United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
Research Triangle Park NC 27711

EPA/600/4-88-007
January 1988

Research and Development

EPA

Precision and Accuracy Assessments for State and Local Air Monitoring Networks, 1986

EPA/600/4-88/007
January 1988

PRECISION AND ACCURACY ASSESSMENTS FOR STATE AND LOCAL AIR MONITORING NETWORKS 1986

by

Raymond C. Rhodes
Quality Assurance Division
Environmental Monitoring Systems Laboratory

E. Gardner Evans
Monitoring and Assessment Division
Environmental Monitoring Systems Laboratory

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

NOTICE

The information in this document has been subjected to the Agency's peer and administrative review and it has been approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

Measurement and monitoring research efforts are designed to anticipate potential environmental problems, to support regulatory actions by developing an in-depth understanding of the nature and processes that impact health and the ecology, to provide innovative means of monitoring compliance with regulations, and to evaluate the effectiveness of health and environmental protection efforts through the monitoring of long-term trends. The Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina, has the responsibility for assessment of environmental monitoring technology and systems; implementation of agency-wide quality assurance programs for air pollution measurement systems; and supplying technical support to other groups in the Agency including the Office of Air and Radiation, the Office of Toxic Substances, and the Office of Enforcement.

Ambient air quality data collected by States and local agencies are used in planning the nation's air pollution control strategy, in determining if National Ambient Air Quality Standards are being attained, and in determining long-term trends of air quality. Prior to the regulations of May 10, 1979, the procedures used in site selection, controlling equipment, and calculating and validating data varied considerably among agencies. These regulations serve to improve and make more uniform the quality assurance programs of the state and local agencies and to require the assessment and reporting of data quality estimates for precision and accuracy. Reporting of precision and accuracy data was first required for calendar year 1981. Previous reports summarized the results for 1981, 1982, 1983, 1984 and 1985. This report summarizes and evaluates the results for 1986.

John C. Puzak
Deputy Director
Environmental Monitoring Systems Laboratory
Research Triangle Park, North Carolina

ABSTRACT

Precision and accuracy data obtained from State and local agencies during 1986 are summarized and evaluated. Some comparisons are made with the results reported for previous years to determine the indication of any trends. Some trends indicate continued improvement in the completeness of reporting of precision and accuracy data. The national summaries indicate a further improvement in the precision and accuracy assessments of the pollutant monitoring data collected. The annual results from each reporting organization are given so that comparisons may be made from year-to-year and with other reporting organizations.

A comparison of the precision and accuracy data from the Precision and Accuracy Reporting System (PARS) with those from the independent National Performance Audit Program (NPAP) conducted by the Environmental Monitoring Systems Laboratory is made.

CONTENTS

FIGURES

TABLES

TABLES (continued)

ACKNOWLEDGMENTS

The authors express appreciation to the following persons and organizations who assisted in the preparation of this report: the States and local agencies, for performing and reporting the results of the precision checks and accuracy audits; the Regional Office persons responsible for reviewing and coordinating the reporting of the precision and accuracy data to EMSL/RTP; Robert L. Lampe, EMSL/RTP, for reviewing and processing the precision and accuracy reports received from the Regional organizations; Robert Lyon, Computer Sciences Corporation, for the computer programing, processing, and summarization of the precision and accuracy data; John Holland, Northrop Services, Incorporated, for assistance in preparing the figures and tables; Edward Barrows, Northrop Services, Incorporated, for programming and reporting of the comparisons of the results of the EMSL performance audit program with the precision and accuracy data; Les Sizemore Northrop Services, Incorporated, for the programming and preparation of the charts showing the results from each reporting organization for the years 1981 through 1986; and to Elizabeth Hunike and Ceci Ellington, EMSL, for typing this report.

SECTION 1

INTRODUCTION

The purpose of this document is to report the sixth year of data from the Precision and Accuracy Reporting System (PARS). Federal regulations promulgated on May 10, 1979, require quality assurance precision and accuracy (P and A)* data to be collected. Collection started January 1, 1981, according to requirements set forth in 40 CFR Part 58 Appendix A.[1] These requirements provide for more uniform Quality Assurance programs and specific precision and accuracy assessment and reporting requirements across all State and local air monitoring agencies.

The major portion of this report consists of summarizations and evaluations of the P and A data obtained by the efforts of the States and local agencies. In addition, comparisons have been made of the accuracy data collected for PARS with the results of the National Performance Audit Program (NPAP) which has been an ongoing program conducted by the Environmental Monitoring Systems Laboratory (EMSL) since the early 1970's.

These summarizations and evaluations of precision and accuracy data serve the following purposes:

1. Provides quantitative estimates of the precision and accuracy of their ambient air monitoring data to State and local agencies.

2. Indicates the need to improve quality assurance systems in specific reporting organizations if a comparison of the data from all the agencies shows excessive variability or bias.

3. Indicates the need for improvement in monitoring methodology if precision and accuracy estimates are excessive or erratic.

4. Provides users of data from the State and Local Air Monitoring Stations (SLAMS) network a quantitative estimate of the precision and accuracy of the ambient air quality data.

*When one speaks of precision and accuracy of measurement data,[2] one really means the precision and accuracy of the measurement process from which the measurement data are obtained. Precision is a measure of the "repeatability of the measurement process under specified conditions." Accuracy is a measure of "closeness to the truth."

Ambient air quality data, collected by States and local agencies since 1957, have been stored in the National Aerometric Data Bank (NADB). These data are used in (1) planning the nation's air pollution control strategy, (2) determining if the National Ambient Air Quality Standards are being achieved, and (3) determining long-term trends of air quality. Prior to the EPA air monitoring regulations of May 10, 1979, the procedures used in selecting monitoring sites, operating and controlling the equipment, and calculating, validating and reporting the data varied considerably among agencies. Frequently the procedures being used were not well-documented. These conditions made it difficult to compare data from different sites and agencies. Furthermore, little information was available on the reliability of the monitoring data.

To help alleviate these problems, EPA's air monitoring regulations imposed uniform requirements on network design, siting, quality assurance, monitoring methods, and data reporting after December 31, 1980. For example, only EPA reference, equivalent, or other EPA-approved air monitoring methods are to be used. Also, calibration standards are to be traceable to the National Bureau of Standards (NBS) or other authoritative standards. Further, the quality assurance systems of the States are required to be documented and approved by the EPA Regional Offices. Finally, the reporting organizations must also follow specific procedures when assessing the P&A of their measurement systems and must report the P&A data to EPA quarterly. Starting January 1, 1981, these regulations became effective for National Air Monitoring Sites (NAMS), and beginning January 1, 1983, for all State and Local Air Monitoring Stations (SLAMS). These regulations have remained in effect for data obtained through 1986. Revised regulations, March 19, 1986, require the reporting of all the raw data to EMSL/RTP effective for all data obtained after December 31, 1986.

The precision assessments were determined by performing repeated measurements of ambient-level "calibration" gases at two-week intervals for continuous methods, or by obtaining duplicate results from collocated samplers for manual methods. Table 1 summarizes the requirements for performing precision checks. The accuracy assessments were generally determined by analyzing blind audit materials traceable to NBS. Table 2 shows the concentration levels. During each calendar year, each site or instrument must be audited at least once. Details concerning the specific procedures and computations used to assess P&A are contained in the regulations.

TABLE 1. REQUIREMENTS FOR PERFORMING PRECISION CHECKS FOR SLAMS NETWORK

Parameter	Precision check	Frequency
CO (continuous analyzer)	8 - 10 ppm	Once each 2 weeks
SO_2, NO_2, and O_3 (continuous analyzer)	0.08 - 0.10 ppm	Once each 2 weeks
TSP, SO_2, and NO_2 (manual)	Collocated sampler (Ambient concentration)	Once each 6 days
Pb	Duplicate strips (Ambient concentration)	Once each 6 days

TABLE 2. CONCENTRATION LEVELS FOR CONDUCTING ACCURACY AUDITS OF SLAMS NETWORK

Parameter	Level 1	Level 2	Level 3	Level 4
SO_2, NO_2, O_3 (continuous)	0.03-0.08 ppm	0.15-0.20 ppm	0.35-0.45 ppm	0.80-0.90 ppm
CO	3-8 ppm	15-20 ppm	35-45 ppm	80-90 ppm
TSP (flow only)		1.13-1.70 m^3/min		
SO_2 (manual)*	0.013-0.020 ppm	0.033-0.040 ppm	0.053-0.059 ppm	
NO_2 (manual)*	0.018-0.028 ppm	0.046-0.055 ppm	0.074-0.083 ppm	
Pb**	0.6-1.8 µg/m^3	3.5-5.9 µg/m^3		

*Concentration levels corresponding to flow rates of .2 L/min.
**Concentration levels corresponding to flow rates of 50 cfm.

When a request is made to the NADB for ambient air quality monitoring data, the requestor receives the P and A data along with the routine monitoring data. The requestor, or user, of the data can feel more confident that the data are of the quality indicated by the assessments and that the data have been obtained from an agency having a planned and documented quality assurance system. The EPA can also rely on the data in producing its control strategies and determining whether standards have been met.

SECTION 2

NATIONAL RESULTS

NATIONAL DATA REPORTING

A measure of the completeness of the precision and accuracy data reporting is the percentage of reporting organizations which were required to report data for a particular pollutant and which have reported results for at least one calendar quarter for that pollutant. Table 3 shows the progress in data reporting over the years 1981 through 1986. Reporting for the manual methods for Pb, SO_2, and NO_2 was required by the regulations beginning January 1, 1983. The reporting of 1986 Pb data has remained the same as for 1985. Only two reporting organizations, Guam and Hawaii, continue to use the manual SO_2 method. The 50 percent reporting indicates that no reports were received from one of the two. The manual NO_2 method is no longer used at any SLAMS sites. The percentages of reporting organizations reporting some data for TSP and the continuous methods for 1986 have remained essentially the same as for 1985.

The reporting organizations which should have reported data for 1986 but did not are listed in Section 3.

TABLE 3. PERCENT OF REPORTING ORGANIZATIONS REPORTING PRECISION AND ACCURACY DATA

Pollutant measurement	1981	1982	1983	1984	1985	1986
CO	77	89	99	99	96	97
SO_2	82	93	96	97	97	96
NO_2	56	72	88	94	96	94
O_3	83	89	99	99	95	96
TSP	94	97	99	99	99	98
Pb	--	--	93	92	96	96
SO_2 (manual)	--	--	75	80	75	50
NO_2 (manual)	--	--	86	100	100	--

NATIONAL ACTIVITY IN PERFORMING PRECISION CHECKS AND ACCURACY AUDITS

A review of Tables 4 and 5 clearly indicates the considerable increase in the total number of precision and accuracy checks from the beginning of

TABLE 4. YEAR-TO-YEAR ACTIVITY OF PRECISION AND ACCURACY ASSESSMENTS FOR THE MANUAL METHODS

Pollutant	Year	Avg. no. of samplers	Precision			Accuracy	
			Avg. no. of collocated sites	No. of valid collocated data pairs	No. of data pairs per site	No. of audits x levels	No. of audits per sampler
TSP	1981	2,334	317	13,335	42.1	5,840	2.5
	1982	2,538	338	16,281	48.2	6,461	2.6
	1983	2,662	342	16,816	49.2	6,989	2.6
	1984	2,650	338	17,152	50.8	7,436	2.8
	1985	2,455	331	16,462	49.7	6,820	2.8
	1986	2,128	316	15,744	49.8	6,292	3.0
Pb	1981	73	13	473	36.4	581	4.0
	1982	164	32	1,704	53.2	655	2.0
	1983	452	76	3,885	51.1	1,389	1.5
	1984	492	92	3,937	42.8	1,657	1.7
	1985	486	86	3,508	40.8	1,616	1.7
	1986	413	61	2,749	45.1	1,612	2.0
SO_2	1981	172	34	965	28.4	711	1.4
	1982	63	21	706	33.6	551	2.9
	1983	46	15	389	25.9	301	1.1
	1984	36	10	297	28.3	203	1.9
	1985	20	6	185	30.8	174	2.9
	1986	8	2	62	31.0	155	6.5
NO_2	1981	185	38	1,422	37.4	769	4.2
	1982	83	25	1,168	46.7	583	2.3
	1983	77	25	1,324	53.0	348	1.5
	1984	50	13	691	53.2	175	1.2
	1985	36	10	469	46.9	161	1.5
	1986	12	5	174	34.8	92	2.6

TABLE 5. YEAR-TO-YEAR ACTIVITY OF PRECISION AND ACCURACY ASSESSMENTS FOR THE CONTINUOUS METHODS

Pollutant	Year	Avg. no. of analyzers	Precision		Accuracy	
			No. of precision checks	Precision checks per analyzer	No. of accuracy audits x levels*	No. of audits per analyzer
CO	1981	282	8,248	29.2	856	1.01
	1982	354	13,089	37.0	1,180	1.11
	1983	447	15,714	35.2	1,501	1.12
	1984	424	14,692	34.7	1,265	0.99
	1985	426	14,465	34.0	1,143	0.89
	1986	391	13,225	33.8	1,052	0.90
SO_2	1981	420	10,851	25.8	1,016	0.81
	1982	566	23,144	36.6	1,248	0.73
	1983	633	36,887	58.3	1,625	0.86
	1984	630	38,312	60.8	1,500	0.79
	1985	571	22,863	40.0	1,397	0.82
	1986	560	30,609	54.1	1,272	0.75
NO_2	1981	127	2,498	19.7	320	0.84
	1982	193	6,876	35.6	442	0.76
	1983	235	9,299	39.6	635	0.90
	1984	240	8,653	36.0	589	0.82
	1985	232	7,695	33.2	550	0.79
	1986	206	6,686	32.5	510	0.83
O_3	1981	404	10,536	26.1	1,162	0.96
	1982	514	18,964	36.9	1,328	0.86
	1983	598	21,342	35.7	1,705	0.95
	1984	579	20,031	34.6	1,629	0.94
	1985	574	18,822	32.8	1,499	0.87
	1986	529	17,438	33.0	1,328	0.84

*Levels 1, 2, and 3 only.

the PARS system through 1984 for all pollutant methods except the manual SO_2 and NO_2 methods. The increase in effort resulted because of the effectivity of the regulation requirements for P and A data for the NAMS* sites on January 1, 1981 and for the SLAMS on January 1, 1983. The reduction in the manual NO_2 and SO_2 methods has resulted from the replacement of the manual methods with continuous analyzers. The average number of analyzers/samplers and the total number of precision checks have decreased from 1983 and 1984 for all measurements. However, the numbers of precision checks per site have decreased in some cases (manual and continuous NO_2), increased in other cases (Pb, manual and continuous SO_2, and O_3), and remained the same for TSP. The reduction of the number of analyzers/samplers since 1983 has reresulted in corresponding decreases in the number of precision checks and accuracy audits. However, the numbers of accuracy audits per analyzer/sampler have increased for all methods except CO, continuous SO_2 and O_3.

For the manual methods, Table 4 shows the average number of data pairs per collocated site for precision checks and the average number of accuracy audits per sampler. If the collocated samplers are operated every sixth day, there should be 365/6 = 61 data pairs per year, assuming that all the results are above the detection limit. This level of precision checks is being approached for the TSP and Pb. The regulations require that each TSP sampler/site be audited for accuracy at least once each year, and that the laboratory for the other manual methods be audited at least twice per quarter. The computed average number of audits per TSP sampler is well above the required frequency.

For the continuous methods, the minimum frequency for precision checks is once every two weeks or 26 per year. Table 5 shows that CO, NO_2, and O_3 analyzers are being checked somewhat more frequently, about 33, and that the SO_2 analyzers are being checked at almost twice a week. Perhaps experience has indicated that the SO_2 analyzers drift at a higher rate than the other instruments. The regulations require at least one accuracy audit per analyzer/site per year. The average number of audits per analyzer for the continuous methods indicates that from 10 to 25 percent of the analyzers are not being audited as required by the regulations. (Note: The tabulated values consider only the audits at the three lower concentration levels. Analyzers requiring level four audits, e.g., episode monitors, are not considered.)

A comparison can be made between the average number of samplers for which PARS data are reported and the number of SLAMS/NAMS sites in the nation:

*See Glossary, Appendix A, for definitions.

		Continuous methods				Manual methods			
		SO_2	NO_2	O_3	CO	TSP	Pb	SO_2	NO_2
No. SLAMS/NAMS sites	1984	540	252	600	439	2477	382	14	15
	1985	538	232	617	440	2424	403	6	14
	1986	534	231	622	450	2363	414	6	0
Avg. no. samplers reporting PARS data	1984	630	240	579	424	2650	492	36	50
	1985	571	232	574	426	2455	486	9	36
	1986	566	206	529	391	2128	413	8	12

It appears that for all of the manual methods and for continuous SO_2 in 1984 and 1985, P and A data from more samplers were received than existed as SLAMS/NAMS sites. Presumably, these extra or additional samplers are being used for special purpose monitoring and/or both samplers at collocated sites (manual methods) are being counted. However, in 1986 neglecting the manual SO_2 and manual NO_2 methods for which none or a few SLAMS sites exist, the average number of samplers reporting PARS data is less than the number of SLAMS/NAMS sites for all methods except continuous SO_2. This would indicate less than the required P and A reporting for most of the methods (except for continuous SO_2).

1986 RESULTS FROM THE PARS PROGRAM

Estimates of precision and accuracy are required to be computed and reported for each calendar quarter by each Reporting Organization (a State or local agency) as percentage deviation values. For precision, the repeatability for each check is measured as the deviation from the expected value as a percentage of the expected value. For accuracy, the deviation of the audit value from the true value is measured as a percentage of the true value. For both precision and accuracy, 95 percent probability limits are computed for the percentage values from the average and standard deviations of the individual percentage values:

$$\overline{D} \pm 1.96\ S$$

where $\overline{D}$ = the average of the individual percent differences;
S = the standard deviation of the individual percent differences;*
1.96 = the multiplication factor corresponding to 95% probability.

It is these upper and lower 95% probability limits which are reported and discussed in this report.

Moreover, it should be noted that the data and the evaluations presented in this report include any outlier values which may have been reported by the States and local agencies. It is possible that the presence of outliers might influence such comparisons by having undue impact on average values for individual reporting organizations.

The probability limits presented throughout this report for states, regions, and the nation have been calculated using the formulas shown in Appendix B and thereby most appropriately reflect the total variability within the entity involved. (Note: Probability limit values in this report and the 1984[5] and 1985[6] reports in Tables 6, 7, 12, and 14 and Figures 1 through 10 cannot be validly compared with corresponding tables and figures of previous reports.[3,4] The limits given in this report are generally wider than corresponding limits of previous reports for the reasons discussed in Appendix B.)

Table 6 exhibits the national probability limits for each of the manual pollutants.

*For the precision of manual methods obtained from paired observations, the standard deviation, S, is divided by $\sqrt{2}$, to obtain variability estimates that apply to individual reported values.

TABLE 6. NATIONAL PRECISION AND ACCURACY PROBABILITY LIMIT VALUES FOR MANUAL METHODS FOR 1986

Pollutant	Precision		Accuracy					
			Probability limits (%)					
	Probability limits (%)		Level 1		Level 2		Level 3	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
TSP	-12	+13	--	--	-8	+8	--	--
Lead	-20	+20	-14	+11	-11	+9	--	--
Sulfur dioxide	-19	+22	-43	+21	-18	+14	-17	+17
Nitrogen dioxide	-48	+45	-8	+12	- 6	+8	-4	+5

The precision limits reflect the repeatability of the methodology used in the field to collect and analyze the samples at ambient levels. The spread of the limits may be somewhat inflated due to measurements at relatively low concentration levels.

The accuracy of the manual methods indicates the limits at predetermined concentration levels for the chemical analysis performed in the samples for lead, sulfur dioxide, and nitrogen dioxide. For the TSP method, the accuracy measurement is for the flow rate only. The probability limits for manual accuracy are very good and reflect the quality of work done in the chemical laboratories for lead, sulfur dioxide, and nitrogen dioxide analyses, and in the field for flow rate measurement for the TSP method. Because of the continual replacement of the manual SO_2 and NO_2 methods with continuous methods, very little data are reported for these methods and further discussion of these manual methods is limited. However, the detailed results, if any, are tabulated in Appendix D.

The precision and accuracy limits for automated methods are presented in Table 7. The results are nearly the same as reported for 1985.

