(4) If the sample is not passed through a dryer during this verification test, measure the $\text{H}_2\text{O}$ mole fraction, $x_{\text{H}_2\text{O}}$, of the humidified CO$_2$ test gas as close as possible to the inlet of the analyzer. For example, measure dewpoint, $T_{\text{dew}}$, and absolute pressure, $p_{\text{total}}$, to calculate $x_{\text{H}_2\text{O}}$. Verify that the H$_2$O content meets the requirement in paragraph (d)(2) of this section. If the sample is passed through a dryer during this verification test, you must verify that the H$_2$O content of the humidified test gas downstream of the vessel meets the requirement in paragraph (d)(2) of this section based on either direct measurement of the H$_2$O content (e.g., dewpoint and pressure) or an estimate based on the vessel pressure and temperature. Use good engineering judgment to estimate the H$_2$O content. For example, you may use previous direct measurements of H$_2$O content to verify the vessel’s level of saturation.

(5) If a sample dryer is not used in this verification test, use good engineering judgment to prevent condensation in the transfer lines, fittings, or valves from the point where $x_{\text{H}_2\text{O}}$ is measured to the analyzer. We recommend that you design your system so that the wall temperatures in the transfer lines, fittings, and valves from the point where $x_{\text{H}_2\text{O}}$ is measured to the analyzer are at least 5 °C above the local sample gas dewpoint.

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

(7) While the analyzer measures the sample’s concentration, record its output for 30 seconds. Calculate the arithmetic mean of this data.

(8) The analyzer meets the interference verification if the result of paragraph (d)(7) of this section meets the tolerance in paragraph (c) of this section.

(9) You may also run interference procedures for CO$_2$ and H$_2$O separately. If the CO$_2$ and H$_2$O levels used are higher than the maximum levels expected during testing, you may scale down each observed interference value by multiplying the observed interference by the ratio of the maximum expected concentration value to the actual value used during this procedure. You may run separate interference concentrations of H$_2$O (down to 0.025 mol/mol H$_2$O content) that are lower than the maximum levels expected during testing, but you must scale up the observed H$_2$O interference by multiplying the observed interference by the ratio of the maximum expected H$_2$O concentration value to the actual value used during this procedure. The sum of the two scaled interference values must meet the tolerance in paragraph (c) of this section.

(e) Exceptions. The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your CO sampling system and your emission-calculation procedures, the combined CO$_2$ and H$_2$O interference for your CO NDIR analyzer always affects your brake-specific CO emission results within ±0.5% of the applicable CO standard.

(2) You may use a CO NDIR 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.


### Hydrocarbon Measurements

§ 1065.360 FID optimization and verification.

(a) Scope and frequency. For all FID analyzers, calibrate the FID upon initial installation. Repeat the calibration as needed using good engineering judgment. For a FID that measures THC, perform the following steps:

(1) Optimize the response to various hydrocarbons after initial analyzer installation and after major maintenance as described in paragraph (c) of this section.

(2) Determine the methane (CH$_4$) response factor after initial analyzer installation and after major maintenance as described in paragraph (d) of this section.
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(3) Verify the CH₄ response within 185 days before testing as described in paragraph (e) of this section.

(b) Calibration. Use good engineering judgment to develop a calibration procedure, such as one based on the FID analyzer manufacturer’s instructions and recommended frequency for calibrating the FID. Alternately, you may remove system components for off-site calibration. For a FID that measures THC, calibrate using C₃H₆ calibration gases that meet the specifications of §1065.750. For a FID that measures CH₄, calibrate using CH₄ calibration gases that meet the specifications of §1065.750. We recommend FID analyzer zero and span gases that contain approximately the flow-weighted mean concentration of O₂ expected during testing. If you use a FID to measure CH₄ downstream of a nonmethane cutter, you may calibrate that FID using CH₄ calibration gases with the cutter.

Regardless of the calibration gas composition, calibrate on a carbon number basis of one (C₁). For example, if you use a C₂H₆ span gas of concentration 200 µmol/mol, span the FID to respond with a value of 600 µmol/mol. As another example, if you use a CH₄ span gas with a concentration of 200 µmol/mol, span the FID to respond with a value of 200 µmol/mol.

(c) THC FID response optimization. This procedure is only for FID analyzers that measure THC. Since FID analyzers generally have a different response to CH₄ versus C₃H₆, determine each THC-FID analyzer’s CH₄ response factor, \(RF_{CH₄[THC-FID]}\), after FID optimization. Use the most recent \(RF_{CH₄[THC-FID]}\) measured according to this section in the calculations for HC concentration described in §1065.660 to compensate for CH₄ response. Determine \(RF_{CH₄[THC-FID]}\) as follows, noting that you do not determine \(RF_{CH₄[THC-FID]}\) for FIDs that are calibrated and spanned using CH₄ with a nonmethane cutter:

(1) Select a C₁H₆ span gas concentration that you use to span your analyzers before emission testing. Use only span gases that meet the specifications of §1065.750. Record the C₁H₆ concentration of the gas.

