

(6) Turn on the NO_x generator O₂ (or air) supply and adjust the O₂ (or air) flow rate so that the NO indicated by the analyzer is about 10 percent less than indicated in paragraph (a)(5) of this section. Record the concentration of NO in this NO + O₂ mixture.

(7) Switch the NO_x generator to the generation mode and adjust the generation rate so that the NO measured on the analyzer is 20 percent of that measured in paragraph (a)(5) of this section. There must be at least 10 percent unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NO_x mode and measure total NO_x. Record this value.

(9) Switch off the NO_x generator but maintain gas flow through the system. The oxides of nitrogen analyzer will indicate the NO_x in the NO + O₂ mixture. Record this value.

(10) Turn off the NO_x generator O₂ (or air) supply. The analyzer will now indicate the NO_x in the original NO-in-N₂ mixture. This value should be no more than 5 percent above the value indicated in paragraph (a)(4) of this section.

(11) Calculate the efficiency of the NO_x converter by substituting the concentrations obtained into the following equation:

$$\text{Percent efficiency} = \left(1 + \frac{a - b}{c - d} \right) \times 100$$

Where:

a = concentration obtained in paragraph (a)(8),

b = concentration obtained in paragraph (a)(9),

c = concentration obtained in paragraph (a)(6),

d = concentration obtained in paragraph (a)(7).

If converter efficiency is not greater than 90 percent corrective action will be required.

(b) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter, the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples. Proceed as follows:

(1) Adjust analyzer to optimize performance.

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

(3) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, NO-in-N₂ calibration gases (e.g., 15, 30, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

(c) The initial and periodic interference, system check, and calibration test procedures specified in 40 CFR part 86, subpart D, may be used in lieu of the procedures specified in this section.

(d) When testing methanol-fueled engines it may be necessary to clean the analyzer frequently to prevent interference with NO_x measurements (see EPA/60/S3-88/040).

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48144, Dec. 10, 1984; 58 FR 58426, Nov. 1, 1993; 60 FR 34374, June 30, 1995; 62 FR 47129, Sept. 5, 1997]

§ 86.1323-2007 Oxides of nitrogen analyzer calibration.

This section describes the initial and periodic calibration of the chemiluminescent oxides of nitrogen analyzer.

(a) Prior to introduction into service and at least monthly thereafter, the chemiluminescent oxides of nitrogen analyzer must be checked for NO₂ to NO converter efficiency. The Administrator may approve less frequent checks of the converter efficiency. Figure N84-9 is a reference for paragraphs (a) (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 zero-grade nitrogen.

(3) Connect the outlet of the NO_x generator to the sample inlet of the oxides of nitrogen analyzer, which has been set to the most common operating range.

(4) Introduce into the NO_x generator-analyzer system an NO-in-nitrogen (N₂) mixture with an NO concentration equal to approximately 80 percent of the most common operating range. The NO₂ content of the gas mixture shall be less than 5 percent of the NO concentration.

(5) With the oxides of nitrogen analyzer in the NO mode, record the concentration of NO indicated by the analyzer.

(6) Turn on the NO_x generator O₂ supply and adjust the O₂ flow rate so that the NO indicated by the analyzer is about 10 percent less than indicated in paragraph (a)(5) of this section. Record the concentration of NO in this NO + O₂ mixture.

(7) Switch the NO_x generator to the generation mode and adjust the generation rate so that the NO measured by the analyzer is 20 percent of that measured in paragraph (a)(5) of this section. There must be at least 10 percent unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NO_x mode and measure total NO_x. Record this value.

(9) Switch off the NO_x generator but maintain gas flow through the system. The oxides of nitrogen analyzer will indicate the NO_x in the NO + O₂ mixture. Record this value.

(10) Turn off the NO_x generator O₂ supply. The analyzer will now indicate the NO_x in the original NO-in-N₂ mixture. This value should be no more than 5 percent above the value indicated in paragraph (a)(4) of this section.

(11) Calculate the efficiency of the NO_x converter by substituting the concentrations obtained into the following equation:

$$\text{Percent - efficiency} = \left(1 + \frac{a - b}{c - d} \right) \times 100$$

Where:

a = concentration obtained in paragraph (a)(8) of this section,

b = concentration obtained in paragraph (a)(9) of this section,

c = concentration obtained in paragraph (a)(6) of this section,

d = concentration obtained in paragraph (a)(7) of this section.