TABLE 7. NATIONAL PRECISION AND ACCURACY PROBABILITY LIMIT VALUES FOR AUTOMATED ANALYZERS FOR 1986

	Precision		Accuracy							
	Probability limits (%)		Probability limits (%)							
			Level 1		Level 2		Level 3		Level 4	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
CO	-9	+9	-16	+15	-8	+8	-8	+7	-15	+15
SO_2	-10	+10	-17	+16	-13	+12	-12	+11	-14	+13
NO_2	-11	+11	-21	+20	-13	+11	-13	+11	-14	+6
O_3	-10	+8	-14	+13	-17	+16	-10	+9	-8	+6

NATIONAL PRECISION RESULTS COMPARISON

Figure 1 shows the national probability limits for precision for the various methods. With data from the four most recent years, some minor trends are evident. Some slight improvement, as measured by a continued reduction in the spread of the limits, is noted for the manual methods -- TSP and SO_2, and the continuous methods -- O_3, CO and NO_2. Increases in precision for the manual methods, Pb and NO_2, and for the continuous method SO_2 may be due to small sample (NO_2) or statistical variations. The slight but persistent negative bias for the continuous SO_2 method indicates that on the average there is some negative instrument drift from the most recent calibration or instrument adjustment to the time of the biweekly precision check.

Although the manual methods for Pb, SO_2, and NO_2 were not required to be reported until 1983, a number of agencies began reporting in 1981. The manual SO_2 and NO_2 methods are much more variable than the continuous methods.

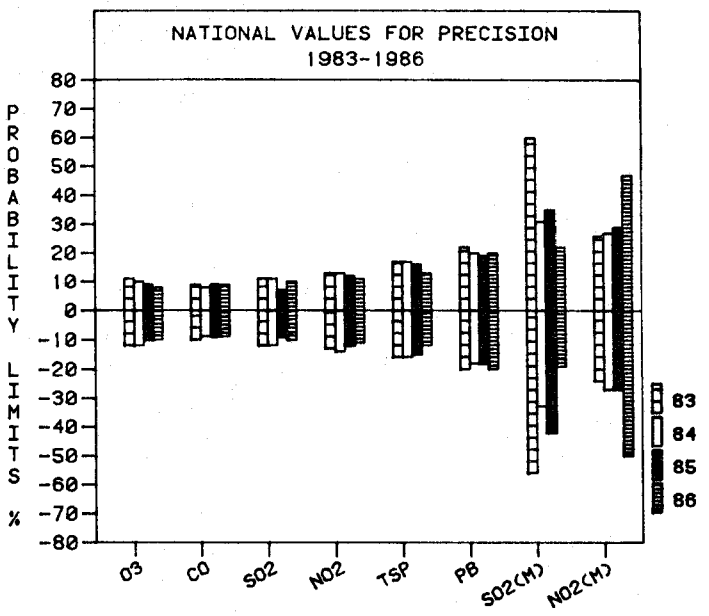


Figure 1. National precision probability limits for 1983 through 1986.

NATIONAL ACCURACY RESULTS COMPARISON

Figures 2a and 2b show the national values for accuracy audits for the continuous and manual methods, respectively, for the four most recent years, 1983-1986. Improvement for the manual methods is not evident except perhaps for Pb and NO_2. The variability for the TSP method remains the same and the SO_2 method has shown a definite increase. The results for the manual methods for SO_2 and NO_2 vary considerably from year to year because the methods are used in only 2 or 3 Regions and are being replaced by the continuous methods. Slight improvement was evident for all the continuous methods over past years, but has not continued for 1986. The continuous methods for SO_2 and NO_2 show more inaccuracy than all other methods. However, it is pointed out that the accuracy audits for the manual methods check only a portion of the measurement method.

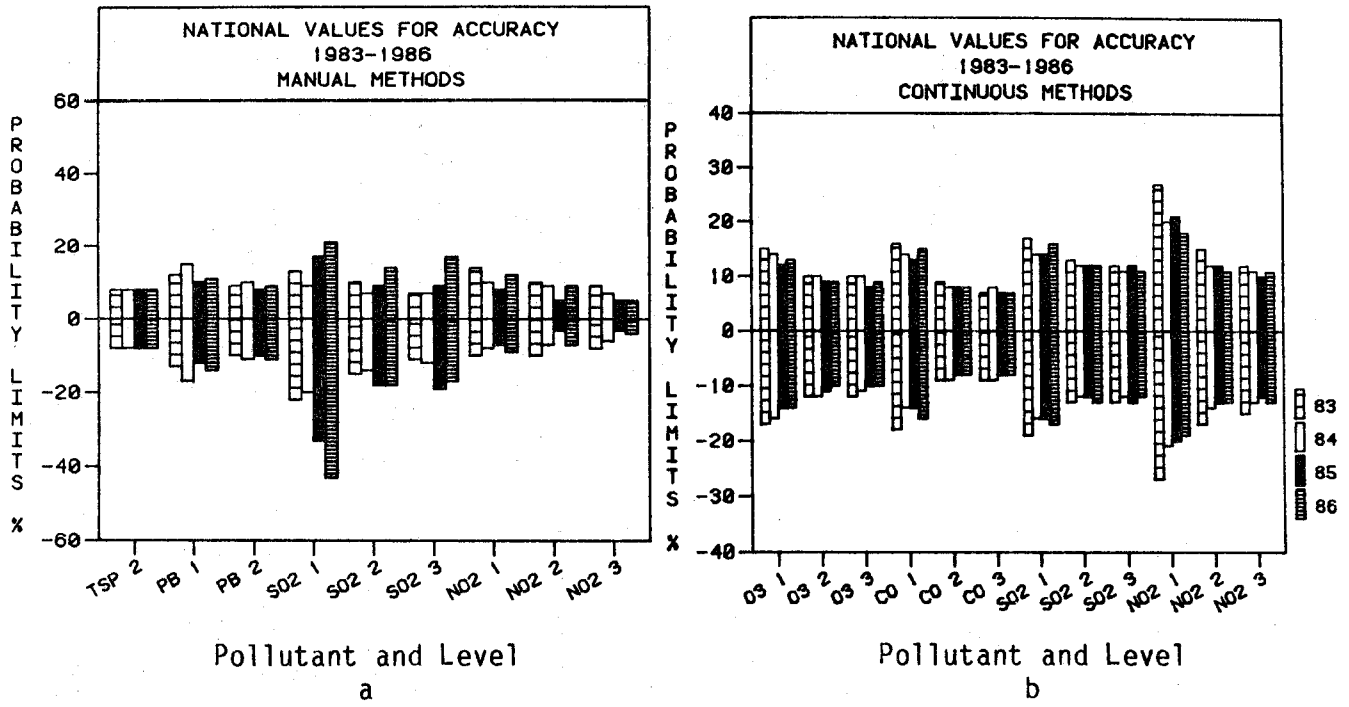


Figure 2. National accuracy probability limits for 1983 through 1986.

Although the continuous NO_2 method is more variable than the other methods, it has shown the greatest improvement, particularly for the level 1 concentration.

The general, and expected, pattern of variability across levels is very evident, with the greatest percentage variability at the lowest concentration levels. The slight negative biases for the continuous SO_2 method is consistent across all three levels. A possible cause is that, on the average, a negative drift occurs with these analyzers from the time of last calibration or instrument adjustment until the time of the accuracy audit.

NATIONAL FREQUENCIES

Table 8 contains the 1986 percentiles for precision probability limits and accuracy probability limits at levels 1, 2, 3, and 4. The percentiles are based on the total number of reporting-organization quarters of data. The individual quarter of data consists of an upper and lower probability limit for precision, and upper and lower probability limits for accuracy for each of the levels. The narrower the distribution, the better the data quality. For example, for precision for CO, the upper 5 percentile value for the upper limit is +15%, and the lower 5 percentile value for the lower limit is -15%. It can be seen from both Figure 2 and Table 8 that CO shows the tightest range of the pollutants presented. The variabilities shown in Table 8 are consistent with those shown in Figures 1 and 2. The 95th percentiles provide criteria beyond which a reported probability limit may be considered excessive and for which the computation should be rechecked or the measurement system investigated and corrected, if so indicated.

TABLE 8. PERCENTILES OF QUARTERLY PROBABILITY LIMITS FOR ALL REPORTING ORGANIZATIONS (1986)

MANUAL METHODS

ENVIRONMENTAL PROTECTION AGENCY

EMSL PRECISION/ACCURACY REPORTING SYSTEM

DATE 10/16/87
PROGRAM PA250

FREQUENCY DISTRIBUTION OF PROBABILITY LIMITS
DATA SELECTED FOR THE YEAR 1986

PAGE NO. 147
REPORT PA250R01

NATIONAL FREQUENCY SUMMARY

MANUAL METHODS

POLLUTANT LEVEL	NUMBER OF REP.ORG.-QTR	LOWER PROBABILITY LIMIT MIN	01%	05%	10%	25%	50%	75%	90%	95%	99%	MAX	MEAN	STD DEV	UPPER PROBABILITY LIMIT MIN	01%	05%	10%	25%	50%	75%	90%	95%	99%	MAX	MEAN	STD DEV
I11101 - TSP																											
PRECISION	546	-34	-29	-21	-17	-13	-09	-06	-03	-02	-00	+20	-10	5.9	-03	+01	+02	+03	+06	+09	+14	+19	+24	+33	+46	+11	6.9
ACC-LVL 2	511	-25	-21	-14	-11	-08	-06	-03	-01	-00	+02	+09	-06	4.5	-10	-04	-01	+01	+03	+05	+08	+12	+15	+25	+46	+06	5.4
I12128 - PB																											
PRECISION	219	-51	-45	-37	-28	-19	-10	-07	-03	-01	-00	-00	-14	10.5	-20	-09	-00	+02	+05	+10	+17	+30	+38	+65	+99	+13	13.8
ACC-LVL 1	273	-59	-48	-18	-15	-10	-06	-03	-01	+01	+05	+13	-08	7.8	-30	-12	-03	-02	+01	+04	+07	+13	+17	+38	+45	+05	7.4
ACC-LVL 2	273	-37	-28	-19	-12	-09	-05	-02	-01	+01	+03	+08	-06	6.0	-15	-08	-03	-01	+01	+03	+07	+10	+15	+18	+69	+04	6.5
I81102 -																											
PRECISION	46	-39	-39	-32	-26	-17	-09	-04	-00	+05	+11	+11	-11	10.9	-09	-09	-01	+02	+04	+06	+17	+22	+24	+33	+33	+10	8.8
ACC-LVL 1	12	-31	-31	-31	-17	-09	-06	-01	-01	-00	-00	-00	-08	8.9	+01	+01	+01	+01	+03	+08	+12	+16	+42	+42	+42	+09	11.4
ACC-LVL 2	25	-27	-27	-24	-17	-10	-06	-03	-01	-00	+04	+04	-08	7.3	-02	-02	-01	-01	+02	+06	+15	+27	+29	+43	+43	+10	11.2
ACC-LVL 3	1	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	0.0	+17	+17	+17	+17	+17	+17	+17	+17	+17	+17	+17	+17	0.0
I42401 - SO2																											
PRECISION	6	-32	-32	-32	-32	-16	-08	-08	-06	-06	-06	-06	-14	9.7	+04	+04	+04	+04	+11	+26	+33	+35	+35	+35	+35	+21	12.3
ACC-LVL 1	11	-75	-75	-75	-51	-48	-30	-11	-08	-07	-07	-07	-31	22.6	+05	+05	+05	+05	+05	+10	+20	+23	+40	+40	+40	+13	10.8
ACC-LVL 2	14	-37	-37	-37	-32	-14	-10	-04	-01	+02	+02	+02	-12	11.1	-03	-03	-03	+02	+04	+06	+13	+20	+25	+25	+25	+08	7.6
ACC-LVL 3	10	-40	-40	-40	-14	-09	-08	-04	-01	-01	-01	-01	-10	11.1	-03	-03	-03	+01	+01	+06	+17	+22	+22	+22	+22	+08	9.1
I42602 - NO2																											
PRECISION	13	-47	-47	-47	-38	-34	-28	-11	-05	+11	+11	+11	-22	16.6	-41	-41	-41	-16	+05	+07	+55	+65	+89	+89	+89	+20	36.0
ACC-LVL 1	12	-18	-18	-18	-17	-11	-07	-01	-00	-00	-00	-00	-08	6.2	-01	-01	-01	+02	+05	+12	+14	+16	+16	+16	+16	+10	5.8
ACC-LVL 2	11	-10	-10	-10	-08	-06	-03	-01	-01	-00	-00	-00	-04	3.1	-02	-02	-02	-01	+02	+04	+08	+12	+12	+12	+12	+05	4.7
ACC-LVL 3	10	-06	-06	-06	-04	-04	-01	-00	+03	+03	+03	+03	-02	2.6	-01	-01	-01	+01	+01	+04	+04	+06	+06	+06	+06	+03	2.3

(Continued)

TABLE 8. PERCENTILES OF QUARTERLY PROBABILITY LIMITS FOR ALL REPORTING ORGANIZATIONS (1986)

ENVIRONMENTAL PROTECTION AGENCY — EMSL PRECISION/ACCURACY REPORTING SYSTEM

DATE 10/16/87 — FREQUENCY DISTRIBUTION OF PROBABILITY LIMITS — PAGE NO. 146
PROGRAM PA250 — DATA SELECTED FOR THE YEAR 1986 — REPORT PA250R01

NATIONAL FREQUENCY SUMMARY

AUTOMATED ANALYZERS

POLLUTANT LEVEL	NUMBER OF REP.ORG.-QTR	LOWER PROBABILITY LIMIT MIN	01%	05%	10%	25%	50%	75%	90%	95%	99%	MAX	MEAN	STD DEV	UPPER PROBABILITY LIMIT MIN	01%	05%	10%	25%	50%	75%	90%	95%	99%	MAX	MEAN	STD DEV
C42101 - CO																											
PRECISION	362	-27	-24	-15	-12	-09	-06	-04	-02	-01	+01	+05	-07	4.5	-05	-03	-00	+01	+03	+06	+09	+13	+15	+22	+48	+07	5.4
ACC-LVL 1	281	-65	-59	-23	-19	-14	-08	-02	-00	+01	+06	+16	-09	9.7	-14	-11	-04	-01	+03	+07	+14	+20	+26	+52	+99	+09	11.2
ACC-LVL 2	274	-41	-21	-14	-12	-08	-05	-02	-00	+02	+06	+06	-05	5.3	-05	-05	-02	-00	+02	+04	+08	+12	+14	+24	+26	+05	5.1
ACC-LVL 3	268	-61	-20	-15	-11	-07	-04	-02	-00	+02	+06	+07	-05	5.9	-05	-05	-01	-00	+02	+04	+07	+11	+13	+23	+34	+05	4.9
ACC-LVL 4	9	-25	-25	-25	-25	-13	-10	-01	-00	-00	-00	-00	-09	8.4	-00	-00	-00	-00	+03	+05	+13	+33	+33	+33	+33	+09	10.6
C42401 - SO2																											
PRECISION	413	-42	-33	-22	-19	-13	-09	-07	-05	-03	+01	+19	-11	6.3	-06	-02	-00	+02	+05	+07	+10	+14	+17	+28	+84	+08	6.8
ACC-LVL 1	332	-76	-44	-29	-24	-17	-11	-06	-02	+01	+05	+13	-12	10.6	-15	-09	-05	-02	+04	+08	+14	+21	+26	+65	+95	+10	11.8
ACC-LVL 2	328	-41	-34	-24	-19	-13	-09	-05	-01	+01	+07	+09	-10	7.5	-09	-07	-03	-01	+03	+07	+12	+18	+20	+28	+37	+08	7.4
ACC-LVL 3	322	-49	-32	-22	-18	-13	-09	-05	-02	-00	+06	+08	-10	7.4	-14	-06	-03	-01	+02	+06	+12	+17	+20	+30	+35	+07	7.2
ACC-LVL 4	44	-37	-37	-17	-16	-12	-06	-02	-00	+02	+07	+07	-08	8.9	-10	-10	-03	-00	+04	+09	+12	+16	+18	+31	+31	+08	7.5
C42602 - NO2																											
PRECISION	236	-53	-41	-25	-19	-12	-09	-06	-03	-01	+01	+04	-10	7.7	-05	-00	+02	+04	+06	+09	+13	+20	+27	+50	+86	+11	9.1
ACC-LVL 1	168	-76	-75	-42	-32	-17	-10	-03	-00	+04	+09	+13	-13	14.7	-47	-18	-05	-00	+05	+10	+17	+26	+33	+55	+78	+12	13.5
ACC-LVL 2	162	-35	-34	-22	-18	-13	-07	-02	+01	+02	+05	+10	-08	8.1	-18	-09	-02	-01	+02	+05	+11	+16	+20	+29	+30	+06	7.4
ACC-LVL 3	160	-85	-51	-21	-18	-12	-07	-04	-01	+01	+04	+07	-09	9.6	-07	-07	-03	-01	+01	+04	+11	+15	+18	+25	+37	+06	7.0
ACC-LVL 4	9	-26	-26	-26	-26	-16	-11	-05	-00	-00	-00	-00	-11	8.1	-08	-08	-08	-08	-00	+04	+06	+11	+11	+11	+11	+03	5.6
C44201 - O3																											
PRECISION	394	-35	-24	-18	-14	-10	-07	-05	-03	-01	+01	+03	-08	5.0	-11	-02	+02	+03	+04	+07	+09	+12	+16	+23	+34	+07	4.7
ACC-LVL 1	305	-68	-40	-25	-19	-13	-08	-04	-01	+01	+04	+09	-09	9.1	-08	-06	-00	+01	+04	+08	+13	+18	+24	+35	+44	+09	7.8
ACC-LVL 2	298	-99	-29	-17	-14	-10	-07	-03	-00	+01	+04	+07	-07	8.3	-09	-08	-01	-00	+03	+06	+10	+15	+18	+31	+99	+07	8.3
ACC-LVL 3	291	-52	-26	-17	-14	-10	-06	-03	-00	+01	+03	+06	-07	6.1	-09	-05	-01	+01	+03	+05	+10	+14	+18	+26	+38	+07	6.1
ACC-LVL 4	22	-13	-13	-12	-12	-10	-07	-03	-02	-01	-01	-01	-07	3.7	-00	-00	+01	+01	+02	+04	+07	+09	+10	+12	+12	+05	3.3
C42601 - NO																											
PRECISION	4	-11	-11	-11	-11	-08	-07	-07	-07	-07	-07	-07	-08	1.9	+03	+03	+03	+03	+04	+06	+07	+07	+07	+07	+07	+05	1.8
ACC-LVL 1	2	-16	-16	-16	-16	-16	-12	-12	-12	-12	-12	-12	-14	2.8	-00	-00	-00	-00	-00	+09	+09	+09	+09	+09	+09	+05	6.4
ACC-LVL 2	2	-09	-09	-09	-09	-09	+03	+03	+03	+03	+03	+03	-03	8.5	+03	+03	+03	+03	+03	+08	+08	+08	+08	+08	+08	+06	3.5
ACC-LVL 3	2	-10	-10	-10	-10	-10	+05	+05	+05	+05	+05	+05	-03	10.6	+09	+09	+09	+09	+09	+16	+16	+16	+16	+16	+16	+13	4.9

SECTION 3

REGIONAL RESULTS

REGIONAL DATA REPORTING

All reporting organizations having SLAMS/NAMS sites for the criteria pollutants are required to report P and A data. The numbers of such reporting organizations are listed in Table 9. Note that only two reporting organizations use the manual SO_2 method at SLAMS sites and none uses the manual NO_2 method.

TABLE 9. TOTAL NUMBER OF REPORTING ORGANIZATIONS REQUIRED TO REPORT FOR THE YEAR 1986, BY POLLUTANT

	Automated methods				Manual methods			
Region	CO C42101	SO_2 C42401	NO_2 C42602	O_3 C44201	TSP I11101	Pb I12128	SO_2 I42401	NO_2 I41602
I	6	6	5	6	6	5	0	0
II	3	5	2	3	4	3	0	0
III	10	12	11	12	14	9	0	0
IV	21	22	10	26	34	11	0	0
V	20	25	12	24	30	15	0	0
VI	10	10	9	10	14	11	0	0
VII	11	9	5	11	12	9	0	0
VIII	2	4	3	5	9	3	0	0
IX	11	9	9	11	12	8	2	0
X	4	3	2	2	4	4	0	0
Nation	98	105	68	110	139	78	2	0

The breakdown of data completeness (defined as the percentage of reporting organizations which reported P&A data to EPA relative to the number required to report each quarter) is given in Table 10.

