

**CHAPTER 11 : DETAILS FOR STANDARDS FOR EVAPORATIVE  
EMISSION FROM VEHICLES WITH SPARK-IGNITION ENGINES  
EFFECTIVE FROM 1.4.2005**

- Annexure 1 : TYPE-IV TEST  
(THE DETERMINATION OF EVAPORATIVE EMISSIONS  
FROM VEHICLES WITH SPARK-IGNITION ENGINES)
- Annexure 2 : CALIBRATION OF EQUIPMENT FOR EVAPORATIVE  
EMISSION TESTING

## **ANNEXURE 1 :**

### **1. INTRODUCTION**

**This Annex describes the procedure of the Type IV test.**

This procedure describes a method for a determination of the loss of hydrocarbons by evaporation from the fuel systems of vehicles with positive-ignition engines.

### **2. DESCRIPTION OF TEST**

**The evaporative emission test (Figure VI.1) is designed to determine hydrocarbon evaporative emissions as a consequence of diurnal temperatures fluctuation, hot soaks during parking, and urban driving. The test consists of these phases :**

- test preparation including an urban (Part One) and extra-urban (Part Two) driving cycle,
- hot soak loss determination,
- diurnal loss determination.

Mass emissions of hydrocarbons from the hot soak and the diurnal loss phases are added up to provide an overall result for the test.

### **3. VEHICLE AND FUEL**

#### **3.1 Vehicle**

The vehicle must be in good mechanical condition and have been run in and driven at least 3000 km before the test. The evaporative emission control system must be connected and have been functioning correctly over this period and the carbon canister(s) must have been subject to normal use, neither undergoing abnormal purging nor abnormal loading.

#### **3.2 Fuel**

The reference fuel as prescribed in the applicable Gazette Notification shall be used

### **4. TEST EQUIPMENT FOR EVAPORATIVE TEST**

#### **4.1 Chassis Dynamometer**

The chassis dynamometer must meet the requirements of Chapter 3.

#### **4.2 Evaporative Emission Measurement Enclosure**

The evaporative emission measurement enclosure must be a gas-tight rectangular measuring chamber able to contain the vehicle under test. The vehicle must be accessible from all sides and the enclosure when sealed must be gas tight in accordance with Appendix 1. The inner surface of the enclosure must be impermeable and non-reactive to hydrocarbons. The temperature

conditioning system must be capable of controlling the internal enclosure air temperature to follow the prescribed temperature versus time profile throughout the test, and an average tolerance of  $\pm 1\text{K}$  over the duration of the test.

The control system must be tuned to provide a smooth temperature pattern that has a minimum of overshoot, hunting and instability about the desired long-term ambient temperature profile. Interior surface temperatures must not be less than  $278\text{ K}(5^{\circ}\text{C})$  nor more than  $320\text{ K}(55^{\circ}\text{C})$  at any time during the diurnal emission test. Wall design must be such as to promote good dissipation of heat. Interior surface temperatures must not be below  $293\text{ K}(20^{\circ}\text{C})$ , nor above  $325\text{ K}(52^{\circ}\text{C})$  for the duration of the hot soak test.

**To accommodate the volume changes due to enclosure temperature changes, either a variable-volume or fixed-volume enclosure may be used.**

#### **4.2.1 Variable-volume Enclosure**

The variable-volume enclosure expands and contracts in response to the temperature change of the air mass in the enclosure. Two potential means of accommodating the internal volume changes are movable panel(s), or a bellows design, in which an impermeable bag or bag(s) inside the enclosure expand(s) and contract(s) in response to internal pressure changes by exchanging air from outside the enclosure. Any design for volume accommodation must maintain the integrity of the enclosure as specified in Appendix 1 over the specified temperature range.

Any method of volume accommodation must limit the differential between the enclosure internal pressure and the barometric pressure to a maximum value of  $\pm 5\text{ hPa}$ .

The enclosure must be capable of latching to a fixed volume. A variable volume enclosure must be capable of accommodating a  $\pm 7\%$  change from its 'nominal volume' (see Appendix 1 section 2.1.1), taking into account temperature and barometric pressure variation during testing.

