CHAPTER 6 : GAS SAMPLING SYSTEMS

1. Scope :

1.1 This Chapter describes two types of gas sampling systems in paragraphs 2.1 and 2.2 meeting the requirements specified in para 4.2 of Chapter 3 of this Part. Another type described in paragraph 2.3, may be used if it meets these requirements.

1.2 The laboratory shall mention, in its communications, the system of sampling used when performing the test. Systems not described in this appendix could be used, if it is proven to give equivalent results.

2. Description of Devices :

2.1 Variable Dilution Device with Positive Displacement Pump (PDP-CVS)

2.1.1 The Positive Displacement Pump - Constant Volume Sampler (PDP-CVS) satisfies the requirements by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional sample is achieved by sampling with pump, flow meter and flow control valve at a constant flow rate.

2.1.2 Figure 6 is a schematic drawing of such a sampling system. Since various configurations can produce accurate results, exact conformity with the drawings is not essential. Additional components such as instruments, valves, solenoids, and switches may be used to provide additional information and co-ordinate the functions of the component system.

2.1.3 The collecting equipment shall consist of :

2.1.3.1 A filter (D) for the dilution air, which can be preheated, if necessary. This filter shall consist of activated charcoal sandwiched between two layers of paper, and shall be used to reduce and stabilise the hydrocarbon concentrations of ambient emissions in the dilution air.

2.1.3.2 A mixing chamber (M) in which exhaust gas and air are mixed homogeneously.

2.1.3.3 A heat exchanger (H) of a capacity sufficient to ensure that throughout the test the temperature of the air/exhaust gas mixture measured at a point immediately upstream of the positive displacement puÿp is within ± 6K of the designed operating temperature. This device shall not affect the pollutant concentrations of diluted gases taken off for analysis.

2.1.3.4 A temperature control system (TC), used to preheat the heat exchanger before the test and to control its temperature during the test, so that deviations from the designed operating temperature are limited to ± 6 K.

The positive displacement pump (PDP), used to transport a constant volume flow of the air exhaust - gas mixture. The flow capacity of the pump shall be large enough to eliminate water condensation in the system under all operating conditions which may occur during a test, this can be generally ensured by using a positive displacement pump with an adequate flow capacity twice as high as the maximum flow of exhaust gas produced by accelerations of the driving cycle or sufficient to ensure that the CO2 concentration in the dilute exhaust sample bag is less than 3 percent by volume.

2.1.3.5 A temperature sensor (T1) (accuracy and precision ± 1° C) fitted at a point immediately upstream of the positive displacement pump. It shall be designed to monitor continuously the temperature of diluted exhaust gas mixture during the test.

2.1.3.6 A pressure gauge (G1) (accuracy and precision ± 0.4 kPa) fitted immediately upstream of the volume meter and used to register the pressure gradient between the gas mixture and the ambient air.

2.1.3.7 Another pressure gauge (G2) (accuracy and precision ± 0.4 kPa) fitted so that the differential pressure between pump inlet and pump outlet can be registered.

2.1.3.8 Two sampling outlets (S_1 and S_2) for taking constant samples of the dilution air and of the diluted exhaust gas/air mixture.

2.1.3.9 A filter (F), to extract solid particles from the flow of gas collected for analysis.

2.1.3.10 Pumps (P), to collect a constant flow of the dilution air as well as of the diluted exhaust-gas/air mixture during the test.

2.1.3.11 Flow controllers (N), to ensure a constant uniform flow of the gas samples taken during the course of the test from sampling probes S_1 and S_2 , and flow of the gas samples shall be such that, at the end of each test, the quantity of the samples is sufficient for analysis (about 10 l/min.)

2.1.3.12 Flow meters (FL), for adjusting and monitoring the constant flow of gas samples during the test.

2.1.3.13 Quick-acting valves (V), to divert a constant flow of gas samples into the sampling bags or to the outside vent.

2.1.3.14 Gas-tight, quick-lock coupling elements (Q) between the quick-acting valves and the sampling bags; the coupling shall close automatically on the sampling-bag side; as an alternative, other ways of transporting the samples to the analyser may be used (three-way stopcocks, for instance).

