concentration of 80 to 100 percent of full scale of a normal operating range shall be passed through the CLD (or HCLD) and the response recorded as D. The NO span gas shall then be bubbled through water at room temperature and passed through the CLD (or HCLD) and the analyzer response recorded as AR. Determine and record the bubbler absolute operating pressure and the bubbler water temperature. (It is important that the NO span gas contains minimal NO_2 concentration for this check. No allowance for absorption of NO_2 in water has been made in the following quench calculations. This test may be optionally run in the NO mode to minimize the effect of any NO_2 in the NO span gas.)

(ii) Calculations for water quench must consider dilution of the NO span gas with water vapor and scaling of the water vapor concentration of the mixture to that expected during testing. Determine the mixture's saturated vapor pressure (designated as *Pwb*) that corresponds to the bubbler water temperature. Calculate the water concentration (Z1, percent) in the mixture by the following equation:

$$Z1 = 100 \times \frac{Pwb}{GP}$$

where

GP = analyzer operating pressure (Pa)

(iii) Calculate the expected dilute NO span gas and water vapor mixture concentration (designated as *D1*) by the following equation:

$$D1 = D \times \left(1 - \frac{Z1}{100}\right)$$

(iv)(A) The maximum raw or dilute exhaust water vapor concentration expected during testing (designated as Wm) can be estimated from the CO_2 span gas (or as defined in the equation in this paragraph and designated as A) criteria in paragraph (c)(1) of this section and the assumption of a fuel atom H/C ratio of 1.8:1 as:

$Wm(\%) = 0.9 \times A(\%)$

Where:

A = maximum CO2 concentration expected in the sample system during testing.

(B) Percent water quench shall not exceed 3 percent and shall be calculated by:

$$\%\text{Water Quench} = 100 \times \frac{D1 - AR}{D1} \times \frac{Wm}{Z1}$$

[59 FR 31335, June 17, 1994. Redesignated and amended at 63 FR 56995, 57011, Oct. 23, 1998; 63 FR 58101, Oct. 29, 1998]

§ 89.319 Hydrocarbon analyzer calibration.

(a) The FID hydrocarbon analyzer shall receive the initial and periodic calibration as described in this section. The HFID used with petroleum-fueled diesel (compression-ignition) engines shall be operated to a set point ±5.5 °C between 185 and 197 °C.

(b) *Initial and periodic optimization of detector response.* Prior to introduction into service and at least annually thereafter, adjust the FID hydrocarbon analyzer for optimum hydrocarbon response as specified in this paragraph. Alternate 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 § 89.312(e)) and zero-grade air.

(2) Optimize the FID's response on the most common operating range. The response is to be optimized with respect to fuel pressure or flow. Efforts shall be made to minimize response variations to different hydrocarbon species that are expected to be in the exhaust. Good engineering judgment is

to be used to trade off optimal FID response to propane-in-air against reductions in relative responses to other hydrocarbons. A good example of trading off response on propane for relative responses to other hydrocarbon species is given in Society of Automotive Engineers (SAE) Paper No. 770141, ‘‘Optimization of Flame Ionization Detector for Determination of Hydrocarbon in Diluted Automotive Exhausts’’; author Glenn D. Reschke. It is also required that the response be set to optimum condition with respect to air flow and sample flow. Heated Flame Ionization Detectors (HFIDs) must be at their specified operating temperature. 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 at § 89.6.

(ii) The HFID optimization procedures outlined in 40 CFR part 1065, subpart D.

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

(iv) The procedures specified by the manufacturer of the FID or HFID.

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

(c) *Initial and periodic calibration.* Prior to introduction into service, after any maintenance which could alter calibration, and monthly thereafter, the FID or HFID hydrocarbon analyzer shall be calibrated on all normally used instrument ranges using the steps in this paragraph (c). Use the same flow rate and pressures as when analyzing samples. Calibration gases shall be introduced directly at the analyzer, unless the ‘‘overflow’’ calibration option of 40 CFR part 1065, subpart F, for the HFID is taken. New calibration curves need not be generated each month if the existing curve can be verified as continuing to meet the requirements of paragraph (c)(3) of this section.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with zero-grade air.

