

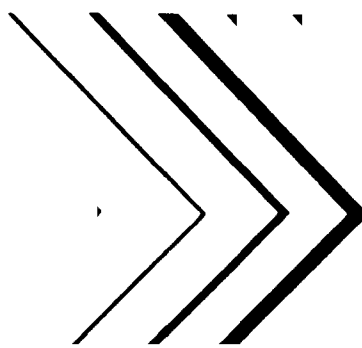
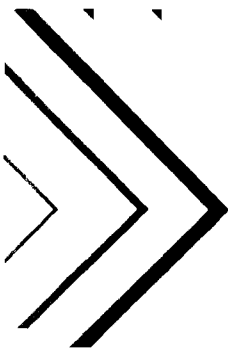
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Research and Development

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# **A Summary of the 1987 EPA National Performance Audit Program on Source Measurements**



EPA/600/3-89/005  
January 1989

A SUMMARY OF THE 1987 EPA NATIONAL PERFORMANCE AUDIT PROGRAM  
ON SOURCE MEASUREMENTS

by

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## 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 environment, to provide innovative means of monitoring compliance with regulations, and to evaluate the effectiveness of health and environmental protection regulations through the monitoring of long-term trends. The Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, North Carolina, has 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 Environmental Protection Agency, including the Office of Air and Radiation and the Office of Toxic Substances.

The major task of this study was to report the results of the national quality assurance audit program for stationary source test methods. Audits were designed to estimate the minimal analytical and computational accuracy that can be expected with Method 3 (carbon dioxide and oxygen), Method 5 (dry gas meter only), Method 6 (sulfur dioxide), Method 7 (nitrogen oxides), and Method 19 (coal). Statistical analysis was used to characterize the data.

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## ABSTRACT

In 1987, the Quality Assurance Division conducted the National Audits for Stationary Source Test Methods. The audit materials consisted of: a disposable gas cylinder for Method 3 (Orsat analyzer), a calibrated orifice for Method 5 (dry gas meter only), five simulated liquid samples for Method 6 (SO<sub>2</sub>) and Method 7 (NO<sub>x</sub>), and two coal samples for Method 19. Participating laboratories sent their data to the Research and Monitoring Evaluation Branch and in return received a written report comparing their results to EPA's.

In the Method 3 audit, each gas component had only one concentration. The mean CO<sub>2</sub>, O<sub>2</sub>, and CO values for all participants differed by 2.6 percent, 1.6 percent, and 33 percent from the expected value, respectively.

In the Method 5 audit, the mean value for all participants differed by 3.1 percent from the expected value. In the Methods 6 and 7 audits, the average mean differed by 0.7 percent and 15.6 percent from the expected value, respectively.

In the two coal audits, the parameters measured were sulfur, moisture, ash, and Btu content. On the average, 91 percent of the participants measured sulfur within 10 percent of the expected value and 98 percent of the participants measured Btu content within 10 percent of the expected value. The corresponding results for ash and moisture were 100 percent and 50 percent, respectively.

This report includes the results of the performance audits done during the period from January to December 1987.

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## ACKNOWLEDGMENT

We express our appreciation to the laboratories that participated in the National Performance Audit Program for Stationary Sources. Thanks also to the staff of the Standards Laboratory/Research and Monitoring Evaluation Branch/Atmospheric Research and Exposure Assessment Laboratory (AREAL), who did the acceptance testing of the audit samples, and to the programmers of the Exposure Assessment Research Division/AREAL for providing the data systems to store and evaluate the data.

## SECTION 1

### INTRODUCTION

The Environmental Protection Agency's (EPA's) Atmospheric Research and Exposure Assessment Laboratory (AREAL) at Research Triangle Park, North Carolina, established an audit program in 1977 to evaluate the performance of companies that conduct compliance testing using EPA reference methods. The audits check the participants' analytical accuracy in applying the analytical phase of EPA Reference Methods 3, 6, 7, and 19 and the calibration accuracy of the Method 5 control console.<sup>(1)</sup> Accuracy is defined as the percent difference between a participant's analytical results and the EPA expected value. By participating in this free and voluntary program, testing companies can compare their performance to the performance of other laboratories conducting similar measurements.

Source Test Methods 3, 5, 6, and 7 were each audited once, and Method 19 was audited twice in 1987. Each participating laboratory received an audit package consisting of the audit sample, a data card, instructions, and an envelope for returning the data to EPA. Participants had 8 weeks to use the audit material and return their data to EPA. At the end of this period, all data received were statistically analyzed to determine the accuracy achieved with respect to the expected value and to provide the participants a means to compare their performance to that of all the laboratories that participated in the audit. This latter comparison can be done using the histograms in Appendix A.