#### **4.2.2 Fixed-volume Enclosure**

The fixed-volume enclosure must be constructed with rigid panels that maintain a fixed enclosure volume, and meet the requirements below :

4.2.2.1 The enclosure must be equipped with an outlet flow stream that withdraws air at a low, constant rate from the enclosure throughout the test. An inlet flow stream may provide make-up air to balance the outgoing flow with incoming ambient air. Inter air must be filtered with activated carbon to provide a relatively constant hydrocarbon level. Any method of volume accommodation must maintain the differential between the enclosure internal pressure and the barometric pressure between  $0$  and  $-5\text{ hPa}$ .

4.2.2.2 The equipment must be capable of measuring the mass of hydrocarbon in the inlet and outlet flow streams with a resolution of 0.01 gram. A bag sampling system may be used to collect a proportional sample of the air withdrawn from and admitted to the enclosure. Alternatively, the inlet and outlet flow streams may be continuously analysed using an on-line FID analyzer and integrated with the flow measurements to provide a continuous record of the mass hydrocarbon removal.

### **4.3 Analytical Systems**

#### **4.3.1 Hydrocarbon Analyser**

4.3.1.1 The atmosphere within the chamber is monitored using a hydrocarbon detector of the flame ionization detector (FID) type. Sample gas must be drawn from the mid-point of one side wall or roof of the chamber and any bypass flow must be returned to the enclosure, preferably to a point immediately downstream of the mixing fan.

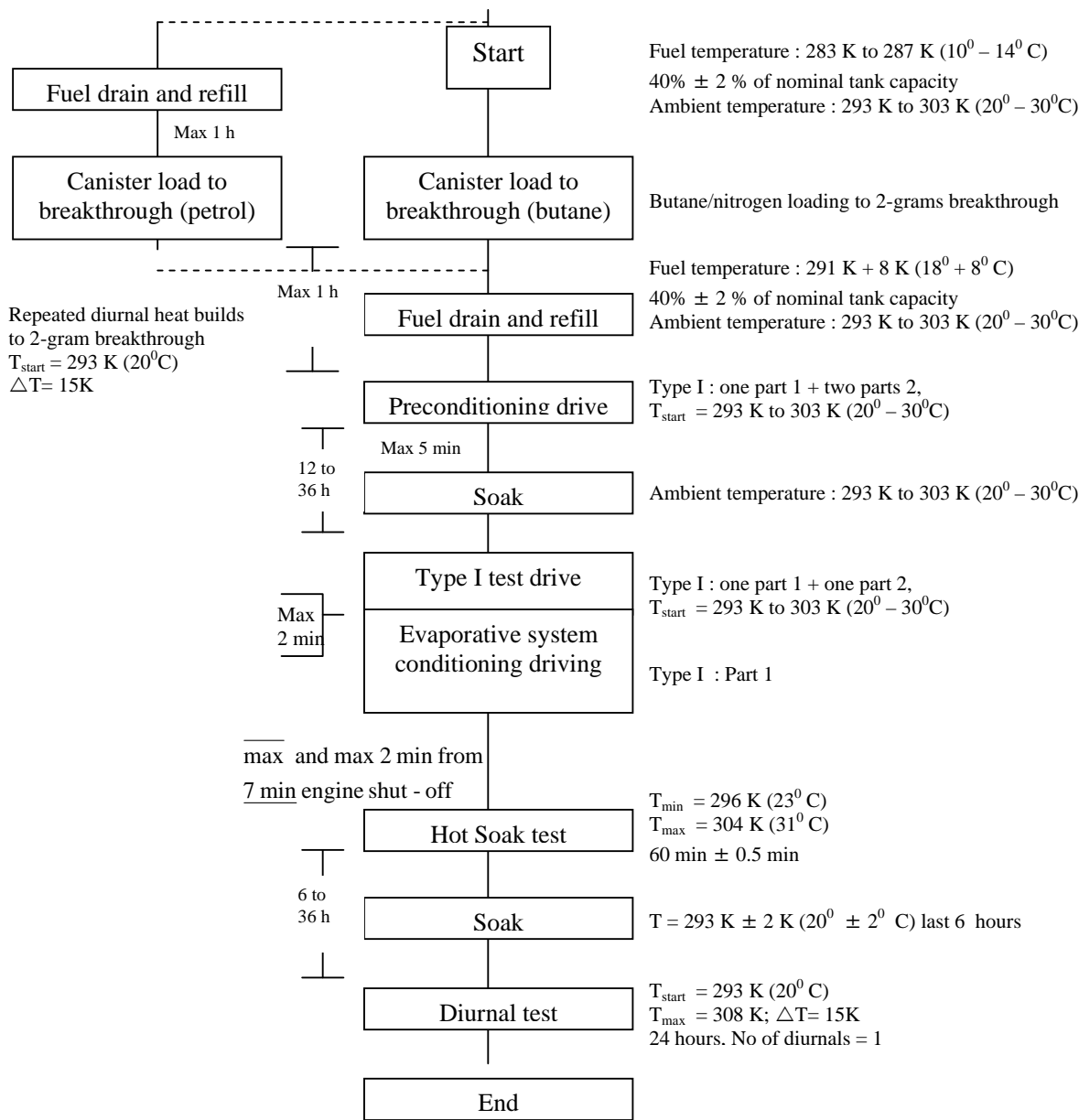
4.3.1.2 The hydrocarbon analyzer must have a response time to 90% of final reading of less than 1.5 seconds. Its stability must be better than 2% of full scale at zero and at  $80\% \pm 20\%$  of full scale over a 15-minute period for all operational ranges.

