

(d) *Emission measurement accuracy—continuous sampling.* Analyzers used for continuous analysis must be operated such that the measured concentration falls between 15 and 100 percent of full-scale chart deflection. Exceptions to these limits are:

(1) The analyzer's response may be less than 15 percent or more than 100 percent of full scale if automatic range change circuitry is used and the limits for range changes are between 15 and 100 percent of full-scale chart deflection;

(2) The analyzer's response may be less than 15 percent of full scale if:

(i) The alternative in paragraph (c)(2) of this section is used to ensure that the accuracy of the calibration curve is maintained below 15 percent; or

(ii) The full-scale value of the range is 155 ppm (C) or less; or

(iii) The emissions from the engine are erratic and the integrated chart deflection value for the cycle is greater than 15 percent of full scale; or

(iv) The contribution of all data read below the 15 percent level is less than 10 percent by mass of the final test results.

§ 90.315 Analyzer initial calibration.

(a) *Warming-up time.* The warming-up time should be according to the recommendations of the manufacturer. If not specified, a minimum of two hours should be allowed for warming up the analyzers.

(b) *NDIR, FID, and HFID analyzer.* Tune and maintain the NDIR analyzer per the instrument manufacturer recommendations or specifications or using good engineering practice. The combustion flame of the FID or HFID analyzer must be optimized in order to meet the specifications in § 90.316(b).

(c) *Zero setting and calibration.* Using purified synthetic air (or nitrogen), set the CO, CO₂, NO_x, and HC analyzers at zero. Connect the appropriate calibrating gases to the analyzers and record the values. Use the same gas flow rates and pressure as when sampling exhaust.

(d) *Rechecking of zero setting.* Recheck the zero setting and, if necessary, repeat the procedure described in paragraph (c) of this section.

§ 90.316 Hydrocarbon analyzer calibration.

(a) Calibrate the FID and HFID hydrocarbon analyzer as described in this section. Operate the HFID to a set point ± 5.5 °C between 185 and 197 °C.

(b) *Initial and periodic optimization of detector response.* Prior to initial use and at least annually thereafter, adjust the FID and HFID hydrocarbon analyzer for optimum hydrocarbon response as specified in this paragraph. Alternative methods yielding equivalent results may be used, if approved in advance by the Administrator.

(1) Follow good engineering practices for initial instrument start-up and basic operating adjustment using the appropriate fuel (see § 90.312) and purified synthetic air or zero-grade nitrogen.

(2) Use of one of the following procedures is required for FID or HFID optimization:

(i) The procedure outlined in Society of Automotive Engineers (SAE) paper No. 770141, "Optimization of a Flame Ionization Detector for Determination of Hydrocarbon in Diluted Automotive Exhausts;" author, Glenn D. Reschke. This procedure has been incorporated by reference. See § 90.7.

(ii) The HFID optimization procedures outlined in § 86.331-79 of this chapter.

(iii) Alternative procedures may be used if approved in advance by the Administrator.

(3) After the optimum flow rates have been determined, record them for future reference.

(c) *Initial and periodic calibration.* Prior to initial use and monthly thereafter, or within one month prior to the certification test, the FID or HFID hydrocarbon analyzer must be calibrated on all normally used instrument ranges using the steps in this paragraph. Use the same flow rate and pressures as when analyzing samples. Introduce calibration gases directly at the analyzer. An optional method for dilute sampling described in § 86.1310-90(b)(3)(i) may be used.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with purified synthetic air or zero-grade nitrogen.

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(3) Calibrate on each used operating range with calibration gases having nominal concentrations between 10 and 90 percent of that range. A minimum of

six evenly spaced points covering at least 80 percent of the 10 to 90 range (64 percent) is required (see following table).

Example calibration points (%)	Acceptable for calibration?
20, 30, 40, 50, 60, 70	No, range covered is 50 percent, not 64.
20, 30, 40, 50, 60, 70, 80, 90	Yes.
10, 25, 40, 55, 70, 85	Yes.
10, 30, 50, 70, 90	No, though equally spaced and entire range covered, a minimum of six points are needed.

For each range calibrated, if the deviation from a least-squares best-fit straight line is two percent or less of the value at each data point, calculate concentration values by use of a single calibration factor for that range. If the deviation exceeds two percent at any point, use the best-fit non-linear equation which represents the data to within two percent of each test point to determine concentration.

(d) *Oxygen interference optimization.* Prior to initial use and monthly thereafter, perform the oxygen interference optimization as described in this paragraph. Choose a range where the oxygen interference check gases will fall in the upper 50 percent. Conduct the test, as outlined in this paragraph, with the oven temperature set as required by the instrument manufac-

turer. Oxygen interference check gas specifications are found in §90.312(d).

