

Convertor Efficiency ________

A = -.0030

B = 1.2235

r^2 = .9998

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 18

QUALITY ASSURANCE AUDIT
Station #120

Date: August 11, 1975

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE
4.5214	.358	.361
2.3242	.188	.184
3.3056	.265	.263

Convertor Efficiency 101.7%

A = -.0122

B = 1.0416

r^2= .9999

NO_X

DATA READING	CALIBRATOR VALUE	STATION VALUE
3.8452	.358	.370
2.0090	.188	.191
2.8564	.265	.274

A = -.0092

B = 1.0469

r^2= .9961

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
2.1212	.144	.135
3.914	.260	.251
4.807	.308	.309
1.6223	.097	.103

A = .0009

B = .9820

r^2= .9943

SO_2 (Sta. Perm tube)

DATA READING	CALIBRATOR VALUE*	STATION VALUE
3.18942	.1361	.1565
1.52194	.0654	.0745
.8911	.0387	.0434

A = -.0015

B = 1.1609

r^2= 1.0000

SO_2(NBS Perm tube)

DATA READING	CALIBRATOR VALUE	STATION VALUE
2.2765	.097	.113
1.8652	.080	.092
1.4550	.063	.072
4.1931	.179	.208

A = .0136

B = .9762

r^2= .9922

Bendix SO_2 Calibrator (EPA)

DATA READING	CALIBRATOR VALUE	STATION VALUE *
1.7871	.072	.076
2.6464	.110	.113
4.62155	.194	.197
1.6699	.067	.072
4.2554	.176	.180

A = .0048

B = .9918

r^2= .9999

Station Value, ppm = A + B (calibrator value, ppm)

*Station system calibrated with NBS permtube.

TABLE 19

QUALITY ASSURANCE AUDIT
Station #122

Date: August 11, 1975

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.0128	0	-.003
2.0422	.193	.188
3.7866	.344	.353
4.6850	.437	.437
4.0014	.381	.373

Convertor Efficiency 99%

A = -.0035
B = 1.0079
r^2= .9987

NO_X

DATA READING	CALIBRATOR VALUE	STATION VALUE
.0494	0	-.001
1.7782	.193	.188
3.4716	.381	.375
3.3129	.344	.357
4.0698	.437	.440

A = -.0024
B = 1.0116
r^2= .9983

CO

DATA READING	CALIBRATOR VALUE	STATION VALUE
.1855	.331	.369
.8544	1.74	1.78
2.2265	4.74	4.48
-.0073	0	-.024

A = .0456
B = .9429
r^2= .9988

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE
.0267	0	.001
2.0434	.229	.235
3.2209	.350	.371
3.9656	.427	.457
1.6210	.165	.186

A = .0020
B = 1.0589
r^2= .9985

DATA READING	CALIBRATOR VALUE	STATION VALUE

DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 20

QUALITY ASSURANCE AUDIT
Station #105 NO-NO_x
Lou Chaney O_3 Monitors

Date: August 6, 1975

NO DATA READING	NO CALIBRATOR VALUE	NO STATION VALUE	NO_x DATA READING	NO_x CALIBRATOR VALUE	NO_x STATION VALUE	O_3 #1	CALIBRATOR VALUE	O_3 #2
3.1738	.424	.374	3.1054	.424	.389	.052	.047	.047
2.5146	.313	.291	2.4829	.313	.310	.022	.019	.021
1.4282	.193	.158	1.3769	.193	.169	.020	.0165	.018
.8276	.101	.084	.7885	.101	.094	.126	.115	.115
						.160	.142	.137
						.000	0	.000

Convertor Efficiency ______

NO	NO_x	#1	#2
A = -.0102	A = -.0028	A = .0005	A = .0016
B = .9209	B = .9439	B = 1.1104	B = .9670
r^2= .9947	r^2= .9910	r^2= .9995	r^2= .9992

