# STANDARD OPERATING PROCEDURES

# THERMO ELECTRON CORPORATION MODEL 48C-TLE

# TRACE LEVEL CO INSTRUMENT

**Version 1.10**

***Final***

## Section 1.1 Acknowledgments

This Standard Operating Procedure (SOP) for Carbon Monoxide – Trace Level is the product of EPA's Office of Air Quality, Planning and Standards. The following individuals are acknowledged for their contributions.

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## 3.0 PROCEDURES

### 3.1 Scope and Applicability

Carbon Monoxide (CO), a colorless, odorless, tasteless, highly poisonous gas has detrimental effects on human health. CO originates from the partial oxidation of hydrocarbon fuels, coal and coke[1]. CO affects the oxygen carrying capacity of the blood. CO can diffuse through the alveolar walls of the lungs and compete with oxygen for one of the four iron sites in the hemoglobin molecule. The affinity of the iron site for CO is approximately 210 times greater than oxygen[2]. Low levels of CO can cause a number of symptoms including headache, mental dullness, dizziness, weakness, nausea, vomiting and loss of muscular control. In extreme cases, collapse, unconsciousness and death can occur.

The Thermo Electron Corporation (TECO) model 48C-TLE is a state of the science instrument for the determination of trace levels of CO by Non-Dispersive Infrared Spectrophotometry (NDIR) using Gas Filter Correlation (GFC). This SOP will detail the operation, preventive maintenance, cautions and health warnings.

The Detection Limit (DL) for non-trace levels of CO is 1.0 parts per million (ppm) *(Code of Federal Regulations,* Volume 40, Part 53.23c, or, in the shortened format used hereafter, 40 CFR 53.23c)[3]. However, the 48C-TLE has a DL to 20 parts per billion (ppb), which is accomplished by modifications to the Federal Reference Method (FRM) instruments. This document will discuss the Trace Level (TL) operating procedures in detail.

### 3.2 Summary of Method

The analytical principle is based on absorption of IR light by the CO molecule. NDIR-GFC analyzers operate on the principle that CO has a sufficiently characteristic IR absorption spectrum such that the absorption of IR by the CO molecule can be used as a measure of CO concentration in the presence of other gases. CO absorbs IR maximally at 2.3 and 4.6 um. Since NDIR is a spectrophotometric method, it is based upon the Beer-Lambert Law. The degree of reduction depends on the length of the sample cell, the absorption coefficient, and CO concentration introduced into the sample cell, as expressed by the Beer-Lambert law shown below:

$T = I/Io = e^{(-axC)}$ (equation 1)

where:

T = Transmittance of light through the gas to the detector
I = light intensity after absorption by CO
Io = light intensity at zero CO concentration
a = specific CO molar absorption coefficient
x = path length, and
C = CO concentration

For Gas Filter Correlation, there is only one sample cell. This cell acts as the sample and reference cell. The broad band of IR radiation is emitted from an IR source. The IR light passes through a very narrow

band pass filter which screens out most wavelengths and allows only the light that CO absorbs to enter the sample cell. The GFC analyzer has a chopper wheel with two pure gases: Nitrogen and CO. As the chopper wheel rotates and allows the IR energy to enter "CO side" of the wheel, all IR energy that could be absorbed by CO in the sample stream is absorbed by the CO in the wheel. This technique effectively "scrubs out" any light that could possibly be attenuated. The single detector records the light level (Io). As the wheel spins, the "N2 side" of the wheel reaches the IR energy beam. This side of the wheel allows all IR light to pass through the wheel and be absorbed by any CO that might be in the sample gas. This light level is CO sensitive (I). The detector records the attenuation of this light, compares the two light levels (I/Io) and sends a signal to the electrometer board that calculates the concentration. The voltage is related to the CO concentration according to the Beer-Lambert law in equation 1 shown above. Thus, TECO 48C-TLE can be measured continuously. The 48C-TLE version has four distinct features that allow it to measure CO at ppb levels:

- Required sample stream dried using permeation dryer;
- Analyzer baseline determined and corrected using heated Carolite catalytic converter;
- Frequent auto-zero, at a minimum once per hour, through the catyalytic converter;
- The instrument has an ultra-sensitive or "hot" detector.

The 48C-TLE instrument operates in the following fashion:

