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Project Summary

Precision and Accuracy Assessments for State and Local Air Monitoring Networks 1985

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Precision and accuracy data obtained from State and local agencies during 1985 are summarized and evaluated. Some comparisons are made with the results reported for prior years 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 year to year.

A comparison is made 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.

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 this document is to report the fifth 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 this report consists of summarizations and evaluations of the P&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. 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 of the above agencies can indicate the need to improve quality assurance systems in specific reporting organizations.

*When one speaks of precision and accuracy of measurement data, 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."

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 quarterly the P&A data to EPA. 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 fifth year of data collected by State and local agencies for P&A has been compiled and summarized. Continuing improvements in the network operation have been made. Table 1 shows the percentage of data reporting for the nation.

Improvement in reporting continues for the continuous NO_2 method. However, the other continuous methods have either remained the same as or slightly decreased from 1984. Reporting for TSP and the manual NO_2 method remain at a high level, 99 and 100 percent, respectively. Reporting for the Pb method has improved to 96 percent. Reporting for the manual SO_2 method, used in 1985 by only three reporting organizations, remains low at 75 percent.

1985 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 from the average and standard deviations of the individual percentage values:

$$\text{Upper Limit} = \bar{D} + 1.96\ S$$

$$\text{Lower Limit} = \bar{D} - 1.96\ S$$

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.

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. The presence of outliers can influence such comparisons by having undue impact on average values for individual reporting organizations.

Table 2 exhibits the national probability limits for each of the manual methods. The probability limits in Tables 2 and 3 reflect the total variability in the nation in 1985. They are the limits which would be obtained if the results of all the individual precision (or accuracy) checks in the nation were combined as one sample. The national limits for this report and the report for 1984 correctly reflect the total variability in the data. They are somewhat wider than the corresponding limits for reports for years 1983 and before due to a change in the

Table 1. *Percent of Reporting Organizations Reporting Precision and Accuracy Data*

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

method of calculation beginning with the 1984 data.

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 on 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, further discussion of the manual methods is limited. The detailed results for each reporting organization are tabulated in an appendix to the full report.

The number of reported precision checks and accuracy audits have decreased from 1984, particularly for the manual SO_2 and NO_2 method which are being replaced by continuous instruments.

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. The numbers of reported precision and accuracy checks for the continuous methods have decreased from 1984, particularly for the continuous SO_2 method. The number of precision checks is 40 percent less, and the number of accuracy audits is 14 percent less in 1985 than for 1984. No explanation can be given for these significant decreases, since the number of sites have remained essentially the same. Details of the results are discussed in the analysis section.

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 reduction in the spread of the limits, is noted for TSP and the continuous methods. 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 continuing improvement. The manual SO_2 and NO_2 methods are much more variable than the continuous methods. And, although they have shown considerable improvement over the five-year period, the results for 1985 are somewhat worse than for 1984.

National Accuracy Results Comparison

Figures 2a and 2b show the national probability limits for accuracy audits for the manual and continuous methods, respectively, for the four most recent years, 1982-1985. Improvement for the manual methods is evident 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 is evident for all the continuous methods. The continuous methods for SO_2 and NO_2 show more inaccuracy than all other methods. However, the accuracy audits for the manual methods check only a portion of the measurement method.

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 bias for the continuous SO_2 method is consistent across all three levels. A possible cause is that, on

Table 2. *National Precision and Accuracy Probability Limit Values for Manual Methods for 1985*

	Precision			Accuracy							
					Probability limits (%)						
	Number of valid collocated data pairs	Probability limits (%)		No. of audits	Level 1		Level 2		Level 3		
Pollutant		Lower	Upper		Lower	Upper	Lower	Upper	Lower	Upper	
TSP	16,462	−15	+17	6,770	—	—	−8	+8	—	—	
Lead	3,308	−18	+19	1,616	−12	+10	−10	+8	—	—	
Sulfur dioxide	185	−42	+35	174	−33	+17	−18	+9	−19	+9	
Nitrogen dioxide	469	−27	+29	161	−7	+8	−3	+5	−3	+5	

