

supply system and after the humidity conditioning has taken place.

(b) *Unconditioned air supply.* Humidity measurements in unconditioned intake air supply systems must be made in the intake air stream entering the supply system. Alternatively, the humidity measurements can be measured within the intake air supply stream.

§ 90.311 Test conditions.

(a) *General requirements.* (1) Ambient temperature levels encountered by the test engine throughout the test sequence may not be less than 20 °C or more than 30 °C. All engines must be installed on the test bed at their design installation angle to prevent abnormal fuel distribution.

(2) Calculate all volumes and volumetric flow rates at standard conditions for temperature and pressure, and use these conditions consistently throughout all calculations. Standard conditions for temperature and pressure are 25 °C and 101.3 kPa.

(b) *Engine test conditions.* Measure the absolute temperature (designated as T and expressed in Kelvin) of the engine air at the inlet to the engine and the dry atmospheric pressure (designated as p_s and expressed in kPa), and determine the parameter f according to the following provisions for naturally aspirated engines:

$$f = \frac{99}{p_s} \times \left(\frac{T}{298} \right)^{0.7}$$

For a certification test to be recognized as valid, the parameter f shall be between the limits as shown below: $0.96 < f < 1.04$

§ 90.312 Analytical gases.

(a) The shelf life of a calibration gas may not be exceeded. The expiration date stated by the gas supplier must be recorded.

(b) *Pure gases.* The required purity of the gases is defined by the contamination limits specified in this subsection. The following gases must be available for operation:

(1) Purified nitrogen, also referred to as “zero-grade nitrogen” (Contamination ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 ppm CO₂, ≤ 0.1 ppm NO);

(2) Purified oxygen (Purity 99.5 percent vol O₂);

(3) Hydrogen-helium mixture (40 ± 2 percent hydrogen, balance helium) (Contamination ≤ 1 ppm C, ≤ 400 ppm CO);

(4) Purified synthetic air, also referred to as “zero air” or “zero gas” (Contamination ≤ 1 ppm C, ≤ 1 ppm CO, ≤ 400 ppm CO₂, ≤ 0.1 ppm NO) (Oxygen content between 18–21 percent vol.).

(c) *Calibration and span gases.* (1) Calibration gas values are to be derived from NIST “Standard Reference Materials” (SRM’s) and are to be single blends as specified in this subsection.

(2) Mixtures of gases having the following chemical compositions must be available:

C₃ H₈ and purified synthetic air and/or

C₃ H₈ and purified nitrogen;

CO and purified nitrogen;

NO_x and purified nitrogen (the amount of NO₂ contained in this calibration gas must not exceed five percent of the NO content);

CO₂ and purified nitrogen.

NOTE: For the HFID or FID the manufacturer may choose to use as a diluent span gas and the calibration gas either purified synthetic air or purified nitrogen. Any mixture of C₃ H₈ and purified synthetic air which contains a concentration of propane higher than what a gas supplier considers to be safe may be substituted with a mixture of C₃ H₈ and purified nitrogen. However, the manufacturer must be consistent in the choice of diluent (zero air or purified nitrogen) between the calibration and span gases. If a manufacturer chooses to use C₃ H₈ and purified nitrogen for the calibration gases, then purified nitrogen must be the diluent for the span gases.

(3) The true concentration of a span gas must be within \pm two percent of the NIST gas standard. The true concentration of a calibration gas must be within \pm one percent of the NIST gas standard. The use of precision blending devices (gas dividers) to obtain the required calibration gas concentrations is acceptable. Give all concentrations of calibration gas on a volume basis (volume percent or volume ppm).

(4) The gas concentrations used for calibration and span may also be obtained by means of a gas divider, diluting either with purified N₂ or with purified synthetic air. The accuracy of the mixing device must be such that

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the concentration of the diluted gases may be determined to within \pm two percent.

(d) Oxygen interference check gases must contain propane with 350 ppmC \pm 75 ppmC hydrocarbon. Determine the concentration value to calibration gas tolerances by chromatographic analysis of total hydrocarbons plus impurities or by dynamic blending. For gasoline fueled engines, oxygen concentration must be between 0 and 1 percent O₂. Nitrogen must be the predominant diluent with the balance oxygen.

(e) Fuel for the hydrocarbon flame ionization detector (HC-FID) must be a blend of 40 \pm two percent hydrogen with the balance being helium. The mixture must contain less than one ppm equivalent carbon response; 98 to 100 percent hydrogen fuel may be used with advance approval of the Administrator.

(f) *Hydrocarbon analyzer burner air.* The concentration of oxygen must be within one mole percent of the oxygen concentration of the burner air used in the latest oxygen interference check (percent O₂ I), see § 90.316(d). If the difference in oxygen concentration is greater than one mole percent, then the oxygen interference must be checked and, if necessary, the analyzer adjusted to meet the percent O₂ I requirements. The burner air must contain less than two ppmC hydrocarbon.

§ 90.313 Analyzers required.

(a) *Analyzers.* Analyze measured gases with the following instruments:

(1) *Carbon monoxide (CO) analysis.* (i) The carbon monoxide analyzer shall be of the non-dispersive infrared (NDIR) absorption type.

(ii) The use of linearizing circuits is permitted.

(2) *Carbon dioxide (CO₂) analysis.* (i) The carbon dioxide analyzer shall be of the non-dispersive infrared (NDIR) absorption type.

(ii) The use of linearizing circuits is permitted.

(3) *Oxygen (O₂) analysis.* Oxygen (O₂) analyzers may be of the paramagnetic (PMD), zirconia (ZRDO) or electrochemical type (ECS).

(4) *Hydrocarbon (HC) analysis.* (i) For Raw Gas Sampling, the hydrocarbon analyzer shall be of the heated flame

ionization (HFID) type. For constant volume sampling, the hydrocarbon analyzer may be of the flame ionization (FID) type or of the heated flame ionization (HFID) type.

(ii) For the HFID system, if the temperature of the exhaust gas at the sample probe is below 190 °C, the temperature of the valves, pipe work, and so forth, must be controlled so as to maintain a wall temperature of 190 °C \pm 11 °C. If the temperature of the exhaust gas at the sample probe is above 190 °C, the temperature of the valves, pipe work, and so forth, must be controlled so as to maintain a wall temperature greater than 180 °C.

(iii) For the HFID analyzer, the detector, oven, and sample-handling components within the oven must be suitable for continuous operation at temperatures to 200 °C. It must be capable of maintaining temperature within \pm 5.5 °C of the set point.

(iv) Fuel and burner air must conform to the specifications in § 90.312.

(v) The percent of oxygen interference must be less than three percent, as specified in § 90.316(d).

(5) *Oxides of nitrogen (NO_x) analysis.*

(i) This analysis device consists of the following items:

(A) A NO₂ to NO converter. The NO₂ to NO converter efficiency must be at least 90 percent.

(B) An ice bath located after the NO_x converter (optional).

(C) A chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD).

(ii) The quench interference must be less than 3.0 percent as measured in § 90.325.

(b) *Other analyzers and equipment.* Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(c) The following requirements must be incorporated as indicated in systems used for testing under this subpart.

(1) Carbon monoxide and carbon dioxide measurements must be made on a dry basis (for raw exhaust measurement only). Specific requirements for the means of drying the sample can be found in § 90.313(e).