

# **MSHA Handbook Series**

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**Carbon Monoxide Inspection Procedures**

## **PREFACE**

This handbook sets forth procedures to follow when conducting inspections of Carbon Monoxide Monitoring Systems. Previously issued procedural and administrative instructions for this subject material are superseded by this handbook. Compliance related instructions that are contained in the MSHA Program Policy Manual are not superseded by this handbook.

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## Chapter 1

### INTRODUCTION

#### A. Purpose

This handbook sets forth Mine Safety and Health Administration's (MSHA) procedures under which carbon monoxide (CO) monitoring systems are inspected during AAA inspections. Chapter 2 contains the pre-inspection preparation and lists the documents which are the basis for enforcement action. Chapters 3, 4, and 5 direct attention to important facets of the monitoring systems, most of which will be related to requirements referred to in Chapter 1.

#### B. Authority

Enforcement authority depends on the purpose of the installation. In some cases the monitoring system is installed to allow air ventilating the belt entry to be used at the face (30 CFR 75.326), to comply with 30 CFR 75.1103, or for some other purpose relating to mine ventilation (30 CFR 75.316). Systems installed in conjunction with 30 CFR 75.326 require a 101(c) petition for modification, except systems installed for such a purpose may be part of the district manager approved ventilation plan. For example, mines developed prior to 1970 may use air coursed in the belt entry to ventilate the face if approved by the district manager, whereas those developed after 1970 can only do so with a petition for modification. Systems installed to meet the requirements of 30 CFR 75.1103-4 do not require a petition, but in many instances petitions have been applied for and granted for such use.

The requirements for the CO monitoring system contained in a 101(c) petition for modification or the approved Ventilation and Methane and Dust Control Plan are enforceable as mandatory standards. In instances of noncompliance with the petition, citations should reference the section of 30 CFR on which the petition is based. In instances of noncompliance with the Ventilation System and Methane and Dust Control Plan, citations should reference 30 CFR 75.316.

CO monitoring system components installed in areas where permissible equipment is required must be part of a system that has been evaluated by MSHA as intrinsically safe. This evaluation is performed by the Approval and Certification Center (A&CC) to ensure that the electric circuits to the sensor will not ignite methane. Systems evaluated must be installed and maintained as evaluated. Also, all systems

that are accepted by MSHA must have an MSHA acceptance label attached. Title 30 CFR 75.503 should be cited for instances of noncompliance.

The petition for modification or approved plan may reference the Firefighting and Evacuation Plan for required responses to CO system alert (warning) and alarm signals. Title 30 CFR 75.1101-23(a) should be cited when there is a failure to follow the prescribed procedures in the Firefighting and Evacuation Plan.

In some instances, a petition for modification may delegate authority to the district manager to require additional measures, such as additional sensors or to set the alert (warning) and alarm levels. This authority and details of the monitoring system will be exercised through the mine ventilation plan. Title 30 CFR 75.316 should be cited for failure to follow requirements set forth in that plan.

Systems installed to provide protection equivalent to point-type heat sensors must satisfy the requirements of 30 CFR 75.1103-4 through 75.1103-7 at all times.

Examples included in this handbook are quotes from petition for modifications, evacuation plans, etc., and are used to provide clarification of authority or as an explanation of the inspection procedures.

**Chapter 2**  
**PRE-INSPECTION INFORMATION**

**A. Review the 101(c) petition for modification, or approved ventilation plan, as applicable, to obtain the following information:**

1. The mandatory standards under 30 CFR 75.316, 75.326, 75.1103-4, etc., governing the use of the monitoring system at the mine;
2. The required location of CO sensors, and the maximum spacing permitted between sensors;
3. The minimum and maximum air velocities permitted in the belt entry (Note: Maximum velocity may not be a requirement);
4. The alert (warning) and alarm levels for the CO sensors, in parts per million (ppm) of carbon monoxide;

**EXAMPLE:**

The low-level carbon monoxide monitoring devices shall be capable of providing both visual and audible alarm signals. A visual alert signal shall be activated when the carbon monoxide level at any sensor is 10 ppm above the ambient level for the mine and an audible alarm signal when the carbon monoxide level is 15 ppm above the ambient level for the mine.