The Quality Assurance Division of AREAL also maintains a limited repository of samples for EPA Methods 3, 6, 7, and 19 that are available to source testing laboratories for purposes such as training new personnel or conducting quality control checks. Because the expected values for these samples are included with the analysis instructions, there is no requirement for the data to be returned to EPA. We recommend that source testing laboratories use this sample repository to help improve their overall analytical performance.

This report summarizes the results obtained in the 1987 audits for stationary sources.

SECTION 2

SUMMARY

In 1987, EPA's AREAL at Research Triangle Park, North Carolina, conducted National Quality Assurance Audits for Stationary Source Test Methods 3 (Orsat analyzer), 5 (dry gas meter only), 6 (SO<sub>2</sub>), 7 (NO<sub>x</sub>), and 19 (coal). Industrial laboratories, contractors, foreign laboratories, as well as local, state, and federal agencies, participated.

The results of the 1987 audit of Method 3 are summarized in Table 1. Participants analyzed the gas sample twice for percentages of carbon dioxide (CO<sub>2</sub>), oxygen (O<sub>2</sub>), and carbon monoxide (CO). The mean values of CO<sub>2</sub> and O<sub>2</sub> differed by 2.6 percent and 1.6 percent from the expected values, respectively. The mean values for CO differed by 33 percent from the expected values.

TABLE 1. PARTICIPANTS' RESULTS FROM METHOD 3 AUDIT  
(ALL DATA--NO OUTLIERS REMOVED)

Type of sample	Parameter	No. of analyses	Repli- cate	EPA true value	Participant results		
					Mean	Median	Std. dev.
Small cylinder (gas)	% CO <sub>2</sub>	50	1	7.00	6.82	6.80	0.65
		48	2	7.00	6.77	6.80	0.65
	% O <sub>2</sub>	50	1	11.00	11.18	11.00	1.02
		48	2	11.00	11.22	11.10	1.07
	% CO	37	1	1.00	1.33	1.00	2.71
		35	2	1.00	1.33	1.00	2.80

The mean for all participants in the Method 5 flow audit was 3.1 percent from the expected value, and the standard deviation was 4.7 percent. After the removal of 7 percent of the data to eliminate statistical outliers, the mean was 2.2 percent from the expected value and the standard deviation was 1.9 percent. The participants' performance based on the standard deviation of all data was good and was consistent with previous years. (2,3,4,5)

Tables 2 and 3 present the data (no outliers removed) from the Methods 6 and 7 audits, respectively. In the Method 6 audit, the procedure requires the participants to determine the sulfate content in five aqueous solutions using the titration procedure. For all five concentrations, the mean of the combined participants' results was less than 2 percent from the expected value, and the median differed by less than 1 percent.

The Method 7 audit procedure requires that the participants determine the nitrate content in five aqueous solutions. For four of the five concentrations, the mean was greater than 10 percent from the expected value, but the median was less than 2 percent.

TABLE 2. PARTICIPANTS' RESULTS FROM METHOD 6 AUDIT  
(ALL DATA--NO OUTLIERS REMOVED)

No. of analyses	EPA true value (mg/DSCM)	Participant results		
		Mean	Median	Std. dev.
89	259.3	260.3	258.2	15.1
90	289.8	295.6	287.5	48.8
92	617.7	621.0	616.0	50.8
91	678.7	674.8	673.2	54.4
92	1189.7	1190.3	1182.5	89.8

TABLE 3. PARTICIPANTS' RESULTS FROM METHOD 7 AUDIT  
(ALL DATA--NO OUTLIERS REMOVED)

No. of analyses	EPA true value (mg/DSCM)	Participant results		
		Mean	Median	Std. dev.
62	99.5	122.8	97.6	228.0
62	125.1	155.2	122.9	262.5
61	329.9	362.8	331.3	279.4
62	590.0	616.7	590.2	397.6
62	649.5	753.7	636.9	1067.9

Table 4 summarizes the results from the two coal audits that were conducted in 1987. Participants analyzed each coal sample in duplicate for percentages of sulfur, moisture, ash, and gross calorific value (Btu/lb). The means of the ash and sulfur results were within 6 percent of the expected value, and the mean for moisture was within 3 percent. The mean of the Btu results was within 1 percent of the expected value. The Btu content as measured by the participants is likely slightly lower than the EPA value because coal oxidation is not prevented in the audit sample. The Btu content results are a good example of the accuracy with which a measurement can be made when that measurement receives good laboratory quality control.

