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Project Summary

Precision and Accuracy Assessments for State and Local Air Monitoring Networks 1984

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Precision and accuracy data obtained from state and local agencies during 1984 are summarized and evaluated. Some comparisons are made with the results previously reported for 1981, 1982, and 1983 to determine any trends. Some trends indicated 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 1981 to 1984 and also with other reporting organizations.

A comparison of the precision and accuracy data from the Precision and Accuracy Reporting System with those from the independent performance audit program conducted by the Environmental Monitoring Systems Laboratory is given.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The purpose of the full document is to report the third 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. 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 the report consists of summaries 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 summaries and evaluations serve the following purposes:

1. Quantitative estimates of the precision and accuracy of their monitoring data are available to state and local agencies.
2. A comparison of the data from all the agencies can indicate the need to im-

*When one speaks of precision and accuracy of measurement data, one really means the precision and accuracy of the measurement process from which the 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."

prove quality assurance systems in specific reporting organizations.

3. An evaluation of the results may indicate a need for improvement in monitoring methodology.
4. The assessments provide 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.

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 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 intercompare 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 criteria on network design, siting, quality assurance, monitoring methods, and data reporting after December 30, 1980. For example, only EPA reference, equivalent, or other EPA-approved air monitoring methods were to be used. Also, calibration standards were to be traceable to the National Bureau of Standards (NBS) or other authoritative standards. Further, the quality assurance systems of the states were required to be documented and approved by the EPA Regional Offices. Finally, the reporting organizations must also follow specific procedures when assessing the P and A of their measurement systems and must report the P and 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.

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. The accuracy assessments were generally determined by analyzing blind audit materials traceable to NBS. 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 and A are contained in the regulations.

National Results

National Data Reporting

The fourth year of data collected by state and local agencies for P and A has been compiled and summarized. The network operation has been continually improved. Table 1 shows the improvement in data reporting for the nation.

Improvement continues for the continuous NO_2 method; however, the percentage still lags behind that for continuous CO, SO_2 and O_3 methods. Reporting for the manual methods for Pb, SO_2 and NO_2 was required by the regulations beginning January 1, 1983. Reporting for Pb is negligibly different from 1983 to 1984. Reportings for the manual methods for SO_2 and NO_2 have significantly improved from 1983 to 1984.

1984 Results From The Pars Program

The measures 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:

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

where $\bar{D}$ = 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.

*Note: 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 1. Percent of Reporting Organizations Reporting Precision and Accuracy Data

Pollutant measurement	1981	1982	1983	198
CO	77	89	99	99
SO_2	82	93	96	97
NO_2	56	72	88	94
O_3	83	89	99	99
TSP	94	97	99	99
Pb	—	—	93	92
SO_2 (manual)	—	—	75	80
NO_2 (manual)	—	—	86	100

It is these upper and lower 95% probabilit limits which are reported and discussed i the full report.

Moreover, it should be noted that th data and the evaluations presented in th report include any outlier values whic may have been reported by the states an local agencies. The presence of outlier can influence such comparisons by havin undue impact on average values for ind vidual reporting organizations.

Table 2 exhibits the national probabilit limits for each of the manual methods. Th probability limits in Tables 2 and 3 are cor solidated and weighted limits of all th reported limits for 1984. They are th limits that would be obtained if the result of all the individual precision (or accurac checks in the nation were combined a one sample. The national limits for th report more correctly reflect the tot variability in the data and are somewh wider than the corresponding limits f previous reports due to a change in th computation of these limits.

The precision limits reflect the repea ability of the methodology used in the fie to collect and analyze the samples at an bient levels. The spread of the limits ma be somewhat inflated due to measur ments at relatively low concentratic levels.