5. The procedures to be followed in the event of a partial or complete monitoring system failure;
6. The procedures to be followed when an alert or alarm is activated [also see Firefighting and Evacuation Plan, 30 CFR 75.1101-23(a)];

**EXAMPLE:**

Supplement to Fire Fighting and Evacuation Plan.

1. If any CO sensor indicates a low alert level (10 ppm above the established ambient level), all persons inby that sensor in the same air split shall be withdrawn to the intake escapeway. All persons shall remain at that location, or be withdrawn from the mine, until the reason for the alert has been determined and action has been taken to correct the condition.

If it is determined that a fire exists, all persons not required for firefighting activities shall be evacuated from the mine.

2. If any CO sensor indicates a high alarm level (15 ppm above the established ambient), all persons inby that sensor in the same air split shall be withdrawn outby to the next sensor that is not in alarm mode. All persons shall remain at that location, or be withdrawn from the mine, until the reason for the alarm has been determined and action has been taken to correct the condition.

If it is determined that a fire exists, all persons not required for firefighting activities shall be evacuated from the mine.

3. When an activity that may result in CO production above the alarm levels, such as cutting, welding, etc., is planned, the person in charge of the activity shall notify the person responsible for monitoring the CO system of:
  - a. Location and type of activity;
  - b. Time activity begins; and
  - c. Time activity is completed.

Alarm levels precipitated by the planned activity and indicated by sensors at or inby the location of the planned activity in the same air split shall not be cause to initiate Items 1 and 2 above during the course of the activity.

7. Special requirements specific to the mine, such as respirable dust sampling, use of diesels, etc;

**EXAMPLE:**

The concentration of respirable dust in the intake air coursed through a belt conveyor haulageway shall not exceed 1.0 milligram per cubic meter ( $\text{mg}/\text{m}^3$ ). Compliance with this requirement will be determined by establishing a designated area (DA) sampling location within 15 feet outby the working section belt tailpiece or just outby any air split point introduced into the belt entry and by sampling in accordance with 30 CFR 70.208. The specific DA sampling location shall be identified in the operator's Ventilation System and Methane and Dust Control Plan with a

four-digit number beginning with 8, followed by the middle two digits of the MMU number, and ending with 9 (i.e., 811-9 for MMU 011-0).

8. Required examinations and tests; and

EXAMPLE:

The carbon monoxide monitoring system shall be examined visually at least once each coal-producing shift and tested for functional operation at intervals not exceeding 7 days to insure the monitoring system is functioning properly and that required maintenance is being performed.

The monitoring system shall be calibrated with known concentrations of carbon monoxide and air mixtures at intervals not exceeding 30 calendar days.

A record of all inspections shall be maintained on the surface. The inspection record shall show the time and date of each weekly inspection, monthly calibration, and all maintenance performed on the system.

9. Review 30 CFR 75.1103-4 through 75.1103-7 for systems installed in lieu of point-type heat sensors. In addition, CO sensors used in such systems, except where belt air is used in the face, shall have a maximum spacing of 2000 feet (NOTE: This maximum spacing is currently under review and may change). Also, a minimum air velocity of 50 feet per minute (fpm) must be maintained.

**B. Review the Firefighting and Evacuation Plan for specific reference to the CO monitoring system.**

**C. The Ventilation System and Methane and Dust Control Plan may contain requirements specific to a CO monitoring system, and the plan should be reviewed, even though an approved 101(c) petition is in effect. These specific requirements may be:**

1. Special requirements in the plan pursuant to the 101(c) petition for modification;
2. The specific location of CO sensors, as plotted on a map (if required);
3. The type of CO monitoring system used, including the manufacturer's name; and
4. The specific areas being monitored by the CO monitoring system.

**EXAMPLE:**

The details for the fire detection system including, but not limited to, type of monitor and specific sensor location on the mine map shall be included as a part of the Ventilation System and Methane and Dust Control Plan required by 30 CFR 75.316. The district manager may require additional carbon monoxide sensors to be installed as a part of said plan to insure the safety of the miners.

