



Project Summary

Performance Test Results and Comparative Data for Designated Equivalent Methods for Sulfur Dioxide

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This report summarizes the results of postdesignation testing (both laboratory and field) conducted on 13 commercially available ambient sulfur dioxide (SO₂) analyzers to characterize their performance, reliability, and operational peculiarities.

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

Under Part 53 of Title 40 of the Code of Federal Regulations (40 CFR Part 53), the U.S. Environmental Protection Agency (EPA) designates specific procedures or analyzers as reference or equivalent methods for the monitoring of ambient air pollutants. The methods are then acceptable for use in National Air Monitoring Stations (NAMS), State and Local Air Monitoring Stations (SLAMS), and Prevention of Significant Deterioration (PSD) monitoring. The Methods Standardization Branch (MSB) of the Environmental Monitoring Systems Laboratory (EMSL) at Research Triangle Park, NC, is responsible for EPA's reference and equivalent method designation program. In this capacity, MSB has acquired performance data and other information on these methods, most of which are commercially available analyzer models.

To summarize these data and make them available to those who may find

them beneficial in the selection of analyzers, MSB, with the assistance of the Research Triangle Institute (RTI), prepared this report on designated methods for sulfur dioxide.

Types of Tests Conducted

Two principal types of postdesignation tests were conducted by MSB. Phase I tests were laboratory tests similar to the predesignation tests required by 40 CFR Part 53. Phase II tests simulated actual use conditions and compared simultaneously operating analyzers. Results from these postdesignation tests provide most of the data in this report.

Analyzers Tested

The report is intended to cover all currently designated reference methods for SO₂. However, as of this writing, the tests have not been completed for all analyzers. Table 1 lists the designated SO₂ analyzers, their detection principles, the tests that have been carried out, and the dates of the tests.

Phase I Test Description and Results

Phase I laboratory performance tests were conducted in accordance with the same procedures and specifications required for the applicant's predesignation tests, with the exception that fewer trials (usually four) were performed for each test parameter. All calibrations, apparatus, pollutant standards, test procedures, test atmospheres, and test documentation were as specified in 40 CFR Part 53. (Individual reports contain-

Table 1. Sulfur Dioxide Analyzers Tested and Test Dates

Manufacturer	Model	Detection principle	Phase I tests	Phase II tests
ASARCO	500	COND	May 1978-Jan 1979	NA
Beckman	953	FD	May 1982-Apr 1983	Nov 1978-Jun 1979
Bendix	8303	FPD	NT	Feb 1979-Jun 1979
Lear Siegler	SM1000	D2	Sep 1976-May 1977	Nov 1978-Jun 1979
Lear Siegler	AM2020	D2	NT	NT
Meloy	SA185-2A	FPD	Oct 1976-Feb 1977	Nov 1978-Jun 1979
Meloy	SA285E	FPD	NT	Nov 1978-June 1979
Meloy	SA700	FD	May 1982-Mar 1983	NT
Monitor Labs	8450	FPD	Mar 1977-Aug 1983	Nov 1978-Jun 1979
Monitor Labs	8850	FD	Aug 1982-June 1983	NT
Philips	PW9700	EC	May 1978-Jan 1979	NA
Philips	PW9755	EC	May 1978-Jan 1979	Jan 1979-Jun 1979
Thermo Electron	43	FD	Oct 1976-Jan 1978	Nov 1978-Jun 1979

COND = Conductimetric detection.

FD = Fluorescence detection.

FPD = Flame photometric detection.

D2 = Second derivative spectroscopic detection.

EC = Electrochemical (coulometric) detection.

NA = No testing anticipated.

NT = Not yet tested.

ing more detailed information on the Phase I tests for each analyzer are available from MSB.)

Analyzers undergoing Phase I tests were allowed to operate for several weeks prior to actual testing. During this startup period, preliminary calibration and linearity checks were performed. If a failure occurred during testing, the manufacturer was notified and given the opportunity to correct the failure. At the conclusion of the tests, all failures and manufacturers' involvement were included in routine documentation.