TABLE 4. PARTICIPANTS' RESULTS FROM METHOD 19 COAL AUDITS  
(ALL DATA--NO OUTLIERS REMOVED)

Audit date	Parameter	No. of analyses	EPA value	Participant results		
				Mean	Median	Std. dev.
0387	% S	112	0.77	0.81	0.77	0.40
0987		110	1.68	1.65	1.65	0.10
0387		112	2.77	2.88	2.74	1.45
0987		109	4.21	4.18	4.14	0.26
0387	% H <sub>2</sub> O	111	1.16	1.14	1.21	0.24
0987		110	1.57	1.61	1.67	0.32
0387		111	2.12	2.18	2.27	0.36
0987		110	2.47	2.40	2.45	0.36
0387	% Ash	112	7.97	7.94	7.96	0.13
0987		110	13.66	13.66	13.70	0.21
0387		112	16.88	16.93	16.93	0.19
0987		110	22.18	22.10	22.11	0.28
0387	Btu/lb	107	12392.00	12334.33	12339.00	137.20
0987		106	11042.00	11129.27	11052.00	732.25
0387		107	13464.00	13392.50	13427.00	151.34
0987		106	12886.00	12861.51	12847.00	470.82

SECTION 3

METHOD 3 AUDIT

The Method 3 audit checks the participants' abilities to analyze a gas sample using an Orsat analyzer. The audit package consists of a disposable cylinder that contains a 4-liter (L) sample of CO<sub>2</sub>, O<sub>2</sub>, and CO. The analyst expels the gas into the Orsat analyzer using the positive pressure of the cylinder. The gas sample is quantitatively analyzed for percentage of CO<sub>2</sub>, O<sub>2</sub>, and CO.

In the 1987 audit, 53 percent of the 94 laboratories receiving the audit package returned data. Table 5 shows the total number of laboratories requesting participation and the number that returned data for the Method 3 audit.

TABLE 5. METHOD 3 AUDIT PARTICIPANTS

Category	No. receiving samples	No. returning data
Contractors	46	20
Industry	31	19
Foreign	2	2
Federal	2	1
State	10	6
Local	3	2
Total	94	50

Table 6 summarizes the Method 3 audit results in terms of the percentage of the results within 5 and 10 percent of the expected value. Each laboratory was asked to analyze the sample in duplicate. Fifty-eight percent of the reporting laboratories achieved an accuracy within 5 percent for CO<sub>2</sub>, and 80 percent achieved an accuracy within 5 percent for O<sub>2</sub>. For the CO analysis, only 32 percent of the laboratories achieved an accuracy within 5 percent; 26 percent of the laboratories did not report a value for CO.

TABLE 6. SOURCE METHOD 3 AUDIT

Parameter	Expected value	No. of analyses*	Laboratories accurate within 5% (%)	Laboratories accurate within 10% (%)
CO <sub>2</sub>	7.00	(1) 50	58	88
		(2) 48	58	90
O <sub>2</sub>	11.00	(1) 50	80	96
		(2) 48	79	94
CO	1.00	(1) 37	32	54
		(2) 35	40	60

\*Numbers in parentheses indicate first and second analyses.



## SECTION 4

### METHOD 5 DRY GAS METER AUDIT

In the Method 5 audit procedure, participants use a calibrated orifice to check the calibration of the dry gas meter in their EPA Method 5 control console (meter box). They insert the orifice in the Method 5 meter box, allow the box to warm up, and then make three 15-min volume measurements. The participants convert each of the three volumes to cubic meters at standard conditions using the formula specified in Eq. 5.1 of Method 5 (Appendix A, 40 CFR 60) and record them on the data card. Then they return the orifice and the data card to EPA.

In the 1987 audit, 60 percent of the 149 laboratories that received the audit package returned data. Table 7 shows the categories of participants, the number of participants who requested participation in the Method 5 audit, and the number who actually returned data. A total of 193 meter boxes were audited.

TABLE 7. METHOD 5 AUDIT PARTICIPANTS

Category	No. receiving orifice	No. returning data
Contractors	72	39
Industry	47	33
Foreign	5	5
Federal	3	2
State	16	7
Local	6	3
Total	149	89

Figure 1 is a cumulative histogram that shows the percent accuracy obtained by participants in the Method 5 audit, expressed as the percent difference from the expected (EPA) value. The Code of Federal Regulations<sup>(1)</sup> requires that the dry gas meter be calibrated within an accuracy of 2 percent. Figure 1 shows that 56 percent of the reporting laboratories attained this accuracy. This is approximately the same as in 1986.

