STANDARD OPERATING PROCEDURES

TELEDYNE - ADVANCED POLLUTION INSTRUMENTS

MODEL 300EU TRACE LEVEL

CARBON MONOXIDE 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. Carbon Monoxide originates from the partial oxidation of hydrocarbon fuels, coal and coke[1]. Carbon Monoxide affects the oxygen carrying capacity of the blood. Carbon Monoxide 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 Teledyne – Advanced Pollution Instruments (TAPI) model 300EU is a state of the science instrument for the determination of trace levels of Carbon Monoxide 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 300EU 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. Carbon Monoxide 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 Carbon Monoxide
Io = light intensity at zero Carbon Monoxide concentration
a = specific Carbon Monoxide molar absorption coefficient
x = path length, and
C = Carbon Monoxide 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 wavelength of light that CO absorbs to enter the sample cell. The GFC analyzer has a chopper wheel with two pure gases: Nitrogen and Carbon Monoxide. 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, TAPI 300EU can measure CO continuously. The 300EU version has four distinct features that allow it to measure CO at ppb levels:

- The sample stream is dried using permeation or Nafion™ Dryer;
- The analyzer baseline is determined and corrected using heated palladium catalytic converter;
- The baseline is frequently auto-zeroed, at a minimum once per hour, through the palladium converter;
- The instrument has an ultra-sensitive or "hot" detector.

The 300 EU 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 sample 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 palladium bed heated to 50^{o} Centrigrade to convert all Carbon Monoxide 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 usually takes between 7-10 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 300EU.

1. Carbon Monoxide 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 300EU, 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.
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 is a major concern. Gas cylinders can sometimes contain pressures as high as 2000 pounds per square inch (psi). 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. Carbon Monoxide 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 TAPI 3000EU is equipped with a Nafion™ drier, which effectively scrubs all water and water vapor. No maintenance is required on the dryer.

Carbon Dioxide: Carbon dioxide 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 CO_2 is much higher in concentration than CO, this UV spectral range must be avoided. To prevent light in this spectral region, the TAPI 300EU analyzer has a band pass filter that blocks these wavelengths.

3.7 Personal Qualifications

The person(s) chosen to operate the TAPI 300EU 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 300EU is identical to the 300E with several major variations. A diagram of the TAPI 300EU instrument is described in Figure 3-1. The three main components are:

- *Pneumatic System:* Consists of sample inlet line, particulate filter, 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. If the 300EU 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 TAPI 300EU operating manual, Appendix B for 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 300EU. This is detailed in the "Data Acquisition and Management SOP."