The accuracy of the manual methods i dicates the limits at predetermined co centration levels for the chemical analys performed in the samples for lead, sulf dioxide, and nitrogen dioxide. For the TS method, the accuracy measurement is f the flow rate only. The probability limits f manual accuracy are very good and refle the quality of work done in the chemic laboratories for lead, sulfur dioxide, a nitrogen dioxide analyses, and in the fie for flow rate measurement for the TS method. Because of the continual replac ment of the manual SO_2 and N methods with continuous methods, f ther discussion of the manual methods

Table 2. *National Precision and Accuracy Probability Limit Values for Manual Methods for 1984*

	Precision			Accuracy						
				Probability limits (%)						
	Number of valid collocated	Probability limits (%)		No. of	Level 1		Level 2		Level 3	
Pollutant	data pairs	Lower	Upper	audits	Lower	Upper	Lower	Upper	Lower	Upper
TSP	17,152	−16	+17	7,436	—	—	−8	+8	—	—
Lead	3,937	−18	+20	1,657	−17	+15	−11	+10	—	—
Sulfur dioxide	297	−33	+31	203	−20	+9	−14	+7	−12	+7
Nitrogen dioxide	691	−27	+27	175	−8	+10	−7	+8	−6	+7

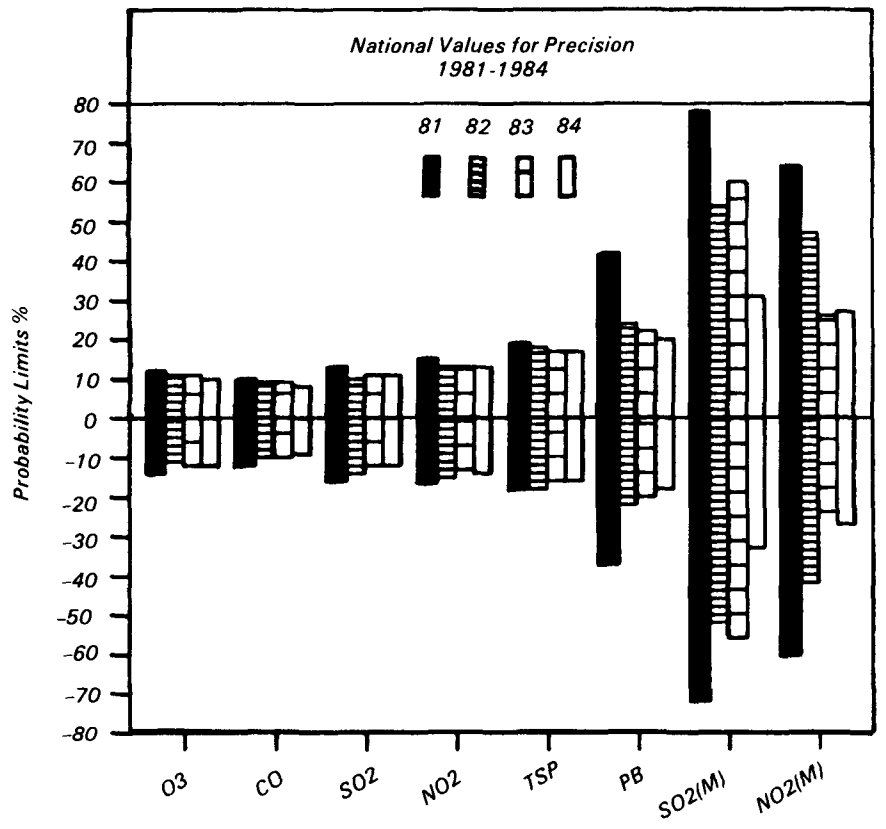

Figure 1. *National precision probability limits for 1981 through 1984.*

limited. The detailed results for each reporting organization are tabulated in an appendix to the full report.

The precision and accuracy limits for automated methods are presented in Table 3. The effort expended for the collection of quality assurance precision and accuracy data is appreciable, but it is necessary to assess data quality.

National Precision Results Comparison

Figure 1 shows the national probability limits for precision for the various methods. With data from four years, some minor trends are evident. Some slight improvement, as measured by a reduction in the spread of the limits, is noted for TSP and the continuous methods, except for NO_2. 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 results for Pb show a decided improvement. The manual SO_2 and NO_2 methods are much more variable than the continuous methods. However, they do show considerable improvement over the four-year period.