Phase I tests included characterization of output signal noise level, lower detectable limit (LDL), interference equivalents, 12-h and 24-h zero drifts, span drift at 20 and 80 percent of full scale, lag time, rise time, fall time, and precision. Results are reported in Table 2. The total interferent equivalent, zero drift, and span drift data reported are averages of *absolute* values; all other values represent the *arithmetic* averages of several repetitions.

Phase I results indicate that the 10 SO₂ analyzers tested to date meet or exceed the performance specifications. Testing of three analyzers is not complete at this time.

Phase II Test Description and Results

The Phase II test was intended to test the analyzers in a more or less typical ambient monitoring configuration where each analyzer's stability, reliability, general performance, and operational peculiarities could be observed and compared with those of other analyzers.

The test was conducted on a group of eight SO₂ analyzers operating simultaneously over a period of 8 months. All analyzers measured ambient air sampled from a common manifold.

All test analyzers were installed, calibrated, operated, and maintained in strict accordance with the manufacturer's instruction manual and good monitoring practice. Analyzers received a multipoint calibration initially and once per month during the test period. Zero and span checks were made two or three times per week. Zero adjustments were made only if the zero response was not within ± 3 percent of full-scale response from nominal; span adjustments were made only if the span (slope of the calibration curve) changed by more than ± 7 percent from nominal. Data were acquired using a Monitor Labs 9300 Datalogger data acquisition system. The acquired data were transferred via magnetic tape to a Hewlett-Packard 9845 Desk Top Computer where they were reduced to a useful form.

Phase II results indicate that most of the SO₂ analyzers are stable and reliable. The comparative data presented in Table 3 generally indicate high correlation coefficients between 0.99 and 1.00. Mean differences are generally within ± 4.0 ppb and standard deviations of the differences are generally less than 8.0 ppb. Likewise, the individual analyzer drift results presented in Table 4 show standard deviations of zero drifts to be generally less than 5.0 ppb and standard deviations of span drifts to be generally less than 3.0 percent.

Table 2. Phase I Postdesignation Test Results--Designated Sulfur Dioxide Analyzers

