

(e) *Procedure for a FID calibrated by bypassing the NMC.* If you use a FID with an NMC that is calibrated by bypassing the NMC, determine penetration fractions as follows:

(1) Select CH<sub>4</sub> and C<sub>2</sub>H<sub>6</sub> analytical gas mixtures that meet the specifications of § 1065.750 with the CH<sub>4</sub> concentration typical of its peak concentration expected at the hydrocarbon standard and the C<sub>2</sub>H<sub>6</sub> concentration typical of the peak total hydrocarbon (THC) concentration expected at the hydrocarbon standard or the THC analyzer span value.

(2) Start and operate the nonmethane cutter according to the manufacturer's instructions, including any temperature optimization.

(3) Confirm that the FID analyzer meets all the specifications of § 1065.360.

(4) Start and operate the FID analyzer according to the manufacturer's instructions.

(5) Zero and span the FID as you would during emission testing. Span the FID by bypassing the cutter and by using C<sub>3</sub>H<sub>8</sub> span gas to span the FID. Note that you must span the FID on a C<sub>1</sub> basis. For example, if your span gas has a propane reference value of 100 μ/mol, the correct FID response to that span gas is 300 μ/mol because there are three carbon atoms per C<sub>3</sub>H<sub>8</sub> molecule.

(6) Introduce the C<sub>2</sub>H<sub>6</sub> analytical gas mixture upstream of the nonmethane cutter.

(7) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the nonmethane cutter and to account for the analyzer's response.

(8) While the analyzer measures a stable concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these data points.

(9) Reroute the flow path to bypass the nonmethane cutter, introduce the C<sub>2</sub>H<sub>6</sub> analytical gas mixture to the bypass, and repeat the steps in paragraphs (e)(7) through (8) of this section.

(10) Divide the mean C<sub>2</sub>H<sub>6</sub> concentration measured through the nonmethane cutter by the mean concentration measured after bypassing the nonmethane cutter. The result is the C<sub>2</sub>H<sub>6</sub> penetration fraction,  $PF_{C_2H_6}$ . Use this penetration fraction according to § 1065.660 or § 1065.665, as applicable.

(11) Repeat the steps in paragraphs (e)(6) through (10) of this section, but with the CH<sub>4</sub> analytical gas mixture instead of C<sub>2</sub>H<sub>6</sub>. The result will be the CH<sub>4</sub> penetration fraction,  $PF_{CH_4}$ . Use this penetration fraction according to § 1065.660 or § 1065.665, as applicable.

#### NO<sub>x</sub> MEASUREMENTS

##### § 1065.370 CLD CO<sub>2</sub> and H<sub>2</sub>O quench verification.

(a) *Scope and frequency.* If you use a CLD analyzer to measure NO<sub>x</sub>, verify the amount of H<sub>2</sub>O and CO<sub>2</sub> quench after installing the CLD analyzer and after major maintenance.

(b) *Measurement principles.* H<sub>2</sub>O and CO<sub>2</sub> can negatively interfere with a CLD's NO<sub>x</sub> response by collisional quenching, which inhibits the chemiluminescent reaction that a CLD utilizes to detect NO<sub>x</sub>. The calculations in § 1065.672 for H<sub>2</sub>O quench account for the water vapor in humidified NO span gas. The procedure and the calculations scale the quench results to the water vapor and CO<sub>2</sub> concentrations expected during testing. If the CLD analyzer uses quench compensation algorithms that utilize H<sub>2</sub>O and/or CO<sub>2</sub> measurement instruments, use these instruments to measure H<sub>2</sub>O and/or CO<sub>2</sub> and evaluate quench with the compensation algorithms applied.

(c) *System requirements.* A CLD analyzer must have a combined H<sub>2</sub>O and CO<sub>2</sub> quench of ±2% or less, though we strongly recommend a quench of ±1% or less. Combined quench is the sum of the CO<sub>2</sub> quench determined as described in paragraph (d) of this section, plus the H<sub>2</sub>O quench determined in paragraph (e) of this section.