TABLE 10. PERCENTAGE OF REPORTING ORGANIZATIONS WITH COMPLETE DATA IN PARS FOR THE YEARS 1983, 1984, 1985 and 1986

Manual Methods

	TSP I11101				Pb I12128				SO_2 I42401				NO_2 I41602			
Region	83	84	85	86	83	84	85	86	83	84	85	86	83	84	85	86
I	98	100	100	74	95	99	90	59	--	--	--	--	--	--	--	--
II	72	97	88	93	75	100	100	96	--	--	--	--	--	--	--	--
III	99	100	98	98	88	95	92	88	--	--	--	--	100	--	--	--
IV	97	99	96	95	78	80	92	85	94	100	100	--	75	100	--	--
V	99	97	94	95	89	85	93	81	--	--	--	--	100	--	--	--
VI	95	98	97	96	83	88	95	85	--	0	0	--	63	100	100	--
VII	97	95	99	98	66	83	76	68	--	--	--	--	0	--	--	--
VIII	96	100	100	88	75	83	75	77	--	--	--	--	--	--	--	--
IX	82	95	73	56	59	74	53	46	50	43	19	19	--	--	--	--
X	100	92	84	93	59	72	72	84	--	--	--	--	--	--	--	--
Nation	95	98	94	91	79	85	85	73	72	64	34	19	73	100	100	--

Automated Methods

	CO C42101				SO_2 C42401				NO_2 C42602				O_3 C44201			
Region	83	84	85	86	83	84	85	86	83	84	85	86	83	84	85	86
I	85	91	90	71	92	98	96	71	56	80	50	49	79	79	73	57
II	92	88	88	91	66	83	63	80	100	100	88	100	96	99	67	91
III	100	100	99	97	100	100	100	97	96	98	89	94	99	100	99	95
IV	83	84	85	82	79	87	79	90	51	63	65	71	81	79	81	82
V	78	85	83	85	77	92	86	92	65	79	66	75	76	88	78	82
VI	91	97	90	89	82	93	84	93	70	85	83	85	96	98	96	94
VII	78	78	80	84	69	77	72	85	68	75	69	84	80	73	68	75
VIII	68	98	90	80	100	98	91	82	92	92	83	80	96	100	88	69
IX	77	89	63	72	60	93	64	73	58	94	71	74	75	95	59	74
X	88	94	84	85	88	97	11	80	81	100	81	18	94	100	100	100
Nation	83	90	84	83	80	92	82	86	69	88	73	78	84	91	80	82

NOTE -- Means no data was required, there being no SLAMS sites for these pollutants.

From 1985 to 1986, the percentages of reporting on a national level decreased for all manual methods and increased for all automated methods, except CO.

A substantial lack of reporting of 1986 data occurred for the fourth quarter, during the time when plans and preparations were being made for the reporting of all raw data, beginning January 1, 1987. The regulations permitted the reporting organizations to begin using the raw data reporting system beginning as early as for the third quarter data of 1986. Start-up problems with the raw data reporting system were no doubt responsible for some loss of data for the third and fourth quarters.

A number of reporting organizations having SLAMS/NAMS sites for certain pollutants have reported no precision or accuracy data for 1986 for these pollutants:

Region	State	Reporting organization Number	Name	Pollutant
I	NH	30001	New Hampshire***	NO_2
II	VI	55001	Virgin Islands	TSP, SO_2
IV	FL	10018	Dade County	SO_2
	TN	44005	Chattanooga-Hamilton Co.,* Air Pollution Control	CO
VII	MO	26003	St. Louis City**	Pb
VIII	MT	27003	Great Falls City-County	O_3
	MT	27004	Missoula City-County	O_3
IX	CA	05036	San Diego***	Pb
	HI	12120	Hawaii	SO_2, NO_2
	NV	29100	State of Nevada***	CO
	NV	29100	State of Nevada***	O_3
	NV	29200	Washoe County	CO, NO_2, O_3, TSP
	NV	29300	Clark County**	Pb, CO
IX	GU	54100	Guam***	TSP, Pb
	GU	54100	Guam***	SO_2 (manual)
X	WA	49001	Washington	NO_2

*Repeats from 1985.
**Repeats from 1984 and 1985.
***Repeats from 1983, 1984 and 1985.

Precision and accuracy reporting for 1986 was complete only for the following Region and pollutant combinations:

Region	Pollutant
II	NO_2
X	O_3

Considering the reporting for all pollutants (omitting the manual SO_2 and NO_2 methods) and all reporting organizations, the reporting organizations of Region III were most complete for 1986 (95%). Region III was also the most complete in 1983, 1984 and 1985. Region I data was the least complete (59%).

Region	Percentage of reports complete			
	83	84	85	86
I	84	91	83	64
II	84	95	82	92
III	97	99	96	95
IV	80	86	85	84
V	83	88	83	85
VI	74	82	81	90
VII	65	80	77	82
VIII	88	95	88	79
IX	66	83	57	66
X	85	93	82	77

When considering the various pollutant methods across all Regions, reporting was most complete for the TSP and SO_2 methods and least complete for the manual SO_2 method, the same as for 1984 and 1985.

Pollutant	Percentage of reports complete			
	83	84	85	86
TSP	95	98	94	91
O_3	84	91	80	82
CO	83	90	84	83
SO_2	80	92	82	86
Pb	79	85	85	73
NO_2 (manual)	73	100	100	--
SO_2 (manual)	72	64	34	19
NO_2	69	88	73	78

REGIONAL COMPARISONS

Figures 3 through 10 compare the precision and accuracy probability limits for 1983, 1984, 1985 and 1986. These comparisons are presented for each pollutant on a Region by Region basis.

CO (Figure 3)

Only Regions VI, VIII, and X showed a noticeable improvement from 1985 for precision. Regions II, IV and V were worse in 1986 for all accuracy levels than in 1985. Regions I, IV and VI, showed consistent improvement at all accuracy levels.

SO_2 (Figure 4)

Regions II, V and VI were consistent in improvements for all three levels of accuracy; however, Regions I, VIII and X were worse in precision and all levels of accuracy.

NO_2 (Figure 5)

More regions showed improvement than not. Regions IV, and VII were better at all accuracy levels in 1986 than in 1985 -- Regions II and VIII were worse.

O_3 (Figure 6)

For 1985 more regions showed improvement in precision and accuracy for ozone than for any other measurement. These significant improvements were possibly attributed to the use of the standard reference photometers (SRP's) developed by the National Bureau of Standards for EPA and located at:

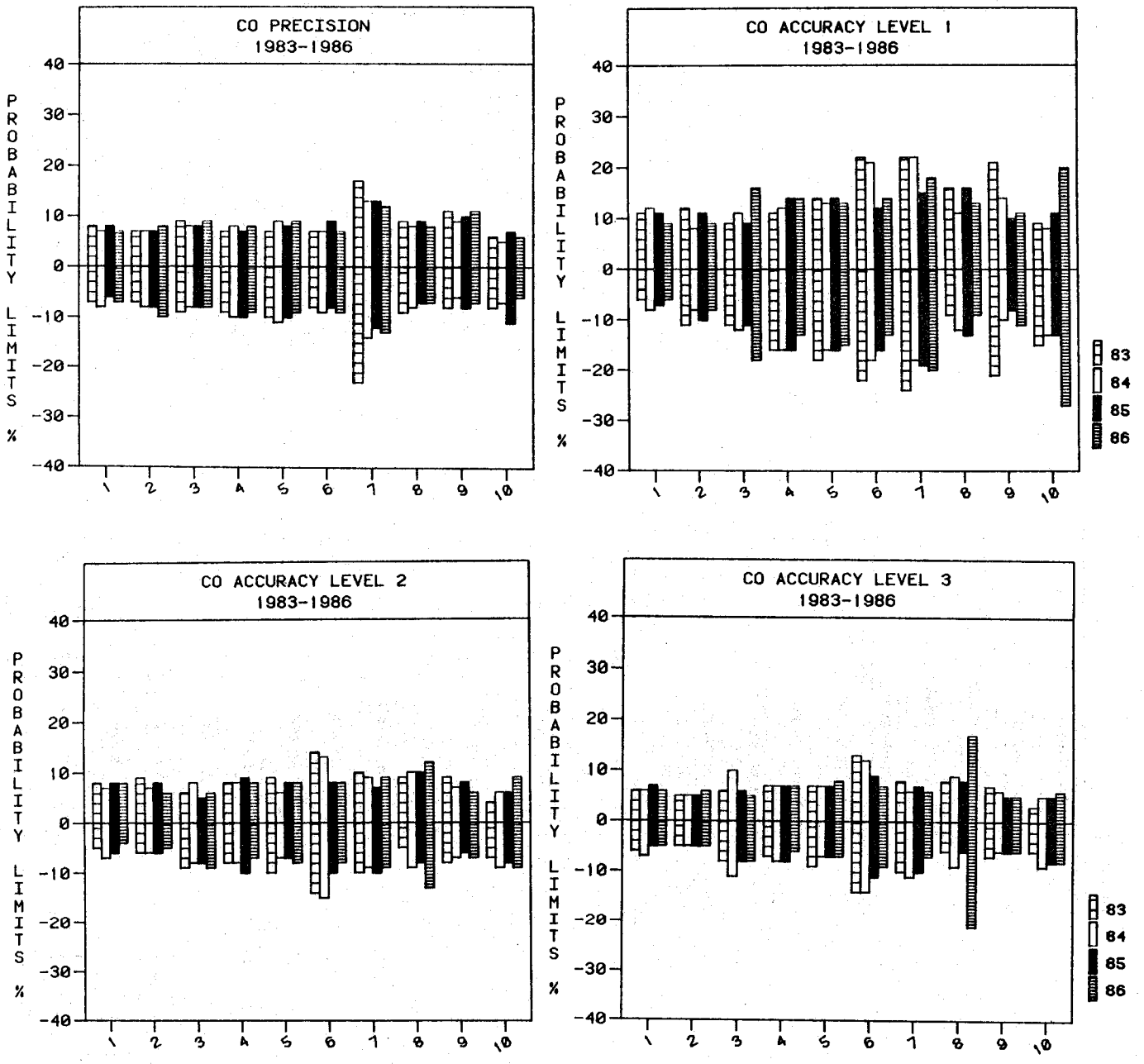


Figure 3. CO precision and accuracy by region for 1983 through 1986.

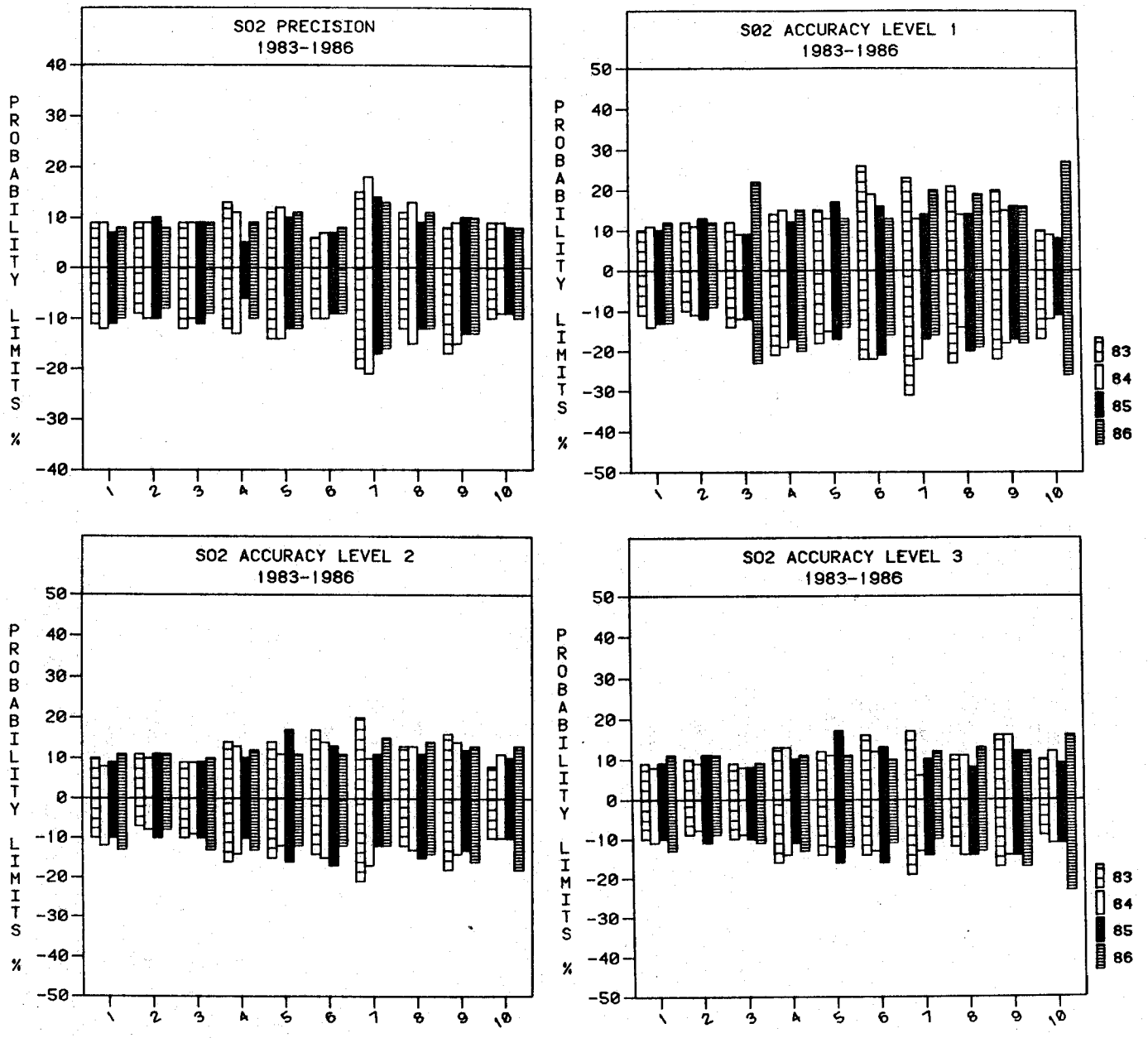


Figure 4. Continuous SO_2 precision and accuracy by region for 1983 through 1986.

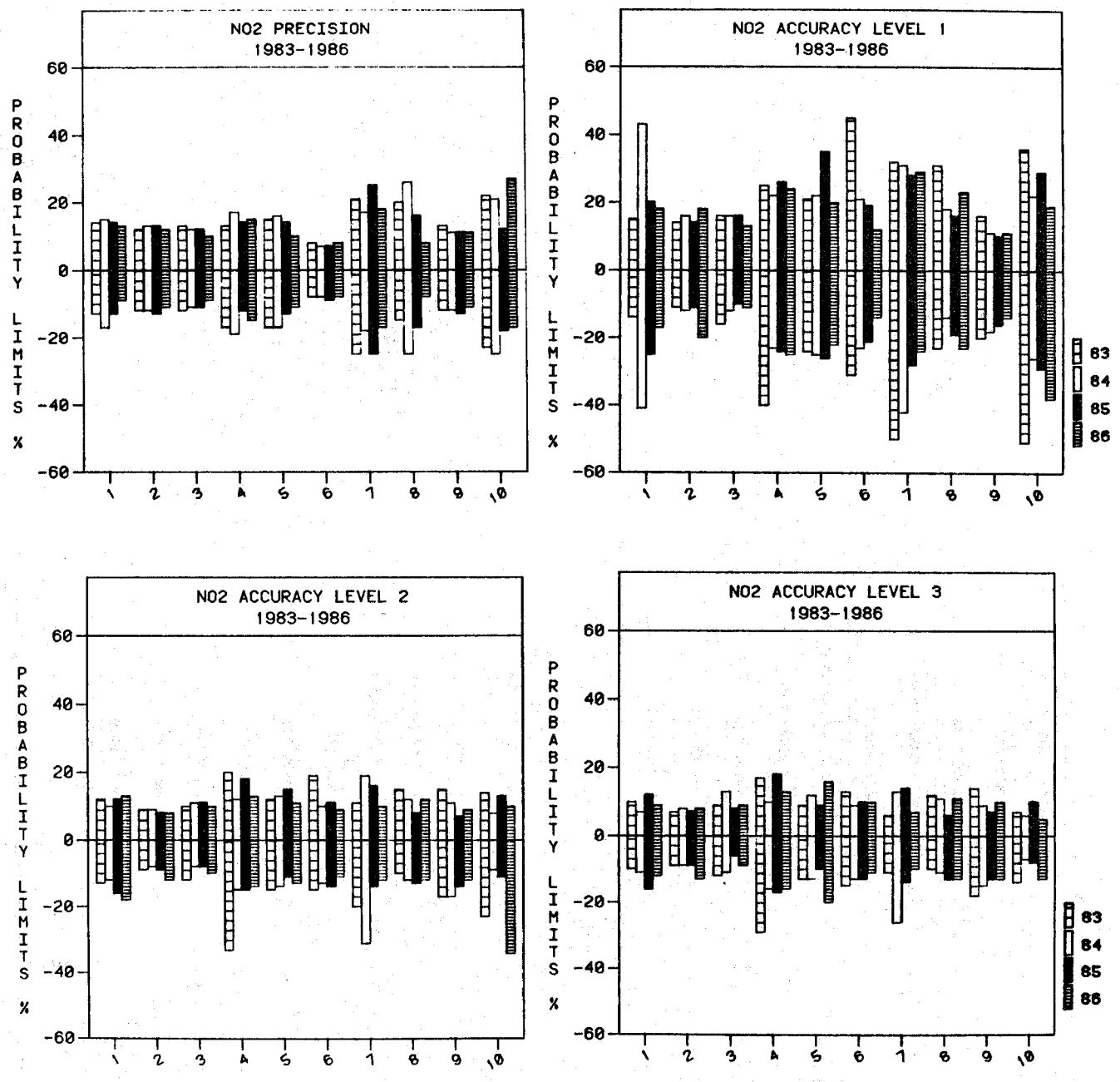


Figure 5. Continuous NO_2 precision and accuracy by region for 1983 through 1986.

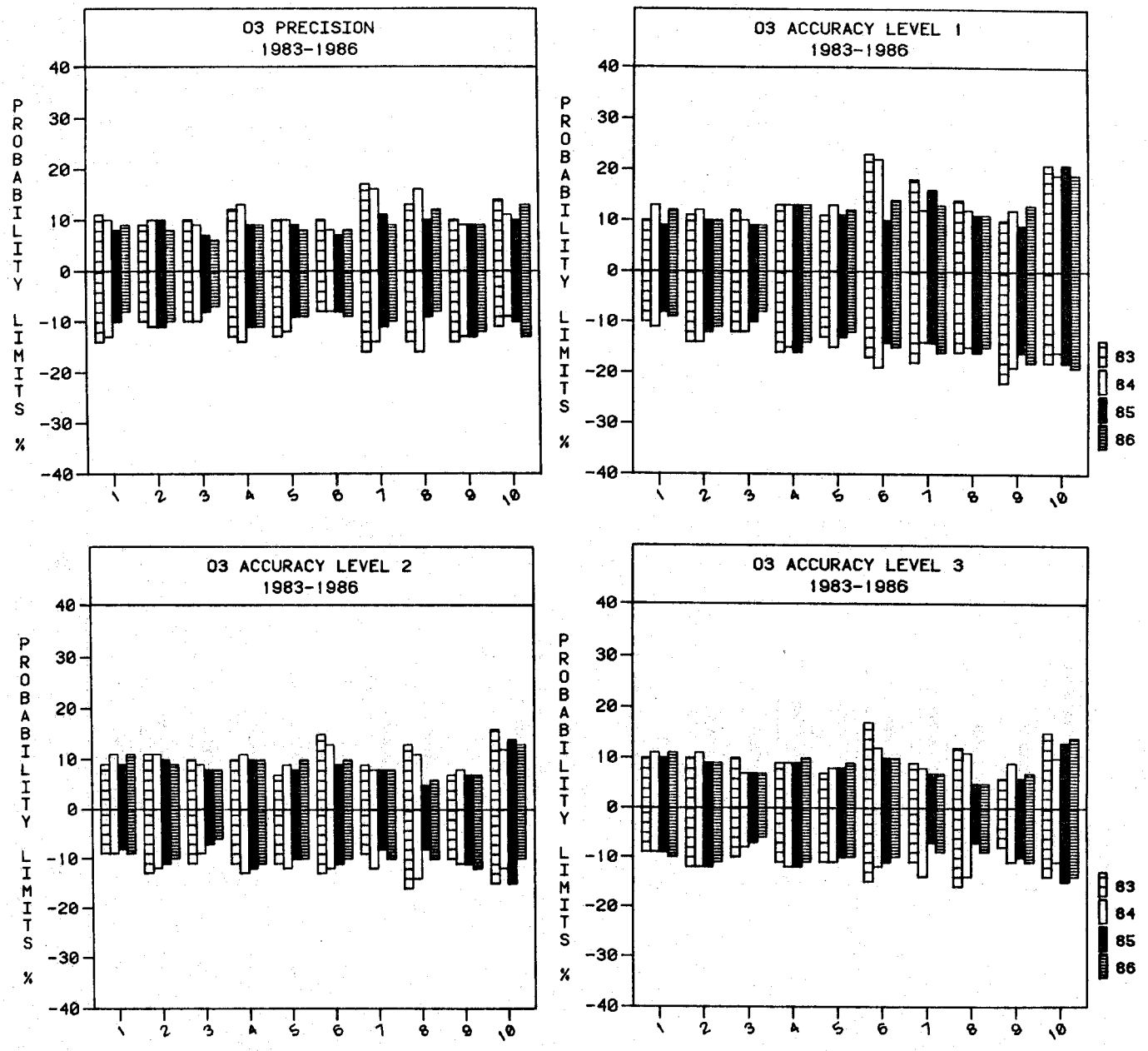


Figure 6. Ozone precision and accuracy by region for 1983 through 1986.