1. In sample mode, ambient air is allowed to enter through the rear bulkhead sample port. Solenoid #1 is in its Normally Open (NO) mode. The ambient air flows through the solenoid to the permeation dryer, which removes the moisture and water from the air stream.
2. The sample stream then passes through a sample filter, which removes particles that can build up on the mirror and sample chamber and attenuate the IR beam.
3. The sample then enters the sample cell. A major difference between a non-TL and TL instrument is the detector. The TL instrument has a detector that is more sensitive to the light emitted and absorbed in the sample cell. This detector must be more sensitive because the amount of attenuation by the CO gas in the sample stream is much lower. Therefore, the detector must be sensitive at lower ambient levels. Temperature of the sample cell is also critical. The sample cell and detector must be maintained at a constant temperature in order for the detector to keep a stable background. Fluctuations of more than $1^{o}$ Centigrade can cause the baseline to drift, giving false readings at low levels.
4. The detector sends the signal to the demodulator which interprets the signal. The demodulator sends a digital value to the Central Processor Unit (CPU).
5. At the end of the hour, the CPU sends a voltage signal to the Solenoid #1 and switches it to the "Normally Closed" (NC) position. This allows room air to be drawn into the instrument and to pass through the catalytic converter. The catalytic converter uses a Carolite bed heated to $50^{o}$ Centrigrade to convert all CO to Carbon Dioxide ($2CO + O_2 \longrightarrow 2CO_2$). This effectively "scrubs" all CO from the sample stream. The CO "free" air flows through the sample cell and the CPU interprets the signal from the demodulator as the "background" or "baseline" value. The baseline is then adjusted at that time. The baseline adjustment takes 10 minutes.
6. The CPU then switches Solenoid #1 to its NO position and ambient air then drawn into the analyzer.

### 3.3 Definitions

Here are some key terms for this method.

**Table 3-1, Definitions of Key Terms**

| Term | Definition |
|---|---|
| DAS | Data acquisition system. Used for automatic collection and recording of CO concentrations. |
| Interferences | Physical or chemical entities that cause CO measurements to be higher (positive) or lower (negative) than they would be without the entity. (See Section 3.6). |

### 3.4 Health and Safety Warnings

To prevent personal injury, please heed these warnings concerning the 48C-TLE.

1. CO is a poisonous gas. Vent any CO or calibration span gas to the atmosphere rather than into the shelter or other sampling area. If this is impossible, limit exposure to CO by getting fresh air every 5 to 10 minutes. If the operator experiences light headedness, headache or dizziness, leave the area immediately.
2. The IR source is a filament resistor that has an electrical current running through it. The IR source can become very hot. When troubleshooting, allow the instrument to cool off especially if you suspect the IR source as the cause of trouble.
3. Always use a third ground wire on all instruments.
4. Always unplug the analyzer when servicing or replacing parts.
5. If it is mandatory to work inside an analyzer while it is in operation, use extreme caution to avoid contact with high voltages. The analyzer has a 110 volt Volts Alternating Current (VAC) power supply. Refer to the manufacturer's instruction manual and know the precise locations of the VAC components before working on the instrument.
6. Avoid electrical contact with jewelry. Remove rings, watches, bracelets, and necklaces to prevent electrical bums.

### 3.5 Cautions

To prevent damage to the 48C-TLE, all cautions should immediately precede the applicable step in this SOP. The following precautions should be taken:

1. Normally, if Teflon™ filters are used in the sample train, cleaning the optical bench will not be required. However, in the event that the bench is cleaned, be careful to avoid damaging the interior of the sample chamber. In addition, some GFC instruments have a series of mirrors that deflect the light in order to increase the path length. The mirrors are aligned at the factory. If the mirrors become misaligned, the IR light beam will not be directed to the detector. Use extreme caution when cleaning or servicing the sample chamber(s). In addition the mirrors are very fragile Avoid dropping the instrument. This may damage, misalign or crack the mirrors and cause expensive repairs.
2. Keep the interior of the analyzer clean.
3. Inspect the system regularly for structural integrity.
4. To prevent major problems with leaks, make sure that all sampling lines are reconnected after required checks and before leaving the site.

5. Inspect tubing for cracks and leaks. The permeation dryer may rest upon parts that vibrate, such as the air pump. Check the areas of the permeation dryer where they come into contact with other parts.
6. It is recommended that the analyzer be leak checked after replacement of any pneumatic parts.
7. If cylinders are used in tandem with Mass Flow Control (MFC) calibrators, use and transport of cylinders are a major concern. Gas cylinders can sometimes contain pressures as high as 2000 pounds per square inch. Handling of cylinders must be done in a safe manner. If a cylinder is accidentally dropped and valve breaks off, the cylinder can become explosive or a projectile.
8. Transportation of cylinders is regulated by the Department of Transportation (DOT). It is strongly recommended that all agencies contact the DOT or Highway Patrol to learn the most recent regulations concerning transport of cylinders.
9. CO is a highly poisonous gas. Long term exposure can cause problems with motor coordination and mental acuity. It is strongly recommended that all agencies have Material Safety Data Sheets (MSDS) at all locations where CO cylinders are stored or used. MSDS can be obtained from the DOT or from your vendor.
10. It is possible (and practical) to blend other compounds with CO. If this is the case, it is recommended that MSDS for all compounds be made available to all staff that use and handle the cylinders or permeation tubes.
11. Shipping of cylinders is governed by the DOT. Contact the DOT or your local courier about the proper procedures and materials needed to ship high-pressure cylinders.