(d) *CO<sub>2</sub> quench verification procedure.* Use the following method to determine CO<sub>2</sub> quench, or use good engineering judgment to develop a different protocol:

(1) Use PTFE tubing to make necessary connections.

(2) Connect a pressure-regulated CO<sub>2</sub> span gas to one of the inlets of a three-way valve made of 300 series stainless steel. Use a CO<sub>2</sub> span gas that meets the specifications of § 1065.750 and attempt to use a concentration that is approximately twice the maximum CO<sub>2</sub> concentration expected to enter the

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CLD sample port during testing, if available.

(3) Connect a pressure-regulated purified N<sub>2</sub> gas to the valve's other inlet. Use a purified N<sub>2</sub> gas that meets the specifications of § 1065.750.

(4) Connect the valve's single outlet to the balance-gas port of a gas divider that meets the specifications in § 1065.248.

(5) Connect a pressure-regulated NO span gas to the span-port of the gas divider. Use an NO span gas that meets the specifications of § 1065.750. Attempt to use an NO concentration that is approximately twice the maximum NO concentration expected during testing, if available.

(6) Configure the gas divider such that nearly equal amounts of the span gas and balance gas are blended with each other. Apply viscosity corrections as necessary to appropriately ensure correct gas division.

(7) While flowing balance and span gases through the gas divider, stabilize the CO<sub>2</sub> concentration downstream of the gas divider and measure the CO<sub>2</sub> concentration with an NDIR analyzer that has been prepared for emission testing. Record this concentration,  $x_{CO_2meas}$ , and use it in the quench verification calculations in § 1065.675.

(8) Measure the NO concentration downstream of the gas divider. If the CLD has an operating mode in which it detects NO-only, as opposed to total NO<sub>x</sub>, operate the CLD in the NO-only operating mode. Record this concentration,  $x_{NO,CO_2}$ , and use it in the quench verification calculations in § 1065.675.

(9) Switch the three-way valve so 100% purified N<sub>2</sub> flows to the gas divider's balance-port inlet. Monitor the CO<sub>2</sub> at the gas divider's outlet until its concentration stabilizes at zero.

(10) Measure NO concentration at the gas divider's outlet. Record this value,  $x_{NO,N_2}$ , and use it in the quench verification calculations in § 1065.675.

(11) Use the values recorded according to this paragraph (d) of this section and paragraph (e) of this section to calculate quench as described in § 1065.675.

(e) *H<sub>2</sub>O quench verification procedure.* Use the following method to determine H<sub>2</sub>O quench, or use good engineering judgment to develop a different protocol:

(1) Use PTFE tubing to make necessary connections.

(2) If the CLD has an operating mode in which it detects NO-only, as opposed to total NO<sub>x</sub>, operate the CLD in the NO-only operating mode.

(3) Measure an NO calibration span gas that meets the specifications of § 1065.750 and is near the maximum concentration expected during testing. Record this concentration,  $x_{NOdry}$ .

(4) Humidify the gas by bubbling it through distilled water in a sealed vessel. We recommend that you humidify the gas to the highest sample dewpoint that you estimate during emission sampling. Regardless of the humidity during this test, the quench verification calculations in § 1065.675 scale the recorded quench to the highest dewpoint that you expect entering the CLD sample port during emission sampling.

(5) If you do not use any sample dryer for NO<sub>x</sub> during emissions testing, record the vessel water temperature as  $T_{dew}$ , and its pressure as  $p_{total}$  and use these values according to § 1065.645 to calculate the amount of water entering the CLD sample port,  $x_{H_2Omeas}$ . If you do use a sample dryer for NO<sub>x</sub> during emissions testing, measure the humidity of the sample just upstream of the CLD sample port and use the measured humidity according to § 1065.645 to calculate the amount of water entering the CLD sample port,  $x_{H_2Omeas}$ .

(6) To prevent subsequent condensation, make sure that any humidified sample will not be exposed to temperatures lower than  $T_{dew}$  during transport from the sealed vessel's outlet to the CLD. We recommend using heated transfer lines.

(7) Introduce the humidified sample upstream of any sample dryer, if one is used.

