CARBON MONOXIDE 6604

CO MW: 28.00 CAS: 630-08-0 RTECS: FG3500000

METHOD: 6004, Issue 2 **EVALUATION:** FULL **Issue 1:** 15 May 1996
Issue 2: 16 March 2016

OSHA: 50 ppm
NIOSH: 35 ppm; C 200 ppm

PROPERTIES: colorless, odorless gas; BP -192 °C MP -207 °C; vapor density (air=1) 0.97; flammable (explosive) limits in air: 12.5 to 74.2%

SYNONYMS: monoxide; carbon oxide; carbonic oxide; flue gas

SAMPLING

SAMPLER: PORTABLE ELECTROCHEMICAL DIRECT-READING CO MONITOR

FLOW RATE: instrument dependent

VOL-MIN: 10 L
-MAX: none

SHIPMENT: routine shipment of instrumentation

SAMPLE STABILITY: at least 7 days @ 25 °C [1] (aluminized air bags)

BLANKS: fresh air or compressed CO-free air from cylinder

ACCURACY

RANGE STUDIED: 0 to 200 ppm

BIAS: - 1.7% [2]

OVERALL PRECISION ($\hat{S}_{rT}$): 0.022 [2]

ACCURACY: ± 6.0%

MEASUREMENT

TECHNIQUE: ELECTROCHEMICAL SENSOR

ANALYTE: carbon monoxide (CO)

CALIBRATION
-ZERO: CO-free air
-SPAN: standard cylinders of span gas in the desired range

RANGE: 0 to 200 ppm

ESTIMATED LOD: 1 ppm

PRECISION ($\bar{S}_r$): 0.035 @ 20 ppm
0.012 @ 50 ppm
0.008 @ 100 ppm [2]

APPLICABILITY: Portable, direct-reading carbon monoxide monitors are applicable to any work environment for personal or area monitoring.

INTERFERENCES: Several gaseous pollutants (e.g., NO_2, SO_2) may cause an interference at levels over 5 ppm. If these or other pollutants are known or suspected to be present, use a monitor with a chemical interference scrubber over the sensor. Unknown pollutants may require further experimentation to determine their effect on the sensor. As tested, SO_2 (5 ppm), CO_2 (5000 ppm), methylene chloride (500 ppm), diesel fuel (6 µL/L, about 0.3 ppm benzene), and gasoline vapor (1 µL/L, about 1 ppm benzene) had no impact on most monitor readings [2]. Some monitors are equipped with a chemical interference scrubber while others offer this as an option.

OTHER METHODS: OSHA methods ID 209 (CO by direct-reading monitor) [3] and ID 210 (CO by gas bag sampling) [4] are similar techniques.

REAGENTS:

1. CO* calibration gas, 20 to 50 ppm, compressed gas cylinder, appropriate pressure regulator, and other items as recommended by manufacturer for field check of monitor response.

   *See SPECIAL PRECAUTIONS.

EQUIPMENT:

1. Electrochemical carbon monoxide monitoring instrument designed and intended for industrial use (not a residential use alarm/monitor); fixed-location mountable for area alarm/monitoring, compact portable for person alarm/monitoring, or both; with integral concentration display.
2. Personal sampling pump, 0.250 L/min, with inlet and outlet, used for bag filling and sample analysis (e.g., when off-site analysis is needed).
3. Air bags, aluminized, 2-L, or other appropriate sizes (optional).
4. Replacement batteries or battery recharger, as appropriate for monitor.

SPECIAL PRECAUTIONS: Carbon monoxide is a highly flammable, dangerous fire and explosive risk, and is toxic by inhalation. Shipments of compressed calibration gases must comply with 49 CFR 1992 regulations.