(12) If converter efficiency is not greater than 90 percent, repair the analyzer. The repaired analyzer must achieve a converter efficiency greater than 90 percent before the analyzer may be used.

(b) *Accuracy.* The accuracy at the minimum limit of the NO_x analyzer is defined in § 86.1338-2007. In general the analyzer's minimum limit shall be the lowest concentration within a given range, in which it has an accuracy of ±2 percent of point.

(c) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter, the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples. Proceed as follows:

(1) Adjust analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero-grade nitrogen (N₂).

(3) (i) Calibrate all operating ranges with a minimum of 9 NO-in-N₂ calibration gases (*e.g.*, 10, 20, 30, 40, 50, 60, 70, 80, and 90 percent of that range) and one zero-grade N₂ gas. Sound engineering judgment shall dictate appropriate spacing and weighting of the calibration points.

(ii) For each range calibrated, if all deviations from a least-squares best-fit straight line are within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated using the linear calibration equation for that range. If the specified deviations are exceeded for ranges that have a minimum limit of 1 ppm or greater, then the best-fit non-linear equation that represents the data within these deviations may be used to determine concentration values. For ranges that have a minimum limit less than 1 ppm, only a linear or second order non-linear equation that represents the data within these deviations, may be used to determine concentration values.

(d) *Chemiluminescent NO_x analyzer interference check (i.e., quench check).*

Prior to its introduction into service and at least once per year thereafter, the quench check described in this section shall be performed on CLD NO_x analyzers. CO₂ and water vapor interfere with the response of a CLD by collisional quenching. The combined quench effect at their highest expected concentrations shall not exceed 2 percent.

(1) *CO₂ quench check procedure:* (i) For the procedure described in this paragraph, variations are acceptable provided that they produce equivalent %CO_{2quench} results. Connect a pressure-regulated CO₂ span gas to one of the inlets of a three-way valve. Its CO₂ concentration should be approximately twice the maximum CO₂ concentration expected during testing. The valve must be leak-free, and its wetted parts must be made of a stainless steel or other inert material. Connect a pressure-regulated zero-grade N₂ gas to the other inlet of the three-way valve. Connect the single outlet of the valve to the balance-gas port of a properly operating gas divider. Connect a pressure-regulated NO span gas, which has approximately twice the typical NO concentration expected during testing, to the span-port of the gas divider. Configure the gas divider such that nearly equal amounts of the span gas and balance gas are blended with each other. Viscosity corrections shall be applied appropriately to ensure correct mass flow determinations.

(ii) With the CO₂ flowing to the balance port and the NO flowing to the span port, measure a stable CO₂ concentration from the gas divider's outlet with a properly calibrated NDIR analyzer. Record this concentration in percent (%); this is "%CO₂". This value will be used in the water vapor quench check calculations that are detailed in the following section. After the %CO₂ measurement, measure the NO concentration at the gas divider outlet with the CLD analyzer in the NO mode. Record this concentration in ppm; this is "NO_{CO₂}". Then switch the three-way valve such that 100 percent N₂ flows to the balance port inlet. Monitor the CO₂ concentration of the gas divider's outlet until its concentration stabilizes at zero. Then measure the stable NO concentration from the gas divider's out-

let. Record this value in ppm; this is "NO_{N₂}". Calculate %CO_{2quench} as follows:

$$\%CO_{2quench} = (1.00 - (NO_{CO_2}/NO_{N_2})) \times 100$$

(2) Water vapor quench check procedure:

(i) For all dry CLD analyzers it must be demonstrated that for the highest expected water vapor concentration (*i.e.*, "%H₂O_{exp}" as calculated later in this section), the water removal technique maintains CLD humidity at less than or equal to 5 g_{water}/kg_{dry air} (or about 0.008 percent H₂O), which is 100% RH at 3.9 °C and 101.3 kPa. This humidity specification is also equivalent to about 25% RH at 25 °C and 101.3 kPa. This may be demonstrated by measuring the temperature at the outlet of a thermal dehumidifier, or by measuring humidity at a point just upstream of the CLD. Humidity of the CLD exhaust might also be measured as long as the only flow into the CLD is the flow out of the dehumidifier.