EPA, EMSL, Research Triangle Park, NC
EPA, Region II, Edison, NJ
EPA, Region V, Chicago, IL
EPA, Region VI, Houston, TX
EPA, Region VIII, Denver, CO
California Air Resources Board, Sacremento, CA

and which are being used as calibration reference sources throughout the nation. In November 1987, a seventh SRP was added at EPA, Region IV, Athens, GA. And, in 1988, an eighth SRP will be added at EPA, Region I, Lexington, MA.

However, comparison of 1986 results with those of 1985 does not indicate a continuing improvement, except for Regions II and III. Regions I and IX show more variability at all accuracy levels in 1986 than 1985.

TSP (Figure 7)

All regions except III did better in precision in 1986 than in 1985. Most Regions, except II, III and IV, were better or the same in 1986 compared to 1985.

Pb (Figure 8)

Only four regions -- II, III, V and VI -- showed improvement in precision. And Regions II, III, IV, VI and IX were worse in accuracy in 1986 than in 1985.

Ranking Comparisons of Regions

Ranking comparisons were made to determine the regions and pollutant-measurement methods which improved most from 1985 to 1986. Improvement was indicated by a reduction in the spread of the probability limits from 1985 to 1986. Considering all pollutant-measurement methods (except manual SO_2 and manual NO_2) and precision and accuracy results, the following table lists the regions in order of improvement.

For comparison, these measures of improvement from 1984 to 1985 are also shown. Interestingly, there were more indications of improvement from 1984 to 1985 than from 1985 to 1986. Also, Region IV averaged at "no change" for both comparisons and Region X was least improved for both comparisons.

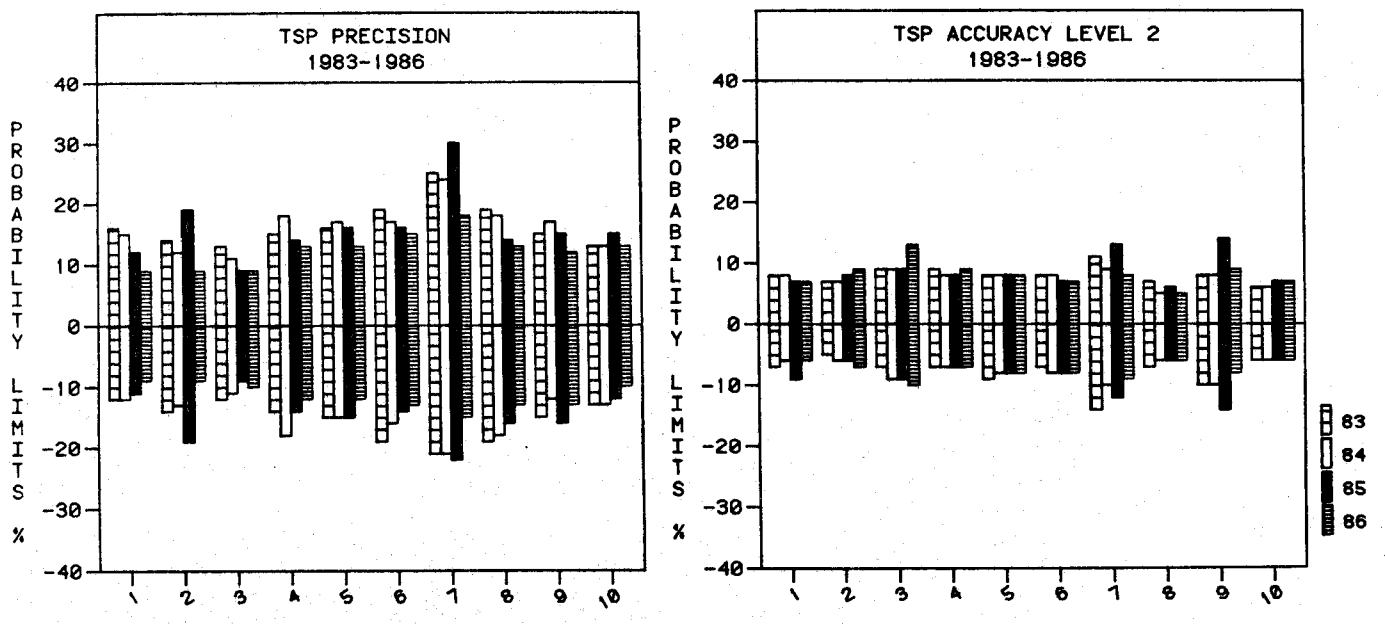


Figure 7. TSP precision and accuracy by region for 1983 through 1986.

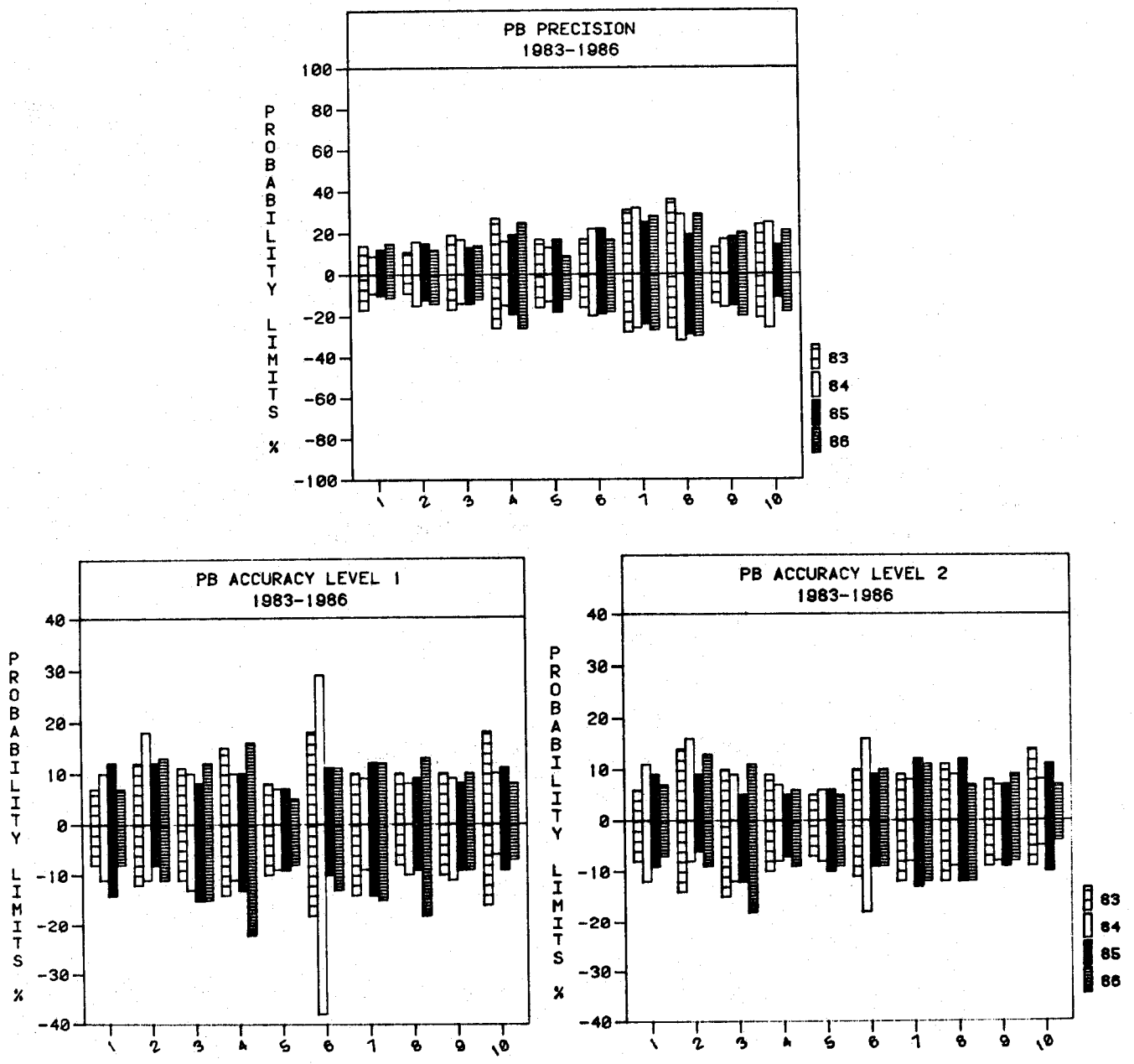


Figure 8. Lead precision and accuracy by region for 1983 through 1986.

Relative Score*	Regions 1984 to 1985	1985 to 1986	
9	III, IX		Most
8	VII	VI	improved
7	I, VI, VIII		
6		V	
5			
4		VII	
3		I, II	
2			
1	V		
0	IV	IV	No change
-1	II		
-2			
-3		III	
-4	X		
-5		IX	
-6			
-7		VIII	Least
-8		X	improved

*The maximum possible score is +12, i.e., if improvement is indicated for precision and accuracy for all 6 methods. Similarly, the most negative possible score is -12.

The most improved measurement method was determined by combining the rankings across regions and across precision and accuracy.

Relative Score	Pollutants 1984 to 1985	1985 to 1986
25	25 ± O_3	
20		
15		
10		
5	8 • CO	9 • TSP
	7 • SO_2	7 • NO_2
0	4 • NO_2	4 • CO
-5	-3 • TSP	-1 • O_3
-10		-6 • Pb
-15		-12 • SO_2

General comparisons among regions can be made on several different bases. One basis is that of improvement, as shown by the above analysis. However, comparisons of improvement may not be fair to those regions which already demonstrate a history of good precision and accuracy -- they have little further room for improvement and may be approaching the inherent limitations or capabilities of the measurement methods. On the contrary,

the regions that have shown poorer precision and accuracy have more room for improvement.

A better measure for comparison may be the magnitude of the accuracy assessments. Not considering any significant biases reflected by the mean of the upper and lower probability limits, the spread of the limits would be a good measure of how well the precision and accuracy of measurement systems are being controlled. The following analysis using the spread of the limits provide this additional and perhaps better way of making general comparisons across regions.

Ranking comparisons were also made to determine the regions and pollutant-measurememt methods which were best based on the widths of the probability limits for 1986. These comparisons were made separately for the continuous methods and manual methods and also separately for precision and accuracy. The rankings were:

Ranking of Regions for Achievement

Continuous Methods

	Precision			Accuracy	
Rank	1985	1986	Rank	1985	1986
1 (best)	VI	VI	1 (best)	III	I
2		III	2	II	III
3	III, IV	I	3		VI
4	I	VIII	4	VIII, IX	IX
5	II	II	5	I	V
6		V	6	X	II
7	V, X	IX	7	VII	VII
8	IX	IV	8		IV
9	VIII	VII	9	V, VI	VIII
10 (worst)	VII	X	10 (worst)	IV	X

Manual Methods (TSP and Pb Only)

	Precision			Accuracy	
Rank	1985	1986	Rank	1985	1986
1 (best)			1 (best)	V	X
2	I, III	I, II	2	II	
3	X	V	3	IV	I, V
4	IX	III	4		IX
5	II	X	5	VI, VIII	IX
6		VI	6	X	VIII
7	IV, V	IX	7	III	II
8	VI	IV	8	I	VII
9	VIII	VIII	9	IX	IV
10 (worst)	VII	VII	10 (worst)	VII	III

The above rankings are similar to those for previous years. The application of Spearman's Rank Correlation tests to the above four sets of data indicate significant correlations (approximate 0.05 significance level) for the precision rankings, but not significant correlations for the accuracy data.

It could be said that the comparisons of improvement relate to measures of progress, whereas the comparisons of variabilities, i.e., the spread of the limits, relate to measures of achievement.

General

Taking into account the minor trends of improvement, the general consistency from year to year of the differences of results among pollutants and among levels of the same pollutants on a national basis, and among regions for given pollutants, is truly surprising. These appreciable differences which persist from year to year strongly indicate that whatever forces or causal factors are in action in each region and in each pollutant measurement system are persistent over the years. These significant differences between regions should be investigated to identify the major causal factors, since some regions consistently produce more precise and accurate data than other regions.

Further, each region should evaluate the differences among the states and reporting organizations in a similar graphical manner as shown by Figures 3 through 10 and the ranking comparisons of improvement and accomplishment as shown above. Then investigations should be conducted to determine why some states or reporting organizations produce better precision and accuracy than others. Appropriate corrective actions should then be taken to improve the precision and accuracy of the reporting organizations having the worst results.

SECTION 4

RESULTS BY REPORTING ORGANIZATIONS

Table 11 shows the total number of Reporting Organizations reporting data to EMSL in 1986. By comparing the numbers between Tables 9 and 11, one can see the extra effort exerted by some of the State and local agencies to provide quality assurance information in cases where they have no SLAMS or NAMS sites. There are an additional 4 reporting organizations for CO, 14 for continuous SO_2, 5 for continuous NO_2, 10 for O_3, 17 for TSP, 8 for Pb, 5 for manual SO_2 and 6 for manual NO_2. Apparently, these additional sites are special purpose monitoring sites or additional local sites not in the SLAMS/ NAMS network.

TABLE 11. NUMBER OF REPORTING ORGANIZATIONS HAVING DATA IN THE PARS MASTER FILE FOR THE YEAR 1986

	Automated pollutants				Manual pollutants			
Region	CO C42101	SO_2 C42401	NO_2 C42602	O_3 C44201	TSP I11101	Pb I12128	SO_2 I42401	NO_2 I41602
I	6	10	4	7	16	5	0	0
II	3	4	2	3	3	3	0	0
III	11	13	11	13	15	9	0	0
IV	20	29	13	33	38	14	3	1
V	20	26	12	25	30	19	1	1
VI	10	11	10	10	14	11	0	1
VII	11	9	7	11	13	8	0	2
VIII	5	4	3	3	9	3	1	1
IX	9	7	7	9	10	7	1	0
X	4	3	1	2	4	4	0	0
Nation	99	116	70	116	152	83	6	6

Appendix D shows the annual combined upper and lower probability limits for each reporting organization. Each reporting organization can compare their values with those of other reporting organizations and with the regional and national values. Also given for each reporting organization are the following informational items:

Continuous methods	Manual methods
No. of SLAMS and NAMS sites	No. of SLAMS and NAMS sites
No. of analyzers	No. of samplers
No. of precision checks	No. of collocated sites
No. of accuracy audits	No. of accuracy audits

Any user of monitoring data from some specific site and time period should obtain, from the local air monitoring agency, the precision and accuracy data for the specific sites and time periods involved.

A graphical summarization of the precision and accuracy probability limits for each reporting organization for the years 1981 through 1986 will be issued as a supplement to this report. A review of these charts will show time trends and other relationships for the data from each reporting organization. In addition, some discussion will be presented on control charts which should be plotted by the reporting organizations for the results from each monitoring site. Also, some examples of precision and analysis data presented in graphical form in some of the periodic state reports will be included.

SECTION 5

FURTHER EVALUATION OF PARS DATA

Some interesting comparisons can be made by considering the corresponding national averages of Tables 6 and 7 and the 50-percentile values of the probability limits of Table 8. Table 12 compares these limits by considering the spread, or range, of the limits.

TABLE 12. COMPARISON OF THE 50-PERCENTILE FREQUENCY DISTRIBUTION VALUES WITH THE NATIONAL LIMIT VALUES FOR 1986

	National values			50-percentile values		
	Lower limit	Upper limit	Range	Lower limit	Upper limit	Range
Manual methods						
TSP Precision	-12	13	25	- 9	9	18
Accuracy*	- 8	8	16	- 6	5	11
Pb Precision	-20	20	40	-10	10	20
Accuracy	-11	9	20	- 5	3	8
Continuous methods						
CO Precision	- 9	9	18	- 6	6	12
Accuracy	- 8	8	16	- 5	4	9
O_3 Precision	-10	8	18	- 7	7	14
Accuracy	-17	16	30	- 7	6	13
	(-10)**	(9)	(19)			
NO_2 Precision	-11	11	22	- 9	9	18
Accuracy	-13	11	24	- 7	5	12
SO_2 Precision	-10	10	20	- 9	7	16
Accuracy	-13	12	25	- 9	7	16

*All accuracy values for all pollutants are for Level 2.

**Values in parentheses were calculated omitting the 4th quarter of New York State results when limits were -99 and +99.

MANUAL METHODS

For the manual methods, in all cases the spreads (ranges) of the probability limits are considerably greater for precision than for accuracy. These differences are consistent for both the National averages and the 50-percentile values. These same relationships have existed for all previous years. This means that the short-term within-sampler variability (precision) is larger than the variability of accuracy which would normally include variations between, or among, samplers as well as imprecision within samplers. This may seem contradictory at first, but giving consideration to exactly how the results are obtained and what the results represent will provide a rational explanation.

TSP. In the case of TSP, the precision results are obtained from collocated sampler data. They include variability from the sample collection process, the analytical filter weighing process, the filter handling and conditioning process, and also the flow rate measurement process; whereas the accuracy audit is a check only on the flow rate measurement. Further, the collocated sampler results are obtained at all ambient concentrations above 1 $\mu g/m^3$, the detection limit for the method. At low concentration levels the relative variability is greater than at higher concentrations. The combined effects of these two causes explain the wider limits for precision.

Manual SO_2 and NO_2. Similar to the TSP data, the precision results are obtained from collocated sampler data. They include variability from the flow measurement, absorbing solutions, sampling, sample handling, and storage effects (stability) of the samples as well as the laboratory analytical portion of the method; whereas the accuracy audit is a check only on the laboratory analytical portion of the method. Further, the collocated sampler results are obtained at all ambient concentrations above the detection limits of the methods. Many of these concentrations are below the concentrations of the accuracy audits. At lower concentrations, the relative variability is greater than at higher concentrations.

As noted from Table 12, these differences are considerable, indicating that only a small portion of the variability results from the laboratory analytical part of the method. A very considerable amount of variability of the method is attributed to other portions of the measurement process. The very wide limits of uncertainty attributed only to the imprecision of these methods strongly emphasizes that the manual methods should be replaced by the continuous analyzers. Alternatively, if any reliance is to be placed on individual daily data from the manual methods, all of the various portions of the measurement processes must be much more closely controlled, if possible.

Pb. The precision estimates for Pb are obtained from the analysis of duplicate strips from the same hi-vol filter. Consequently, actual variability of Pb content across the length of the filter, filter handling (with possible loss of particulate), variation in cutting filter strips, and the

extraction of real-world particulate are involved in addition to the chemical analytical portion of the method. The accuracy audit data are obtained from the chemical analysis of strips to which known amounts of water-soluble Pb salts have been added and thus do not involve the other portions of the measurement process, nor do they involve real-world particulates.