- (1) Zero the analyzer.
- (2) Span the analyzer with the 21 percent oxygen blend.
- (3) Recheck zero response. If it has changed more than 0.5 percent of full scale repeat paragraphs (d)(1) and (d)(2) of this section to correct the problem.
- (4) Introduce the five percent and 10 percent oxygen interference check gases.
- (5) Recheck the zero response. If it has changed by more than ± one percent of full scale, repeat the test.
- (6) Calculate the percent of oxygen interference (designated as percent O₂ I) for each mixture in paragraph (d)(4) of this section according to the following equation.

$$\text{Percent O}_2\text{I} = \frac{\text{B} - \text{Analyzer response (ppmC)}}{\text{B}} (100)$$

$$\text{Analyzer response} = \left(\frac{\text{A}}{\% \text{ of full-scale analyzer response due to A}} \right) \times (\% \text{ of full-scale analyzer response due to B})$$

Where:

A = hydrocarbon concentration (ppmC) of the span gas used in paragraph (d)(2) of this section.

B = hydrocarbon concentration (ppmC) of the oxygen interference check gases used in paragraph (d)(4) of this section.

(7) The percent of oxygen interference (designated as percent O₂ I)

must be less than ± three percent for all required oxygen interference check gases prior to testing.

(8) If the oxygen interference is greater than the specifications, incrementally adjust the air flow above and below the manufacturer's specifications, repeating paragraphs (d)(1)

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through (d)(7) of this section for each flow.

(9) If the oxygen interference is greater than the specification after adjusting the air flow, vary the fuel flow and thereafter the sample flow, repeating paragraphs (d)(1) through (d)(7) of this section for each new setting.

(10) If the oxygen interference is still greater than the specifications, repair or replace the analyzer, FID fuel, or burner air prior to testing. Repeat this section with the repaired or replaced equipment or gases.

§ 90.317 Carbon monoxide analyzer calibration.

(a) Calibrate the NDIR carbon monoxide analyzer as described in this section.

(b) *Initial and periodic interference.* Prior to its initial use and annually thereafter, check the NDIR carbon monoxide analyzer for response to water vapor and CO₂.

(1) Follow good engineering practices for instrument start-up and operation. Adjust the analyzer to optimize performance on the most sensitive range to be used.

(2) Zero the carbon monoxide analyzer with either purified synthetic air or zero-grade nitrogen.

(3) Bubble a mixture of three percent CO₂ in N₂ through water at room temperature and record analyzer response.

(4) An analyzer response of more than one percent of full scale for ranges above 300 ppm full scale or more than three ppm on ranges below 300 ppm full scale requires corrective action. (Use of conditioning columns is one form of corrective action which may be taken.)

(c) *Initial and periodic calibration.* Prior to its initial use and monthly thereafter, or within one month prior to the certification test, calibrate the NDIR carbon monoxide analyzer.

(1) Adjust the analyzer to optimize performance.

(2) Zero the carbon monoxide analyzer with either purified synthetic air or zero-grade nitrogen.

(3) Calibrate on each used operating range with carbon monoxide-in-N₂ calibration gases having nominal concentrations between 10 and 90 percent of that range. A minimum of six evenly spaced points covering at least 80 percent of the 10 to 90 range (64 percent) is required (see following table).

Example calibration points (%)	Acceptable for calibration?
20, 30, 40, 50, 60, 70	No, range covered is 50 percent, not 64.
20, 30, 40, 50, 60, 70, 80, 90	Yes.
10, 25, 40, 55, 70, 85	Yes.
10, 30, 50, 70, 90	No, though equally spaced and entire range covered, a minimum of six points are needed.

Additional calibration points may be generated. For each range calibrated, if the deviation from a least-squares best-fit straight line is two percent or less of the value at each data point, calculate concentration values by use of a single calibration factor for that range. If the deviation exceeds two percent at any point, use the best-fit non-linear equation which represents the data to within two percent of each test point to determine concentration.

§ 90.318 Oxides of nitrogen analyzer calibration.

(a) Calibrate the chemiluminescent oxides of nitrogen analyzer as described in this section.

(b) *Initial and Periodic Interference:* Prior to its initial use and monthly thereafter, or within one month prior to the certification test, check the chemiluminescent oxides of nitrogen analyzer for NO₂ to NO converter efficiency. Figure 1 in Appendix B of this subpart is a reference for paragraphs (b)(1) through (11) of this section:

(1) Follow good engineering practices for instrument start-up and operation. Adjust the analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with purified synthetic air or zero-grade nitrogen.

(3) Connect the outlet of the NO_x generator to the sample inlet of the oxides of nitrogen analyzer which has