2.1.3.15 Bags (B), for collecting samples of the diluted exhaust gas and of the dilution air during the test. They shall be of sufficient capacity not to impede the sample flow. The bag material shall be such as to affect neither the measurements themselves nor the chemical composition of the gas samples (for instance: laminated polyethylene/polyamide films, or fluorinated polyhydrocarbons).

2.1.3.16 A digital counter (C), to register the number of revolutions performed by the positive displacement pump during the test.

2.1.4 Additional equipment required when testing diesel engined vehicles.

2.1.4.1 The additional components shown within the dotted lines of Figure 6 shall be used when testing Diesel Engined Vehicles.

F_h is a heated filter

S_3 is a sample point close to the mixing chamber

V_h is a heated multiway valve

Q is a quick connector to allow the ambient air sample BA to be analysed on the HFID

HFID is a heated flame, ionisation analyser.

R & I are a means of integrating and recording the instantaneous hydrocarbon concentrations.

L_h is a heated sample line

All heated components will be maintained at 190 ± 10 deg.C.

2.1.4.2 If compensation for varying flow is not possible then a heat exchanger (H) and temperature control system (TC) as described in Paragraph 2.1.3 of this Chapter will be required to ensure constant flow through the ventury (MV) and thus proportional flow through S3.

2.2 Critical-flow venturi dilution device/(CFV-CVS)

2.2.1 Using a critical-flow venturi in connection with the CVS sampling procedure is based on the principles of flow mechanics for critical flow. The variable mixture flow rate of dilution and exhaust gas is maintained at sonic velocity which is directly proportional to the square root of the gas temperature. Flow is continually monitored, computed, and integrated over the test. If an additional critical-flow sampling venturi is used the proportionality of the gas samples taken is ensured. As both pressure and temperature are equal at the two venturi inlets, the volume of the gas flow diverted for sampling is proportional to the total volume of diluted exhaust gas mixture produced, and thus the requirements of this test are met.

2.2.2 Figure 7 is a schematic drawing of such a sampling system. Since various configurations can produce accurate results, exact conformity with the drawing is not essential. Additional components such as instruments, valve, solenoids, and switches may be used to provide additional information and co-ordinate the functions of the component system.

2.2.3 The collecting equipment shall consist of :

2.2.3.1 A filter (D), for the dilution air, which can be preheated if necessary; the filter shall consist of activated charcoal sandwiched between layers of paper, and shall be used to reduce and stabilize the hydrocarbon background emission of the dilution air.

2.2.3.2 A mixing chamber (M), in which exhaust gas and air are mixed homogeneously.

2.2.3.3 A cyclone separator (CS), to extract particles.

2.2.3.4 The sampling probes (S_1 and S_2), for taking samples of the dilution air as well as of the diluted exhaust gas.

2.2.3.5 A sampling critical flow venturi (SV), to take proportional samples of the diluted exhaust gas at sampling probe, S_2.

2.2.3.6 A filter (F), to extract solid particles from the gas flows diverted for analysis.

2.2.3.7 Pump (P), to collect part of the flow of air and diluted exhaust gas in bags during the test.

2.2.3.8 A flow controller (N), to ensure a constant flow of the gas samples taken in the course of the test from sampling probe S1. The flow of the gas samples shall be such, that at the end of the test, the quantity of the samples is sufficient for analysis (about 10 l/min)

2.2.3.9 Flow meters (FL), for adjusting and monitoring the flow of gas samples during tests.

2.2.3.10 A scrubber (PS), in the sampling line.

2.2.3.11 Quick-acting solenoid valves (V), to divert a constant flow of gas samples into the sampling bags or to the vent.

2.2.3.12 Gas-tight, quick-lock coupling elements (Q), between the quick acting valves and the sampling bags; the couplings shall close automatically on the sampling bag side. As an alternative, other ways of transporting the samples to the analyser may be used (three-way stopcock, for instance).

2.2.3.13 Bags (B), for collecting samples of the diluted exhaust gas and the dilution air during the test; they shall be of sufficient capacity not to impede the sample flow. The bag material shall be such as to affect neither the measurements themselves nor the chemical composition of the gas samples (for instance, laminated polyethylene/polyamide films, or fluorinated polyhydrocarbons).

2.2.3.14 A pressure gauge (G), which shall be precise and accurate to within 0.4 kPa.

2.2.3.15 A temperature sensor (T), which shall be precise and accurate to within 1K and have a response time of 0.1 seconds to 62 percent of a temperature change (as measured in silicone oil).

