during the test cycle conforms to paragraph (b)(2) of this section. Your measurements must compensate for increased or decreased flywheel torque because of the armature's inertia during accelerations and decelerations in the test cycle.

(b) To verify that the test engine has followed the test cycle correctly, collect the dynamometer or engine readout signals for speed and torque so you can statistically correlate the engine's actual performance with the test cycle (see § 1065.530). Normally, to do this, you would convert analog signals from the dynamometer or engine into digital values for computer storage, but all conversions must meet two criteria:

(1) Speed values used to evaluate cycles must be accurate to within 2 percent of the readout value for dynamometer or engine speed.

(2) Engine flywheel torque values used to evaluate cycles must be accurate to within 2 percent of the readout value for dynamometer or engine flywheel torque.

(c) You may combine the tolerances in paragraphs (a) and (b) of this section if you use the root mean square (RMS) method and refer accuracies of the RMS values to absolute-standard or NIST true values.

(1) Speed values used to evaluate cycles must be accurate to within ±2.8 percent of the absolute standard values, as defined in paragraph (a)(1) of this section.

(2) Engine flywheel torque values used to evaluate cycles must be accurate to within ±3.6 percent of NIST true values, as determined in § 1065.315.

§ 1065.110 Exhaust gas sampling system; spark-ignition (SI) engines.

(a) *General.* The exhaust gas sampling system described in this section is designed to measure the true mass of gaseous emissions in the exhaust of SI engines. (If the standard-setting part requires determination of THCE or NMHCE for your engine, then see subpart I of this part for additional requirements.) Under the constant-volume sampler (CVS) concept, you must measure the total volume of the mixture of exhaust and dilution air and collect a continuously proportioned volume of sample for analysis. You must control flow rates so that the ratio of sample flow to CVS flow remains constant. You then determine the mass emissions from the sample concentration and total flow over the test period.

(1) Do not let the CVS or dilution air inlet system artificially lower exhaust system backpressure. To verify proper backpressures, measure pressure in the raw exhaust immediately upstream of the inlet to the CVS. Continuously measure and compare the static pressure of the raw exhaust observed during a transient cycle—with and without the CVS operating. Static pressure measured with the CVS system operating must remain within ±5 inches of water (1.2 kPa) of the static pressure measured when disconnected from the CVS, at identical moments in the test cycle. (Note: We will use sampling systems that can maintain the static pressure to within ±1 inch of water (0.25 kPa) if your written request shows that this closer tolerance is necessary.) This requirement serves as a design specification for the CVS/dilution air inlet system, and should be performed as often as good engineering practice dictates (for example, after installing an uncharacterized CVS, adding an unknown inlet restriction on the dilution air, or otherwise altering the system).

(2) The system for measuring temperature (sensors and readout) must have an accuracy and precision of ±3.4° F (±1.9° C). The temperature measuring system for a CVS without a heat exchanger must respond within 1.50 seconds to 62.5 percent of a temperature change (as measured in hot silicone oil). For a CVS with a heat exchanger, there is no specific requirement for response time.

(3) The system for measuring pressure (sensors and readout) must have an accuracy and precision of ±3 mm Hg (0.4 kPa).

(4) The flow capacity of the CVS must be large enough to keep water from condensing in the system. You may dehumidify the dilution air before it enters the CVS. You also may heat or cool the air if three conditions exist:

(i) The air (or air plus exhaust gas) temperature does not exceed 250° F (121° C).

(ii) You calculate the CVS flow rate necessary to prevent water condensation based on the lowest temperature in the CVS before sampling. (We recommend insulating the CVS system when you use heated dilution air.)

(iii) The dilution ratio is high enough to prevent condensation in bag samples as they cool to room temperature.

(5) Bags for collecting dilution air and exhaust samples must be big enough for samples to flow freely.