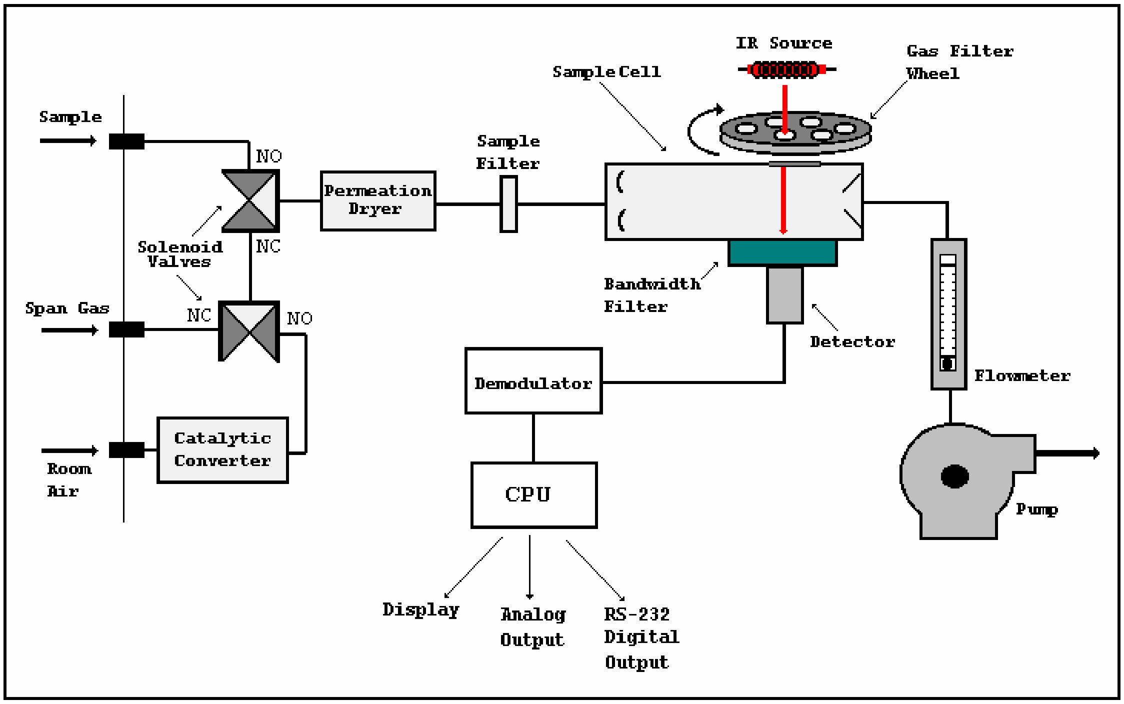

Figure 3-1 Schema of the Teledyne API 300EU

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 300EU bulkhead inlet. Examine and discard if particulate matter collects in the 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 TAPI 300EU 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 continuously drawing ambient air through a sample manifold directly into the analyzer 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: Carbon Monoxide samples receive no special preparation prior to analysis. Therefore this SOP does not have a section on Sample Handling and Preservation.

3.9.3 Instrument Operation, Startup and Maintenance

This section discusses startup, operation and maintenance of the 300EU. The TAPI 300EU series instrument has a digital front panel screen with toggle 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 user 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 TAPI 300EU owner's manual and read it carefully before adjusting any parameters that are set by the factory.**

3.9.3.1 Start up

1. Before the instrument is operated, inspect the instrument for any damage. If damage is observed to the shipping box or the instrument, contact your shipping personnel.
2. Carefully remove the cover and check for internal damage. Please see Section 3.1 of the TAPI 300EU manual.
3. Remove the 6 red shipping screws that hold down the internal bench and parts. See Section 3.1 of the TAPI 300EU manual.
4. Once you have removed the shipping screws and performed your inspection, replace the cover.
5. Plug the instrument into a grounded power strip that has surge protection. It is also advisable to purchase an Uninterrupted Power Supply (UPS). An UPS will protect the 300EU from power surges and keep the unit operating until an operator can shut it down.
6. Check to see that the 300EU has enough clearance so that it gets proper ventilation. Check the TAPI 300EU manual Section 3.1.
7. Connect the output of the analog to a DAS via shielded two wire cable. Please see EPA SOP on "Data Management" for details.
8. Connect the digital RS-232 port to an appropriate cable and connect it to the DAS. Please see EPA SOP on "Data Management" for further details.
9. Connect the sample inlet port to the station intake manifold.
10. Press the power rocker switch to "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. You will see in the upper right hand corner that the fault warning light will be flashing red. This is letting you know that the analyzer has been off.
2. To clear the fault warning, press the "CLR" button below the display. This will clear the warning and the sample green light will flash. If the red fault light continues to flash, and clearing it does not change this condition, then reference section 6.2.1 of the TAPI 300EU manual for instruction.
3. Once the red fault light is cleared, the operator will see the main menu. At this time, the time of day and date must be verified and reset if necessary.