The histogram in Figure 2 depicts the individual results from all participants of the 1987 audit and includes the mean and median values. Most laboratories reported values lower than the EPA value for reasons that are unknown.

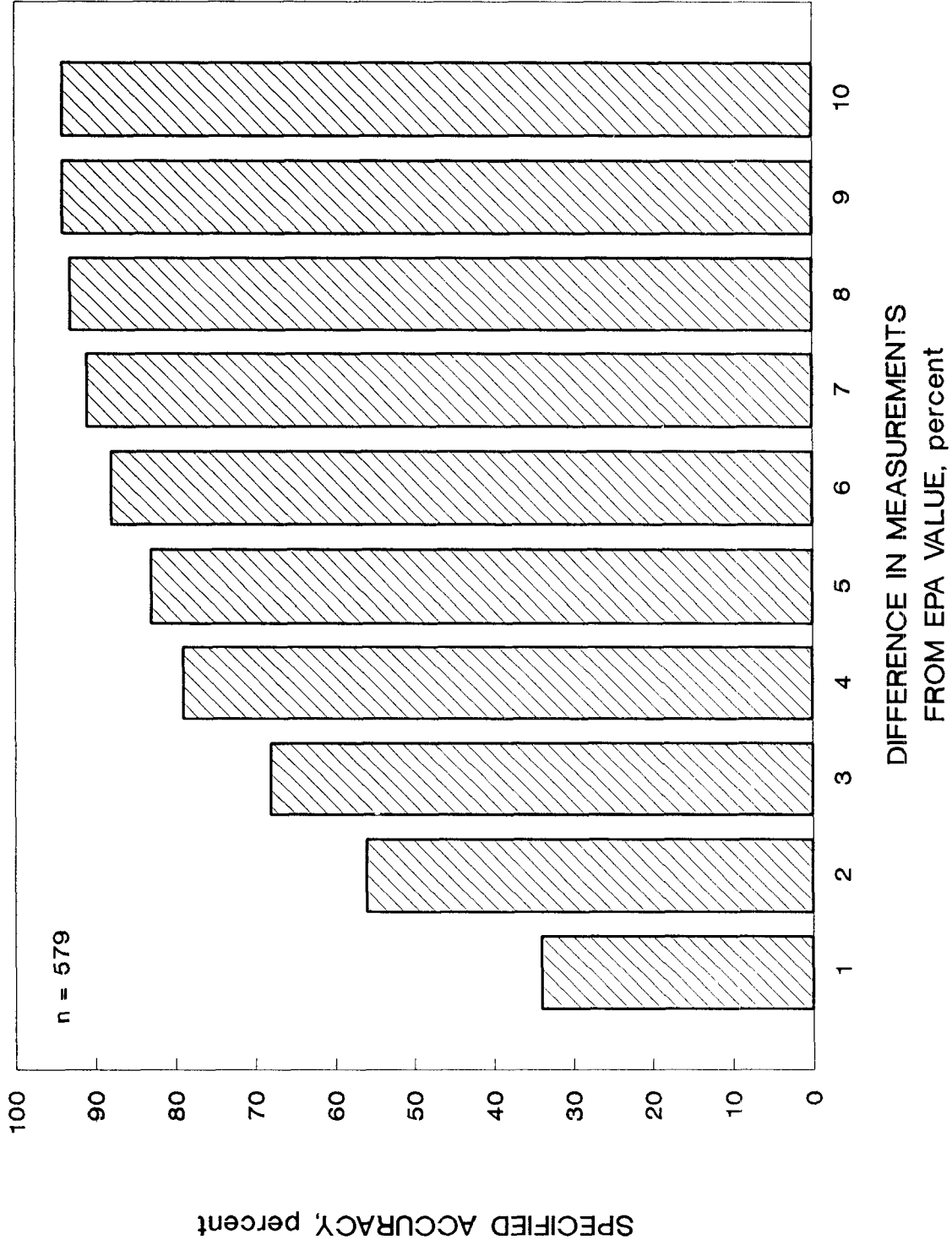


FIGURE 1. Cumulative accuracy for participants in method 5 audit

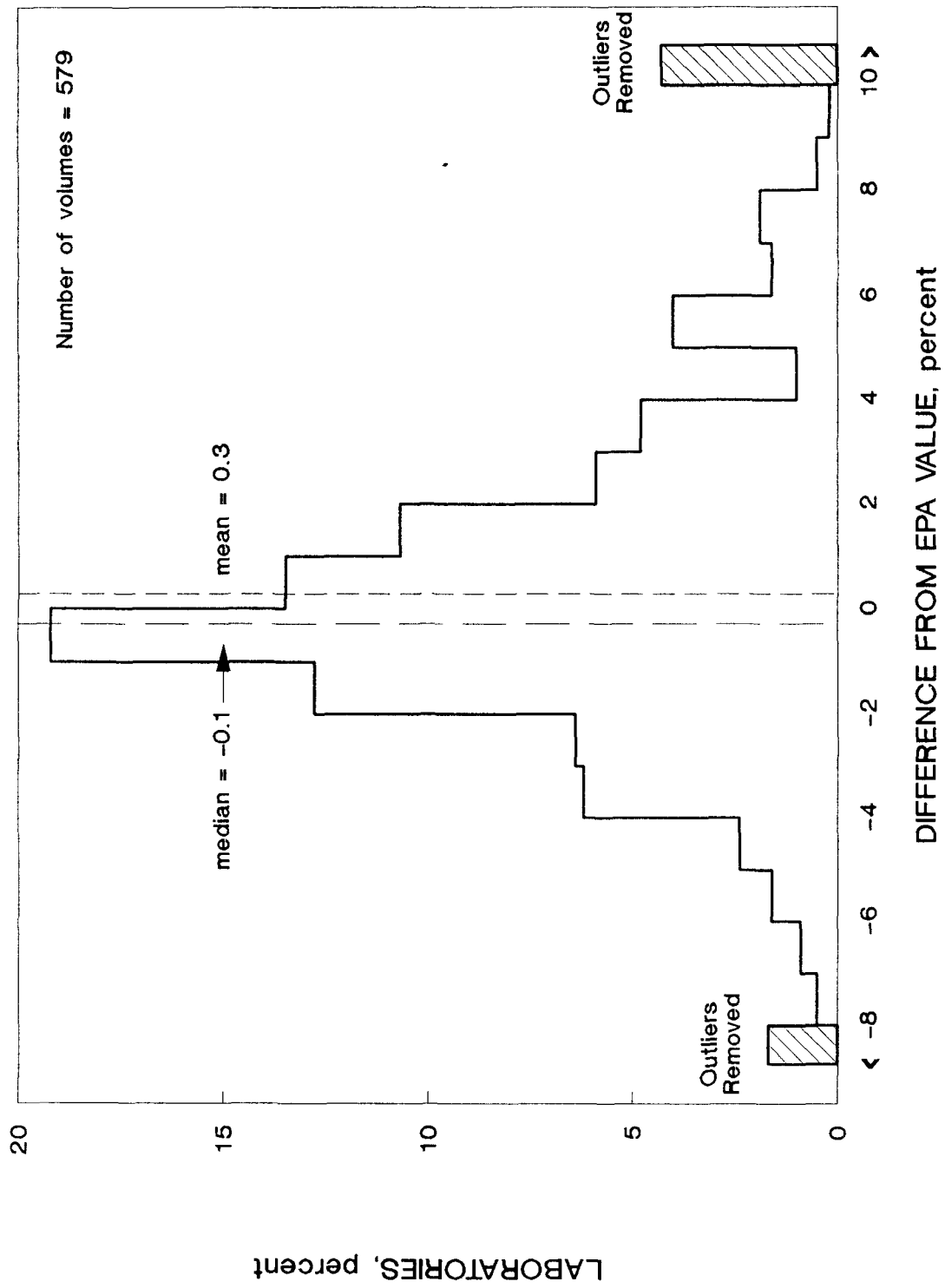


Figure 2. Results of Method 5 audit

SECTION 5

METHOD 6 AUDIT

The Method 6 audit checks the participants' abilities to quantitatively analyze Method 6 samples for sulfur dioxide content. The audit set consists of five aqueous dilutions of 10 N sulfuric acid in 25 mL sealed glass ampoules. The analyst withdraws 5 mL from each ampoule, adds 30 mL of 3 percent hydrogen peroxide, and dilutes this sample to 100 mL with distilled water. A 20-mL aliquot is then withdrawn from the diluted sample, 80 mL of 100 percent isopropanol and thiorin indicator are added, and the sample is titrated with barium perchlorate to a pink endpoint. In calculating the results, the participants assume an original liquid sample volume of 100 mL and a gas sample volume of 0.021 dry standard cubic meter (DSCM) of stack gas.