Performance parameters	EPA specifications	ASARCO 500	Beckman 953	Bendix 8303	Lear Siegler SM1000	Lear Siegler AM2020	Meloy SA185-2A	Meloy SA285E	Meloy SA700	Monitor Labs 8450	Monitor Labs 8850	Philips PW9700	Philips PW9755	Thermo Electron 43
Noise--0% URL	0.005 ppm	NT	0.001		0.002		<0.001		0.001	<0.001	<0.001	0.000	0.000	0.001
Noise--80% URL	0.005 ppm	NT	0.002		0.002		0.001		0.001	0.001	0.001	0.001	0.002	0.002
Lower detectable limit		0.008	0.009		0.010		0.005		0.009	0.009	0.010	0.007	0.009	0.009
Interferents														
CO	±0.02 ppm	NR	NR		NR		-0.003		NR	-0.002	NR	NR	NR	NR
CO ₂	±0.02	0.011	NR		NR		-0.026		NR	-0.019	NR	NR	NR	NR
C ₂ H ₄	±0.02 ppm	NR	NR		NR		NR		NR	NR	NR	-0.001	<0.001	NR
HCl	±0.02	0.008	NR		NR		NR		NR	NR	NR	-0.001	0.000	NR
H ₂ O	±0.02 ppm	NR	-0.010		NR		-0.002		0.005	-0.003	0.007	0.009	0.002	NR
H ₂ S	±0.02 ppm	NR	0.001		NR		<0.001		0.001	0.017	0.000	<0.001	0.000	NR
Metaxylene	±0.02 ppm	NR	0.007		-0.001		NR		0.009	NR	0.002	NR	NR	<0.001
Naphthalene	±0.02	NR	0.005		NR		NR		<-0.001	NR	0.001	NR	NR	NR
NH ₃	±0.02 ppm	0.000	NR		NR		NR		NR	NR	NR	0.000	<0.001	NR
NO	±0.02 ppm	NR	<0.001		0.001		NR		0.009	NR	0.005	0.001	0.000	0.003
NO ₂	±0.02 ppm	0.011	-0.002		-0.004		NR		0.000	NR	0.002	-0.001	0.000	<0.001
O ₃	±0.02 ppm	NR	-0.014		-0.003		NR		-0.003	-0.007	-0.004	-0.008	-0.004	-0.002
Total	≤0.06 ppm	0.030	0.040		0.009		0.031		0.028	0.048	0.021	0.021	0.006	0.005
Zero drift--12 h	±0.02 ppm	0.001	0.003		0.014		0.001		0.012	0.001	0.002	0.001	0.002	0.004
Zero drift--24 h	±0.02 ppm	0.001	0.001		0.010		0.003		0.003	0.004	0.005	0.002	0.003	0.003
Span drift--20% URL	±20.0%	2.60	3.23		5.50		0.49		2.21	1.49	3.46	5.00	1.35	2.22
Span drift--80% URL	±5.0%	2.80	1.62		2.18		1.05		1.28	1.00	0.56	1.80	0.30	1.82
Lag time	20 min	NT	0.2		0.3		0.1		0.8	0.3	0.5	0.2	0.6	0.5
Rise time	15 min	NT	2.3		7.5		0.7		1.8	1.6	3.9	2.2	0.7	4.9
Fall time	15 min	NT	2.3		7.0		0.6		1.8	2.1	3.9	1.4	0.8	5.3
Precision--20% URL	0.010 ppm	0.005	<0.001		0.002		0.001		0.000	0.002	<0.001	0.001	<0.001	0.001
Precision--80% URL	0.015 ppm	0.012	0.001		0.002		0.002		0.001	0.002	0.001	0.002	0.001	0.001

URL = Upper range Limit.

ND = None detected.

NR = Not required

NT = Not tested.

Note: Phase I postdesignation testing not completed for the Bendix 8303, the Lear Siegler AM2020, or the Meloy SA285E.

Table 3. Summary of Phase II Postdesignation Test Results for Designated Sulfur Dioxide Analyzers when Compared to the Average of the Other Seven Analyzers

Statistics	Beckman 953	Bendix 8303	Lear Siegler SM1000	Meloy SA185-2A	Meloy SA285E	Monitor Labs 8450	Philips PW9755	Thermo Electron 43
Correlation coefficient	0.997	0.997	0.936	0.999	0.999	0.999	0.998	0.997
Mean difference, ppb	12.00	-2.61	+3.74	-3.81	+0.50	+0.02	+5.68	-0.43
Standard deviation of differences, ppb	6.12	4.68	20.73	3.95	3.43	4.77	4.68	7.20
Number of absolute differences > 20 ppb	689	1	390	0	0	0	15	49
Maximum absolute difference, ppb	30	21	100	20	17	19	25	30
Number of differences	3,038	1,969	1,797	3,285	3,290	3,170	3,055	3,209

Table 4. Phase II Postdesignation Test Results for Drift

Statistics	Beckman 953	Bendix 8303	Lear Siegler SM1000	Meloy SA185-2A	Meloy SA285E	Monitor Labs 8450	Philips PW9755	Thermo Electron 43
Standard deviation of zero drift, ppb	4.6	4.7	16.1	1.6	2.4	2.0	3.4	4.9
Standard deviation of span drift, %	2.2	2.5	5.5	3.0	2.3	2.2	2.5	3.9

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The complete report, entitled "Performance Test Results and Comparative Data for Designated Equivalent Methods for Sulfur Dioxide," (Order No. PB 84-155 373; Cost: \$14.50, subject to change) will be available only from:

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