National Accuracy Results Comparison

Figures 2a and 2b show the national probability limits for accuracy audits for the continuous and manual methods, respectively. Improvement for the manual methods is not evident except perhaps for TSP and SO_2. The variability for the Pb method is increased and for the NO_2 method has shown no definite trend. Slight improvement is evident for all the continuous methods. The continuous methods for SO_2 and NO_2 show more inaccuracy than all other methods. However,

Table 3. *National Precision and Accuracy Probability Limit Values for Automated Analyzers for 1984*

	Precision			Accuracy								
				No. of audits		Probability limits (%)						
	No. of precision	Probability limits (%)			Level	Level 1		Level 2		Level 3		Level 4	
	checks	Lower	Upper	Total	4	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
CO	14,692	−9	+8	1,288	23	−14	+13	−9	+8	−9	+8	−10	+9
SO_2	38,312	−12	+11	1,666	166	−16	+14	−12	+11	−12	+11	−13	+12
NO_2	8,653	−14	+13	613	24	−21	+20	−13	+12	−13	+10	−18	+14
O_3	20,031	−12	+10	1,773	144	−16	+14	−12	+10	−11	+10	−6	+5

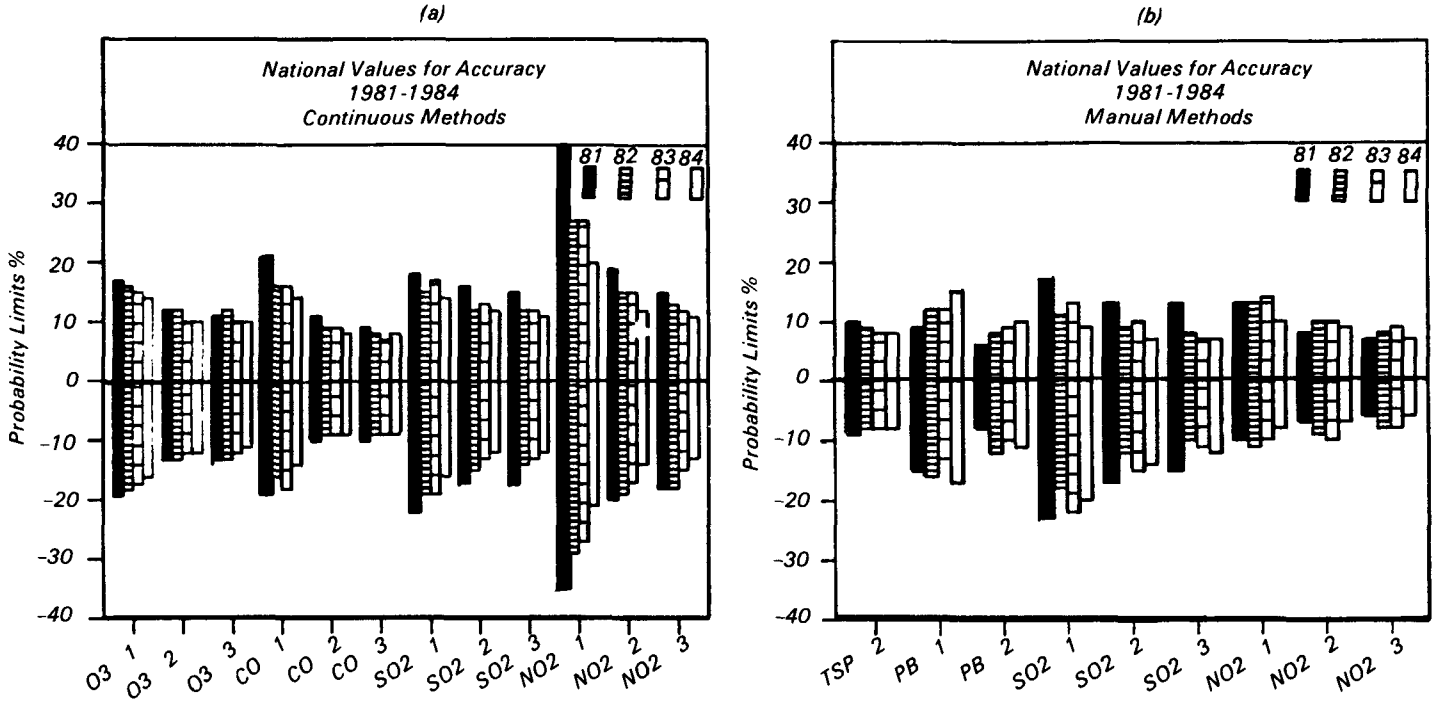

Figure 2. *National accuracy probability limits for 1981 through 1984.*

in the accuracy audits for the manual methods, only a portion of the measurement method is checked.

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

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 bias 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.

Comparison of Results from the PARS and the Performance Audit Program

A general comparison between the accuracy data of the PARS program and the Performance Audit (PA) data is included in the full report. The Performance Audit data are the results of an indpendent check conducted by the Quality Asssurance 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 analytical
NO_2 (manual)	Aqueous sodium nitrite	Chemical analytical
Pb	Filter strip with lead nitrate	Chemical analytical
TSP	Reference flow device	Flow
CO	Cylinders containing CO gas	Continuous instrument
SO_2	Cylinder containing SO_2 gas	Continuous instrument

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.

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 these pollutants.

Since precision assessments are no made in the PA program, only accurac can be compared across the PARS and th PA programs. For the purpose of the fu report, the results from PARS and the P system are compared at approximately th same levels by matching laboratories an reporting organizations. Since the PAR data are presented with outliers, the sam approach was taken with the audit data Knowledge of the historical audit dat reports, however, indicates that the pres ence of outliers may make a significant di ference in the audit results for som agencies.