Table 8 shows the categories of the participants and compares the total number of participants requesting participation with the number returning data. In the 1987 audit, 67 percent of the 137 laboratories that received the audit package returned data.

TABLE 8. METHOD 6 AUDIT PARTICIPANTS

Category	No. receiving samples	No. returning data
Contractors	69	43
Industry	42	32
Foreign	4	3
Federal	2	0
State	12	8
Local	8	6
Total	137	92

Table 9 shows the percentage of laboratories that achieved 5 and 10 percent accuracy for each of the five different concentrations in the Method 6 audit. At least 75 percent of the reporting laboratories achieved an accuracy within 5 percent for all five concentrations. This is the accuracy criterion used for acceptable source SO<sub>2</sub> compliance audit results (Section 4.4 of Method 6).

TABLE 9. SUMMARY OF SOURCE SO<sub>2</sub> AUDITS

Concentration (mg/DSCM)	% Laboratories accurate within ± 5%	% Laboratories accurate within ± 10%
259.3	75.3	95.5
289.8	81.1	93.3
617.7	93.5	98.9
678.7	86.8	95.6
1189.7	90.2	97.8
N	92	

## SECTION 6

### METHOD 7 AUDIT

The Method 7 audit checks the participants' ability to quantitatively analyze Method 7 samples for nitrate content. The NO<sub>x</sub> audit set consists of five aqueous dilutions of a potassium nitrate solution in glass ampoules that are autoclaved after sealing so that bacteria that might attack the nitrate are destroyed. The analyst withdraws 5 mL of solution from an ampoule, adds this with 25 mL of Method 7 absorbing solution to a flask, adjusts the pH with sodium hydroxide, and dilutes to 50 mL with distilled water. A 25-mL aliquot is withdrawn from the diluted sample, placed in an evaporating dish, and analyzed as described in Section 4.3 of Method 7.<sup>(1)</sup> After this treatment is completed, the absorbance is measured at 410 nanometers (nm) with a calibrated spectrophotometer. In calculating the concentrations, the participant assumes that 2000 mL of stack gas was sampled.

Table 10 shows the total number of laboratories requesting participation and the number that returned data for the 1987 Method 7 audit. Sixty percent of the 103 laboratories receiving the audit package returned data.

TABLE 10. METHOD 7 AUDIT PARTICIPANTS

Category	No. receiving samples	No. returning data
Contractors	58	30
Industry	30	22
Foreign	3	1
Federal	1	0
State	5	4
Local	6	5
<b>Total</b>	<b>103</b>	<b>62</b>

The percentage of laboratories that achieved 10 and 20 percent accuracy for each of the five concentrations is shown in Table 11. Sixty-six percent of the reporting laboratories achieved an accuracy within 10 percent on the lower concentrations, and 80 percent achieved an accuracy within 10 percent on the higher concentrations. Ten percent is the minimum level of accuracy for acceptable NO<sub>2</sub> compliance audit samples (Section 4.4 of Method 7).

TABLE 11. SUMMARY OF SOURCE NO<sub>x</sub> AUDIT

Concentration (mg/DSCM)	% Laboratories accurate within ± 5%	% Laboratories accurate within ± 10%
99.5	66.1	77.4
125.1	66.1	82.3
329.9	78.7	88.5
590.0	79.0	90.3
649.5	82.3	90.3
N	62	

## SECTION 7

### METHOD 19 AUDIT

Standards of performance for newer electric utility steam generators (Subpart Da of 40 CFR 60) allow coal sampling and analysis to serve as an acceptable method for determining sulfur concentration in the scrubber inlet flue gas. The coal audit checks participants' ability to analyze coal samples for sulfur, ash, moisture, and Btu content.

The coal audit samples consisted of two samples each with 50 grams (g) of 60-mesh coal but with different parameter levels. The following American Society for Testing and Materials (ASTM) procedures<sup>(7)</sup> were recommended, but not required, for participants' use in analyzing the coal samples:

- ASTM D-3177 (Standard Test Method for Total Sulfur in the Analysis of Coal and Coke)
- ASTM D-3174 (Standard Test Method for Ash in the Analysis Sample of Coal and Coke)
- ASTM D-3173 (Test for Moisture in the Analysis Sample of Coal)
- ASTM D-2015 (Standard Test Method for Gross Calorific Value of Solid Fuel by the Adiabatic Bomb Method)

Participants measured the parameters and reported their results for moisture (%) on an as-received basis, and their results for sulfur (%), ash (%), and gross calorific value (Btu/lb) on a dry basis.