Further, similar to the other manual methods (TSP, NO_2, and SO_2), the precision estimates are obtained at all concentrations above the detection limit. Many of these concentrations are less than those of the accuracy audits. At lower concentrations, the relative variability is expected to be greater than at higher concentrations.

Beginning January 1, 1987, the precision for Pb samplers must be estimated by the use of collocated samplers similar to the TSP measurement. It is expected that more variability will be exhibited by the differences in the results between collocated samplers then between duplicate strips of the same filter. In anticipation of the effectivity of the regulation, some agencies may have begun using collocated samplers for Pb during the latter part of 1986.

Manual Methods (General). To make valid comparisons of the precision and accuracy data, such comparisons should be made at the same concentration levels. Only then will it be possible to determine whether the larger variabilities of the precision estimates are due to differences in concentration level or to the larger scope of the measurement system involved.

Such comparison studies can be accomplished when the raw concentration data are obtained from the State and local agencies for each precision and accuracy check beginning January 1, 1987, as specified by the proposed regulation revisions to Appendix A of 40 CFR, Part 58 promulgated March 19, 1986. Heretofore, only the reporting organizations could perform such studies, since only they had the raw data available.

The estimation of the magnitude of the contributions of the various sources of variability to the total measurement processes could also be systematically studied in specially designed experiments.

CO, SO_2, NO_2, O_3 (Continuous Methods). The national values for precision for the continuous methods are nearly the same as the accuracy values at level 2. For these continuous measurement methods, the precision assessments reflect the within-instrument variability obtained from bi-weekly checks at relatively low concentrations, namely

8 - 10 ppm for CO
and .08 -.10 ppm for SO_2, NO_2, and O_3.

In comparison, the accuracy audits include between-instrument variability as well as imprecision, but are conducted at somewhat higher (level 2) concentrations.

15 - 20 ppm for CO
.15 - .20 ppm for SO_2, NO_2, and O_3.

Thus, the added between-instrument variability for the level 2 accuracy audit is almost exactly offset by the improved percentage within-instrument variability for the precision.

Level 1 accuracy audits are conducted at concentrations of

.03 - .08 ppm for CO
3 - 8 ppm for SO_2, NO_2, and O_3.

At Level 1, concentrations less than those for the precision checks, the probability limits for accuracy are, as expected, wider than for precision. (See Table 7.)

COMPARISON OF NATIONAL LIMIT VALUES AND 50-PERCENTILE VALUES

With reference again to Table 12, in all cases the spreads (ranges) of the national values for both precision and accuracy are greater than for the corresponding 50-percentile values. For the continuous SO_2 method, the ranges for the national values were wider than for the 50-percentile values. There are two reasons why the spreads of the national values are much wider than the 50-percentile values. First, the presence of significant differences between quarters within reporting organizations, between reporting organizations within States, between States within regions, and between regions cause some increase in the total variability over and above that which would be obtained from only random variability. Second, the national values are unduly influenced by extreme or outlier values. If there were no significant differences and no outlier values, the 50-percentile values should closely agree with the national values.

An evaluation of the shape of the distributions does in fact show that the distributions are not normal due to an excessive number of extreme values (i.e., values in the tails of the distribution).

All of the distributions of the upper and lower probability limits are generally symmetric about zero. The only exception is for the SO_2 method. For prior years the accuracy audits for the manual method and the precision and accuracy audits for the continuous methods were biased negatively. For 1986, the limits for the 50 percentile values for the continuous SO_2 method continue to indicate a slight negative bias for both the precision and the accuracy data. A possible explanation for the negative bias for precision is that the relatively low concentrations of SO_2 (0.08 - 0.10 ppm) in cylinders specially prepared for precision checks may degrade after preparation. These biases for SO_2 were observed in prior years seem to be consistent in magnitude and direction. These consistent biases should be investigated and corrected, if possible.

Based on the percentiles of Table 8, quarterly probability limit values which exceed those listed in Table 13 should be considered excessive or outlier values and should initiate immediate investigation to determine and, hopefully, correct the cause of such excessive values. The values given in Table 13 are slightly tighter in some cases than the corresponding values given in the report for the 1985 data.

TABLE 13. VALUES OF QUARTERLY PROBABILITY LIMITS CONSIDERED AS EXCESSIVE BASED ON 1986 DATA

	Precision limits	Accuracy limits		
		Level 1	Level 2	Level 3
Manual methods				
TSP	± 23	---	± 14	---
Pb	± 35	± 18	± 15	---
Continuous methods				
CO	± 15	± 25	± 15	± 14
O_3	± 17	± 24	± 18	± 17
NO_2	± 26	± 38	± 21	± 19
SO_2	± 20	± 28	± 22	± 21

SECTION 6

COMPARISON OF RESULTS FROM THE PARS AND THE PA AUDIT PROGRAM

A general comparison between the accuracy data of the PARS program and the Performance Audit (PA) data is included in this report. The Performance Audit data are the results of an independent check conducted by the Quality Assurance Division (QAD) of the EMSL under the National Performance Audit Program (NPAP).

In the NPAP, specially prepared audit samples or devices are sent from QAD to the participating ambient air monitoring agencies. The samples or devices are carefully and accurately assessed by EMSL utilizing NBS Standard Reference Materials (SRM's) or standards. The monitoring agencies analyze or measure the samples or devices as unknowns or blinds and report their results to QAD for evaluation. Audit programs are conducted for the following pollutant measurements, using the materials indicated:

Measurement	Audit materials	Portion of measurement system audited
SO_2 (manual)	Freeze-dried sodium sulfite	Chemical analysis
NO_2 (manual)	Aqueous sodium nitrite	Chemical analysis
Pb	Filter strip with lead nitrate	Chemical analysis
TSP	Reference flow device	Flow
CO	Cylinders containing CO gas	Sampling and analysis
SO_2	Cylinder containing SO_2 gas	Sampling and analysis

The audit materials or devices are prepared at three to six different concentrations or flow levels. Separate reports on the evaluation of the PA data are published by EMSL.[7-11] Also, other reports[12,13] have dealt with the use of PA and PARS data.

As indicated above, the NPAP does not yet include an audit for the ozone or continuous NO_2 methods. Therefore, no comparisons of the NPAP or PA data with the PARS data are possible for those pollutants.

Since precision assessments are not made in the PA program, only accuracy can be compared across the PARS and the PA programs. For the purpose of this report, the results from PARS and the PA system are compared at approximately the same levels by matching laboratories and reporting organizations. (See Appendix E for a more detailed discussion of the problems involved in comparing the PARS and PA data.) Since the PARS data are presented with outliers, if any, the same approach was taken with the audit data. Knowledge of the past audit data reports, however, indicates that the presence of outliers may make a significant difference in the audit results for some agencies.

Comparisons of the national values of the probability limits (Table 14) exhibit fairly good agreement between the results of the two programs. Variations due to many sources of error for both data sets are averaged together to obtain the national values, thereby masking any correlations which may have existed for the results of individual agencies. There is considerable variation between the results of the two programs when comparisons are made on Regional and reporting organization bases. Lack of better agreement results from several factors. First, the inclusion of outlier values in the PA and PARS data appears to have introduced some excessive distortion of general trends. Second, the concentration levels for the two systems do not coincide exactly at each of the audit levels. Third, the PA data are the results of independent external audits, while the PARS accuracy data are based on the results of independent internal audits. The expected effects of the last-mentioned factor would cause the spread of the limits for the PA to be wider than that for the PARS. Examination of the results (see Table 14) confirm these expectations. The PA data for 1986 are generally better than the corresponding data for 1985.

TABLE 14. SUMMARY COMPARISON OF EMSL PERFORMANCE AUDITS (PA) vs. PARS ACCURACY AUDIT DATA FOR 1986

		National values 95% probability limits (%)					
		Level 1		Level 2		Level 3	
Pollutant	Audits	Lower	Upper	Lower	Upper	Lower	Upper
CO							
PA	501	-13	11	- 6	6	- 6	6
PARS	695	-14	14	- 8	8	- 7	7
SO_2							
PA	704	-10	16	- 9	14	- 9	12
PARS	961	-15	14	-13	13	-13	11
TSP							
PA	3350			- 7	9		
PARS	4357			- 7	7		
Pb							
PA	592	-16	13	-18	13		
PARS	901	-14	10	-13	10		

Comparisons of the 95 percent probability limits for the PA and the PARS results by Region are shown in Figures 9a through d for selected concentration levels. The figures show considerable variation among Regions.

CO. (Figure 9a)

The width of the PARS probability limits for level 2 exceed those for PA for nine of the ten Regions. For previous years, the PA limits have generally been wider than the PARS limits.

TSP. (Figure 9b)

For five Regions, the width of the probability limits for PARS is less than for PA. This may be explained by the fact that within each reporting organization the flow rate checks are not as completely independent from their internal standards as are the PA audits. Regions I and X have more variability of PA audit data than other Regions.

Pb. (Figure 9c)

There is considerable variation in the results from Region to Region. However, for most Regions, the PARS variability is considerably less than for PA. This may be explained by the fact that the local independently-prepared standards for PARS have close traceability to the materials used for calibration, whereas the standards for PA, since they are prepared at EMSL/RTP, are more completely independent.

Regions I and III results have much more variability for PA than the other Regions, indicating a need for investigations to determine the major causes and appropriate corrective actions.

SO_2 (Continuous). (Figure 9d)

Figure 9d shows the available comparisons of the PA and PARS data for the continuous SO_2 method.

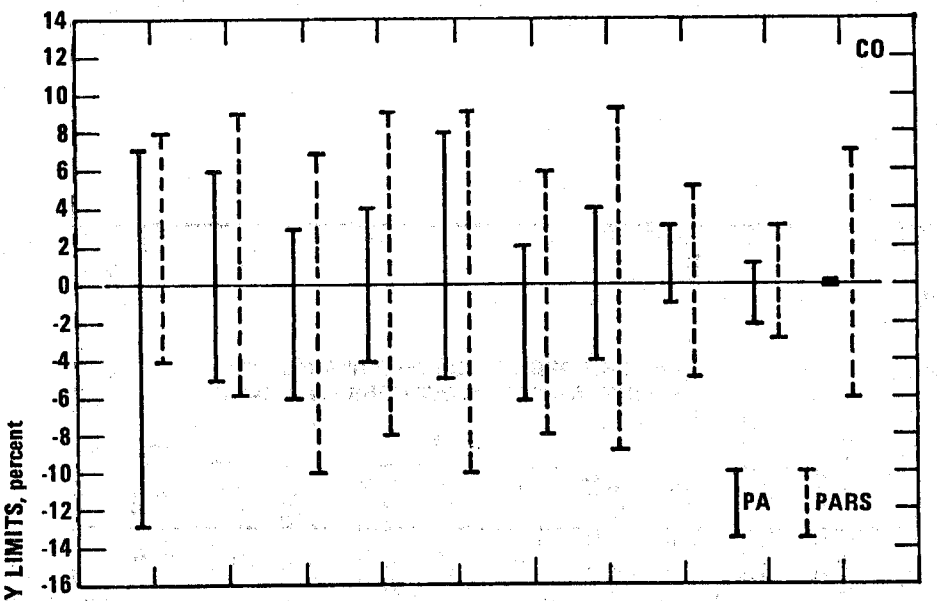


Figure 9a. Comparison of PA and PARS for CO (level 2).

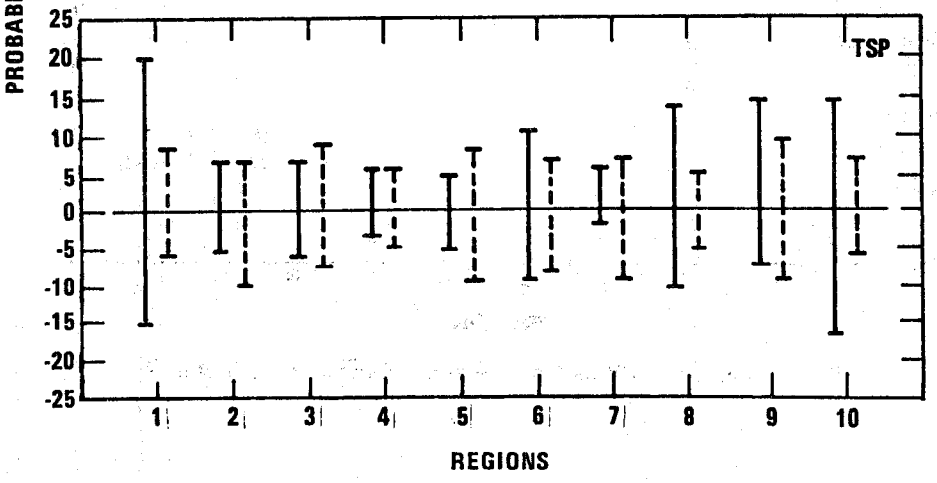


Figure 9b. Comparison of PA and PARS for TSP (level 2).

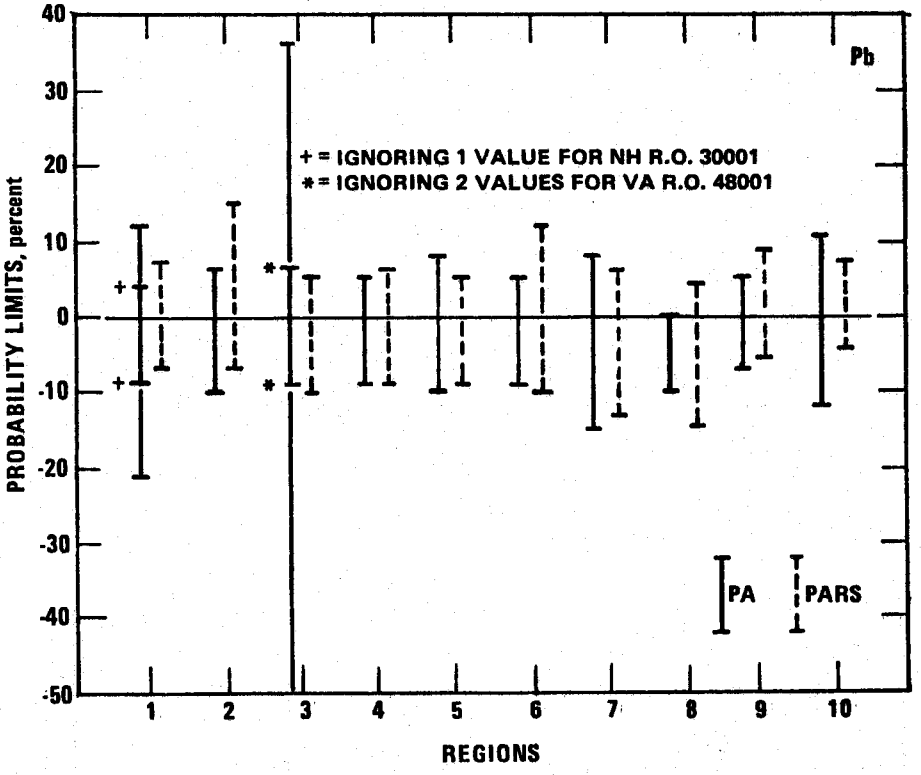


Figure 9c. Comparison of PA and PARS for Pb (level 2).

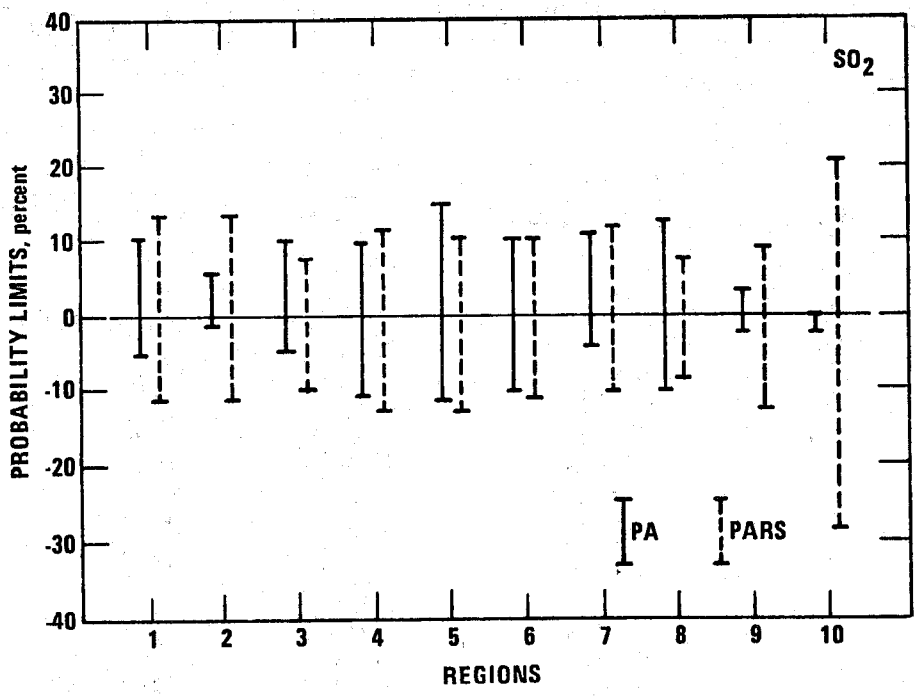


Figure 9d. Comparison of PA and PARS for continuous SO_2 (level 3).

In eight of the ten regions, the PARS limits are wider than the PA limits. No explanation can be given to these differences.

National Comparison

Figure 10 shows the available PA and PARS comparisons on a national basis for all levels for each pollutant method. For the CO and SO_2 methods, the PARS limits are slightly wider than for PA which was not the case for CY-85 results. For Pb and TSP the PA limits are wider than for PARS, the same as for CY-85 results.

Missing PA and PARS Comparisons.

Comparison of the results from PARS and PA are, of course, possible only when the data are available from both systems for paired reporting organization-laboratory combinations. Paired data were not available for comparison. Of these, data was not available because of missing data from the PARS for 23 comparisons:

Region	State	Reporting organization	Laboratory number	Pollutant(s)
I	ME	20107	501012	TSP
	ME	20112	501002	TSP
II	VI	55001	310001	TSP,*** SO_2
IV	FL	10018	423002	SO_2**
	TN	44005	417001	CO*
VI	NM	32002	430001	SO_2
	TX	45003	433001	SO_2
VII	IA	16001	436001	Pb
	MO	26003	438003	Pb***
	NE	28003	435002	SO_2*
			435003	
IX	AZ	03100	347001	CO
	AZ	03200	447001	SO_2,* Pb
	HI	12120	348001	SO_2*
	NV	29100	346001	CO***
			346002	
	NV	29200	446001	CO,* TSP*
	NV	29300	446002	Pb,** CO
	GU	54100	349001	SO_2,** TSP,*** Pb

*Also missing for 1985.
**Also missing for 1984 and 1985.
***Also missing for 1983, 1984 and 1985.

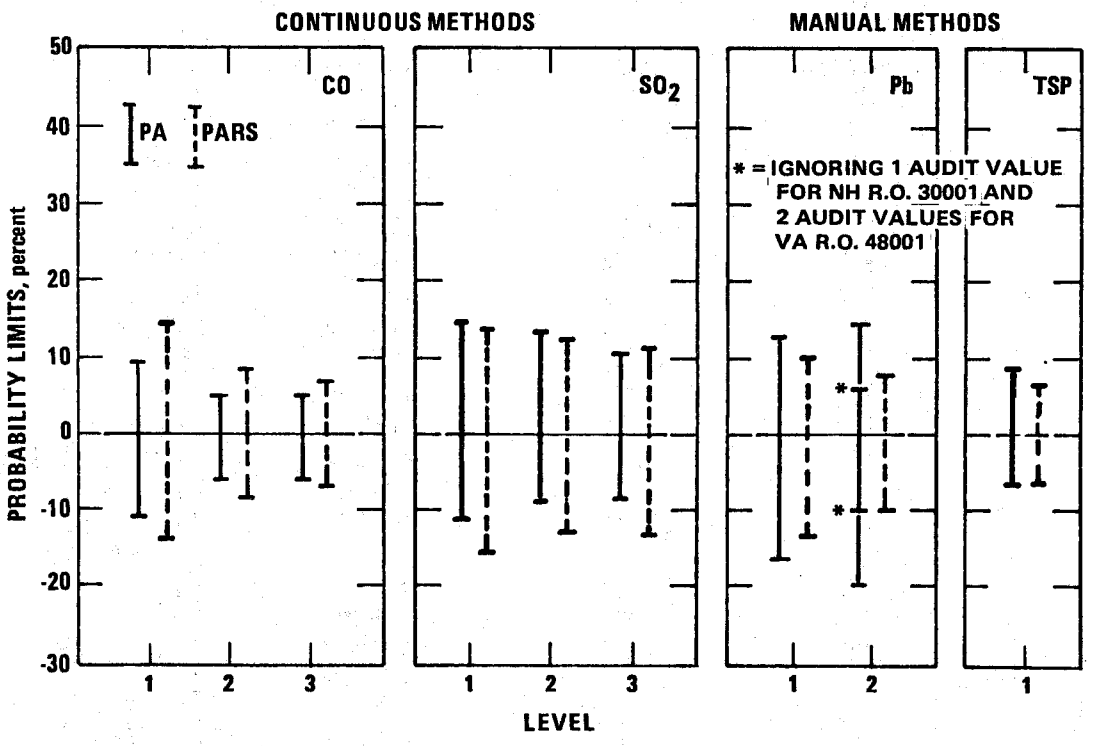


Figure 10. Comparison of PA and PARS, national values, 1986.