(ii) For all "wet" CLD analyzers the following water vapor quench check procedure shall be followed. Measure an NO span gas, which has 90% to 100% of the typical NO expected during testing, using the CLD in the NO mode. Record this concentration in ppm; this is "NO_{dry}". Then bubble the same NO span gas through distilled water in a sealed vessel at 25 °C ±10 °C. This temperature specification imposed to ensure that the H₂O_{vol} calculation (refer to (iii) of this section) returns an accurate result. To prevent subsequent condensation, this temperature must also be less than any temperature that the wetted sample will experience between the sealed vessel's outlet and the CLD. Record the vessel's water temperature in °C; this is "T_{sat}". Record the vessel's absolute pressure in kPa; this is "P_{sat}". Measure the wetted span gas with the CLD, and record this value in ppm; this is "NO_{wet}".

(iii) Calculations for water quench must consider dilution of the NO span gas with water vapor and scaling of the water vapor concentration to that expected during testing.

(A) Calculate the volume fraction of water vapor in the wetted span gas, as $H_2O_{vol} = (\exp(3.69 - (81.28/T_{sat})) + 1.61)/P_{sat}$. This calculation approximates some of the thermodynamic properties of water

based on the “1995 Formulation for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use”, issued by The International Association for the Properties of Water and Steam (IAPWS). However, this approximation should only be used as prescribed in this section because it is an exponential fit that is accurate for data at 25 °C ±10 °C. Then, assuming a diesel fuel atomic hydrogen to carbon ratio of 1.8, and an intake and dilution air humidity of 75 grains (10.71 g_{water}/kg_{dry air} or 54.13 percent RH at 25 °C and 101.3 kPa),

(B) Calculate the maximum percent water vapor expected during testing; as $\%H_2O_{exp} = (0.90 \times \%CO_2) + 1.69$. $\%CO_2$ is the value measured during the $\%CO_2$ quench check.

(C) Calculate the expected wet concentration of NO in ppm; as $NO_{exp} = NO_{dry} \times (1.00 - H_2O_{vol})$

(iv) Calculate the percent water vapor quench as:

$$\%H_2O_{quench} = ((NO_{exp} - NO_{wet})/NO_{exp}) \times (\%H_2O_{exp}/H_2O_{vol})$$

(3) Add the $\%CO_{2quench}$ and the $\%H_2O_{quench}$ values. Their sum may not exceed the limit set in paragraph (d). If their sum is greater than this limit, then the CLD instrument may not be used to perform testing unless it is repaired. The analyzer must be shown to pass this quench check after the repair before it may be used for testing.

[66 FR 5182, Jan. 18, 2001]

§ 86.1324-84 Carbon dioxide analyzer calibration.

Prior to its introduction into service and monthly thereafter, the NDIR carbon dioxide analyzer shall be calibrated as follows:

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

(b) Zero the carbon dioxide analyzer with either zero-grade air or zero-grade nitrogen.

(c) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, carbon dioxide-in-N₂ calibration or span gases (e.g., 15, 30, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-

fit straight line is within ±2 percent or less of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated by using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

(d) The initial and periodic interference, system check, and calibration test procedures specified in 40 CFR part 86, subpart D, may be used in lieu of the procedures in this section.

[48 FR 52210, Nov. 16, 1983, as amended at 62 FR 47129, Sept. 5, 1997]

§ 86.1325-94 Methane analyzer calibration.

Prior to introduction into service and monthly thereafter, the methane analyzer shall be calibrated:

(a) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(b) Zero the methane analyzer with zero-grade air.

(c) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, CH₄ in air calibration gases (e.g., 15, 40, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated by using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

[59 FR 48531, Sept. 21, 1994, as amended at 62 FR 47129, Sept. 5, 1997]

§ 86.1326-90 Calibration of other equipment.

Other test equipment used for testing shall be calibrated as often as required by the manufacturer or as necessary according to good practice. Specific equipment requiring calibration is the