In both audits, 84 percent of the laboratories that received the audit package returned data. Seventy-nine of the same laboratories participated in both audits and returned data. This was a decrease from last year's audit. Table 12 shows the total number of laboratories requesting participation and the number that returned data for the two coal audits (0387 and 0987).



TABLE 12. COAL AUDIT PARTICIPANTS

Category	<u>No. requesting samples</u>		<u>No. returning data</u>	
	0387	0987	0387	0987
Contractors	55	52	44	45
Industry	38	44	35	39
Federal	0	0	0	0
State	12	12	9	9
Local	5	3	4	2
Total	110	111	92	95

Tables 13 and 14 summarize the coal audit results. The number of analyses is greater than the number of participants because some companies had more than one laboratory participating. Each laboratory received its own set of samples and was asked to analyze the samples in duplicate. Accuracies of 5 and 10 percent were chosen as the target criteria for each of the four parameters.

Comparison of the 0387 audit to the 0987 audit shows an improvement in the latter audit for the moisture parameters and the low level sulfur concentration. In the 0387 audit, the sulfur level was considerably lower, therefore allowing a greater chance for error in compliance testing.

TABLE 13. SOURCE COAL AUDIT--0387

Expected value	No. of analyses*	Laboratories accurate within 5% (%)	Laboratories accurate within 10% (%)
<u>Sulfur</u>			
0.77	(1) 112	55.3	80.4
	(2) 106	56.6	87.7
2.77	(1) 112	74.1	92.0
	(2) 106	79.2	95.3
<u>Moisture</u>			
1.16	(1) 111	21.6	48.6
	(2) 105	19.0	52.4
2.12	(1) 111	18.0	50.5
	(2) 105	20.0	43.8
<u>Ash</u>			
7.97	(1) 112	99.1	99.1
	(2) 105	99.0	100.0
16.88	(1) 112	100.0	100.0
	(2) 105	99.0	100.0
<u>Gross Calorific</u>			
12392	(1) 107	99.1	100.0
	(2) 102	99.0	100.0
13464	(1) 107	99.1	100.0
	(2) 102	99.0	100.0

\*Numbers in parentheses indicate first and second analyses.

TABLE 14. SOURCE COAL AUDIT--0987

Expected value	No. of analyses*	Laboratories accurate within 5% (%)	Laboratories accurate within 10% (%)
<u>Sulfur</u>			
1.68	(1) 110	73.6	90.9
	(2) 104	74.0	92.3
4.21	(1) 109	79.8	95.4
	(2) 103	77.7	94.2
<u>Moisture</u>			
1.57	(1) 110	23.6	40.9
	(2) 101	22.8	47.5
2.47	(1) 110	33.6	66.4
	(2) 101	41.6	69.3
<u>Ash</u>			
13.66	(1) 110	99.1	99.1
	(2) 103	99.0	100.0
22.18	(1) 110	100.0	100.0
	(2) 103	100.0	100.0
<u>Gross Calorific</u>			
11042	(1) 106	96.2	98.1
	(2) 101	96.0	98.0
12886	(1) 106	97.2	98.1
	(2) 101	97.0	98.0

\*Numbers in parentheses indicate first and second analyses.

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## APPENDIX

### FREQUENCY DISTRIBUTIONS

The following frequency distributions are provided to allow each participating laboratory to compare its performance to the performance of other laboratories that participated in the audit. For example, Table A-1 (Orsat) shows that for CO<sub>2</sub>, 50 percent of the participants reported results within 4.29 percent of the true value. Similarly for O<sub>2</sub>, 50 percent of the participants reported results within 1.82 percent of the true value.