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 21

QUALITY ASSURANCE AUDIT
Station #105
CO Analysis for Lou Chaney

Date: August 7-8, 1975

DATA READING	CO CALIBRATOR VALUE	Philco Ford Value	DATA READING	CO CALIBRATOR VALUE	STATION VALUE*	DATA READING	CALIBRATOR VALUE	STATION VALUE
	3.79	3.01	4.1406	8.66	8.74			
	3.81	3.49	1.6064	3.55	3.31			
	1.04	1.70	2.3193	5.20	4.84			
	0	.00	0.0314	0	0.052			
	3.81	3.41*	0.6152	1.044	1.19			
			1.8701	3.81	3.87			

* August 7

Convertor Efficiency ________

A = .3717 A = .0092

B = .7832 B = .9858

r^2 = .9395 r^2 = .9957

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 22

QUALITY ASSURANCE AUDIT
Station #105
(O_3 Analysis for Lou Chaney)

Date: August 14, 1975

O_3

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE
.9815	.1026	.109						
.5908	.0576	.064						
.4155	.0383	.044						
.2595	.0208[a]	.026						

a. Produced by change in sleeve setting of ozone lamp. Reproducibility of sleeve position may be questionable.

Convertor Efficiency ________

A = .0055

B = 1.0090

r^2= .9999

NO

DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE	DATA READING	CALIBRATOR VALUE	STATION VALUE
2.3372	.344	.285						
1.7895	.266	.215						
1.300	.188	.153						

A = -.0074

B = .8462

r^2= .9988

Station Value, ppm = A + B (calibrator value, ppm)

TABLE 23

CALIBRATION DIFFERENCE SUMMARY

(In Percent)

SITE	NO	NO_x	O_3	CO	CH_4	THC	SO_2	TS
RAPS Helicopter 1	17	16		-23				
RAPS Helicopter 3	0	0	-12	-2			7	
RAPS Helicopter 3	-6	-7	-19	-31			2	
MRI Plane 7/19 (.2)	39	47	21					
MRI Plane 7/19 (.5)	9	15						
MRI Plane 7/19 (1.0)	4	12						
MRI Plane 7/19 (2.0)	4	12						
MRI Plane 7/19 (5.0)	4	11						
MRI Plane 7/31	-1	-5	-3				-23	
Aerosol Trailer 7/28	-19	-19	+32	23	8	18	-6	
Aerosol Trailer 8/13	9	12	0	174	3	24	47	
RTI Trailer				1	-25	-6		
EMI Van		-25					53	
EMI Calibrator							6	
Station 120 (.5)	-2	-6	0	-12	-12	-11	28	21
Station 120 (1.0)	-2	2						
Station 113	-10	-7	-9				20	
Station 120 8/11			20					
Station 122	0	1	7	5				
Station 105	-12	-8	6	1				
Chaney	-17		11	-3,1				

TECHNICAL REPORT DATA

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1. REPORT NO. EPA-600/4-76-032	2.	3. RECIPIENT'S ACCESSION NO.
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16. ABSTRACT

Aerometric data is being collected by the Regional Air Pollution Study (RAPS) for use in developing and evaluating air quality simulation models. In addition to the Regional Air Monitoring System (RAMS), data is also collected by research teams in periodic expeditions to the St. Louis study area. Data from all sources are made available for integration through the RAPS Data Bank. A quality assurance audit of instrument systems employed in the Summer 1975 RAPS Expeditionary Research Program was conducted to check the various systems for accuracy. Additionally such checks provide a basis for determining the extent to which data from different instrument systems may be integrated. This report describes the audit equipment and standards used and problems encountered. Quantitative audit results from individual instrument systems are presented. The audits included analyzers for NO, NO_x, O_3, SO_2, CO, CH_4 and THC measurements.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Air Pollution		13B
*Measuring instruments		14B
*Quality assurance		14A
Auditing		05A

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 44
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

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