### 3.6 Interferences

**Water Vapor:** Studies have shown conclusively that NDIR analyzers have interference from water vapor. Water absorbs very strongly across several bands of IR spectra. Water vapor interference occurs because water vapor absorption of light in the region of 3.1, 5.0 -5.5 and 7.1 -10.0 *u*m in the IR region. Since water vapor absorbs light in this region, this has a quenching effect on the reaction of CO. The TECO 48C-TLE is equipped with a permeation drier, which effectively scrubs all water and water vapor. No maintenance is required on the dryer.

**Carbon Dioxide:** CO2 absorbs in the IR spectrum at 2.7, 5.2, and 8.0 to 12.0 *u*m. This is very close to the regions that CO absorbs within as well. However, since atmospheric carbon dioxide is much higher in concentration than CO, this UV spectral range must be avoided. To prevent light in this spectral region, the TECO 48C-TLE analyzer has a band pass filter that blocks these wavelengths.

### 3.7 Personal Qualifications

The person(s) chosen to operate the TECO 48C-TLE should have a minimum of qualifications. The understanding of basic chemistry and electronics are a must. The understanding of digital circuitry is helpful, but not required. Also, courses in data processing and validation are also welcome.

### 3.8 Equipment and Supplies

**Monitoring Apparatus:** The design of the 48C-TLE is identical to the 48C, with several major variations. A diagram of the TECO 48C-TLE instrument is described in Figure 3-1. The three main components are:

- *Pneumatic System:* Consists of sample inlet line, particulate filter, filter holder, permeation dryer, reaction chamber, flowmeter, and pump, all used to bring ambient air samples to the analyzer inlet.
- *Analytical System*: This portion of the instrument consists of the IR source, the correlation wheel, motor, mirrors, detector and band pass filter.

- *Electronic Hardware:* The part of the analyzer that generally requires little or no maintenance. The brain of the 48C series is the CPU. It monitors and regulates motor speed, temperatures, flows and pressure. It also monitors and stores diagnostic information. If the 48C-TLE is operated above the manufacturer's recommended temperature limit, however, individual integrated chips can fail and cause problems with data storage or retrieval.

Other apparatus and equipment includes the following.

**Instrument Shelter:** A shelter is required to protect the analyzer from precipitation and adverse weather conditions, maintain operating temperature within the analyzer's temperature range requirements, and provide security and electrical power. The recommended shelter temperature range is 20-30$^{o}$C.
**Spare Parts and Incidental Supplies:** See the TECO 48C-TLE operating manual, Section 5-1for specific maintenance and replacement requirements.
**Calibration System**: A system that creates concentrations of CO of known quality is necessary for establishing traceability. This is described in detail in the "Calibration of Trace Gas Instruments SOP." Please reference this document.
**DAS**: A data acquisition system is necessary for storage of ambient and ancillary data collected by the 48C-TLE. This is detailed in the "Acquisition and Management SOP."