(6) The general CVS sample system consists of a dilution air filter (optional) and mixing assembly, cyclone particulate separator (optional), a sample line for the bag sample or other sample lines a dilution tunnel, and associated valves and sensors for pressure and temperature. Except for the system to sample hydrocarbons from two-stroke engines, the temperature of the sample lines must be more than 3° C above the mixture's maximum dew point and less than 121° C. We recommend maintaining them at 113 ± 8° C. For the hydrocarbon sampling system with two-stroke engines, the temperature of the sample lines should be maintained at 191 ± 11° C. A general schematic of the SI sampling system is shown in Figure 1065.110–1, which follows:

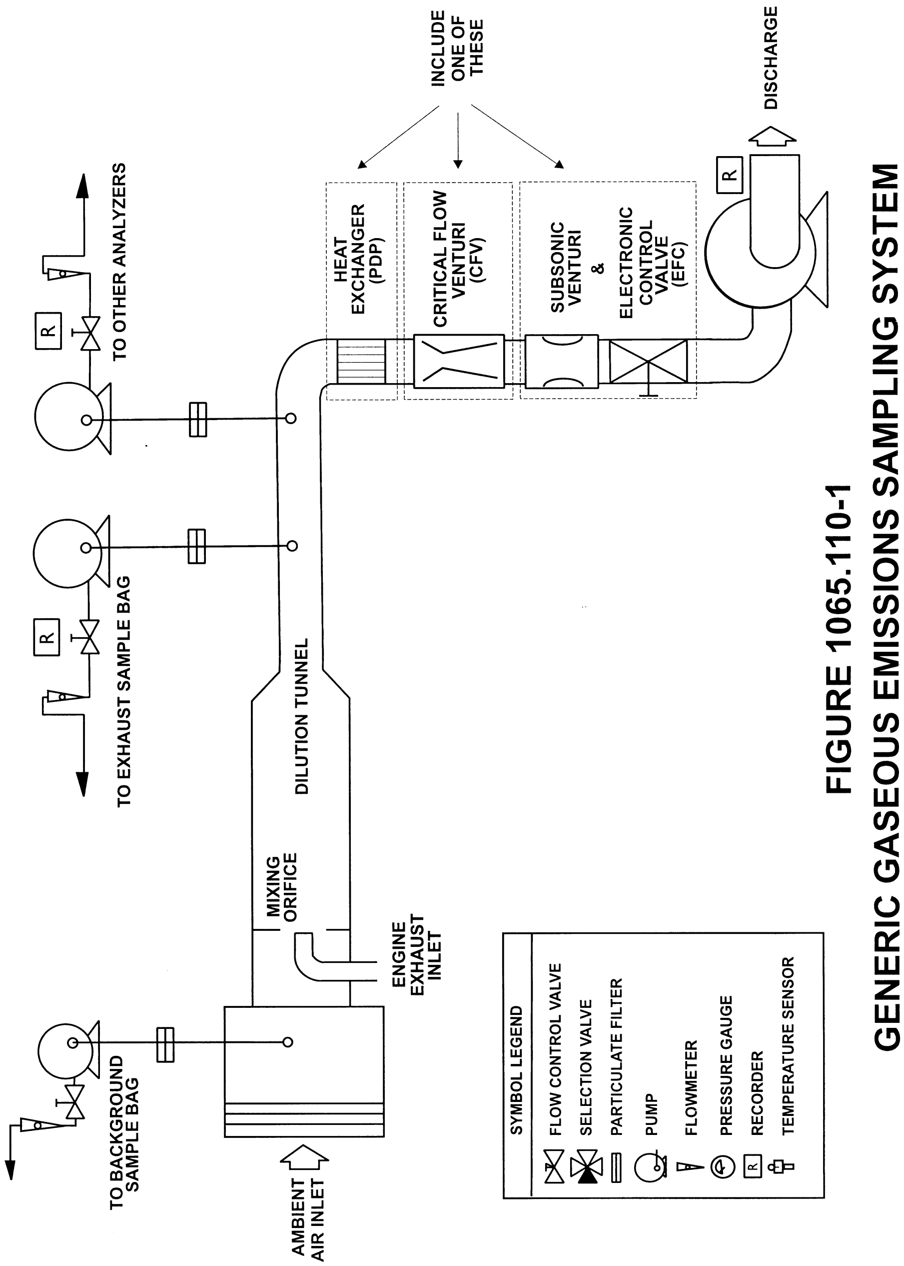

FIGURE 1065.110-1
GENERIC GASEOUS EMISSIONS SAMPLING SYSTEM

(b) *Steady-state testing.* Constant proportional sampling is required throughout transient testing, but is not required throughout steady-state testing.

Steady-state testing requires that you draw a proportional sample for each test mode, but you may sample in different proportions for different test modes, as long as you know the ratio of the sample flow to total flow during each test mode. This allowance means that you may use simpler flow control systems for steady-state testing than are shown in Figure 1065.110–1 of this section.

(c) *Configuration variations.* Since various configurations can produce equivalent results, you need not conform exactly to the drawings in this subpart. You may use other components—such as instruments, valves, solenoids, pumps and switches—to provide more information and coordinate the components' functions. Based on good engineering judgment, you may exclude other components that are not needed to maintain accuracy on some systems.

(d) *CFV–CVS component description.* The flow characteristics of a Critical-Flow Venturi, Constant-Volume Sampler (CFV–CVS) are governed by the principles of fluid dynamics associated with critical flow. The CFV system is commonly called a constant-volume system (CVS) even though the mass flow varies. More properly, they are constant-proportion sampling systems, because small CFVs in each of the sample lines maintains proportional sampling while temperatures vary. This CFV maintains the mixture's flow rate at choked flow, which is inversely proportional to the square root of the gas temperature, and the system computes the actual flow rate continuously. Because pressures and temperatures are the same at all venturi inlets, the sample volume is proportional to the total volume. The CFV–CVS sample system uses critical flow venturis for the bag sample or other sample lines (these are shown in the figure as flow control valves) and a critical flow venturi for the dilution tunnel. All venturis must be maintained at the same temperature.