2.2.3.16 A measuring critical flow venturi tube (MV), to measure the flow volume of the diluted exhaust gas.

2.2.3.17 A blower (BL), of sufficient capacity to handle the total volume of diluted gas.

2.2.3.18 The capacity of the CFV-CVS system shall be such that under all operating conditions which may possibly occur during a test there will be no condensation of water. This is generally ensured by using a blower whose capacity is;

2.2.3.18.1 Twice as high as the maximum flow of exhaust gas produced by accelerations of the driving cycle or

2.2.3.18.2 Sufficient to ensure that the CO_2 concentration in the dilute exhaust sample bag is less than 3 percent by volume.

2.2.4 Additional equipment required when testing diesel engined vehicles.

2.2.4.1 The additional components shown within the dotted lines of Figure 7 shall be used when testing Diesel Engined Vehicles.

Fh : is a heated filter

S_3 : is a sample point close to the mixing chamber

Vh : is a heated multiway valve

Q : is a quick connector to allow the ambient air sample BA to be analysed on the HFID

HFID is a heated flame, ionisation analyser.

R & I are a means of integrating and recording the instantaneous hydrocarbon concentrations.

Lh : is a heated sample line

All heated components will be maintained at 190 ± 10 deg.C.

2.2.4.2 If compensation for varying flow is not possible then a heat exchanger (H) and temperature control system (TC) as described in Paragraph 2.1.3 of this Chapter will be required to ensure constant flow through the ventury (MV) and thus proportional flow through S_3.

2.3 Variable dilution device with constant flow control by orifice (CFO-CVS) (Figure 8)

2.3.1 The collection equipment shall consist of :

2.3.1.1 A sampling tube connecting the vehicle's exhaust pipe to the device itself;

2.3.1.2 A sampling device consisting of a pump for drawing in the diluted mixture of exhaust gas and air;

2.3.1.3 A mixing chamber (M) in which exhaust gas and air are mixed homogeneously.

2.3.1.4 A heat exchanger (H) of a capacity sufficient to ensure that throughout the test the temperature of the air/exhaust gas mixture measured at a point immediately before the positive displacement of the flow rate measuring device is within ± 6° K. This device shall not alter the pollutant concentration of diluted gases taken off for analysis. Should this condition not be satisfied for certain pollutants, sampling will be effected before the cyclone for one or several considered pollutants.

If necessary, a device for temperature control (TC) is used to preheat the heat exchanger before testing and to keep up its temperature during the test within ± 6° K of the designed operating temperature.

2.3.1.5 Two probes (S_1 and S_2) for sampling by means of pumps (P), flowmeters (FL) and, if necessary, filters (F) allowing for the collection of solid particles from gases used for the analysis.

2.3.1.6 One pump for dilution air and another one for diluted mixture.

2.3.1.7 A volume-meter with an orifice.

2.3.1.8 A temperature sensor (T1) (accuracy and precision ± 1 K) fitted at a point immediately before the volume measurement device. It shall be designed to monitor continuously the temperature of the diluted exhaust gas mixture during the test.

2.3.1.9 A pressure gauge (G1) (capacity and precision ± 0.4 kPa) fitted immediately before the volume meter and used to register the pressure gradient between the gas mixture and the ambient air.

2.3.1.10 Another pressure gauge (G_2) (accuracy and precision ± 0.4 kPa fitted so that the differential pressure between pump inlet and pump outlet can be registered.

2.3.1.11 Two controllers (N) to ensure a constant uniform flow of gas samples taken during the course of the test from sampling outlets S_1 and S_2 . The flow of the gas samples shall be such that, at the end of each test, the quantity of the samples is sufficient for analysis (about 10 l/min).

2.3.1.12 Flow meters (FL) for adjusting and monitoring the constant flow of gas samples during the test.

2.3.1.13 Three-way valves (V) to divert a constant flow of gas samples into the sampling bags or to the outside vent.

2.3.1.14 Gas-tight, quick lock sampling elements (G) between the three-way valves and the sampling bags. The coupling shall close automatically on the sampling bag side. Other ways of transporting the samples to the analyser may be used (three-way stopcocks, for instance).