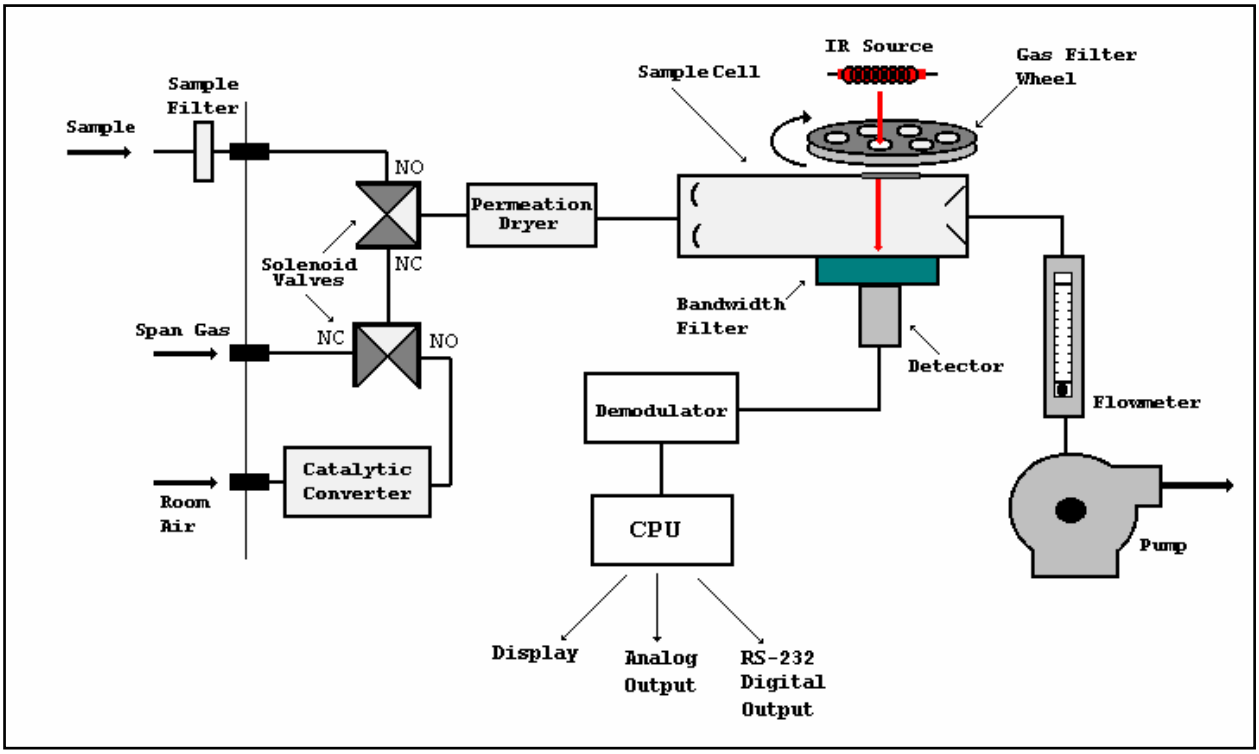


**Figure 3-1 Schema of the TECO 48C-TLE**

**Wiring, Tubing and Fittings***:* Teflon™ and borosilicate glass are inert materials that should be used exclusively throughout the intake system. It is recommended that Polytetrafluoroethylene (PTFE) or Fluoroethylpropylene (FEP) Teflon™ tubing be used. PTFE and FEP are the best choice for the connection between the intake manifold and the 48C-TLE bulkhead fitting. Examine and discard if particulate matter collects in the inlet tubing. All fittings and ferrules should be made of Teflon™ or stainless steel. Connection wiring to the DAS should shielded two strand wire or RS-232 cables for digital connections.

**Reagents and Standard:** The TECO 48C-TLE does not require any reagents since the instrument uses photometry to analyze for CO. All standards for the CO method can be obtained in compressed cylinders and must be NIST traceable. Please see the "Calibration of Trace Gas Analyzers" SOP.

### 3.9 Procedure

**3.9.1 Sample Collection:** Sampling for Trace Level CO is performed by drawing ambient air through a sample manifold directly into the analyzer continuously via a vacuum pump. All inlet materials must be constructed from Teflon™ or borosilicate glass as detailed in 40 CFR 58. The siting criteria for CO Trace Level instruments in detailed in 40 CFR 58, appendix A[4] .

**3.9.2 Sample Handling and Preservation:** CO samples receive no special preparation prior to analysis. Therefore this SOP does not need a section on Sample Handling and Preservation.

**3.9.3 Instrument Operation, Startup and Maintenance**

This section discusses startup, operation and maintenance of the 48C-TLE. The TECO 48C-TLE series instrument has a digital front panel screen with selection switches below. This allows the user to check functions, switch operating parameters, adjust zero and span and read warnings messages. **It is extremely important that the users familiarize themselves with the menus available. Inadvertently changing parameters within the analyzer can damage the instrument and possibly invalidate data as well. Please reference the TECO 48C-TLE owner's manual and read it carefully before adjusting any parameters that are set by the factory.**

**3.9.3.1 Start up**

The following text is taken from the TECO 48C-TL manual. It is the identical for the 48C-TLE model.

The Model 48C Trace Level is shipped complete in one container. If, upon receipt of the analyzer, there is obvious damage to the shipping container, notify the carrier immediately and hold for inspection. The carrier, and not Thermo Environmental Instruments Inc., is responsible for any damage incurred during shipment. Follow the procedure below to unpack and inspect the instrument.

1. Remove the instrument from the shipping container and set on a table or bench that allows easy access to both the front and rear of the instrument.
2. Remove the instrument cover to expose the internal components and remove any packing material.
3. Check for possible damage during shipment and check that all connectors and printed circuit boards are firmly attached.
4. Re-install the instrument cover.
5. Connect the sample line to the sample bulkhead on the rear panel. Ensure that the sample line is not contaminated by dirty, wet or incompatible materials. All tubing should be constructed of Teflon™ or borosilicate glass with an OD of ¼" and a minimum ID of 1/8".
6. The length of the tubing should be less than 10 feet.
7. All gas must be delivered to the instrument at atmospheric pressure. It may be necessary to employ an atmospheric bypass plumbing arrangement or attach the instrument inlet line to a manifold that is vented to the atmosphere.
8. Connect the exhaust bulkhead to a suitable vent. The exhaust line should be ¼" OD (outside diameter) with a minimum ID of 1/8" OD. The length of the exhaust line should be less than 10 feet. Verify that there is no restriction in this line.

9. Connect a suitable recording device to the rear panel terminals. The EPA recommends, but does not require, recording of the data digitally. The TECO 48C-TLE has this option. Please refer to the "Data Acquisition and Management" SOP. If the DAS system that you have does not have the RS-232 capabilities, then proceed to the next section, Diagnostic Checks/Manual Checks. If you have connected the 48C-TLE to a computer or DAS, review the Diagnostic Check from your computer screen. TECO offers TECO communication software, a computer program that allows the operator to log the diagnostic data that is collected by the 48C-TLE CPU. Several DAS manufacturers offer this type of software as well.
10. Plug the instrument into an outlet of the appropriate voltage and frequency. The Model 48C Trace Level is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated.
11. Turn the power on.