**D. Check the approved training plan to determine if the CO monitoring system alarm response is included.**

**EXAMPLE:**

Within 60 days after this Proposed Decision and Order is granted, the Petitioner shall submit proposed revisions for their approved 30 CFR Part 48 training plan to the Coal Mine Safety and Health District Manager. These proposed revisions shall specify initial and refresher training regarding compliance with the alternative method and revisions specified in the Petition and the Proposed Decision and Order.

**Chapter 3**  
**SURFACE INSPECTIONS**

**A. Check the company's calibration and inspection records for compliance with the applicable CO system approval.**

1. Calibration.
  - a. Sensors are required to be calibrated at intervals not to exceed 30 calendar days.
  - b. Company inspection records shall identify the date of sensor calibrations.
2. Testing and inspection.
  - a. A test of the system is required at least every 7 days (weekly at some mines) to ensure that system and alarms are functioning properly.
  - b. A visual examination of the CO monitoring system is required on each coal-producing shift.
  - c. Records of these tests and examinations are required.
  - d. Note maintenance that has been performed.

**EXAMPLE:**

The carbon monoxide monitoring system shall be examined visually at least once each coal-producing shift and tested for functional operation at intervals not exceeding 7 days to insure the monitoring system is functioning properly and that required maintenance is being performed. The monitoring system shall be calibrated with known concentrations of carbon monoxide and air mixtures at intervals not exceeding 30 calendar days. A record of all inspections shall be maintained on the surface. The inspection record shall identify the time and date of each weekly inspection, monthly calibration, and all maintenance performed on the system.

**B. Check the map or schematic showing location of CO sensors.**

1. A map or schematic is required by petitions or approved plans to be posted at the mine.
  - a. The map or schematic is to identify affected areas of the mine when a CO sensor is in alert (warning) or alarm status.
  - b. The map or schematic is to be located to allow a responsible person on the surface to determine quickly which area of the mine to notify first in case of an alert or alarm.
  - c. If the map or schematic is on the video display terminal, the responsible person on the surface is to have access to display it when a sensor gives an alert (warning) or alarm signal.
2. Map or schematic is to be accurate.
  - a. Accuracy of the map or schematic can be determined by information obtained through inspections of the mine.
  - b. Accuracy may also be determined using a current list of active sensors.
  - c. Maps or schematics should be updated promptly after a change. Updates made within 24 hours of changes are acceptable, otherwise, the map or schematic is out of date.
3. Obtain a copy of map or schematic (if available).

A copy can be an aid in underground inspection and identification of sensor locations.

**EXAMPLE:**

The carbon monoxide monitoring system shall be capable of identifying any activated sensor. A map or schematic identifying each belt flight and the details for the monitoring system shall be posted at the mine.

**C. Observe operation of the system.**

1. Check video display terminal.

- a. By observation determine that all outstations and sensors are being scanned by the system (compare with map or schematic showing location of sensors).
  - b. Check levels of CO displayed for abnormally high or low readings. These may indicate a sensor calibration drift or an older sensor beginning to fail. High readings can also be true CO measurements.
  - c. Check that CO levels indicated on the display terminal are stable and are not fluctuating over a wide range each time sensor is scanned (more than 2 ppm). Erratic readings are not normal and may indicate a malfunctioning sensor.
  - d. Make a note of sensors with abnormal readings for follow-up during the inspection.
  - e. Compare the established ambient level for the mine with the CO readings shown on the display. If the ambient level is not set properly, appropriate action shall be taken during the plan review process to correct it.
2. Obtain a printout of recent CO sensor readings (if available).
    - a. A printout provides a record of abnormal readings.
    - b. Printouts can be used to compare readings of sensors over extended time periods.
    - c. Printouts can be used to compare sensors monitored with the map or schematic of sensor locations.
3. Determine the duties of the responsible person assigned to monitor the CO system at a surface location.
    - a. Ascertain if the monitoring system activates underground alarms automatically or if action of the responsible person on the surface is necessary to notify the sections. The responsible person must always be located where he or she can manually activate the section alarm and notify those affected if an emergency situation arises.
    - b. Determine if the responsible person is aware of the actions that must be taken when an alert or alarm level has been indicated.