Table 3. *National Precision and Accuracy Probability Limit Values for Automated Analyzers for 1985*

	Precision			Accuracy									
				No. of audits		Probability Limits (%)							
	No. of precision checks	Probability limits (%)			Level 4	Level 1		Level 2		Level 3		Level 4	
		Lower	Upper	Total		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
CO	14,465	−9	+9	1,159	16	−14	+13	−8	+8	−8	+7	−19	+14
SO_2	22,863	−9	+7	1,481	84	−16	+14	−12	+12	−13	+12	−8	+10
NO_2	7,695	−12	+12	573	23	−20	+21	−13	+12	−12	+10	−14	+5
O_3	18,822	−10	+9	1,620	121	−14	+12	−11	+9	−10	+8	−7	+5

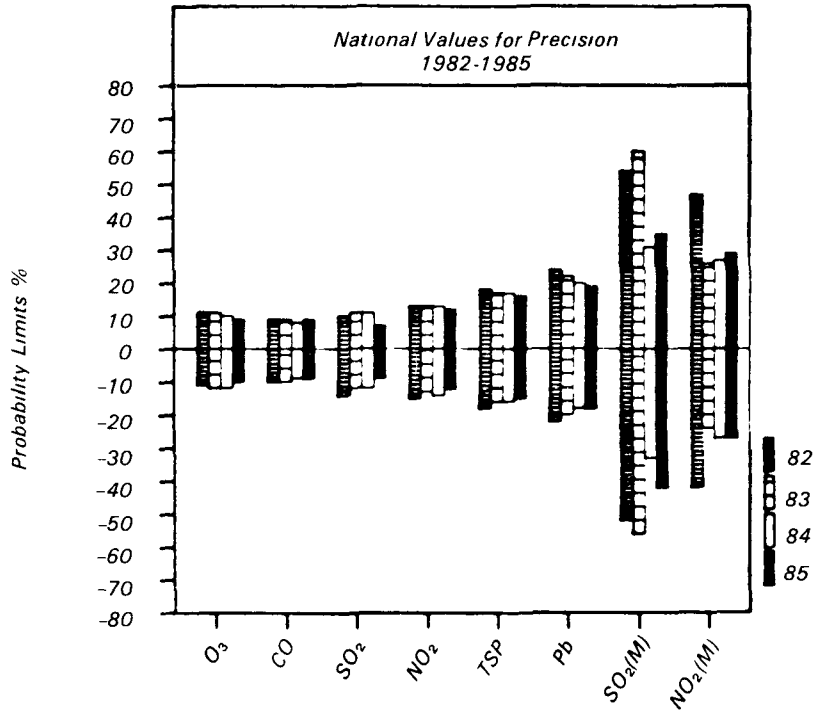

Figure 1. *National precision probability limits for 1982 through 1985*

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 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:

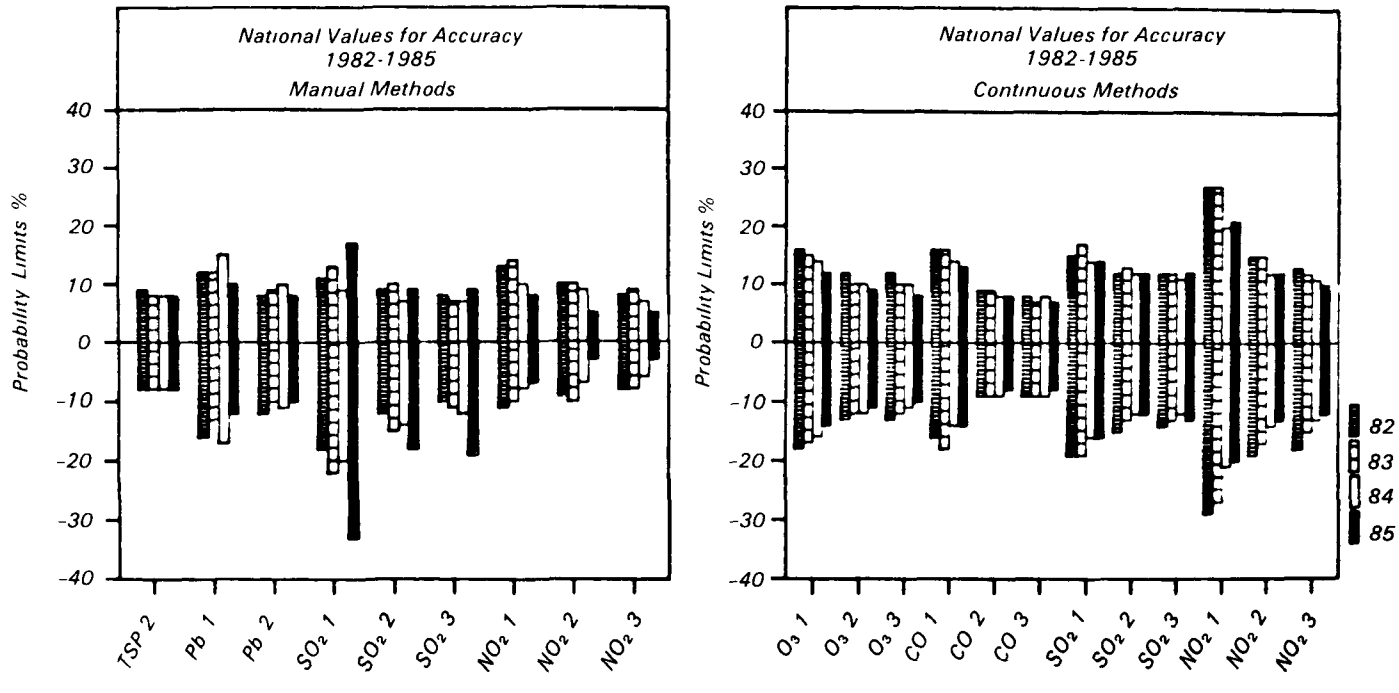

Figure 2. *National accuracy probability limits for 1982 through 1985.*

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 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. Since the PARS data are presented with outliers, the same approach was taken with the audit data. Knowledge of the historical 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 4) exhibit fairly good agreement between the results of the two programs. However, 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 both data sets 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 4) confirm these expectations for all pollutants except the manual NO_2. The manual NO_2 limits are wider for PARS than for PA, perhaps because of small sample variability or that more care was taken with the external audits.

Conclusions and Recommendations

The results of PARS data for 1985 indicate some further 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. Elimination of the causes of the excessive deviations will further improve the quality assessments of the measurement systems used for routine monitoring in the nation.

Comparisons of PARS and PA data show more variability of the PA data than for PARS except for CO, SO_2 and manual NO_2 methods. 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.

Table 4. *Summary Comparison of EMSL Performance Audits (PA) vs. PARS Accuracy Audit Data for Year 1985*

		National values 95% probability limits (%)					
		Level 1		Level 2		Level 3	
Pollutant	Audits	Lower	Upper	Lower	Upper	Lower	Upper
CO							
PA	388	−14	10	−10	9	−8	9
PARS	667	−13	13	−8	8	−8	7
SO_2							
PA	756	−20	26	−18	22	−17	20
PARS	1326	−17	14	−13	12	−13	12
TSP							
PA	3772			−10	12		
PARS	5928			−8	8		
Pb							
PA	432	−16	16	−15	10		
PARS	777	−12	9	−9	7		
SO_2 (manual)							
PA	15	−24	25	−9	22	−1	9
PARS	55	−21	20	−10	12	−10	11
NO_2 (manual)							
PA	15	0	3	0	7	−2	4
PARS	40	−20	20	−10	15	−14	19

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The complete report, entitled "Precision and Accuracy Assessments for State and Local Air Monitoring Networks 1985," (Order No. PB 87-145 447/AS; Cost: $24.95, subject to change) will be available only from:

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