### 3.9.3.2 Operation and Range Setting

1. The exhaust fan will start and the display will come on. The Central Processing Unit (CPU) will boot the system and load the firmware.
2. The display has a 4 line by 20 character alphanumeric display that shows the sample concentration, instrument parameters, instrument controls and help/warning messages. The menus for access (as described in sections 3.9.3.4 and 3.9.3.5 of this SOP) are performed using the display and the 6 push-buttons just below the display.
3. Once the instrument loads the firmware, the display will display "CO PPM XX.XX, below this value is the time and "REMOTE." This is the "RUN" menu and should always be left in the "RUN" menu when it is collecting ambient data.
4. To access the Main Menu, press the "Menu." This will put you into the Main Menu.
5. From the Main Menu, Use the ↑ and ↓ pushbuttons move the cursor down so that the arrow is next to "Range" selection. Press "Enter."
6. The Range menu contains the gas units, CO ranges, and the custom ranges. In the upper right corner of the display, the words "SINGLE, DUAL, or AUTO" is displayed to indicate the active mode. The "Range" menu in the dual and auto-range modes appear the same except for the word DUAL or AUTO, displayed in the upper right corner. For more information about the SINGLE, DUAL, or AUTO-range modes, see page 3-6 of the owner's manual. The default is set to single range.
7. To set the upper scale range, use the ↑ and ↓ pushbuttons to move the cursor down so that the arrow is next to "CO Range" selection. Press "Enter."
8. Use the "↑↓→←" buttons on the front panel to enter in the desired concentration, this should be "5." Press "Enter."
9. Press "Menu" and then press "Run." The full scale range has now been set to 5.00 ppm. The default for the units is "ppm." It is recommended that this not be changed.
10. In single range mode, there is one range, one averaging time, and one span coefficient. The two CO analog outputs are arranged on the rear panel terminal strip as shown in Figure 3-3 of the owner's manual. To use the single range mode, set option switches 4 and 5 off. For more information about setting the internal option switches, see .Internal Option Switches, on page 3-7.

### 3.9.3.3 Diagnostic Checks/Manual Checks

To determine whether the 48C-TLE is working properly, the field operators should perform the Diagnostic Checks every time they visit the monitoring station. It is good practice for the operator to check these Diagnostic Checks either by the computer or manually. Figure 3-2 of this SOP has the menu

"tree" that was taken from the TECO 48 C-TL manual. By pressing the "menu" button and following the tree, an operator can easily get to the location needed.