- c. Determine if problems with the monitoring system are reported and corrected immediately.
- d. Determine if the responsible person is notified when activities such as cutting, welding, or calibrating, which may cause alarms, are to be performed.

EXAMPLE:

The carbon monoxide monitoring system shall initiate the fire alarm signals at a surface location where a responsible person is always on duty when miners are underground. The person shall be located so that the signal can be seen if carbon monoxide reaches 10 ppm above the established ambient level and heard at 15 ppm above the ambient. This person shall have two-way communications with all working sections. When the established alert and alarm levels are reached, the person shall notify all working sections and other personnel who may be endangered. The person shall be trained in the operation of the carbon monoxide monitoring system and in the proper procedures to follow in the event of an emergency or malfunction, and in that event, shall take appropriate action immediately.

- 4. Ascertain if a battery backup is provided for the system.
- 5. Evaluate the means of de-energizing the monitoring system upon loss of ventilation ("kill feature"). The means of de-energizing a particular system should be specified since 30 CFR 75.321 requires removal of power from underground upon a fan stoppage. On most monitoring systems, the de-energization of the outstations can be observed at the main console whether it has a monitor screen or digital readout. Systems with battery backup power supplies that cannot be disconnected automatically do not comply with the requirements of 75.1103-7. After the "kill feature" has been initiated, all batteries must be manually reset after power has been restored to the fan. During inspections of CO monitoring systems, you should ascertain that a responsible person knows how to invoke the "kill feature" which disconnects all batteries. Since the data line is considered a power circuit, determine the means of disconnecting the data line. Examination of the master control station will reveal the disconnect method used.
- 6. Obtain an installation and maintenance check-list provided by the manufacturer. The Approval and Certification Center will provide information on the system upon request.

**D. Check visual and audible alarms on the surface.**

1. Check location of alarms and duties of responsible person.
  - a. The responsible person is to be located so the visual alert signal can be seen and the audible alarm can be heard when the CO concentration at any sensor reaches the levels established by the petition or ventilation plan.
  - b. Determine if the duties of the responsible person require that person to be away from the surface readout station and, if so, determine if the visual and audible signals can be seen and heard by the responsible person while at these remote locations.
2. Ask the responsible person to activate the surface alarms.

**E. Check the communication system between the surface and underground.**

1. The responsible person on the surface is to have two-way communications with all working sections.
2. The responsible person is to be able to monitor CO levels while in communication with the section workers.

**F. Check the data line for lightning arresters within 100 feet of the point where the data line enters the underground portion of the mine as required by 30 CFR 75.521.**

**Chapter 4**  
**UNDERGROUND INSPECTIONS**

**A. Air currents in conveyor belt entries.**

Check the direction of the air currents with relation to the approved ventilation plan or 101(c) petition for modification requirements.

**B. Air velocities in conveyor belt entries.**

1. The airflow velocities should be equal to or greater than the minimum requirements of the ventilation plan or 101(c) petition for modification.
2. The airflow velocities should be equal to or less than the maximum velocities if a maximum is imposed.
3. Representative cross-sectional areas of the entries should be used when determining the air velocities. Large areas such as belt channels, boom holes or fall areas should not be used, nor should restricted areas such as overcasts be used.

EXAMPLE:

The velocity of air in the belt conveyor entry shall be 50 feet a minute or greater and have a definite and distinct movement in the designated direction, in order to comply with the requirements of this petition.

**C. Installation of CO sensors.**

1. Check to ensure that the CO sensors are installed at the locations required by the approved plan or 101(c) petition for modification.