SAMPLING:

1. Zero monitor with CO-free air at the same temperature and relative humidity as the work environment, if possible.
   NOTE 1: Monitors are more sensitive to temperature variations than to humidity variations. Most monitors have temperature compensating circuitry.
   NOTE 2: If applicable, bag samples may be collected in aluminized bags (2-L or larger) and analyzed later by placing the calibration cap over the sensor and pumping the sample across the sensor at a nominal rate of 0.250 L/min with a personal sampling pump.
2. For personal monitoring, locate the monitor as near the worker's breathing zone as possible.
3. For area monitoring, locate monitor in an area with good air circulation about 60 to 70 inches above the floor.
   NOTE: Make sure the sensor is not obstructed in either application.

CALIBRATION AND QUALITY CONTROL:

4. Calibrate with a standard calibration mixture of CO in air (e.g., in gas bag samples of known concentrations) from a pressurized cylinder at the CO level recommended by the monitor manufacturer (normally, 20 to 50 ppm CO). The monitor should be calibrated at the temperature and relative humidity as near as possible to that of the work environment in which it will be used.
5. Check the calibration daily and recalibrate whenever the monitor reading varies from the span gas by 5% or more, or as the manufacturer recommends.

MEASUREMENT:

6. Read concentration directly (in ppm) from the monitor display.
   Some monitors (data logger models) will maintain a continuous record of the data as it is accumulated and will calculate the average, TWA, peak, etc. concentrations. These data may be read from the display at any time. Some monitors will also store this information for downloading to a computer or printer at the end of the monitoring period. Other monitors only display the current reading, requiring

the operator to manually record the data. All monitor models are equipped with alarms that will warn the user (audibly, visually or both) whenever the concentration of CO exceeds the preset level of the alarm. Many are equipped with two-level alarms [5].

EVALUATION OF METHOD:

The performance of six direct-reading carbon monoxide monitors was evaluated over a period of 12 months at CO concentrations up to 200 ppm and a range of ambient temperatures and relative humidity. Most of the tests were conducted at or near the PEL. For mean recovery studies, six different monitors were used and readings were taken approximately 1 h apart. Recovery at 20 ppm was 105% (n = 42); at 50 ppm, 99.6% (n = 36); and at 100 ppm, 99.9% (n = 30). Thus, the overall mean bias was calculated at -1.7%. The precision ($\overline{S}_r$) at 20 ppm was 0.035 (35 readings from 5 monitors over a 7-h period). At 50 ppm, $\overline{S}_r$ was 0.012 (30 readings from 5 monitors over a 6-h period), and at 100 ppm, $\overline{S}_r$ was 0.008 (36 readings from 6 monitors over a 6-h period). Tests also were conducted to determine response time, zero and span drift, alarm decibel level, battery life, life of the sensors, as well as the effects of selected interferences (gases, vapors, and RF) and the effects of handling and transporting to remote sites. See [6] for preliminary work on carbon monoxide monitoring.

REFERENCES:

[1] Stanford Research Institute [1977]. Backup Data Report: Method S340. Menlo Park, CA: Stanford Research Institute. NIOSH contract no. 210-76-0123.

[2] Woodfin WJ, Woebkenberg ML [1985]. Evaluation of portable direct-reading carbon monoxide monitors. Unpublished.

[3] OSHA [1993]. Method ID 209, Carbon monoxide in workplace atmospheres (Direct-reading monitor); In: Sampling and analytical methods. Salt Lake City, UT: U.S. Department of Labor, Occupational Safety and Health Association.

[4] OSHA [1991]. Method ID 210, Carbon monoxide in workplace atmospheres (Gas bag sampling); In: Sampling and analytical methods. Salt Lake City, UT: U.S. Department of Labor, Occupational Safety and Health Association.

[5] Ashley K [1994]. Electroanalytical applications in occupational and environmental health. Electroanalysis *6*:805-820.

[6] Woebkenberg ML [1983]. Monitoring methodology for gaseous hazards – Passive monitors and portable instruments. Scand J Work Environ Health *9*:223-229.

METHOD REVISED BY:

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