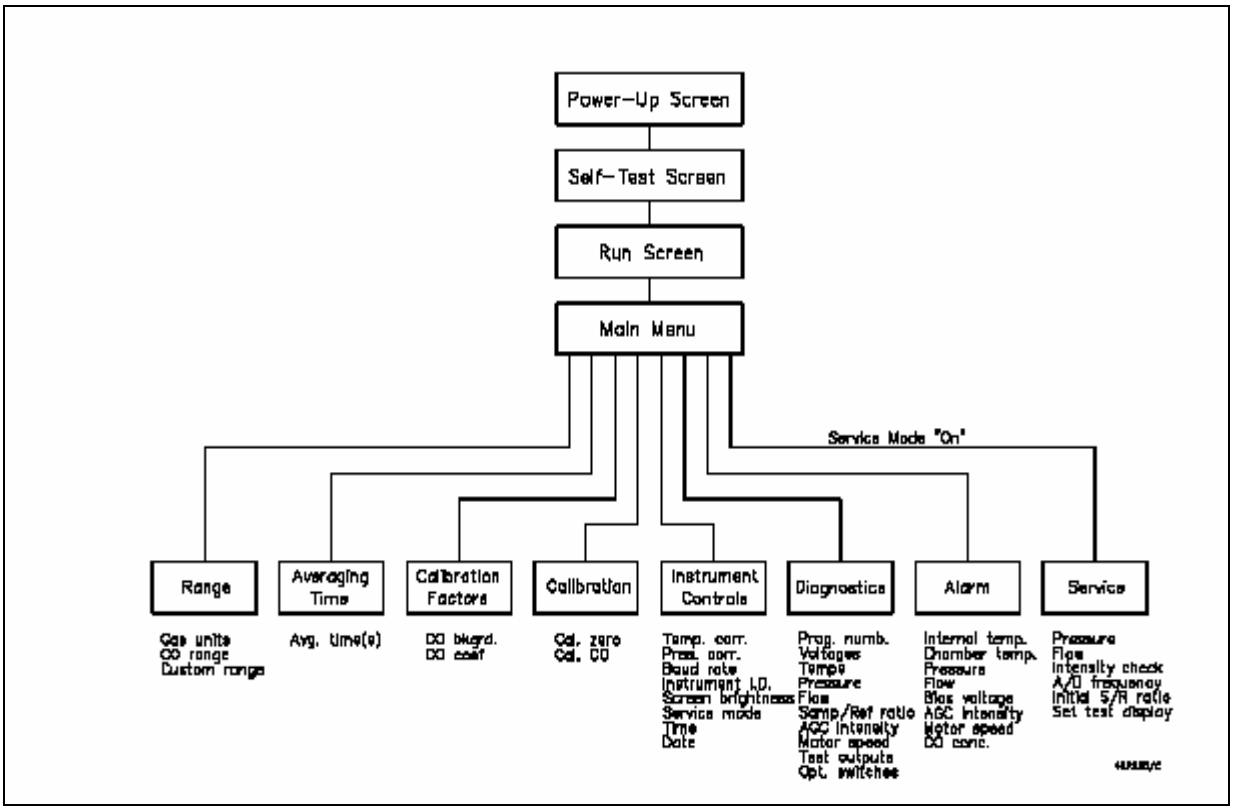


**Figure 3-2 Menu Tree Schema**

Below are instructions on how to perform the diagnostic checks manually. Please note that the TECO 48C-TLE has set upper and lower ranges for some of these Diagnostic checks. Please reference the owner's manual for these ranges. Please use the following instructions to access the Diagnostic data.

1. While in the "Run" menu, press the "Menu" button. This will put you into the Main Menu.

2. From the Main Menu, Use the ↑ and ↓ pushbuttons move the cursor down so that the arrow is next to "Diagnostics" selection. Press "Enter."

3. In the Diagnostics Menu, the operator can toggle the arrow using the ↑ and ↓ pushbuttons to align the arrow to the selection. Once the operator has toggled the arrow to the diagnostic check desired, press "Enter." This will allow you to see the desired information. Record this information on your field work sheet. Please see Table 3-2 for a list of Diagnostic Checks and a brief explanation. Please check the Owners Manual for the manufacturer's recommended ranges.

4. Once the operator has reviewed all of the diagnostic information, return to the Main Menu by pressing "Menu" followed by "Run."

**Table 3-2 Diagnostic Checks**

| Check | Explanation |
|---|---|
| Program Number | The current software version used by the instrument |
| Voltages | There are four voltages that should be recorded. |
| Temperatures | There are two temperatures that should be recorded: internal and chamber. Reference Page 3-47 for details. |
| Pressure | This is the pressure inside of the optics bench. |
| Flow | This is the actual flow rate through the optics bench. Reference page 3-53 for specifications. |
| S/R Ratio | Sample/Reference Ratio. This is the ratio of the intensities of the light source through the sample side and the reference side of the correlation wheel. Please See page 3-38 for the optimal values. |
| AGC Intensity | Automatic Gain Control. The AGC displays the intensity (in Hertz) of the reference channel. The AGC circuit optimizes the noise and resolution level of the analyzer. Please see page 3-39 for details. |
| Motor Speed | This displays, in percentage, the status of the chopper motor. This value should be 100%. |

Once the Diagnostic checks have been established and recorded for the 48C-TLE, it is time to calibrate the instrument. Please refer to section 3.9.4 of this SOP.

### 3.9.3.4 Preventive Maintenance

Preventive maintenance should **prevent** down-time and data loss. Table 3.3 lists the preventive maintenance items that are should be performed. Please see section 5-1 of the owner's manual. Section 5-1 also has a list of the spare parts that the operator should keep in stock.

**Table 3-3 Preventive Maintenance Schedule the TECO 48C-TLE**

| **Item** | **Schedule** |
|---|---|
| Replace particle filter | Weekly |
| Diagnostics Checks | Weekly |
| Perform Level I calibration | Daily |
| Replace IR source | As needed |
| Leak Check and Pump Check Out | Annually |
| Inspect Pneumatic Lines | Semi-annually |
| Clean inside of Chassis | As needed |
| Rebuild or replace pump | As needed |
| Clean optic bench | As needed |
| Replace wheel motor | As needed |
| Replace gases in correlation wheel | As needed |

### 3.9.3.5 Instrument Troubleshooting

The TECO 48C-TLE manual has an excellent troubleshooting guide in Section 6-1 of the manual. For details on using the Test Functions for predicting failures, please reference this section.

### 3.9.4 Calibration and Standardization

The calibration of the TECO 48C-TLE is performed by comparing the digital or analog output of the instrument against standardized gases of known quality. Generation of these gases is detailed in the "Calibration of Trace Gas Analyzers" SOP. The recommended ranges for the calibration are detailed in Table 4-2. This section will detail how to adjust the 48C-TLE to the standardized gases. Once the calibration has been performed, compare the response of your DAS to the calculated "source" value. If this is outside of +/-10%, then adjust the instrument response as detailed in the next sections of this SOP.

### 3.9.4.1 Adjustment to Zero Air

In order to adjust the output of the 48C-TLE to zero air, perform the following:

1. Allow the instrument to sample zero air from a manifold that is at near atmospheric pressure for a minimum of 15 minutes.
2. On the front panel press the "Menu" button. This will bring up the main menu. Using the ↓ arrow until the cursor is on the "Calibration" selection. Press "Enter."
3. This next screen is the "Calibration" screen. In this screen press the ↑↓ buttons until you align the cursor at the "Calibrate Zero" selection. Press "Enter."
4. The next screen will show a "CO PPM X.X above the words "SET TO ZERO?" If the analyzer has stabilized to zero air, press "Enter." Then Press "Menu" and then press "Run." This will adjust the baseline to the zero air. If you decide to adjust the higher range response, continue on to Section 3.9.4.2.