TABLE A-1. NATIONAL ORSAT AUDIT FREQUENCY DISTRIBUTION OF ABSOLUTE PERCENT DIFFERENCES OF EXPECTED AND REPORTED VALUES

Sample no.	No.	Min.	10%	20%	30%	40%	50%	60%	70%	80%	90%	Max.	Mean	Std. dev.
							CO <sub>2</sub>							
7000	98	0.00	0.00	1.43	2.86	2.86	4.29	5.71	5.71	7.14	11.43	51.43	5.71	7.80
							O <sub>2</sub>							
7000	98	0.00	0.00	0.00	0.91	1.82	1.82	1.82	2.73	4.55	8.18	60.00	3.99	8.70
							CO							
7000	72	0.00	0.00	0.00	0.00	10.00	10.00	20.00	30.00	40.00	70.00	1630.00	65.83	267.39

TABLE A-2. DGM FREQUENCY DISTRIBUTION OF ABSOLUTE PERCENT DIFFERENCE

Sample no.	Min.	10%	20%	30%	40%	50%	60%	70%	80%	90%	Max.	Mean	Std. dev.	Skewness	Median
579	0.0	0.3	0.6	1.0	1.3	1.8	2.3	3.1	4.2	6.6	40.2	3.1	4.7	4.66	1.8
541	0.0	0.3	0.6	0.9	1.2	1.6	2.0	2.8	3.6	5.2	8.3	2.2	1.9	-0.63	1.6

TABLE A-3. SO<sub>2</sub> FREQUENCY DISTRIBUTION OF PERCENT DIFFERENCE--NO OUTLIERS REMOVED

Sample no.	No.	Min.	10%	20%	30%	40%	50%	60%	70%	80%	90%	Max.	Mean	Std. dev.
1	89	0.00	0.39	0.89	1.27	1.77	2.82	3.36	4.36	5.24	7.44	35.29	3.71	4.48
2	92	0.05	0.28	0.40	0.65	1.04	1.25	1.85	2.49	3.35	4.00	74.08	2.75	7.76
3	92	0.00	0.19	0.39	0.82	1.24	1.66	2.08	2.56	3.23	4.20	66.66	2.78	7.01
4	90	0.00	0.28	0.72	1.31	1.59	2.48	3.24	4.07	4.90	6.59	127.36	5.57	16.01
5	91	0.00	0.25	0.63	0.99	1.47	1.72	2.37	3.05	3.65	5.41	57.29	3.53	7.22

TABLE A-4. NO<sub>x</sub> FREQUENCY DISTRIBUTION OF PERCENT DIFFERENCE--NO OUTLIERS REMOVED

Sample no.	No.	Min.	10%	20%	30%	40%	50%	60%	70%	80%	90%	Max.	Mean	Std. dev.
4	62	0.00	0.50	1.71	2.31	3.52	5.93	8.34	10.85	20.60	38.99	1789.45	42.06	226.39
5	62	0.08	0.80	1.28	2.24	3.60	4.72	7.99	10.23	14.15	25.82	1642.61	37.73	207.79
6	62	0.08	0.69	1.46	2.06	2.76	3.82	4.85	6.04	9.41	18.86	1281.06	29.98	162.42
8	62	0.08	0.47	0.75	1.36	1.76	2.17	3.42	5.59	9.86	17.46	501.69	17.22	65.28
9	61	0.00	0.42	0.88	1.49	2.39	2.76	3.70	4.88	9.67	19.67	642.65	19.54	82.97





TABLE A-6. NATIONAL COAL AUDIT FREQUENCY DISTRIBUTION OF ABSOLUTE PERCENT DIFFERENCES OF EXPECTED AND REPORTED VALUES - STUDY 0987

Sample no.	No.	Min.	10%	20%	30%	40%	50%	60%	70%	80%	90%	Max.	Mean	Std. dev.
Sulfur														
4000	214	0.00	0.60	1.19	1.79	2.38	2.98	3.57	4.76	5.95	8.33	32.74	4.11	4.41
6000	212	0.00	0.48	0.95	1.43	1.90	2.14	2.85	4.04	5.23	6.65	44.42	3.75	5.24
Moisture														
4000	211	0.00	1.91	3.82	5.73	8.28	10.83	13.38	15.92	21.02	29.30	73.89	14.62	14.35
6000	211	0.00	1.21	2.83	3.64	5.26	6.88	8.91	10.53	15.38	25.10	59.11	10.45	10.68
Ash														
4000	213	0.00	0.15	0.29	0.44	0.51	0.66	0.88	1.02	1.32	1.61	11.86	0.90	1.10
6000	213	0.00	0.14	0.23	0.36	0.54	0.72	0.95	1.26	1.62	2.03	4.01	0.97	0.86
Gross Calorific														
4000	207	0.00	0.08	0.14	0.23	0.28	0.37	0.43	0.54	0.75	1.64	33.48	1.02	3.56
6000	207	0.01	0.06	0.13	0.19	0.27	0.34	0.45	0.60	0.89	2.34	64.94	1.49	6.52