4.3.1.3 The repeatability for the analyzer expressed as one standard deviation must be better than 1% of full scale deflection at zero and at  $80\% \pm 20\%$  of full scale on all ranges used.

4.3.1.4 The operational ranges of the analyzer must be chosen to give best resolution over the measurement, calibration and leak checking procedures.

#### **4.3.2 Hydrocarbon Analyser Data Recording System**

4.3.2.1 The hydrocarbon analyzer must be fitted with a device to record electrical signal output either by strip chart recorder or other data processing system at a frequency of at least once per minute. The recording system must have operating characteristics at least equivalent to the signal being recorded and must provide a permanent record of results. The record must show a positive indication of the beginning and end of the hot soak or diurnal emission test (including beginning and end of sampling periods along with the time elapsed between start and completion of each test)



**Figure VI.1**  
**Evaporative Emission Determination**  
 3000 km run-in period (no excessive purge/load)  
 Ageing of canister(s) verified  
 Steam clean of vehicle (if necessary)

- Note : 1) Evaporative emission control families – details clarified.  
 2) Tailpipe emissions may be measured during Type I test drive, but these are not used for legislative purposes. Exhaust emission legislative test remains separate

#### **4.4 Fuel Tank Heating (only applicable for gasoline canister load option)**

- 4.4.1 The fuel in the vehicle tank(s) must be heated by a controllable source of heat, for example a heating pad of 2000 W capacity is suitable. The heating system must apply heat evenly to the tank walls beneath the level of the fuel so as not to cause local overheating of the fuel. Heat must not be applied to the vapour in the tank above the fuel.
- 4.4.2 The tank heating device must make it possible to heat the fuel in the tank evenly by  $14^{\circ}\text{K}$  from  $289^{\circ}\text{K}$  ( $16^{\circ}\text{C}$ ) within 60 minutes, with the temperature sensor position as in 5.1.1. The heating system must be capable of controlling the fuel temperature to  $\pm 1.5^{\circ}\text{K}$  of the required temperature during the tank heating process.

#### **4.5 Temperature Recording**

- 4.5.1 The temperature in the chamber is recorded at two points by temperature sensors which are connected so as to show a mean value. The measuring points are extended approximately 0,1 m into the enclosure from the vertical center line of each side wall at a height of  $0.9 \pm 0.2$  m.
- 4.5.2 The temperature of the fuel tank(s) are recorded by means of the sensor positioned in the fuel tank as in 5.1.1 in the case of use of the gasoline canister load option (5.1.5)
- 4.5.3 Temperatures must, throughout the evaporative emission measurements, be recorded or entered into a data processing system at a frequency of at least once per minute.
- 4.5.4 The accuracy of the temperature recording system must be within  $\pm 1.0$  K and the temperature must be capable of being resolved to  $\pm 0.4$  K.
- 4.5.5 The recording or data processing system must be capable of resolving time to  $\pm 15$  seconds.