### 3.9.4.2 Adjustment to Calibration Gas

In order to adjust the output of the 48C-TLE to NIST traceable calibration gas, perform the following:

1. Switch the calibration unit to generate a known concentration of CO. Allow the instrument to sample calibration gas from a manifold that is at near atmospheric pressure for a minimum of 15 minutes.
2. On the front panel press the "Menu" button. This will bring up the main menu. Using the ↓ arrow until the cursor is on the "Calibration" selection. Press "Enter."
3. This next screen is the "Calibration" screen. In this screen press the ↑↓ buttons until you align the cursor at the "Calibrate CO" selection. Press "Enter."
4. The first line of the display shows the current CO concentration reading. The second line shows the instrument range and the third line states, "SET TO…… XX.XX." The next line shows "↑↓ INC/DEC." The cursor should be under one of the digits in the third line. Use the "↑↓→←" buttons on the front panel to enter in the desired concentration, that is being generated by the calibration system. Press "Enter."
5. Then Press "Menu" and then press "Run." This will adjust the response of the instrument to the calibration gas concentration. The instrument is now calibrated.

### 3.10 Data Analysis and Calculations

Data analysis for this analyzer is detailed in "Data Acquisition and Management" SOP. For the TECO 48C-TLE, there is one design detail of which the operator must be aware; the auto-zero function. As detailed in Section 3.1 of this SOP, the TECO 48C-TLE has an auto-zero sequence that occurs at the end of the hour (default). During this period, the 48C-TLE analog output will be at or close to zero, since the detector is sampling air with the CO "scrubbed out." While this occurs the display will illustrate "ZERO." If the operator records the data during this sequence via the analog output, then the operator must be aware and flag this data in the DAS. The digital output via the RS-232 is flagged; therefore, no other flagging is required. The auto-zero function can be modified from once per hour to any increment up to once per day. It is recommended that the factory default not be changed from once per hour at this time.

## 4.0 QUALITY CONTROL AND QUALITY ASSURANCE

The following section has brief definitions of the QA/QC indicators. Table 4-1 has the Measurement Quality Objectives (MQOs) of the TECO 48C-TLE. Please note that this section details primarily with the QA indicators. Quality Control for continuous electronic instruments, such as the TECO 48C-TLE consists of performing the diagnostic checks, maintenance and calibrations. These procedures are detailed in sections 3.9.3 and 3.9.4: Instrument Operation, Startup and Maintenance and Calibration and Standardization. Appendix A has an example of a Quality Control and Maintenance Record developed by the EPA for this instrument. In addition, please review Table 4-2, which has the recommended operation parameters for the TECO 48C-TLE. The operation parameters include recommended operating full scale range, calibration ranges and recommended cylinder concentrations.

### 4.1 Precision

Precision is defined as the measure of agreement among individual measurements of the same property taken under the same conditions. For CO, this refers to testing the CO analyzer in the field at concentrations between 0.250 and 0.500 ppm. The test must be performed, at a minimum, once every two weeks. Calculations for Precision can be found in Reference 4.

### 4.2 Bias

Bias is defined as the degree of agreement between a measured value and the true, expected, or accepted value. Quantitative comparisons are made between the measured value and the true, standard value during audits. Generally, three upscale points and a zero point are compared. Two audit types commonly used for CO, direct comparison and blind, are discussed below. The SOP should discuss plans for each type of audit.

- **Direct Comparison Audits:** An independent audit system is brought to the monitoring location and produces gas concentrations that are assayed by the monitoring station's CO analyzer. In most cases, a person outside of the agency or part of an independent QA group within the agency performs the audit. The responses of the on-site analyzer are then compared against the calculated concentration from the independent audit system and a linear regression is generated

- **Blind Audits:** In blind audits (also called performance evaluation audits) State or Local agency staff are sent an audit device, such as the National Performance Evaluation Program (NPEP). The agency staff does not know the CO concentrations produced by the audit equipment. Responses of the on-site analyzer are then compared against those of the generator and a linear regression is calculated.

### 4.3 Representativeness

Representativeness refers to whether the data collected accurately reflect the conditions being measured. It is the data quality indicator most difficult to quantify. Unless the samples are truly representative, the other indicators are meaningless. Since the NCORE Level I and II siting criteria are urban and regional, the CO Trace Level criteria are the same. Please reference the National Monitoring Strategy[5] for a discussion of NCORE Level II CO monitoring scale.

### 4.4 Completeness

Completeness is defined as the amount of data collected compared to a pre-specified target amount. For CO, EPA requires a minimum completeness of 75% (40 CFR 50, App.H.3). Typical completeness with the TECO 48C-TLE values can approach 90-93%.