4. From main menu press the toggle button under the “SETUP” label.
5. In this menu, you will see “8 1 8” on the bottom of the display. This is the default password. In addition, you will see on the top of the display the words “ENTER SETUP PASS:818.”
6. At this time, press the toggle under “ENTR.”
7. This will bring up the “PRIMARY SETUP MENU” screen.
8. In this menu, press the toggle button under “CLK.”
9. In the next menu, press the “TIME” toggle switch.
10. In the next menu, you will see the time above 3 or 4 toggle switches. Adjust these toggles so that the time is correct. Press the “ENTR” toggle switch.
11. This returns you to the “TIME OF DAY CLOCK” menu. Press the toggle switch under “DATE.”
12. This will put you in the date menu. You should see the day (digits), month and year (digits) above 5 toggle switches. Adjust these toggles until the correct date is obtained. Press the “ENTR” toggle switch. Press the “EXIT” toggle switch twice. This returns you to the main menu.
13. The range should be illustrated in the top middle of the main menu. This value should be set to 5000 ppb. If it is not set to this range, then it must be reset.
14. To change the range of the instrument, press the toggle under “SETUP.” If the password is correct, then press “ENTR.”
15. In this menu, you will see “8 1 8” on the bottom of the display. This is the default password. In addition, you will see on the top of the display the words “ENTER SETUP PASS:818.”
16. At this time, press the toggle under “ENTR.”
17. This will bring up the “PRIMARY SETUP MENU” screen.
18. Press the toggle switch under the “RNGE.”
19. This is the “RANGE CONTROL MENU.” Press the toggle switch under the “UNIT.”
20. This display will show the range options. Press the toggle under the “PPB.” Press the toggle under the “ENTR.”
21. This will put you into the “RANGE CONTROL MENU.” Press the toggle switch under the “SET.”
22. This display will show the full scale range value. Press the toggles under the digits to adjust the instrument to the full scale value desired. Press the toggle under the “ENTR.”
23. Press the “EXIT” toggle switch twice.
24. The instrument is now set with the appropriate time, date and full scale range.
25. It is recommended that you allow the 300EU 24 hours before you attempt function checks or calibration.
26. 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 300EU to a computer or DAS, review the Diagnostic Check from your computer screen. TAPI offers API.COM, a computer program that allows the operator to log the diagnostic data that is collected by the 300EU CPU. Several DAS manufacturers offer this type of software as well.

3.9.3.3 Diagnostic Checks/Manual Checks

To determine whether the 300EU 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. Below are instructions on how to perform this manually. Please note that the TAPI 300EU has set upper and lower ranges for some of these Diagnostic checks. Please reference the owner’s manual for these ranges.

1. If you observe the display, it should show “Sample” in the left hand corner, “Range” in the middle of the display and “CO= XX.XX.” Below this line there should be one line that read “<TST”, “TST>”, “CAL” and “SETUP.”

2. There is a series of toggle switches/ buttons below the display. These correspond to the bottom row of the display.

3. If you press the button below the left hand “<TST,” you will toggle the display into function check tree in one direction. The button under the “TST>,” will allow you to access the function check tree in the opposite direction.

4. Toggle through the function check tree. The following table illustrates the functions that should be recorded. Please see section 6.2.2 of the TAPI 300EU manual for more details. A manual check list on maintenance check sheet is attached in Appendix A of this SOP.

Table 3-2 Diagnostic Checks

Check	Explanation
Range	The full scale range of the instrument
Stabil	The standard deviation of CO concentrations for the last 25 readings
CO Meas	The demodulated peak of the IR detector output on the measure side of the wheel
CO Ref	The demodulated peak of the IR detector on the reference side of the wheel
MR ratio	The result of the CO meas/CO Ref
Azero ratio	The result of the CO meas/CO Ref during the Azero cycle
Sample Pres	The absolute pressure of the sample gas in the sample chamber
Sample FL	Mass flow rate of sample air
Sample Temp	The temperature of the gas inside the sample chamber
Bench Temp	Optical bench temperature
Wheel Temp	Filter wheel temperature
Box Temp	The temperature inside the instrument chassis.
PHT Drive	The voltage needed to the thermoelectric coolers of the IR detector board
Slope	The sensitivity of the instrument as calculated during the last calibration.
Offset	The overall offset of the instrument calculated during the last calibration
Time	Displays current time.

Once the Diagnostic checks have been established and recorded for the 300EU, 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 listed in the Model 300EU manual, section 9.1.

Table 3-3 Preventive Maintenance Schedule the TAPI 300EU

Item	Schedule
Replace particle filter	Weekly
Verify Test Function	Weekly
Perform Level I calibration	Daily
Pump Diaphragm	Bi-annually
Perform Leak Check	Annually
Inspect Pneumatic Lines	Annually
Clean inside of Chassis	As needed
Rebuild or replace pump	As needed
Replace IR source	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 TAPI 300EU manual has an excellent troubleshooting guide in Section 9.2. Please reference page 143 of the manual for details on using the Test Functions for predicting failures.