#### **4.6 Pressure Recording**

- 4.6.1 The difference  $\Delta_p$  between barometric pressure within the test area and the enclosure internal pressure must, throughout the evaporative emission measurements, be recorded or entered into a data processing system at a frequency of at least once per minute.
- 4.6.2 The accuracy of the pressure recording system must be within  $\pm 2$  hPa and the pressure must be capable of being resolved to  $\pm 0.2$  hPa.

4.6.3 The recording or data processing system must be capable of resolving time to  $\pm 15$  seconds.

#### **4.7 Fans**

4.7.1 By the use of one or more fans or blowers with the SHED door(s) open it must be possible to reduce the hydrocarbons concentration in the chamber to the ambient hydrocarbon level.

4.7.2 The chamber must have one or more fans or blowers of likely capacity  $0.1$  to  $0.5 \text{ m}^3\text{s}^{-1}$  with which to thoroughly mix the atmosphere in the enclosure. It must be possible to attain an even temperature and hydrocarbon concentration in the chamber during measurements. The vehicle in the enclosure must not be subjected to a direct stream of air from the fans or blowers.

#### **4.8 Gases**

4.8.1 The following pure gases must be available for calibration and operation :

- purified synthetic air (purity :  $< 1$  ppm C1 equivalent  $\pm 1$  ppm CO,  $\pm 400$  ppm CO<sub>2</sub>,  $\pm 0.1$  ppm NO); oxygen content between 18% and 21% by volume.
- Hydrocarbon analyzer fuel gas (40%  $\pm$ hydrocarbon, less than 400 ppm CO<sub>2</sub>)
- Propane (C<sub>3</sub>H<sub>8</sub>), 99.5% minimum purity,
- Butane (C<sub>4</sub>H<sub>10</sub>), 98% minimum purity,
- Nitrogen (N<sub>2</sub>), 98% minimum purity.

4.8.2 Calibration and span gases must be available containing mixtures of propane (C<sub>3</sub>H<sub>8</sub>) and purified synthetic air. The true concentrations of a calibration gas must be within  $\pm 2\%$  of stated figures. The accuracy of the diluted gases obtained when using a gas divider must be to within  $\pm 2\%$  of the true value. The concentrations specified in Appendix 1 may also be obtained by the use of a gas divider using synthetic air as the diluent gas.

#### **4.9 Additional Equipment**

4.9.1 The absolute humidity in the tests area must be measurable to within  $\pm 5\%$ .

### **5 TEST PROCEDURE**

#### **5.1 Test Preparation**

5.1.1 The vehicle is mechanically prepared before the test as follows:

- the exhaust system of the vehicle must not exhibit any leaks
- the vehicle may be steam cleaned before the test,
- In the case of use of the gasoline canister load option (5.1.5) the fuel tank of the vehicle must be equipped with a temperature sensor to enable the temperature to be measured at the mid-point of the fuel in the fuel tank when filled to 40% of its capacity,
- Additional fittings, adapters or devices may be fitted to the fuel system in order to allow a complete draining of the fuel tank. For this purpose it is not necessary to modify the shell of the tank.
- The manufacturer may propose a test method in order to take into account the loss of hydrocarbons by evaporation coming only from the fuel system of the vehicle.

5.1.2 The vehicle is taken into the test area where the ambient temperature is between 293 K and 303 K (20 and 30°C)

5.1.3 The ageing of the canister(s) has to be verified. This may be done by demonstrating that it has accumulated a minimum of 3000 km. If this demonstration is not given, the following procedure is used. In the case of a multiple canister system each canister must undergo the procedure separately.

5.1.3.1 The canister is removed from the vehicle. Special care must be taken during this step to avoid damage to components and the integrity of the fuel system.

5.1.3.2 The weight of the canister must be checked.

5.1.3.3 The canister is connected to a fuel tank, possibly an external one, filled with reference fuel, to 40% volume of the fuel tank(s).

5.1.3.4 The fuel temperature in the fuel tank must be between 283 K (10°C) and 287 K (14°C)

5.1.3.5 The (external) fuel tank is heated from 288 K to 318 K (15°C to 45°C) (1°C increase every 9 minutes)

5.1.3.6 If the canister reaches breakthrough before the temperature reaches 318 K (45°C), the heat source must be turned off. Then the canister is weighed. If the canister did not reach breakthrough during the heating to 318 K (45°C), the procedure from 5.1.3.3 must be repeated until breakthrough occurs.