(3) Calibrate on each used operating range with propane-in-air (dilute or raw) or propane-in-nitrogen (raw) calibration gases having nominal concentrations starting between 10–15 percent and increasing in at least six incremental steps to 90 percent (e.g., 15, 30, 45, 60, 75, and 90 percent of that range) of that range. The incremental steps are to be spaced to represent good engineering practice. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each data point, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds 2 percent at each non-zero data point and within ±0.3 percent of full scale on the zero, the best-fit non-linear equation which represents the data to within these limits shall be used to determine concentration.

(d) *Oxygen interference optimization (required for raw).* 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 manufacturer. Oxygen interference check gas specifications are found in § 89.312(d).

(1) Zero the analyzer.

(2) Span the analyzer with the 21% oxygen interference gas specified in § 89.312(d).

(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 problem.

(4) Introduce the 5 percent and 10 percent oxygen interference check gases.

(5) Recheck the zero response. If it has changed more ±1 percent of full scale, repeat the test.

(6) Calculate the percent of oxygen interference (designated as percent O_2I) for each mixture in paragraph (d)(4) of this section.

$$\text{percent } O_2I = ((B - C) \times 100)/B$$

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.

C = analyzer response (ppmC) = A/D; where

D = (percent of full-scale analyzer response due to A) × (percent of full-scale analyzer response due to B)

[59 FR 31335, June 17, 1994. Redesignated and amended at 63 FR 56995, 57011, Oct. 23, 1998; 70 FR 40445, July 13, 2005]

§ 89.320 Carbon monoxide analyzer calibration.

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

(b) *Initial and periodic interference check.* Prior to its introduction into service and annually thereafter, the NDIR carbon monoxide analyzer shall be checked for response to water vapor and CO_2 in accordance with § 318.96(b).

(c) *Initial and periodic calibration.* Prior to its introduction into service, after any maintenance which could alter calibration, and every two months thereafter, the NDIR carbon monoxide analyzer shall be calibrated. New calibration curves need not be generated every two months if the existing curve can be verified as continuing to meet the requirements of paragraph (c)(3) of this section.

(1) Adjust the analyzer to optimize performance.

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

(3) Calibrate on each used operating range with carbon monoxide-in-N_2 calibration gases having nominal concentrations starting between 10 and 15 percent and increasing in at least six incremental steps to 90 percent (e.g., 15, 30, 45, 60, 75, and 90 percent) of that range. The incremental steps are to be spaced to represent good engineering practice. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each non-zero data point and within ± 0.3 percent of full scale on the zero, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds these limits, the best-fit non-linear equation which represents the data to within these limits shall be used to determine concentration.

(d) The initial and periodic interference, system check, and calibration test procedures specified in 40 CFR part 1065 may be used in lieu of the procedures specified in this section.

[59 FR 31335, June 17, 1994. Redesignated and amended at 63 FR 56995, 57012, Oct. 23, 1998; 70 FR 40445, July 13, 2005]

§ 89.321 Oxides of nitrogen analyzer calibration.

(a) The chemiluminescent oxides of nitrogen analyzer shall receive the initial and periodic calibration described in this section.

(b) Prior to its introduction into service, and monthly thereafter, the chemiluminescent oxides of nitrogen analyzer is checked for NO_2 to NO converter efficiency according to § 89.317.

(c) *Initial and periodic calibration.* Prior to its introduction into service, after any maintenance which could alter calibration, and monthly thereafter, the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. New calibration curves need not be generated each month if the existing curve can be verified as continuing to meet the requirements of paragraph (c)(3) of this section. 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 normally used operating range with NO-in-N_2 calibration gases with nominal concentrations starting at between 10 and 15 percent and increasing in at least six incremental steps to 90 percent (e.g., 15, 30, 45, 60, 75, and 90 percent) of that range. The incremental steps are to be spaced to represent good engineering practice. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 percent or less of the value at each non-zero data point and within ± 0.3 percent of full scale on the zero, concentration values may be calculated by use of a single calibration factor for that range. If the deviation exceeds these limits, the best-fit non-linear equation which represents the data to within these limits shall be used to determine concentration.