Lack of laboratory participation in the National Performance Audit Program in 1986 is the reason there is no paired data available for 89 cases compared to 135 for 1985. In these cases, the laboratories (reporting organization) did not comply with the requirements of the federal regulations. In some of these cases, the laboratory requested the audit samples but did not report any results. A listing of missing PA audit data follows:

Region	State	Reporting organization	Laboratory number	Pollutant
II	NY	33001	307001	CO, Pb
	NY	33001	307002	CO, Pb
	NY	33001	307003	CO
	NY	33001	307004	CO
	NY	33001	307005	CO
	NY	33001	307006	CO
	NY	33001	307007	CO
	NY	33001	307008	CO
	NY	33001	307009	CO
	NY	33001	307010	CO
	PR	40001	309001	CO
III	DC	09001	312100	TSP*
	MD	21003	412004	SO_2**
	WV	50001	314001	SO_2
	WV	50002	314002	CO***
IV	AL	01011	319001	Pb
	AL	01013	419003	TSP***
	FL	10001	323005	TSP
	FL	10003	323004	TSP
	FL	10004	323008	TSP,* SO_2
	FL	10011	423003	CO,* Pb,* SO_2
	FL	10014	423005	TSP*
	FL	10018	423002	CO,** Pb,* SO_2,** TSP
	NC	34001	318001	SO_2
	NC	34001	318004	SO_2
	NC	34001	418005	SO_2
	TN	44003	317001	CO**
	TN	44003	417003	CO
	TN	44005	417001	CO, TSP*
V	IL	14003	428003	SO_2
	IN	15001	329001	CO
	IN	15001	429009	CO
	IN	15005	429005	SO_2**
	IN	15008	429004	Pb**
V	IN	15010	529002	TSP***
	IN	15100	329002	Pb,** SO_2
	MI	23002	426001	Pb,* SO_2, TSP
	MN	24001	324001	SO_2

(continued)

Region	State	Reporting organization	Laboratory number	Pollutant
V	OH	36001	327001	CO,* TSP*
	OH	36002	327003	SO_2
	OH	36004	327007	SO_2
	OH	36006	427001	Pb***
	OH	36008	427003	Pb***
	OH	36009	427004	Pb,*** SO_2
	OH	36010	427005	Pb***
	OH	36012	427007	TSP
VI	LA	19001	334001	CO*
	NM	32002	430001	CO, Pb, TSP*
	OK	37102	431001	CO,*** Pb,* TSP
	TX	45002	433002	CO,* TSP
VII	IA	16001	436001	Pb
	IA	16002	436002	CO*
	IA	16003	336001	TSP
	MO	26003	438003	Pb,* SO_2
	NE	28002	435001	TSP
	NE	28003	435002	SO_2
	NE	28003	435003	SO_2
VIII	CO	06001	344001	CO, Pb,*** TSP***
	MT	27002	439001	TSP
	MT	27003	439002	TSP
	MT	27004	439003	TSP
IX	AZ	03200	447001	SO_2**
	CA	05036	445003	CO, SO_2, TSP
	CA	05061	445002	CO, SO_2,** TSP
		05061	445017	CO, SO_2,** TSP
	HI	12120	348001	CO,*** SO_2*
		12120	348002	CO,***, SO_2*
	NV	29100	346001	TSP*
	NV	29200	446001	CO,* TSP*
	NV	29300	446002	Pb**
	GU	54100	349001	SO_2,** TSP***
X	AK	02020	451001	CO
	AK	02020	451002	CO
	ID	13001	354001	CO, SO_2,** TSP
	ID	13001	354002	CO, SO_2,** TSP
	OR	38001	353001	CO, SO_2

*Also missing for 1985.
**Also missing for 1984 and 1985.
***Also missing for 1983, 1984 and 1985.

In 13 cases, data were unavailable from both PARS and PA:

Region	State	Reporting Organization	Laboratory number	Pollutant
IV	FL	10018	423002	SO_2**
	TN	44005	417001	CO*
VII	IA	16001	436001	Pb
	MO	26003	438003	Pb***
	NE	28003	435002	SO_2*
	NE	28003	435003	SO_2*
IX	AZ	03200	447001	SO_2,* Pb
	HI	12120	348001	SO_2*
	NV	29200	446001	CO,* TSP*
	NV	29300	446002	Pb**
	GU	54100	349001	SO_2,** TSP***

*Also missing for 1985.
**Also missing for 1984 and 1985.
***Also missing for 1983, 1984 and 1985.

SECTION 7

CONCLUSIONS AND RECOMMENDATIONS

The results of PARS data for 1986 indicate some general improvement over the data for previous years. However, considerable differences exist among Regions and individual reporting organizations for most measurement methods. Investigations should be made by the Regions and the States to determine the causes of these significant differences.

The PA data for TSP and Pb show more variability than for PARS. These differences are presumably due to the fact that the external PA accuracy audits are more completely independent than the internal PARS accuracy audits. These differences have been consistent for past years.

Further improvement in the data quality assessments, which are measures of the monitoring data quality, can be achieved only through continuing efforts of State and local agency personnel involved (first-hand) with the operation and quality control of their measurement systems. Regional QA Coordinators can also assist through their review of the operations and quality control practices across the States in their Regions.

Each Regional QA Coordinator should evaluate the PARS data from all the reporting organizations within his Region to identify those organizations having excessively large variations of probability limits. Investigation should be made to determine the causes and correct them to preclude future excessive deviations. Similarly, Regional QA Coordinators should review the operations of the reporting organizations having significantly better precision and accuracy results in order to identify specific procedures which should be uniformly used throughout the Region and the Nation to further improve the reliability of the monitoring data in the National Aerometric Data Base.

REFERENCES

1. Code of Federal Regulations, Title 40, Part 58, "Ambient Air Quality and Surveillance, Appendix A, Quality Assurance Requirements for SLAMS."

2. Rhodes, R.C. "Guideline on the Meaning and Use of Precision and Accuracy Data Required by 40 CFR Part 58, Appendices A and B." U.S. Environmental Protection Agency Report, EPA 450/4-84-006. Research Triangle Park, NC 27711. June 1983.

3. Evans, E.G., R.C. Rhodes, W.J. Mitchell and J.C. Puzak. "Summary of Precision and Acuracy Assessments for the State and Local Air Monitoring Networks, 1982." U.S. Environmental Protection Agency Report, EPA-600/4-85-031. Research Triangle Park, NC 27711. April 1985.

4. Rhodes, R.C. and E.G. Evans. "Precision and Accuracy Assessments for State and Local Air Monitoring Networks, 1983." U.S. Environmental Protection Agency Report, EPA-600/4-86-012. Research Triangle Park, NC 27711. February 1986.

5. Rhodes, R.C. and E.G. Evans. "Precision and Accuracy Assessments for State and Local Air Monitoring Networks, 1984." U.S. Environmental Protection Agency Report, EPA-600/4-86-031. Research Triangle Park, NC 27711. August 1986.

6. Rhodes, R.C. and E.G. Evans. "Precision and Accuracy Assessments for State and Local Air Monitoring Networks, 1985." U.S. Environmental Protection Agency Report, EPA-600/4-87-003. Research Triangle Park, NC 27711. January 1987.

7. Rhodes, R.C., B.I. Bennett and J.C. Puzak. "EPA's National Performance Audit Program for Ambient Air Pollution Measurements." In Proceedings of the 75th Annual Meeting of the Air Pollution Control Association, New Orleans, LA, June 1982. Presentation 82-23.

8. Lampe, R.L., B.F. Parr, G. Pratt, O.L. Dowler and W.J. Mitchell. "National Performance Audit Program: Ambient Air Audits of Analytical Proficiency-1983." U.S. Environmental Protection Agency Report, EPA-600/4-84-077. Research Triangle Park, NC 27711. October 1984.

9. Parr, B.F., R.L. Lampe, G. Pratt, O.L. Dowler and W.J. Mitchell. "National Performance Audit Program: Ambient Air Audits of Analytical Proficiency, 1984." U.S. Environmental Protection Agency Report, EPA-600/4-86-013. Research Triangle Park, NC 27711. February 1986.

10. Parr, B.F., R.L. Lampe, G. Pratt, O.L. Dowler and W.J. Mitchell. "National Performance Audit Program: Ambient Air Audits of Analytical Proficiency, 1985." U.S. Environmental Protection Agency Report, EPA-600/4-87-002. Research Triangle Park, NC 27711. January 1987.

11. Parr, B.F., R.L. Lampe, G. Pratt, O.L. Dowler, and W.J. Mitchell. "National Performance Audit Program Ambient Air Audits of Analytical Proficiency, 1986." U.S. Environmental Protection Agency Report, EPA-600/4-87-xxx. Research Triangle Park, NC 27711. November 1987.

12. Rhodes, R.C., W.J. Mitchell, J.C. Puzak and E.G. Evans. "Comparison of Precision and Accuracy Estimates from State and Local Agency Air Monitoring Stations with Results of EPA's National Performance Audit Program." Journal of Testing and Evaluation, JTEVA, Vol. 13, No. 5, September 1985, p. 374-378.

13. Thrall, A.D. and C.S. Burton. "Special Report, Issues Concerning the Use of Precision and Accuracy Data." U.S. Environmental Protection Agency Report, EPA-450/4-84-006. Research Triangle Park, North Carolina 27711. February 1984.

APPENDIX A

GLOSSARY

State and Local Air Monitoring Stations (SLAMS) -- monitoring stations selected by the states and included in the State Implementation Plans. The stations and the plans are approved by the Regional Administrator. The purposes of the monitoring are to determine compliance to the National Ambient Air Quality Standards (NAAQS) and to determine background levels of the criteria pollutants.

National Air Monitoring Sites (NAMS) -- a subset of the SLAMS, selected by the states in collaboration with the Regional Offices and approved by the Administrator. The purpose of the sites is to monitor in the areas where pollution concentration and population exposure are expected to be highest in terms of the NAAQS. Although, in actuality the NAMS are a subset of SLAMS, the NAMS sites and the non-NAMS SLAMS sites are often referred to as two separate groups, the NAMS and SLAMS sites, respectively.

Reporting Organization -- a state, or subordinate organization within the state, that is responsible for a set of SLAMS stations, monitoring for the same pollutant and for which PARS data can be logically pooled (statistically combined). It is important to emphasize that a reporting organization is pollutant- and site-specific and is responsible for the sampling, calibration, analysis, data quality assessment, and reporting of the monitoring data for the specific pollutant. It is possible that a particular SLAMS station may belong to two different reporting organizations, but the likelihood of this occurring is small.

Precision (Continuous Analyzers) -- a measure of repeatability obtained from repeated measurements of a standard concentration in a gas cylinder and the values indicated by the analyzer. For SO_2, NO_2, and O_3 analyzers, the gas concentration used for the precision check must be between 0.08 and 0.10 ppm and for CO it must be between 8 and 10 ppm. The data from all biweekly analyzer checks for a given pollutant are combined, and 95% probability limit values are reported to EPA each quarter by each reporting organization. For this report, the quarterly values for 1986 were combined, and overall 95% probability limits were calculated for each reporting organization, for each Region, and for the nation, as described in Appendix B.

Precision (Manual Methods) -- a measure of repeatability for TSP, NO_2, and SO_2 manual methods (bubblers) determined by operating collocated samplers at selected sites. At each collocated site one sampler is designated as the "actual" sampler and the other as the "check" sampler, and the difference between the two samplers provides the precision estimate. For Pb, precision

estimates are obtained by analyzing duplicate strips from a high volume filter sample collected at a site where high Pb concentrations exist. These precision checks are made from samples, usually taken every 6th day, and are reported quarterly. The data from the manual methods were calculated in a similar manner as the continuous analyzers.

Accuracy (Continuous Analyzers) -- the agreement between an analyzer measurement and a known audit standard concentration. Accuracy estimates are obtained at least once per year for each analyzer by introducing blind audit standards into the analyzer. The audit samples must span at least three concentration levels and, whenever possible, must be traceable to NBS or other authoritative reference. At least 25% of the analyzers in each reporting organization must be audited each quarter. The percentage difference for each audit concentration is determined, and the average for all analyzers checked within that quarter is calculated for each level. The standard deviation for each level is then used to calculate the 95% probability limits for the reporting organization, which in turn are submitted quarterly to EPA. These quarterly values were combined to determine the annual values presented here. They were calculated in the same manner as described earlier for precision.

Accuracy (Manual Methods) -- the agreement between an observed or measured value and a known or reference value. For NO_2 and SO_2 manual methods, the accuracy of the analytical portion of the method is assessed at three levels by the analysis of audit materials of known characteristics. For Pb, the accuracy of the analytical portion of the method is assessed at two levels. For TSP, the flow rate (or air volume) portion of the method is assessed at the nominal flow rate.

Completeness -- the number of the precision and accuracy checks reported as compared to the number that should have been reported if all checks had been done in accordance with the regulations. This value, expressed as a percentage, is not corrected for instances where equipment failure prevented conducting the check, or for periods when monitoring data were invalidated.

National Performance Air Audit Program (NPAP) -- an external performance audit program conducted by EPA on State and local agency organizatons. Organizations operating SLAMS stations are required to participate in this program directed by the Environmental Monitoring Systems Laboratory (EMSL) of the EPA at Research Triangle Park, NC. In this program, blind audit materials prepared by EMSL are sent to participating laboratories. The laboratories analyze the samples and return the results to EMSL. Shortly after the audit is completed each participant receives a report that compares his performance to that of all other participants. The audit materials for the manual methods for SO_2, NO_2 and Pb are used to evaluate the accuracy of only the analytical laboratory portion of the method, and are as follows:

Method	Audit Materials
Manual SO_2	Freeze-dried Na_2SO_3
Manual NO_2	$NaNO_2$ solution
Pb	Filter strips spiked with Pb SO_4

(Note: Because the manual SO_2 and manual NO_2 methods are being replaced by continuous methods, these performance audits have been discontinued.)

The reference flow device used in the TSP sampler audit evaluates only the accuracy of the flow calibration. However, the CO and SO_2 continuous analyzer audits evaluate the entire measurement system. As explained above, the external NPAP audits are conducted in essentially the same manner as the internal audits (accuracy checks) for the PARS program. The audits for the Pb method are conducted semi-annually and those for flow (TSP), and continuous CO and SO_2 monitors are conducted at least once per year.

95-Percent Probability Limits -- probability limits are used in the reporting of precision and accuracy data to measure the expected spread or variability of the data from a particular population--a reporting organization, a state, a region, or the nation. These expected limits are expressed simply as a mean plus or minus a constant (1.96) times the standard deviation as follows:

$$L = \bar{x} \pm ks \qquad (1)$$

where: L = probability limits (upper limit, L_U, lower limit, L_L)
$\bar{x}$ = mean value
k = 1.96, a constant
s = standard deviation

Under the assumptions of (a) an underlying normal population, (b) the mean $\bar{x}$, being the estimate of the true mean, μ, of the underlying population, and (c) the standard deviation, s, being the estimate of the true standard deviation, σ, of the underlying distribution, then $\bar{x} \pm 1.96s$ represents the expected limits which should include 95 percent of all the individual measurement of the population. Under the assumption given, $\bar{x} \pm 1.96s$ limits are the expected 95 percent probability limits, regardless of the sample size.

The requirement for the computation of "probability" limits (rather than confidence limits) is to provide the State and local agencies with limits which will be of practical meaning and usefulness for internal control applications without involving overly complicated and sophisticated statistics. The selection of the 95 percent level was made because even for non-statisticians, the chance or probability of obtaining one value out of twenty exceeding the limits has practical meaning.

APPENDIX B

FORMULAS FOR COMBINING PROBABILITY LIMITS

Section 5.2, Annual Reports, of Appendix A of 40 CFR Part 58 required that simple unweighted arithmetic averages of the probability limits for precision and accuracy from the four quarterly periods of the calendar year be reported with the annual SLAMS report. The simple unweighted arithmetic averages were specified to simplify the calculations for the states. Such limits would be essentially correct if only random variations occurred between quarters within a reporting organization and between reporting organizations within a State, i.e., if no statistically significant differences occurred between quarters within reporting organizations or between reporting organizations within States. However, experience has shown that significant differences do occur. Because of this fact, it is most correct to combine the data across quarters and across reporting organizations within States (and also across States within regions and across regions within the nation) in the manner described below. These formulas determine the yearly probability limits for the reporting organization which would have been computed from all the individual percent difference values, d_i, obtained during the year. To accomplish this, from each quarterly pair of probability limits, the average, $\bar{D}_i$, and standard deviation, S_i, are back-calculated:

$$\bar{D}_i = \frac{LL + UL}{2} \qquad (1)$$

$$S_i = \frac{UL - LL}{2(1.96)} \qquad (2)$$

where LL = lower probability limit
UL = upper probability limit

Except for the effect of the round-off of the reported probability limits to integer values, the above equations determine the original $\bar{D}$ and S_a values used by the reporting organizations to compute the originally reported limits.

Yearly average, $\bar{\bar{D}}$, and standard deviation, S_a values are computed from the quarterly values as follows:

$$\bar{\bar{D}} = \frac{\sum n_i \bar{D}_i}{\sum n_i} \qquad (3)$$

where n_i = the number of individual percent difference, d_i, values for each quarter

$$S_a = \sqrt{\frac{\sum(n_i-1)S_i^2 + \sum n_i(\bar{D}_i-\bar{\bar{D}})^2}{(\sum n_i) - 1}} \qquad (4)$$

The appropriate yearly probability limits for the reporting organization are computed using the formulas:

$$UL = \bar{\bar{D}} + 1.96\ S_a \qquad (5)$$

$$LL = \bar{\bar{D}} - 1.96\ S_a \qquad (6)$$

NOTE: The same formulas are used for combining yearly reporting organization limits into State limits, State limits into Region limits, and Region limits into National limits.

Example: Suppose that the lower and upper 95% probability limits for CO for precision for the four quarters of a year are:

Quarter	Number of Precision Checks	Lower Probability Limit	Upper Probability Limit
1	10	-8	+6
2	9	-5	+9
3	13	-6	+4
4	7	-12	+11

For Quarter 1:

$$\bar{D}_1 = \frac{LL + UL}{2} = \frac{-8+6}{2} = -1 \qquad \text{by equation (1)}$$

$$S_1 = \frac{UL - LL}{2(1.96)} = \frac{6-(-8)}{2(1.96)} = 3.6 \qquad \text{by equation (2)}$$

Similar computations for the other quarters, give values in the following table.