(8) Use the CLD to measure the NO concentration of the humidified span gas and record this value,  $x_{NOwet}$ .

(9) Use the recorded values from this paragraph (e) to calculate the quench as described in § 1065.675.

(10) Use the values recorded according to this paragraph (e) of this section and paragraph (d) of this section to calculate quench as described in § 1065.675.

(f) *Corrective action.* If the sum of the H<sub>2</sub>O quench plus the CO<sub>2</sub> quench is not

within  $\pm 2\%$ , take corrective action by repairing or replacing the analyzer. Before using a CLD for emission testing, demonstrate that the corrective action resulted in a value within  $\pm 2\%$  combined quench.

(g) *Exceptions.* The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your  $\text{NO}_x$  sampling system and your emission calculations procedures, the combined  $\text{CO}_2$  and  $\text{H}_2\text{O}$  interference for your  $\text{NO}_x$  CLD analyzer always affects your brake-specific  $\text{NO}_x$  emission results within no more than  $\pm 1.0\%$  of the applicable  $\text{NO}_x$  standard.

(2) You may use a  $\text{NO}_x$  CLD analyzer that you determine does not meet this verification, as long as you try to correct the problem and the measurement deficiency does not adversely affect your ability to show that engines comply with all applicable emission standards.

**§ 1065.372 NDUV analyzer HC and  $\text{H}_2\text{O}$  interference verification.**

(a) *Scope and frequency.* If you measure  $\text{NO}_x$  using an NDUV analyzer, verify the amount of  $\text{H}_2\text{O}$  and hydrocarbon interference after initial analyzer installation and after major maintenance.

(b) *Measurement principles.* Hydrocarbons and  $\text{H}_2\text{O}$  can positively interfere with an NDUV analyzer by causing a response similar to  $\text{NO}_x$ . If the NDUV analyzer uses compensation algorithms that utilize measurements of other gases to meet this interference verification, simultaneously conduct such measurements to test the algorithms during the analyzer interference verification.

(c) *System requirements.* A  $\text{NO}_x$  NDUV analyzer must have combined  $\text{H}_2\text{O}$  and HC interference within  $\pm 2\%$  of the flow-weighted mean concentration of  $\text{NO}_x$  expected at the standard, though we strongly recommend keeping interference within  $\pm 1\%$ .

(d) *Procedure.* Perform the interference verification as follows:

(1) Start, operate, zero, and span the  $\text{NO}_x$  NDUV analyzer according to the instrument manufacturer's instructions.

(2) We recommend that you extract engine exhaust to perform this verification. Use a CLD that meets the specifications of subpart C of this part to quantify  $\text{NO}_x$  in the exhaust. Use the CLD response as the reference value. Also measure HC in the exhaust with a FID analyzer that meets the specifications of subpart C of this part. Use the FID response as the reference hydrocarbon value.

(3) Upstream of any sample dryer, if one is used during testing, introduce the engine exhaust to the NDUV analyzer.

(4) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the transfer line and to account for analyzer response.

(5) While all analyzers measure the sample's concentration, record 30 seconds of sampled data, and calculate the arithmetic means for the three analyzers.

(6) Subtract the CLD mean from the NDUV mean.

(7) Multiply this difference by the ratio of the flow-weighted mean HC concentration expected at the standard to the HC concentration measured during the verification. The analyzer meets the interference verification of this section if this result is within  $\pm 2\%$  of the HC concentration expected at the standard.

(e) *Exceptions.* The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your  $\text{NO}_x$  sampling system and your emission calculations procedures, the combined HC and  $\text{H}_2\text{O}$  interference for your  $\text{NO}_x$  NDUV analyzer always affects your brake-specific  $\text{NO}_x$  emission results by less than 0.5% of the applicable  $\text{NO}_x$  standard.

(2) You may use a  $\text{NO}_x$  NDUV analyzer that you determine does not meet this verification, as long as you try to correct the problem and the measurement deficiency does not adversely affect your ability to show that engines comply with all applicable emission standards.

**§ 1065.376 Chiller  $\text{NO}_2$  penetration.**

(a) *Scope and frequency.* If you use a chiller to dry a sample upstream of a