2.3.1.15 Bags (B) for collecting samples of diluted exhaust gas and of dilution air during the test. They shall be of sufficient capacity not to impede the sample flow. The bag material shall be such as to affect neither the measurements themselves nor the chemical composition of the gas samples for instance, laminated polyethylene/polyamide films, or fluorinated polyhydrocarbons).

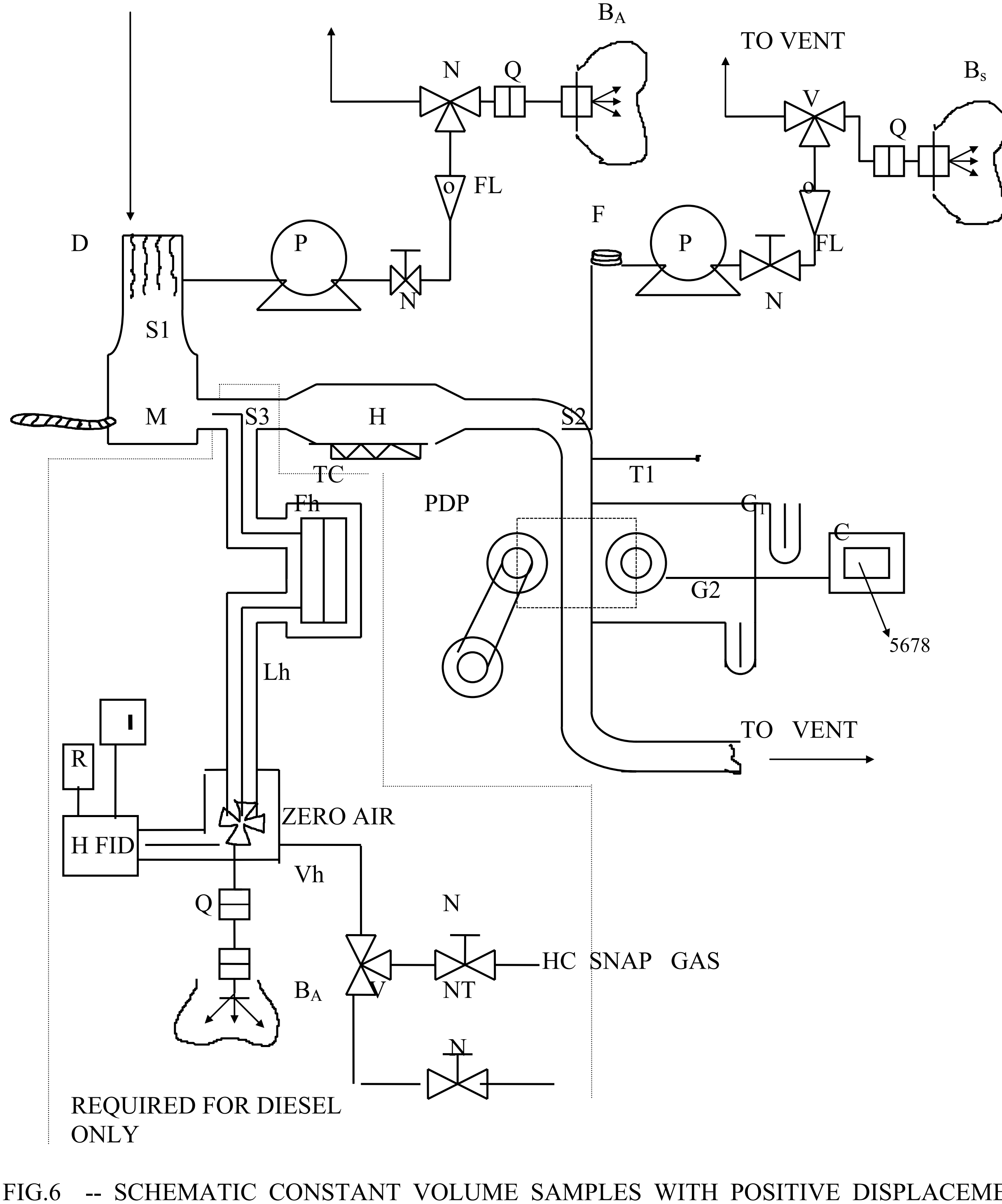

FIG.6 -- SCHEMATIC CONSTANT VOLUME SAMPLES WITH POSITIVE DISPLACEMENT PUMP (PDP-CVS) (PL. REF. PARA. 2.1.2. OF CHAPTER 6 Part 3)