EXAMPLE:

An early warning fire detection system meeting the following requirements shall be installed as follows:

1. A low-level carbon monoxide detection system shall be installed in all belt entries utilized as intake aircourses; and

2. The CO sensors shall be located so that the air is monitored at each belt drive and tailpiece and at intervals not to exceed 1,000 feet along each conveyor belt entry. The monitoring device located at the tailpiece shall be at the tailpiece or not more than 50 feet downwind of the tailpiece on the same split of air.
2. Determine if additional sensors are required to provide protection in the event of a fire. An example would be a CO sensor installed in the airstream passing through a regulator.
3. Sensors, cables, and hoses are to be located as follows:
  - a. In the airstream for optimum CO detection;
  - b. In a manner that will provide protection from physical damage;
  - c. In an area that will enable calibration and examination of the system to be performed safely; and
  - d. In an area where sensors, cables, and hoses will not be affected by water sprays, fire suppression systems, or direct application of rock dust, or near battery-charging stations where hydrogen can interfere with the CO sensors.

**D. Inspection of CO sensors.**

1. Diffusion-type and pump-type CO sensors should be visually checked for blockage of airflow.
2. Check for visible damage to the sensor and/or the cable and hose to the sensor.
3. Sensors and associated current-carrying conductors installed where permissibility requirements apply are to be part of a Mine Wide Monitoring System (MWMS) that has been evaluated by MSHA. Such sensors are to be identified by an MSHA classification label attached to the sensor. The sensor circuit is to be protected as intrinsically safe by a barrier on the outby end of the sensor circuit cable. The barrier is to display an MSHA classification label of the same letter designation as the sensor classification. The barrier is to be located at a blue outstation which is to be identified by an MSHA evaluation label.
4. Observe calibration of a representative number of sensors. A representative number of sensors is defined as 10% of the total sensors but no less than 5 sensors.

Sensors that have been in operation for a period of 2 years or longer should be included in this number. Some systems have a means to temporarily bypass the sensor during calibration to avoid false alarms to the section or main control center. The bypass is to be used where available.

Calibration gas should be of sufficient concentration to activate all alarms. The sensors are to be maintained within plus or minus 10% of the stated concentration of the calibration gas. Manufacturer's guidelines for calibration are to be used.

**EXAMPLE:**

**Generic CO Sensor Calibration Procedures:**

1. Once you are ready to begin the calibration of the sensor, notify the person at the manned location on the surface that you are going to calibrate the sensor at that particular location;
2. Apply the zero air calibration gas to verify proper zero reading. Some zero settings are manually set at 1-2 ppm to prevent zero or negative readings at the surface readout. A note of the sensor reading should be taken;
3. Apply a known CO-air mixture of calibration gas (25 ppm, 50 ppm, 95 ppm, etc.) and make a note of the time the gas was applied to compare with the printout on the surface. Leave the calibration gas on for the specified time (usually two minutes) and observe and note the meter reading; and
4. When calibrating the sensor on a section while a section alarm is present, note the level at which the visual and audible alarms were activated.

**E. Outstations.**

1. All outstations are to be located in intake air.
2. Outstations are to be identified as "RED" or "BLUE". If the entire outstation cannot be painted, then other means of identification are to readily identify the outstation as red or blue at a distance.
  - a. Red outstations are designed for sensors located in intake air only.

- b. Blue outstations are designed for sensors located in both fresh air and areas where permissible equipment is required.
  - c. No wiring passing into or through an area where permissible equipment is required may be connected to a red outstation.
  - d. Blue outstations are required to have an Evaluation Label.
3. Have the company representative demonstrate that the battery backup will function properly.
4. For blue outstations connected to a sensor in an area where permissible equipment is required:
- a. Check that the power circuit barriers (PC), and letter class barriers (LTR), are housed in separate compartments or enclosures. Part 18, Section 18.68(c)(3) requires intrinsically safe circuits to be protected against intermingling of wiring with non-intrinsically safe circuits. Failure to maintain this separation is a violation of 75.503;
  - b. Occasionally LTR barriers will be used in parallel. If so, the paralleled LTR barriers must be the same letter class and issue number. To determine if the number of LTR barriers paralleled is acceptable, contact the Approval and Certification Center (A&CC) at (304) 547-0400. When contacting the A&CC, please have the barrier letter class and issue number;
  - c. Check that the wiring of any non-classified sensors connected directly to blue outstations does not enter the classified (LTR) barriers compartment of the blue outstation. Such sensors cannot connect to any electrical equipment other than the blue outstation unless connected through a power circuit barrier;
  - d. Check that all sensors and alarms have the same classification as the barrier to which they are connected; and
  - e. For electrical interconnection of MWMS components to X/P enclosures.
    - 1. Check that the MSHA evaluation label on the blue outstation indicates that connection to X/P equipment is permitted. A barrier classification label is to be located on the exterior of the enclosure and in close proximity to each and every barrier cable entrance.

