Method for sampling and determination of carbon monoxide
# Carbon Monoxide

**Method:** NIOSH Manual of Analytical Methods (NMAM), Fifth Edition

**CAS:** 630-08-0  **RTECS:** FG3500000

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

**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

<table>
<thead>
<tr>
<th>Sampler:</th>
<th>Portable Electrochemical Direct-Reading CO Monitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Rate:</td>
<td>Instrument dependent</td>
</tr>
<tr>
<td>Vol-Min:</td>
<td>10 L</td>
</tr>
<tr>
<td>Vol-Max:</td>
<td>None</td>
</tr>
<tr>
<td>Shipment:</td>
<td>Routine shipment of instrumentation</td>
</tr>
<tr>
<td>Sample Stability:</td>
<td>At least 7 days @ 25 °C [1] (aluminized air bags)</td>
</tr>
<tr>
<td>Blanks:</td>
<td>Fresh air or compressed CO-free air from cylinder</td>
</tr>
</tbody>
</table>

## Measurement

<table>
<thead>
<tr>
<th>Technique:</th>
<th>Electrochemical Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyte:</td>
<td>Carbon monoxide (CO)</td>
</tr>
<tr>
<td>Calibration - Zero:</td>
<td>CO-free air</td>
</tr>
<tr>
<td>Calibration - Span:</td>
<td>Standard cylinders of span gas in the desired range</td>
</tr>
<tr>
<td>Range:</td>
<td>0 to 200 ppm</td>
</tr>
<tr>
<td>Estimated LOD:</td>
<td>1 ppm</td>
</tr>
<tr>
<td>Precision ($S_T$):</td>
<td>0.035 @ 20 ppm</td>
</tr>
<tr>
<td></td>
<td>0.012 @ 50 ppm</td>
</tr>
<tr>
<td></td>
<td>0.008 @ 100 ppm</td>
</tr>
</tbody>
</table>

## Accuracy

<table>
<thead>
<tr>
<th>Range Studied:</th>
<th>0 to 200 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bias:</td>
<td>-1.7% [2]</td>
</tr>
<tr>
<td>Overall Precision ($S_T$):</td>
<td>0.022 [2]</td>
</tr>
<tr>
<td>Accuracy:</td>
<td>± 6.0%</td>
</tr>
</tbody>
</table>

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

**Interferences:** Several gaseous pollutants (e.g., NO₂, SO₂) 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, SO₂ (5 ppm), CO₂ (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 ($S_r$) at 20 ppm was 0.035 (35 readings from 5 monitors over a 7-h
period). At 50 ppm, $S_r$ was 0.012 (30 readings from 5 monitors over a 6-h period), and at 100 ppm,
$S_r$ 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

REFERENCES:

Research Institute. NIOSH contract no. 210-76-0123.


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.

Electroanalysis 6:805-820.


METHOD REVISED BY:

W. James Woodfin, NIOSH

Disclaimer: Mention of any company or product does not constitute endorsement by NIOSH. In addition,
citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring
organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of
these websites. All web addresses referenced in this document were accessible as of the publication date.