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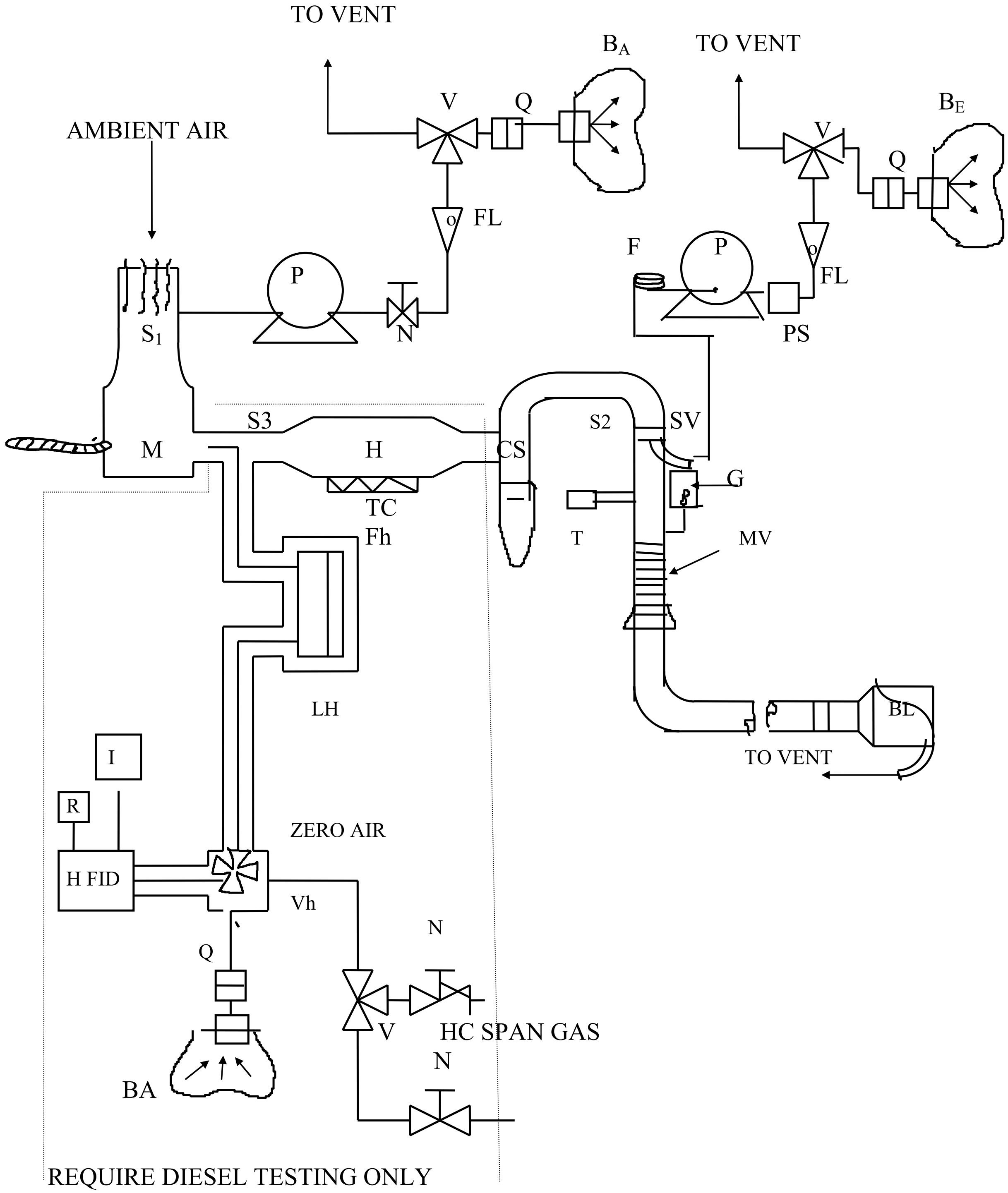