2. Check that information regarding the X/P enclosure has been documented.
3. Check that barriers (LTR and PC) installed inside the X/P enclosure corresponds with the label on the outside of the enclosure.

F. Section alarms (where required).

1. Check alarm location for compliance with the 101(c) petition for modification or the ventilation plan.
  - a. Alarms within 150 feet of longwalls, pillar lines, or in return air, are to have a classification label attached and are to originate from a blue outstation.
  - b. Alarms are to be located where they can be seen and heard when an alert (warning) or alarm condition exists.
2. Test the section alarm.

Request that management activate the section alarm from the surface station.

G. Hand-held CO detectors (if applicable).

1. When all or part of the CO monitoring system fails, a sufficient number of trained persons and hand-held detectors are to be available to permit operation of the conveyor belts.
2. CO detectors may also be required in the Firefighting and Evacuation Plan.
3. Check if persons designated to monitor for CO with hand-held detectors are properly trained.
  - a. Persons designated should know when monitoring is required and know what steps are to be taken when CO is detected.
  - b. Persons designated are to be trained in the use of the specific instrument used at the mine.

EXAMPLE:

If at any time the carbon monoxide monitoring system or any portion of the system required by this petition has been de-energized for reasons such as routine maintenance or failure of a sensor unit, the belt conveyor may continue to operate provided the affected portion of the belt conveyor entry shall be continuously patrolled and monitored for carbon monoxide by a qualified person in the following manner until the monitor system is returned to normal operation:

1. If one sensor becomes inoperative, a qualified person shall monitor at that location;
2. If two or more adjacent sensors become inoperative, a qualified person shall patrol and monitor the area affected; and
3. If the complete system becomes inoperative, a sufficient number of qualified person(s) shall patrol and monitor the belt entries of the mine whereby the entire belt haulage entries will be traveled each hour in their entirety or qualified persons shall be located at the end of each belt conveyor flight and monitor for carbon monoxide.

Each of these qualified persons shall be provided with a hand-held carbon monoxide detection device. A carbon monoxide detection device shall also be available for use on each working section in the event the monitoring system is de-energized or fails.

**Chapter 5**  
**RESPONSE TO OBSERVED ALARMS**

If an inspector is at a mine when the carbon monoxide monitoring system activates an alarm signal, he or she should determine if the response was in accordance with the ventilation plan, Firefighting and Evacuation Plan, or 101(c) Petition for Modification (DO NOT initiate alarms to observe the reaction of personnel).

EXAMPLE:

SUPPLEMENT TO FIRE FIGHTING AND EVACUATION PLAN.

1. If any CO sensor indicates a low level alert (10 ppm above the established ambient), all persons inby that sensor in the same air split shall be withdrawn to the intake escapeway. All persons shall remain at that location, or be withdrawn from the mine, until the reason for the alert has been determined and action has been taken to correct the condition.

If it is determined that a fire exists, all persons not required for firefighting activities shall be evacuated from the mine.

2. If any CO sensor indicates a high alarm level (15 ppm above the established ambient), all persons inby that sensor in the same air split shall be withdrawn outby to the next sensor not in alarm mode. All persons shall remain at that location until the reason for the alarm has been determined and action has been taken to correct the condition.

If it is determined that a fire exists, all persons not required for firefighting activities shall be evacuated from the mine.

3. When an activity that may result in CO above the alarm levels being produced, such as cutting, welding, etc., is planned, the person in charge of the activity shall notify the person responsible for monitoring the CO system of:

- a. Location and type of activity;
- b. Time activity begins; and
- c. Time activity is completed.

Alarm levels indicated by sensors at or inby the location of the planned activity in the same air split shall not be cause to initiate Items 1 and 2 above during the course of the activity.