### 4.5 Comparability

Comparability is defined as the process of collecting data under conditions that are consistent with those used for other data sets of the same pollutant. The TECO 48C-TLE meets the MQOs for a Trace Level CO instrument. Please see Table 4-1.

### 4.6 Method Detection Limit

The method detection limit (MDL) or detectability refers to the lowest concentration of a substance that can be determined by a given procedure. The TECO 48C-TLE must be able to detect a minimum value of 0.040 ppm of CO.

**Table 4-1 Measurement Quality Assurance Objectives**

| Requirement | Frequency | Acceptance Criteria | Reference | Information or Action |
|---|---|---|---|---|
| Bias | NCORE, once per year | To be Determined from Data Quality Objectives | 40 CFR Pt.58 | Use of NIST generated gas concentrations with Mass Flow Calibration unit that is NIST traceable |
| Precision | 1 every 2 weeks | Concentration: 0.250 -0.500 ppm, Coefficient of Variance: To be determined | 40 CFR Pt.58 Appendix A | To be determined |
| Completeness | Quarterly, Annually | NCORE, 75% | National Monitoring Strategy. | If under 75%, institute Quality Control Measures |
| Representativeness | N/A | Neighborhood, Urban or Regional | 40 CFR 58 | N/A |

| | | | | |
|---|---|---|---|---|
| | | Scale | | |
| Comparability | N/A | Must be a Trace Level instrument. See Sections 3.1 and 3.2 of this document. | National Monitoring Strategy. | N/A |
| Method Detection Limit | NA | 0.040 ppm | National Monitoring Strategy | Testing is performed at the factory. |

**Table 4-2 Operating Parameters for the TECO 48C-TLE Trace Gas Instrument**

| Item | Range | Comments |
|---|---|---|
| Full Scale Range | 0 to 5.000 ppm | Suggested Range. Reduce to 1.000 ppm if rural site |
| Units | Part per million (ppm) | Recommended |
| Compressed Gas Cylinder | 200 – 250 ppm | NIST Traceable Protocol #1 cylinder with CO concentration between 200 – 250 ppm. |
| Calibration Ranges | | |
| a. zero | 0 – 0.010 ppm | There are a number of commercially available vendors. |
| b. Level I Span | 4.000 – 5.000 ppm | NIST Traceable Protocol #1 cylinder with CO concentration between 200 – 250 ppm. Recommended gas flow range 75 – 90 cc/min. Zero air flow 4.80 – 5.00 liters/min. |
| c. Mid Point Span | 2.000 – 2.500 ppm | NIST Traceable Protocol #1 cylinder with CO concentration between 200 – 250 ppm. Recommended gas flow range 75 – 90 cc/min. Zero air flow 8.00 10.00 liters/min. |
| d. Precision Level | 0.250 – 0.500 ppm | NIST Traceable Protocol #1 cylinder with CO concentration between 200 – 250 ppm. Recommended gas flow range 20 - 35 cc/min. Zero air flow 18.00 – 20.00 liters/min. |

## 5.0 REFERENCES

1. Merck Index, twelfth edition 1996, page 296
2. Seinfeld,, John H., Atmospheric Chemistry and Physics of Air Pollution, 1986, page 54
3. Code of Federal Regulations, Title 40, Part 53.23c
4. Code of Federal Regulation, Title 40, Part 58, Appendix A
5. The National Air Monitoring Strategy, Final Draft, 4/29/04, http://www.epa.gov/ttn/amtic/monstratdoc.html

**Appendix A**

Environmental Protection Agency
Monthly Quality Control and Maintenance Records
TECO 48C-TLE CO Analyzer

Site Name/Location_____

Technician_____
Month/Year_____
Serial Number_____Range_____

| Parameter | Date | Date | Date | Acceptance Criteria |
|---|---|---|---|---|
| Program Number | | | | 48 TR007 00 Communications 48LTR007 00 |
| Bias Voltage | | | | -105-115V |
| +5 volt supply | | | | NA |
| +15 volt supply | | | | NA |
| -15 volt supply | | | | NA |
| Battery | | | | NA |
| Internal Temp | | | | 8.0 – 47 deg. C |
| Chamber Temp | | | | 48.0 – 52.0 deg. C |
| Pressure | | | | 250 – 1000 mm Hg |
| Flow | | | | 0.35 - 2.5 LPM |
| S/R Ratio | | | | 1.14 – 1.18 |
| AGC Intensity | | | | 200,000 – 300,000 Hz |
| Motor Speed | | | | 100% |
| Test Analog Outputs* | | | | See note below |
| Option Switches** | | | | See note below |

* When the operator needs to set the analog output against the DAS, this function should be utilized. Please refer to page 3-41 to 3-44 of the owner's manual to initiate this feature.
* *The option switches are set at the factory. Please reference owner's manual, Page 3-62 "Service Mode Menu" on changing these options switches.

| Date | Comments and Notes |
|---|---|
| | |
| | |
| | |
| | |

**Figure A-1 TECO 48C-TLE Quality Control and Maintenance Record**