3.9.4 Calibration and Standardization

The calibration of the TAPI 300EU is performed by comparing the output of the instrument against standardized gases of known quality. Generation of these gases is detailed in the "Calibration of Trace Gas Analyzers" SOP. This section will detail how to adjust the 300EU 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.

3.9.4.1 Adjustment to Zero Air

In order to adjust the output of the 300EU 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 bottom of the front panel screen there is a toggle switch/ button that is beneath the "CAL" label. Press this button.
3. This next screen is the "M-P CAL" screen. In this screen press the button below the "ZERO" label.
4. The next screen will show an "ENTR, SPAN and CONC" above the toggle switches on the bottom of the panel. Press the button below the "ENTR" label. This operation changes the calculation equation and zeros the instrument.
5. Press the button below the "EXIT" label. This returns the operator to the main "SETUP" menu.

3.9.4.2 Adjustment to Calibration Gas

In order to adjust the output of the 300EU 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 bottom of the front panel screen of the main menu there is a button that is beneath the “CAL” label. Press this button.
3. This next screen is the “M-P CAL” screen. The next screen will show an “ENTR, SPAN and CONC” above the toggle switches on the bottom of the panel. Press the button below the “CONC” label. On the bottom line, there will be digits below each toggle button. In order to change the concentration, toggle each digit before and after the decimal place to get the concentration that is being generated in the manifold by the calibrator. At this time, press the “ENTR.”
4. At this time, press the toggle below the “SPAN” switch.
5. This operation changes the calculation equation and adjusts the slope of the instrument.
6. Press the button below the “EXIT” label. This returns the operator to the main “SETUP” menu.

3.10 Data Analysis and Calculations

Data analysis for this analyzer is detailed in the “Data Acquisition and Management” SOP. For the TAPI 300EU, there is one design detail of which the operator must be aware; the auto-zero (Azero) function. As detailed in Section 3.1, the TAPI 300EU has an Azero sequence that occurs at the end of the hour. During this period, the 300EU “freezes” the output to the CPU at the last value calculated by the CPU and the display will illustrate “AZERO.” During the auto-zero sequence, the display and analog output are “frozen” on one value. If the operator records the data via the analog output, then the operator must be aware of this sequence and flag this data in the DAS. The digital output via the RS-232 is flagged; therefore, no other flagging is required. The Azero 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 TAPI 300EU. Please note that this section deals primarily with the data quality indicators. Quality Control for continuous electronic instruments, such as the TAPI 300EU 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.

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 (250 – 500 ppb). 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 done in the National Performance Audit Program (NPAP). 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 audit device 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 TL-CO 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 TAPI 300EU 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 TAPI 300EU meets the MQOs for a TL-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 TAPI 300EU must be able to detect a minimum value of 0.020 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 Scale	40 CFR 58	N/A
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	0.020 ppm	National Monitoring Strategy	Testing is performed at the factory.

Table 4-2 Operating Parameters for the TAPI 300EU Trace Gas Instrument

Item	Range	Comments
Full Scale Range	0 to 5000 ppb	Suggested Range. Reduce to 1000 ppb if rural site
Units	Part per billion (ppb)	Recommended
Compressed Gas Cylinder	200 – 250 ppm	NIST Traceable Protocol #1 cylinder with CO concentration between 200 – 250 ppm.
Calibration Ranges		
a. zero	0 – 10 ppb	There are a number of commercially available vendors.
b. Level I Span	4000 – 5000 ppb	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	2000 – 2500 ppb	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	250 – 500 ppb	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
Teledyne API 300EU CO Analyzer

Site Name/Location________________________

Technician________________
Month/Year________________
Serial Number______________Range______________

Parameter	**Date**	**Date**	**Date**	**Acceptance Criteria**
Offset				
Slope				
PHT Drive				
Box Temp				
Wheel Temp				
Bench Temp				
Sample Temp				
Sample Flow				
Sample Pressure				
A-zero Ratio				
MR Ratio				
CO Reference				
CO Measured				
Stability				
Range				
Other Tests				
Dark Current				

Date	**Comments and Notes**

Figure A-1 Teledyne API 300 EU Quality Control and Maintenance Record