Comparisons of the national values c the probability limits (Table 4) exhibit fairl good agreement between the results c the two programs. However, there is cor siderable variation between the results c the two programs when comparisons ar made on Regional and reporting organiza

Table 4. *Summary Comparison of EMSL Performance Audits (PA) vs. PARS Accuracy Audit Data for Year 1984*

		National values probability limits (%)							
		Level 1		Level 2		Level 3		Level 4	
Pollutant	Audits	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
CO									
PA	771	− 9	12	−20	21	− 7	8		
PARS	974	−14	13	− 8	8	− 8	7	−10	8
SO_2									
PA	357	−23	19	−16	14	−17	14	−22	20
PARS	819	−13	11	−12	11	−12	10	−11	9
TSP									
PA	2447			−15	18				
PARS	6559			− 6	7				
Pb									
PA	723	−35	30	−17	11	−22	14		
PARS	1259	−17	15	−11	10				
SO_2 (manual)									
PA	30			−15	6	−18	15	−14	16
PARS	190	−18	8	−12	6	−12	6		
NO_2 (manual)									
PA	30	− 5	− 1	− 7	− 2	− 3	4	− 7	− 3
PARS	139	− 6	8	− 6	7	− 4	5		

tion bases. Lack of better agreement results from several factors. First, the inclusion of outlier values in the PA data appears to have introduced some excessive distortion of general trends. Second, even though the PARS averages in Table 4 are weighted by the number of audits, 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. Third, the concentration levels for the two systems do not coincide exactly at each of the audit levels. Fourth, 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 4) confirm these expectations.

Conclusions and Recommendations

The results of PARS data for 1984 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.

Comparison of PARS and PA data show more variability of the PA data than for PARS except for CO. 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 firsthand 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 that 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.

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The complete report, entitled "Precision and Accuracy Assessments for State and Local Air Monitoring Networks 1984," (Order No. PB 87-111 720/AS; Cost: $18.95, subject to change) will be available only from:

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