(2) Select a CH₄ span gas concentration that you use to span your analyzers before emission testing. Use only span gases that meet the specifications of §1065.750. Record the CH₄ concentration of the gas.

(3) Start and operate the FID analyzer according to the manufacturer’s instructions.

(4) Confirm that the FID analyzer has been calibrated using C₁H₆. Calibrate on a carbon number basis of one (C₁). For example, if you use a C₂H₆ span gas of concentration 200 µmol/mol, span the FID to respond with a value of 600 µmol/mol.

(5) Zero the FID with a zero gas that you use for emission testing.

(6) Span the FID with the C₁H₆ span gas that you selected under paragraph (d)(1) of this section.

(7) Introduce at the sample port of the FID analyzer, the CH₄ span gas that you selected under paragraph (d)(2) of this section.

(8) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the analyzer and to account for its response.

(9) While the analyzer measures the CH₄ concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these values.

sures for FID fuel, burner air, and sample and record them for future reference.

(d) THC FID CH₄ response factor determination. This procedure is only for FID analyzers that measure THC. If you use a FID to measure CH₄ and cannot determine each THC–FID analyzer’s CH₄ response factor, \(RF_{CH₄[THC-FID]}\), after FID optimization. Use the most recent \(RF_{CH₄[THC-FID]}\) measured according to this section in the calculations for HC concentration described in §1065.660 to compensate for CH₄ response. Determine \(RF_{CH₄[THC-FID]}\) as follows, noting that you do not determine \(RF_{CH₄[THC-FID]}\) for FIDs that are calibrated and spanned using CH₄ with a nonmethane cutter:

(1) Select a C₁H₆ span gas concentration that you use to span your analyzers before emission testing. Use only span gases that meet the specifications of §1065.750. Record the C₁H₆ concentration of the gas.

(2) Select a CH₄ span gas concentration that you use to span your analyzers before emission testing. Use only span gases that meet the specifications of §1065.750. Record the CH₄ concentration of the gas.

(3) Start and operate the FID analyzer according to the manufacturer’s instructions.

(4) Confirm that the FID analyzer has been calibrated using C₁H₆. Calibrate on a carbon number basis of one (C₁). For example, if you use a C₂H₆ span gas of concentration 200 µmol/mol, span the FID to respond with a value of 600 µmol/mol.

(5) Zero the FID with a zero gas that you use for emission testing.

(6) Span the FID with the C₁H₆ span gas that you selected under paragraph (d)(1) of this section.

(7) Introduce at the sample port of the FID analyzer, the CH₄ span gas that you selected under paragraph (d)(2) of this section.

(8) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the analyzer and to account for its response.

(9) While the analyzer measures the CH₄ concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these values.
§ 1065.362 Non-stoichiometric raw exhaust FID $O_2$ interference verification.

(a) Scope and frequency. If you use FID analyzers for raw exhaust measurements from engines that operate in a non-stoichiometric mode of combustion (e.g., compression-ignition, lean-burn), verify the amount of FID $O_2$ interference upon initial installation and after major maintenance.

(b) Measurement principles. Changes in $O_2$ concentration in raw exhaust can affect FID response by changing FID flame temperature. Optimize FID fuel, burner air, and sample flow to meet this verification. Verify FID performance with the compensation algorithms for FID $O_2$ interference that you have active during an emission test.

(c) System requirements. Any FID analyzer used during testing must meet the FID $O_2$ interference verification according to the procedure in this section.

(d) Procedure. Determine FID $O_2$ interference as follows, noting that you may use one or more gas dividers to create the reference gas concentrations that are required to perform this verification:

1. Select three span reference gases that contain a $CH_4$ concentration that you use to span your analyzers before emission testing. Use only span gases that meet the specifications of §1065.750. You may use $CH_4$ span reference gases for FIDs calibrated on $CH_4$ with a nonmethane cutter. Select the three balance gas concentrations such that the concentrations of $O_2$ and $N_2$ represent the minimum, maximum, and average $O_2$ concentrations expected during testing. The requirement for using the average $O_2$ concentration can be removed if you choose to calibrate the FID with span gas balanced with the average expected oxygen concentration.

2. Confirm that the FID analyzer meets all the specifications of §1065.360.

3. Start and operate the FID analyzer as you would before an emission test. Regardless of the FID burner’s air source during testing, use zero air as the FID burner’s air source for this verification.

4. Zero the FID analyzer using the zero gas used during emission testing.