FIG 7: SCHEMATIC --CONSTANT VOLUME SAMPLER WITH CRITICAL FLOW VENTURI (CFV-CVS)(PL.REF.PARA. 2.2.2 OF CHAPTER 6 Part 3)

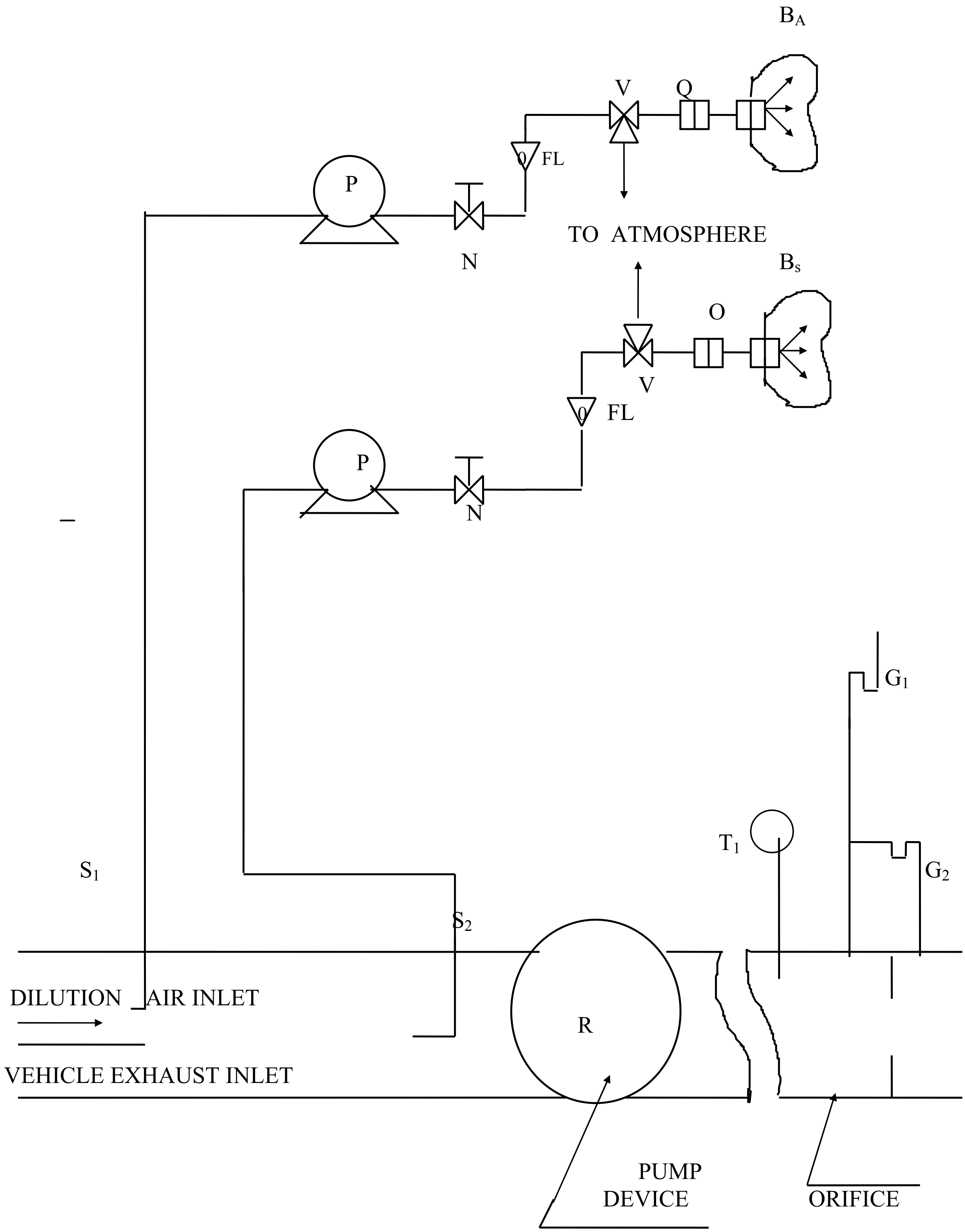

FIG: 8 SCHEMATIC OF VARIABLE DILUTION DEVICE WITH CONSTANT FLOW CONTROL BY ORIFICE (CFO-CVS) (PL.REF. PARA. 2.3 OF CHAPTER 6)