(e) *EFC–CVS component description.* The electronic flow control-CVS (EFC–CVS) system for sampling is identical to the CFV system described in paragraph (b) of this section, except that it adds electronic flow controllers (instead of sampling venturis), a subsonic venturi and an electronic flow controller for the CVS (instead of the critical flow venturi), metering valves, and separate flow meters (optional) to totalize sample flow volumes. The EFC sample system must conform to the following requirements:

(1) The system must meet all the requirements in paragraph (b) of this section.

(2) The ratio of sample flow to CVS flow must not vary by more than ±5 percent from the test's setpoint.

(3) Sample flow totalizers must meet the accuracy specifications in § 1065.150. You may obtain total volumes from the flow controllers, with our advance approval, if you can show they meet these accuracies.

(f) *Component description, PDP–CVS.* The positive-displacement pump-CVS (PDP–CVS) system for sampling is identical to the CFV system described in paragraph (b) of this section, except for the following changes:

(1) Include a heat exchanger.

(2) Use positive-displacement pumps for the CVS flow and sampling-system flow. You do not need sampling venturis or a venturi for the dilution tunnel. All pumps must operate at a constant flow rate.

(3) All pumps must operate at a nominally constant temperature. Maintain the gas mixture's temperature—measured at a point just ahead of the positive-displacement pump (and after the heat exchanger for the main CVS pump)—within ±10° F (±5.6° C) of the average operating temperature observed during the test. (You may estimate the average operating temperature from the temperatures observed during similar tests.) The system for measuring temperature (sensors and readout) must have an accuracy and precision of ±3.4° F (1.9° C), and response time consistent with good engineering judgment.

(g) *Mixed systems.* You may combine elements of paragraphs (d), (e), and (f) consistent with good engineering judgment. For example, you may control the CVS flow rate using a CFV, and control sample flow rates using electronic flow controllers.