Quarter	n	$\bar{D}$	S	$\bar{D} - \bar{\bar{D}}$
1	10	-1	3.6	-0.78
2	9	+2	3.6	2.22
3	13	-1	2.6	-0.78
4	7	-0.5	5.9	-0.28
	39			

Then

$$= \bar{\bar{D}} = \frac{\sum n_i \bar{D}_i}{\sum n_i}$$ by equation (3)

$$= \frac{10(-1) + 9(2) + 13(-1) + 7(-0.5)}{39}$$

$$= \frac{-8.5}{39} = -0.22$$

$$S_a = \sqrt{\frac{\sum (n_i - 1)\, S_i^2 + \sum n_i (\bar{D}_i - \bar{\bar{D}})^2}{(\sum n_i) - 1}}$$ by equation (4)

$$= \sqrt{\frac{9(3.6)^2+8(3.6)^2+12(2.6)^2+6(5.9)^2+10(-0.78)^2+9(2.22)^2+13(-0.78)^2+7(-0.28)^2}{39 - 1}}$$

$$= \sqrt{\frac{510.30 + 58.90}{38}}$$

$$= \sqrt{14.98} = 3.87$$

The upper and lower 95% probability limits are then computed as:

$$UL = \bar{\bar{D}} + 1.96\, S_a$$ by equation (5)

$$= -0.22 + 1.96(3.87)$$

$$= 7.37 \text{ or } 7 \text{ rounded off to nearest integer}$$

$$LL = \bar{\bar{D}} - 1.96\ S_a \qquad \text{by equation (6)}$$

$$= -0.22 - 1.96(3.87)$$

$$= -7.81 \text{ or } -8 \text{ rounded off to nearest integer}$$

In this particular example, the results by the weighted combined formulas are very close to the simple unweighted arithmetic averages. However, in many cases the weighted combined formulas result in wider limits than the simple unweighted arithmetic averages and more correctly reflect the total variability exhibited by the individual percent differences.

Alternate Method of Computation

An alternate method which eliminates the need to compute $\bar{D}_i - \bar{\bar{D}}$, the differences between the quarterly averages and the weighted annual average, follows.

1. Compute $\bar{D}_i$ and S_i for each quarter according to equations (1) and (2) as above.

2. Compute for each quarter.

$$\Sigma d = n_i\ \bar{D}_i \qquad (7)$$

3. Compute for each quarter.

$$\Sigma d^2 = (n_i - 1)\ S_i^2 + \frac{(\Sigma d)^2}{n_i} \qquad (8)$$

4. Compute:

Σn_i = the sum of n for all quarters (9)

$\Sigma\Sigma d$ = the sum of Σd for all quarters (10)

$\Sigma\Sigma d^2$ = the sum of Σd^2 for all quarters (11)

5. Compute $\bar{\bar{D}}$ according to equation (3) above, or

$$\bar{\bar{D}} = \frac{\Sigma\Sigma d}{\Sigma n} \qquad (12)$$

6. Compute S_a:

$$S_a = \sqrt{\frac{\Sigma\Sigma d^2 - \frac{(\Sigma\Sigma d)_2}{\Sigma n}}{(\Sigma n) - 1}} \qquad (13)$$

7. Then compute the probability limits, UL and LL, according to equations (5) and (6).

Example

The data for the previous example on page B-2 will be used.

Quarter	Number of Precision Checks	Lower Probability Limit	Upper Probability Limit
1	10	-8	+6
2	9	-5	+9
3	13	-6	+4
4	7	-12	+11

1. $\bar{D}_i$ and S_i are computed as before. Compute Σd and Σd^2 by equations (7) and (8) respectively.

Quarter	n	$\bar{D}$	S	Σd	Σd^2
1	10	-1	3.6	-10	126.64
2	9	+2	3.6	+18	139.68
3	13	-1	2.6	-13	94.12
4	7	-0.5	5.9	-3.5	210.61
				-8.5	

For quarter 1:

$$\Sigma d^2 = (n - 1)\, S^2 + \frac{(\Sigma d)^2}{n} \qquad (8)$$

$$= (9)(3.6)^2 + \frac{(-10)^2}{10}$$

$$= 116.64 + 10$$

$$= 126.64$$

2. By equation (12):

$$\bar{D} = \frac{\Sigma\Sigma d}{\Sigma n} = \frac{-8.5}{39} = -0.22 \qquad \text{the same as before}$$

3. By equation (13):

$$S_a = \sqrt{\frac{\Sigma\Sigma d^2 - \frac{(\Sigma\Sigma d)^2}{\Sigma n}}{(\Sigma n) - 1}} \qquad (13)$$

$$S_a = \sqrt{\frac{571.05 - \frac{(-8.5)^2}{39}}{39 - 1}}$$

$$= \sqrt{\frac{571.05 - 1.85}{38}}$$

$$= 3.87 \qquad \text{the same as before}$$

4. The probability limits are then calculated as before using equations (5) and (6).

A Second Example

The following example more clearly shows computationally and graphically that the arithmetic averages of the quarterly upper and lower probability limits do not correctly reflect the total variability when significant differences occur between quarters. Suppose the following individual percent differences have been obtained for the precision checks for a continuous instrument during the past year.

Quarter	Individual Percent Differences
1	-12, -9, -5, -5, -1, 2
2	1, 4.5, 5, 5, 5.5, 9
3	-6, 0, 5, 5, 10, 16
4	-17, -14, -10, -10, -6, -3

From the previous formulas, the following $\bar{D}$, S, and probability limits for each quarter are calculated.

Quarter	$\bar{D}$	S	n	LL	UL
1	-5	5.10	6	-15	5
2	5	2.55	6	0	10
3	5	7.64	6	-10	20
4	-10	5.10	6	-20	0
				-11.25	8.75
				(-11)	(+9)

As indicated above, the simple arithmetic averages of the lower and upper probability limits are -11.25 and 8.75, or -11 and 9 when rounded-off.

The calculations of the annual probability limits by equations (3) through (6) are shown below.

$$\bar{\bar{D}} = \frac{\Sigma n\bar{D}}{\Sigma n} = \frac{-30}{24} = -1.25 \qquad (3)$$

$$S_a = \sqrt{\frac{\Sigma(n_i - 1)S_i^2 + \Sigma n_i(\bar{D}_i - \bar{\bar{D}})^2}{(\Sigma n_i) - 1}} \qquad (4)$$

$$= \sqrt{\frac{5(5.10)^2+5(2.55)^2+5(7.64)^2+5(5.10)^2+6(-3.75)^2+6(6.25)^2+6(6.25)^2+6(-8.75)^2}{24 - 1}}$$

$$= \sqrt{\frac{1596.961}{23}} = 8.333$$

$$UL = \bar{\bar{D}} + 1.96\ S \qquad (5)$$

$$= -1.25 + 1.96\ (8.333)$$

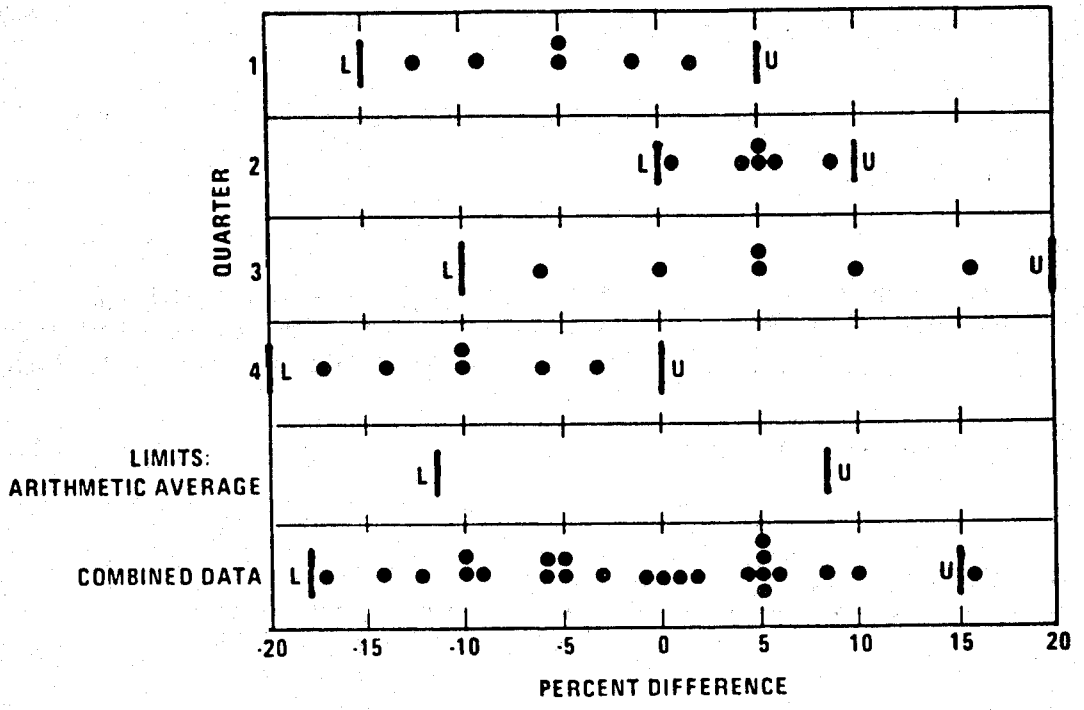
$$= 15.083 \text{ or } (15)$$

$$LL = \bar{\bar{D}} - 1.96\ S \qquad (6)$$

$$= -1.25 - 1.96\ (8.333)$$

$$= -17.583 \text{ or } (-18)$$

The individual percent differences, the quarterly probability limits, the arithmetic annual probability limits and the combined annual probability limits are shown graphically on the following figure.



It is clear from the above figure that the combined limits more correctly represent the total spread of the individual percent differences during the year. In fact, the calculated values of the average and standard deviation for all 24 of the individual percent differences are -1.25 and 8.333, respectively, which are in exact agreement with the previous calculations as they must be because of the exact equality of the mathematical formulas involved.

APPENDIX C

LISTING OF REPORTING ORGANIZATIONS

Region	State No.	State Name	Reporting Organization No.	Reporting Organization Name
01	07	CONNECTICUT	001	AIR MONIT. SEC. DEPT. OF ENV. PROTECT.
01	20	MAINE	001	BUREAU OF A.Q.C. DEPT. OF ENV. PROTECT.
01	20	MAINE	101	S.D. WARREN CO., WESTBROOK
01	20	MAINE	102	S.D. WARREN CO., HINCKLEY
01	20	MAINE	103	INTERNATIONAL PAPER CO., JAY
01	20	MAINE	104	BOISE CASCADE CO., RUMFORD
01	20	MAINE	106	DRAGON PRODUCTS, THOMASTON
01	20	MAINE	107	SCOTT PAPER CO., WINSLOW
01	20	MAINE	108	CHAMPION INTERNATIONAL CORP., BUCKSPORT
01	20	MAINE	109	LINCOLN PULP AND PAPER CO., LINCOLN
01	20	MAINE	110	GREAT NORTHERN PAPER CO., MILLINOCKE
01	20	MAINE	112	GEORGIA PACIFIC CO., WOODLAND
01	22	MASSACHUSETTS	001	DIV. OF AQC. DEPT. OF ENV. QUAL. ENG.
01	30	NEW HAMPSHIRE	001	AIR RESOURCES AGENCY
01	41	RHODE ISLAND	001	DIV. OF A. HAZ. MAT. DEPT. OF ENV. MANAGE.
01	47	VERMONT	001	AIR & SOLID WASTE PROGRAMS
02	31	NEW JERSEY	001	DEPT. OF ENV. PROT., DIV. OF ENV. QUAL.
02	33	NEW YORK	001	DEPT. OF ENV. CONSERV., DIV. OF AIR
02	40	PUERTO RICO	001	ENVIRONMENTAL QUALITY BOARD
02	55	VIRGIN ISLANDS	001	DEPT. OF CONS. AND CULTURAL AFFAIRS
02	55	VIRGIN ISLANDS	017	MARTIN MARIETTA
03	08	DELAWARE	001	STATE OF DELAWARE, DNR & EC
03	09	DISTRICT OF COLUMBIA	001	WASHINGTON, DC DC & RA
03	21	MARYLAND	001	STATE OF MARYLAND
03	21	MARYLAND	002	ALLEGANY COUNTY
03	21	MARYLAND	003	ANNE ARUNDEL COUNTY
03	21	MARYLAND	005	BALTIMORE COUNTY
03	21	MARYLAND	006	PRINCE GEORGE'S COUNTY
03	39	PENNSYLVANIA	001	PENNSYLVANIA DER
03	39	PENNSYLVANIA	002	ALLEGHENY CO. BAPC
03	39	PENNSYLVANIA	003	PHILADELPHIA AMS
03	48	VIRGINIA	001	VIRGINIA STATE AIR POLL. CONTROL BOARD
03	48	VIRGINIA	002	CITY OF ALEXANDRIA
03	48	VIRGINIA	003	FAIRFAX COUNTY
03	48	VIRGINIA	006	TENNESSEE VALLEY AUTHORITY - VA
03	50	WEST VIRGINIA	001	STATE OF WEST VIRGINIA
03	50	WEST VIRGINIA	002	WVA NORTHERN PANHANDLE REGIONAL OFFICE
04	01	ALABAMA	011	ALABAMA DEPT. OF ENVIRONMENTAL MGT.
04	01	ALABAMA	012	AL, JEFFERSON CNTY. BUREAU OF ENV. HLTH.
04	01	ALABAMA	013	AL DEPT. OF ENV. MANAGEMENT - MOBILE
04	01	ALABAMA	014	AL, HUNTSVILLE AIR POLL. CONTROL DEPT.
04	01	ALABAMA	015	AL, TRICOUNTY DIV. OF AIR POLL. CONTROL

Region	State No.	State Name	Reporting Organization No.	Reporting Organization Name
04	01	ALABAMA	016	TENNESSEE VALLEY AUTHORITY - ALABAMA
04	10	FLORIDA	001	FDER, NORTHWEST DISTRICT
04	10	FLORIDA	002	FDER, NORTHEAST DISTRICT
04	10	FLORIDA	003	FDER, ST. JOHNS RIVER DISTRICT
04	10	FLORIDA	004	FDER, SOUTHWEST DISTRICT
04	10	FLORIDA	005	FDER, SOUTH FLORIDA DISTRICT
04	10	FLORIDA	006	FDER, SOUTHEAST FLORIDA DISTRICT
04	10	FLORIDA	007	FDER, NORTHEAST DISTRICT BRANCH OFFICE
04	10	FLORIDA	011	FL, JACKSONVILLE BIO-ENV. SERVICES DIV.
04	10	FLORIDA	012	FL, HILLSBOROUGH CO., ENV. SERVICES DIV.
04	10	FLORIDA	013	FL, PINELAS CO. DEPT. OF ENV. MANAGEMENT
04	10	FLORIDA	014	FL, MANATEE COUNTY HEALTH DEPARTMENT
04	10	FLORIDA	015	FL, SARASOTA CO. AIR POLL. CONTROL DIV.
04	10	FLORIDA	016	FL, PALM BEACH COUNTY HEALTH DEPARTMENT
04	10	FLORIDA	017	FL, BROWARD CO. ENV. QUAL. CONTROL BOARD
04	10	FLORIDA	018	FL, DADE CO. DEPT OF ENV. RESOURCES MGT.
04	10	FLORIDA	020	FL, ORANGE CO. ENV. PROTECTION DEPT.
04	10	FLORIDA	022	EVERGLADES NATIONAL PARK
04	11	GEORGIA	010	GEORGIA AIR QUAL. EVALUATION SECTION EPD
04	18	KENTUCKY	001	KENTUCKY DIV. OF AIR POLL. CONTROL
04	18	KENTUCKY	002	KY, JEFFERSON CO. AIR POLL. CONTROL DIST.
04	18	KENTUCKY	003	TENNESSEE VALLEY AUTHORITY - KENTUCKY
04	25	MISSISSIPPI	100	MISSISSIPPI BUREAU OF POLLUTION CONTROL
04	34	NORTH CAROLINA	001	NC NATURAL RESOURCES & COMMUNITY DEVEL.
04	34	NORTH CAROLINA	002	NC, FORSYTH COUNTY ENV. AFFAIRS DEPT.
04	34	NORTH CAROLINA	003	NC, MECKLENBURG CO. DEPT. OF ENV. HEALTH
04	34	NORTH CAROLINA	004	NC, WESTERN REGIONAL AIR POLL. CONTROL
04	42	SOUTH CAROLINA	001	SC DEPT. OF HEALTH & ENV. CONTROL
04	44	TENNESSEE	001	TENNESSEE DIV. OF AIR POLL. CONTROL
04	44	TENNESSEE	002	TN, MEMPHIS-SHELBY CO. HEALTH DEPARTMENT
04	44	TENNESSEE	003	METRO HEALTH DEPT. NASHVILLE-DAVIDSON CO.
04	44	TENNESSEE	004	TN, KNOX COUNTY DEPT. OF AIR POLL. CONTROL
04	44	TENNESSEE	005	TN, CHATTANOGGA-HAMILTON CO. AIR POLL. CONT.
04	44	TENNESSEE	006	TENNESSEE VALLEY AUTHORITY - TENNESSEE
05	14	ILLINOIS	001	DIV. OF AIR POLL. CONT., ILLINOIS EPA
05	14	ILLINOIS	002	CHICAGO DEPT. OF CONSUMER SERVICES
05	14	ILLINOIS	003	COOK COUNTY DEPT. OF ENVIRONMENTAL CONT.
05	15	INDIANA	001	AIR POLL. CONT. DIV. OF INDIANA STATE
05	15	INDIANA	002	DIV. OF AIR POLL. CONT., EVANSVILLE
05	15	INDIANA	003	ST. JOSEPH COUNTY
05	15	INDIANA	005	AIR POLL. CONT. DIV., VIGO COUNTY
05	15	INDIANA	008	INDIANAPOLIS APC DIVISION
05	15	INDIANA	009	ANDERSON LOCAL AGENCY
05	15	INDIANA	010	PORTER COUNTY HEALTH DEPARTMENT
05	15	INDIANA	100	LAKE COUNTY CONSOLDTD. AQ MONIT. WRK. GRP.
05	23	MICHIGAN	001	AIR QUAL. DIV., MI DEPT. OF NAT. RES.
05	23	MICHIGAN	002	AIR POLL. CONT. DIV., WAYNE COUNTY
05	24	MINNESOTA	001	MINNESOTA POLL. CONT. AGENCY, AIR MO
05	36	OHIO	001	OHIO EPA, CENTRAL DISTRICT OFFICE

Region	State No.	State Name	Reporting Organization No.	Reporting Organization Name
05	36	OHIO	002	OHIO EPA, NORTHEAST DISTRICT OFFICE
05	36	OHIO	003	OHIO EPA, NORTHWEST DISTRICT OFFICE
05	36	OHIO	004	OHIO EPA, SOUTHEAST DISTRICT OFFICE
05	36	OHIO	005	OHIO EPA, SOUTHWEST DISTRICT OFFICE
05	36	OHIO	006	AKRON AIR POLLUTION CONTROL
05	36	OHIO	007	AIR POLL. CONT. DIV., CANTON CITY
05	36	OHIO	008	SOUTHWESTERN OHIO AIR POLL. AGENCY
05	36	OHIO	009	CLEVELAND DIV. OF AIR POLL. AGENCY
05	36	OHIO	010	REGIONAL APC AGENCY, DAYTON
05	36	OHIO	012	AIR POLL. CONT. DIV. OF LAKE COUNTY
05	36	OHIO	013	AIR POLL. UNIT, PORTSMOUTH CITY
05	36	OHIO	014	NORTH OHIO VALLEY AIR AUTHORITY
05	36	OHIO	015	TOLEDO POLL. CONTROL AGENCY
05	36	OHIO	016	MAHONING TRUMBULL AIR POLL. CONTROL
05	51	WISCONSIN	001	WI. DEPT. OF NAT. RES., AIR MONIT. UNIT
06	04	ARKANSAS	001	DEPT. OF POLL. CONT. & ECOLOGY CONT. MON
06	04	ARKANSAS	002	DEPT. OF POLL. CONT. & ECOLOGY
06	19	LOUISIANA	001	DEPT. OF NATURAL RESOURCES, NEW ORLEANS
06	32	NEW MEXICO	001	ENV. IMPROVEMENT DIV., SANTA FE
06	32	NEW MEXICO	002	CITY OF ALBUQUERQUE ENV. HEALTH DIV.
06	37	OKLAHOMA	101	OK STATE DEPT. OF HEALTH
06	37	OKLAHOMA	102	OKLAHOMA CITY-CNTY. HEALTH DEPT.
06	37	OKLAHOMA	103	TULSA CITY-CNTY. HEALTH DEPT.
06	45	TEXAS	001	TEXAS AIR CONTROL BOARD
06	45	TEXAS	002	DALLAS ENV. HEALTH & CONSERVATION DEPT.
06	45	TEXAS	003	EL PASO CITY-CNTY. HEALTH DEPT.
06	45	TEXAS	004	FT. WORTH PUBLIC HEALTH DEPT.
06	45	TEXAS	005	GALVESTON COUNTY HEALTH DISTRICT
06	45	TEXAS	006	HOUSTON DEPT. OF PUBLIC HEALTH
06	45	TEXAS	007	SAN ANTONIO METRO. HEALTH DISTRICT
07	16	IOWA	001	POLK COUNTY PHYSICAL PLANNING
07	16	IOWA	002	LINN COUNTY HEALTH DEPARTMENT
07	16	IOWA	003	UNIVERSITY HYGIENIC LABORATORY
07	17	KANSAS	001	STATE OF KANSAS
07	26	MISSOURI	001	LABORATORY SERVICES PROGRAM
07	26	MISSOURI	002	ST. LOUIS COUNTY
07	26	MISSOURI	003	ST. LOUIS CITY
07	26	MISSOURI	004	KANSAS CITY
07	26	MISSOURI	005	SPRINGFIELD
07	26	MISSOURI	006	AMAX LEAD CO. OF MO, BOSS, MO
07	26	MISSOURI	007	ST. JOE LEAD CO., HERCULANEUM, MO
07	28	NEBRASKA	001	STATE OF NEBRASKA
07	28	NEBRASKA	002	LINCOLN
07	28	NEBRASKA	003	OMAHA
08	06	COLORADO	001	DEPARTMENT OF HEALTH
08	27	MONTANA	001	MT AIR QUAL. BUREAU, DEPT. OF H&ENV.
08	27	MONTANA	002	YELLOWSTONE CNTY. AIR POLL. CONT. AGY.
08	27	MONTANA	003	GREAT FALLS CITY-CNTY. HEALTH DEPT.

