



## Project Summary

# Performance Test Results and Comparative Data for Designated Reference Methods for Carbon Monoxide

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**This report summarizes the results of postdesignation testing (both laboratory and field) conducted on eight commercially available and one commercially unavailable ambient carbon monoxide 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, pri-

marily by testing commercially available analyzer models.

To summarize these data and make them available to those who may find them beneficial in selecting analyzers, MSB, with the assistance of the Research Triangle Institute, prepared this report on designated methods for carbon monoxide.

### 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 post designation tests provide most of the data in this report.

### Analyzers Tested

The report is intended to cover all currently designated reference and equivalent methods for CO. However, as of this writing, the tests have not been completed for all analyzers. Table 1 lists the designated CO analyzers, their detection principles, the tests that have been carried out, and the dates of the tests. Please note that nondispersive infrared spectroscopy and gas filter correlation spectroscopy as used in these analyzers are so closely allied that they are considered to be the same principle of measurement. Thus, all of the analyzers discussed in this report are designated as reference methods for carbon monoxide.

**Table 1. CO Analyzers Tested and Test Dates**

Manufacturer	Model	Detection principle	Phase I Tests	Phase II tests
Beckman	866	NDIR	Nov. 1977	May - Sept. 1980
Bendix	8501-5CA	NDIR	Jan. 1981	May - Sept. 1980
Dasibi	3003	GFC	June 1982	Not yet performed
Horiba	APMA300E/ 300SE	NDIR	June 1982	Not yet performed
Horiba	AQM-10	NDIR	Jan.-Oct. 1981	May - Sept. 1980
MASS-CO	Model 1	NDIR	Postdesignation testing not anticipated	
Monitor Labs	8310	NDIR	Jan. 1981	May - Sept. 1980
MSA	202S	NDIR	Nov. 1977	May - Sept. 1980
Thermo Electron	48	GFC	June 1982	Not yet performed

NDIR = Nondispersive infrared spectroscopy.  
GFC = Gas filter correlation spectroscopy.

### 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 containing 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 test, all failures and manufacturer involve-

ment were included in routine documentation.

Phase I tests included characterization of output signal noise level, lower detectable limit, interference equivalents, 12-h and 24-h zero drifts, span drift at 20 percent and at 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 indicated that all carbon monoxide analyzers tested met or exceeded the performance specifications.

### 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 peculi-

arities could be observed and compared with other analyzers. The test was conducted simultaneously on a group of five carbon monoxide analyzers over a period of 4 months. All analyzers measured ambient air sampled from a common manifold. The ambient pollutant concentrations were sometimes augmented with artificially generated pollutant to increase the concentration readings.

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  $\pm 3$  percent of full-scale response from nominal; span adjustments were made only if the span (slope of the calibration curve) changed by more than  $\pm 7$  percent from nominal. For this test, data were acquired using a Monitor Labs 9300 Datalogger data acquisition system. The acquired data were transferred via magnetic tape to a Hewlett-Packard 9831 A Desk Top Computer where they were reduced into a useful form.

Phase II results indicated that most of the carbon monoxide analyzers tested are stable and reliable. The comparative data presented in Table 3 indicate consistently high correlation coefficients of 0.99-1.00, mean differences of <0.5 ppm, and standard deviations of differences of <0.5 ppm. Similarly, Table 4 indicates low zero and span drift.

**Table 2. Phase I Postdesignation Test Results—Designated Carbon Monoxide Analyzers**

Performance parameters	EPA specifications	Beckman	Bendix	Dasibi	Horiba APMA 300E	Horiba AQM-10	MASS-CO	Monitor Labs	MSA	Thermo Electron
Noise-0% URL	0.50 ppm	0.037	0.042	0.107	0.031	0.043		0.016	0.049	0.027
Noise-80% URL	0.50 ppm	0.059	0.073	0.158	0.061	0.098		0.055	0.061	0.053
Lower detectable limit	1.0 ppm	1.00	1.03	1.05	0.76	0.62		1.00	1.05	1.02
<b>Interferents</b>										
CO <sub>2</sub>	$\pm 1.0$ ppm	0.100	0.000	-0.420	-0.040	-0.225		-0.013	0.113	0.200
H <sub>2</sub> O	$\pm 1.0$ ppm	-0.138	0.215	0.060	0.080	-0.425		-0.228	0.200	-0.040
Total interferents	$\leq 1.5$ ppm	0.238	0.238	0.490	0.140	0.648		0.240	0.313	0.240
Zero drift-12 h	$\pm 1.0$ ppm	0.615	0.406	NC	0.200	0.199	NO TESTING ANTICIPATED	0.300	0.503	0.112
Zero drift-24 h	$\pm 1.0$ ppm	0.082	0.400	NC	0.050	0.249		0.330	0.252	0.044
Span drift-20% URL	$\pm 10.0\%$	1.33	2.79	NC	0.91	1.54		2.34	2.40	0.86
Span drift-80% URL	$\pm 2.5\%$	0.87	0.38	NC	0.70	0.67		0.82	0.86	0.69
Lag time	10 min	0.2	0.5	NC	<0.2	0.3		0.3	0.4	<0.2
Rise time	5 min	0.3	1.0	NC	0.6	0.2		0.7	0.6	0.8
Fall time	5 min	0.6	0.8	NC	0.9	0.3		0.5	0.5	1.0
Precision-20% URL	0.5 ppm	0.067	0.032	NC	0.044	0.046		0.022	0.055	0.039
Precision-80% URL	0.5 ppm	0.059	0.108	NC	0.035	0.040		0.104	0.038	0.031

URL = Upper range limit.  
NC = Not completed.

**Table 3. Summary of Phase II Postdesignation Test Results for Designated Carbon Monoxide Analyzers When Compared to the Average of the Other Four Analyzers**

Statistics	Beckman	Bendix	Horiba	Monitor Labs	MSA
Correlation coefficient	0.99	1.00	1.00	1.00	0.99
Mean difference, ppm	-0.10	0.15	-0.39	-0.18	0.44
Standard deviation of differences, ppm	0.46	0.30	0.43	0.34	0.49
Number of absolute differences > 2.0	0	0	0	0	5

**Table 4. Phase II Postdesignation Test Results for Drift**

Statistics	Beckman	Bendix	Horiba	Monitor Labs	MSA
Standard deviation of zero drift (ppm)	0.4	0.3	0.3	0.2	0.4
Standard deviation of span drift (%)	2.4	2.0	1.7	1.4	1.2

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*Frank F. McElroy and Vinson L. Thompson are the EPA Project Officers (see below).*

*The complete report, entitled "Performance Test Results and Comparative Data for Designated Reference Methods for Carbon Monoxide," (Order No. PB 83-196 808; Cost: \$11.50, subject to change) will be available only from:*

*National Technical Information Service  
5285 Port Royal Road  
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Telephone: 703-487-4650*

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