Region	State No.	State Name	Reporting Organization No.	Reporting Organization Name
08	27	MONTANA	004	MISSOULA CITY-CNTY HEALTH DEPT.
08	35	NORTH DAKOTA	001	STATE DEPARTMENT OF HEALTH
08	43	SOUTH DAKOTA	001	DEPT. OF HEALTH, DIV. OF ENV. HEALTH
08	46	UTAH	001	STATE BUREAU OF AIR QUALITY
08	52	WYOMING	001	DEPT. OF ENV. QUAL., AIR QUAL. DIV.
09	03	ARIZONA	100	ARIZONA DEPT. OF HEALTH SERVICES
09	03	ARIZONA	200	MARICOPA COUNTY
09	03	ARIZONA	300	PIMA COUNTY
09	05	CALIFORNIA	001	CALIFORNIA AIR RESOURCES BOARD
09	05	CALIFORNIA	004	BAY AREA AIR QUAL. MANAGEMENT DISTRICT
09	05	CALIFORNIA	036	SAN DIEGO AIR POLL. CONTROL DISTRICT
09	05	CALIFORNIA	061	SOUTH COAST AIR QUAL. MANAGEMENT DIST.
09	05	CALIFORNIA	061	SOUTH COAST AIR QUAL. MANAGEMENT DIST.
09	12	HAWAII	120	STATE OF HAWAII, DEPT. OF HEALTH
09	29	NEVADA	100	NEVADA DIV. OF ENV. PROTECTION
09	29	NEVADA	200	WASHOE COUNTY
09	29	NEVADA	300	CLARK COUNTY
09	54	GUAM	100	GUAM EPA
10	02	ALASKA	020	DEPT. OF ENVIRONMENTAL CONSERVATION
10	13	IDAHO	001	DEPARTMENT OF HEALTH AND WELFARE
10	38	OREGON	001	DEPT. OF ENVIRONMENTAL QUALITY
10	49	WASHINGTON	001	DEPT. OF ECOLOGY

APPENDIX D

PRECISION AND ACCURACY DATA BY REPORTING ORGANIZATIONS

To reduce printing expenses, the detailed tabulations of the numerical values for each pollutant for each reporting organization are not included here, but can be obtained by written request to R.C. Rhodes, EPA, MD-77B, Research Triangle Park, NC 27711. The format of the tables is the same as for the previous annual reports. Please indicate in your request the particular pollutant mesurement system(s) you desire copies for.

APPENDIX E

PROBLEMS INVOLVED IN THE COMPARISON OF PERFORMANCE AUDIT (PA) DATA AND PRECISION AND ACCURACY (PARS) DATA

Several problems are encountered when attempting to compare Performance Audit (PA) data and Precision and Accuracy (PARS) data. Obviously, comparisons can be made only where the same pollutant measurement methods are audited in both programs. The following pollutant measurement methods are audited in both programs.

Continuous Methods	CO
	SO_2
Manual Methods	TSP
	Pb
	SO_2
	NO_2

Further, only the accuracies of the PARS system can be compared because no precision assessments are currently made from the PA data.

Other factors to consider in making comparisons are:

1. source of data (organization performing the audits),
2. time of audit, and
3. concentration level (or flow rate level for TSP).

Valid comparisons can only be made for those organizations where both the PA and the PARS audits are performed. The PARS data are reported by Reporting Organization, whereas the PA data are reported by Laboratory.

A cross-reference listing has been prepared to match up each Reporting Organization number with its corresponding Laboratory number. The comparisons made on a state, regional, or national basis are made using only those Reporting Organization-Laboratory match-ups where both have reported accuracy audit data.

Good agreement should be expected between the PARS and PA data for a given Reporting Organization-Laboratory combination if the two audits were performed at nearly the same time. However, the PA audits are scheduled at various times during the year. And, the regulation requirement for the PARS accuracy audit is that (1) at least one audit per year shall be conducted on each instrument (or site) for continuous instruments (CO and SO_2) and for the TSP method and (2) at least two audits per quarter shall be

conducted at the laboratory for the manual Pb, SO_2, and NO_2 methods. Further, there is no requirement or planned schedules to assure that the two types of audits are conducted at nearly the same time. The comparisons can therefore be made only on an annual basis for a given Reporting Organization-Laboratory matchup. Comparisons for the continuous methods, CO and SO_2, and TSP cannot be made on an individual site (instrument) basis because the PARS data are not reported on a site basis although the PA data are. (Beginning January 1, 1987, these PARS data will be reported to EMSL by site so that it will be possible to make comparisons on a site basis. However, because of the possible large differences in times of the audits, such comparisons may not be meaningful.)

Because of the relatively small amount of data for comparison on a Reporting Organization-Laboratory basis and the time differences, study of the comparisons of PA and PARS data has been limited to comparisons of larger samples or aggregates of data, i.e., on a Regional or National basis.

Another bothersome problem in comparing PA and PARS data is that the concentration levels do not correspond. The concentration levels are fixed by regulation for the PARS accuracy audits whereas the levels for PA vary from year to year and in some cases from audit to audit. Because of these variations in concentration for the PA audits, the concentration levels for PARS are used as a basis for defining concentration ranges for comparison.

The following tables present the concentration levels for PARS as specified by the regulation and the concentration levels actually used for PA audits during calendar year 1985.

TABLE E-1. CONCENTRATION LEVELS FOR PARS AND PA AUDITS FOR 1985 FOR THE CONTINUOUS METHODS

Pollutant	Concentration levels, ppm PARS	PA
CO	3- 8	6.70
	15-20	16.50
	35-45	39.90
	80-90	
SO_2	.03-.08	.05-.08
	.15-.20	.17-.20
	.35-.45	.22-.26
	.80-.90	.40-.49
		.62-.69

TABLE E-2. CONCENTRATION (OR FLOW) LEVELS FOR PARS AND PA AUDITS FOR 1985 FOR MANUAL METHODS

Pollutant	Concentration (or flow) levels PARS		PA	
TSP	ft^3/min	m^3min	m^3/min	ft^3/min
	50 (nominal)	1.416*	.7	24.7
	40-60	1.133-1.699	.9	31.8
			1.1	38.8
			1.2	42.4
			1.3	45.9
			1/85	7/85
Pb	µg/strip	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
	100- 300	0.6-1.8*	0.53	0.45
	600-1000	3.5-5.9	1.06	1.00
			3.03	1.15
			4.31	2.00
			4.83	2.70
			6.65	5.40
SO_2	µg/ml	ppm	$\mu g/m^3$	ppm
	0.2-0.3	.013-.020*	44.30	.017
	0.5-0.6	.033-.040	61.00	.023
	0.8-0.9	.053-.059	90.60	.034
			124.50	.0473
			271.90	.103
NO_2	µg/ml	ppm	µg/ml	$\mu g/m^3$ ppm
	0.2-0.3	.018-.028*	.345	59.90 .032
	0.5-0.6	.046-.055	.434	75.35 .040
	0.8-0.9	.074-.083	.686	119.10 .063
			.944	163.89 .087
			1.114	193.40 .103

*See conversion factors on following page.

Conversion Factors

To convert	Multiply by
ft^3 to m^3	0.02832
$\mu g/m^3$ to ppm	
SO_2	0.00038
NO_2	0.00053
CO	0.00087
O_3	0.00051
μg/strip to $\mu g/m^3$ for Pb	0.00589

$$\left[\frac{\mu g}{3/4"x8"\ strip} \cdot \frac{12\ exposed\ strips}{8"x10"\ filter} \cdot \frac{1}{50\ ft^3/min} \cdot \frac{1\ filter/day}{1440\ min/day} \cdot \frac{1}{.02832\ m^3/ft^3}\right]$$

$$= .00589\ \mu g/m^3$$

$\mu g/ml$ to $\mu g/m^3$ 173.61

$$\left[\frac{\mu g}{ml} \cdot \frac{50\ ml}{sample} \cdot \frac{1\ sample/day}{.2\ L/min} \cdot \frac{1}{1440\ min/day} \cdot \frac{1000\ L}{m^3}\right]$$

$$= 173.61\ \mu g/m^3$$

$\mu g/ml$ to ppm

SO_2 $(173.61)(0.00038) = 0.066$

NO_2 $(173.61)(0.00053) = 0.092$

The following example illustrates the procedure for establishing the concentration ranges for comparison purposes. For CO the four accuracy audit levels for the PARS are 3-8, 15-20, 35-45, and 80-90 ppm. During 1985 the three concentration levels for the performance audits were 6.70, 16.50, and 39.90 ppm. The calculated midpoints between the adjacent concentration levels for the PARS are considered the boundaries of the ranges for comparison:

Comparison levels	Conc. levels, ppm	Calculated midpoints, ppm	Ranges for comparison, ppm	Performance audit levels, ppm
1	3-8		0-11.5	6.70
		11.5		
2	15-20		11.5-27.5	16.50
		27.5		
3	35-45		27.5-62.5	39.90
		62.5		
4	80-90		62.5-	

As shown above the calculated midpoint between 8, the upper limit of PARS level 1, and 15, the lower limit of PARS level 2, is

$$\frac{8 + 15}{2} \text{ or } 11.5.$$

Similarly the calculated midpoint between comparison levels 2 and 3 is 27.5 ppm, and between levels 3 and 4, 62.5 ppm. Thus, the newly defined CO ranges for comparison are

0 to 11.5
11.5 to 27.5
27.5 to 62.5
and 62.5 and above.

Therefore, the results of PA audits at 6.70 ppm are compared with the results of PARS audits at 3 to 8 ppm, etc., shown in the above table.

Following the same procedure, the comparison ranges for all the pollutant methods have been computed and are summarized in Tables E-3 and E-4.

The problem in comparing results within the defined ranges are illustrated by Figures E-1 and E-2.

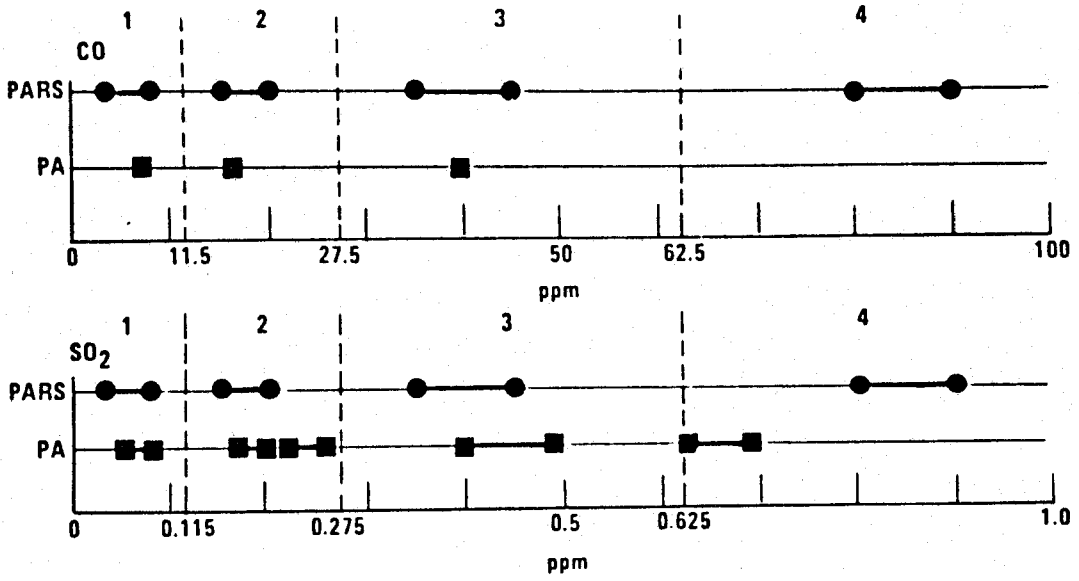


Figure E-1. Concentration levels for comparing PARS and PA data, continuous methods.

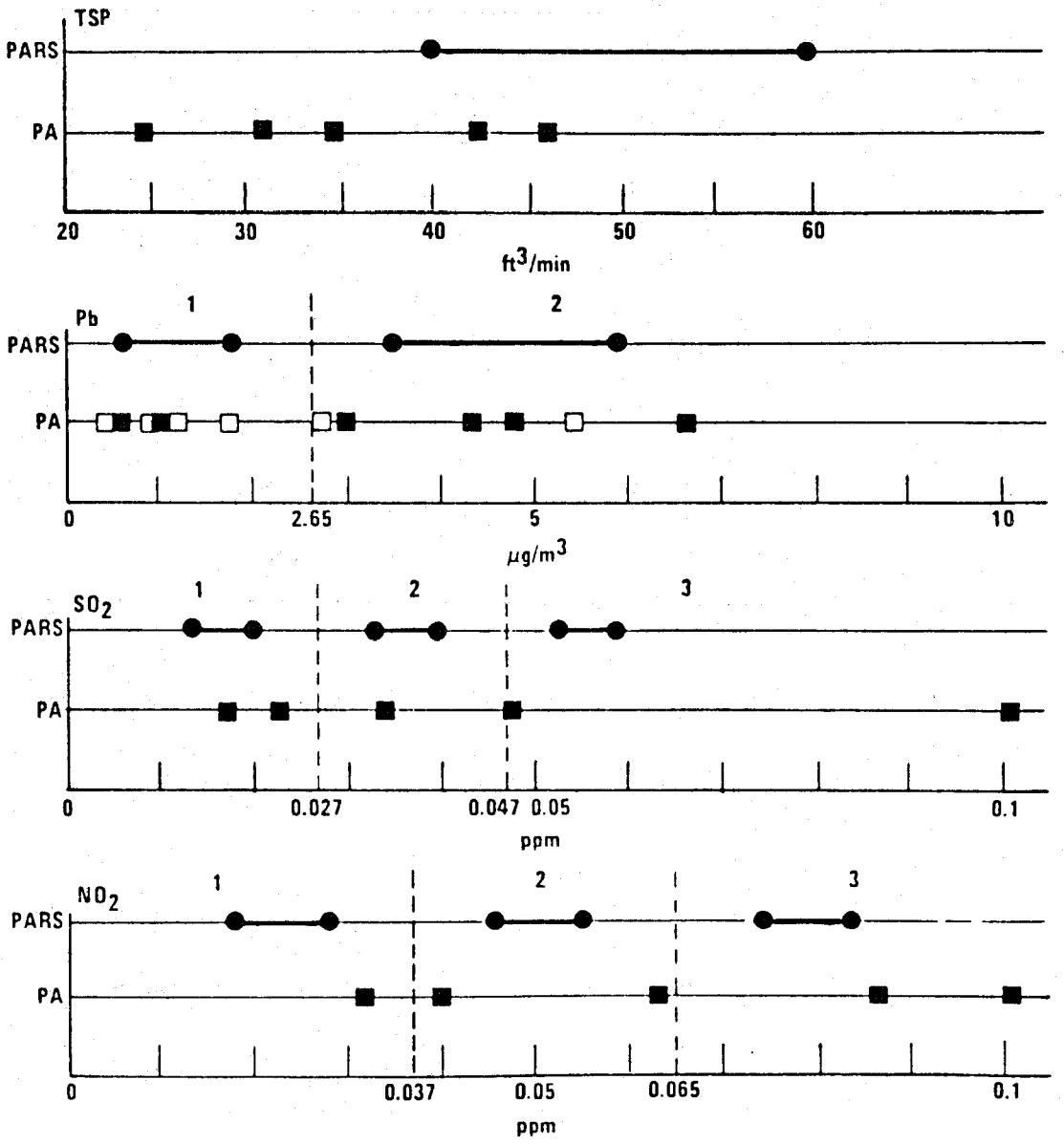


Figure E-2. Concentration or flow levels for comparing PARS and PA data, manual methods.

TABLE E-3. CONCENTRATION RANGES FOR COMPARISON OF PARS AND PA DATA - CONTINUOUS METHODS

Pollutant	Comparison level	PARS conc. levels, ppm	Calculated midpoints, ppm	Ranges for comparison, ppm	PA levels, ppm
CO	1	3-8		0-11.5	6.70
			11.5		
	2	15-20		11.5-27.5	16.50
			27.5		
	3	35-45		27.5-62.5	39.90
			62.5		
	4	80-90		62.5-	
SO_2	1	.03-.08		0-.115	.05-.08
			.115		
	2	.15-.20		.115-.275	.17-.20 .22-.26
			.275		
	3	.35-.45		.275-.625	.40-.49
			.625		
	4	.80-.90		.625-	

TABLE E-4. RANGES FOR COMPARISON OF PARS AND PA DATA - MANUAL METHODS

Pollutant	Comparison level	PARS level	Calculated mid-point	Ranges for comparison	Performance audit levels
		ft^3/min			
TSP	2	40-60	NA	all	24.7 31.8 38.8 42.4 45.9
		$\mu g/m^3$			
					1/85: .53, 1.06; 7/85: .45, 1.00, 1.15, 2.00
Pb	1	0.6-1.8		0-2.65	
			2.65		
	2	3.5-5.9		2.65-	3.03, 4.31, 4.83, 6.65; 2.70, 5.40
		ppm			
SO_2	1	.013-.020		0-.027	.017 .023
			.027		
	2	.033-.040		.027-.047	.034
			.047		
	3	.053-.059		.047-	.0473 .103
NO_2	1	.018-.028		0-.037	.032
			.037		
	2	.046-.055		.037-.065	.040 .063
			.065		
	3	.074-.083		.065-	.087 .103

As shown in Table E-3, the results of level 2 PARS continuous SO_2 accuracy audits at concentrations .15-.20 ppm are compared with the results of performance audits at concentration levels .17-.20 and .22-.26 ppm.

And, from Table E-4, the results of level 1 PARS Pb accuracy audits at concentrations 0.6-1.8 $\mu g/m^3$ are compared with the results of performance audits at concentration levels .53 and 1.06 $\mu g/m^3$ of the 1/85 audit and .45, 1.00, 1.15, and 2.00 $\mu g/m^3$ of the 7/85 audit.

It has been recommended that the concentration levels for the performance audits be adjusted to more closely correspond to those of the PARS in order to provide more valid comparisons.

Another factor which makes the PA and PARS comparisons somewhat complicated is the reporting units which differ for some of the pollutant measurement methods and which require the conversion of units. Further, the persons submitting data are required to convert some informational items to computer codes: methods, units, laboratory names/addresses, reporting organization names/addresses, audit levels (for PARS only), etc. These conversions could be the source of some errors in proper identification of the data used in making the comparisons.

APPENDIX F

COMPARISON OF PARS AND PERFORMANCE AUDIT DATA

To reduce printing expenses, the detailed tabulations of the numerical values of this appendix are not included here, but can be obtained by written request to R.C. Rhodes, EPA, MD-77B, Research Triangle Park, NC 27711. The format of the tables is the same as for the previous annual reports. Please indicate in your request the particular pollutant mesurement system(s) you desire copies for.