5.1.3.7 Breakthrough may be checked as is described in 5.1.5 and 5.1.6 of this Annex, or with the use of another sampling and analytical arrangement capable of detecting the emission of hydrocarbons from the canister at breakthrough.



- 5.1.3.8 The canister must be purged with  $25 \pm 5$  litres per minute with the emission laboratory air until 300 bed volume exchanges are reached
- 5.1.3.9 The weight of the canister must be checked.
- 5.1.3.10 The steps of the procedure in 5.1.3.4 and 5.1.3.9 must be repeated nine times. The test may be terminated prior to that, after not less than three ageing cycles, if the weight of the canister after the last cycles has stabilized.
- 5.1.3.11 The evaporative emission canister is reconnected and the vehicle restored to its normal operating condition.
- 5.1.4 One of the methods specified in 5.1.5 and 5.1.6 must be used to precondition the evaporative canister. For vehicles with multiple canisters, each canister must be preconditioned separately.
- 5.1.4.1 Canister emissions are measured to determine breakthrough  
Breakthrough is here defined as the point at which the cumulative quantity of hydrocarbons emitted is equal to 2 grams.
- 5.1.4.2 Breakthrough may be verified using the evaporative emission enclosure as described in 5.1.5 and 5.1.6 respectively. Alternatively, breakthrough may be determined using an auxiliary evaporative canister connected downstream of the vehicle's canister. The auxiliary canister must be well purged with dry air prior to loading.
- 5.1.4.3 The measuring chamber must be purged for several minutes immediately before the test until a stable background is obtained. The chamber air mixing fan(s) must be switched on at this time.  
The hydrocarbon analyzer must be zeroed and spanned immediately before the test.
- 5.1.5 *Canister Loading with Repeated Heat Builds to Breakthrough*
- 5.1.5.1 The fuel tank(s) of the vehicle(s) is (are) emptied using the fuel tank drain(s). This must be done so as not to abnormally purge or abnormally load the evaporative control devices fitted to the vehicle. Removal of the fuel cap is normally sufficient to achieve this.

5.1.5.2 The fuel tank(s) is (are) refilled with test fuel at a temperature of between 283 K to 287 K (10 to 14<sup>0</sup> C) to 40% ± 2 % of the tank's normal volumetric capacity. The fuel cap(s) of the vehicle must be fitted at this point.

5.1.5.3 Within one hour of being refueled the vehicle must be placed, with the engine shut off, in the evaporative emission enclosure. The fuel tank temperature sensor is connected to the temperature recording system. A heat source must be properly positioned with respect to the fuel tank(s) and connected to the temperature controller. The heat source is specified in 4.4 In the case of vehicles fitted with more than one fuel tank, all the tanks must be heated in the same way as described below. The temperatures of the tanks must be identical to within ± 1.5 K.

5.1.5.4 The fuel may be artificially heated to the starting diurnal temperature of 293 K (20<sup>0</sup> C) ± 1 K.

5.1.5.5 When the fuel temperature reaches at least 292 K (19<sup>0</sup> C), the following steps must be taken immediately; the purge blower must be turned off; enclosure doors closed and sealed; and measurement initiated of the hydrocarbon level in the enclosure.

5.1.5.6 When the fuel temperature of the fuel tank reaches 293 K (20<sup>0</sup> C) a linear heat build of 15 K (15<sup>0</sup> C) begins. The fuel must be heated in such a way that the temperature of the fuel during the heating conforms to the function below to within ± 1.5<sup>0</sup> K. The elapsed time of the heat build and temperature rise is recorded.

$$T_r = T_0 + 0.2333 \times t$$

Where :

$T_r$  = required temperature (K);

$T_0$  = initial temperature (K);

T = time from start of the tank heat build in minutes.

5.1.5.7 As soon as breakthrough occurs or when the fuel temperature reaches 308<sup>0</sup> K (35<sup>0</sup> C), whichever occurs first, the heat source is turned off, the enclosure doors unsealed and opened, the vehicle fuel tank cap(s) removed. If breakthrough has not occurred by the time the fuel temperature reaches 308<sup>0</sup> K (35<sup>0</sup> C), the heat source is removed from the vehicle, the vehicle removed from the evaporative emission enclosure and

the entire procedure outlined in 5.1.7 repeated until breakthrough occurs.

### **5.1.6 Butane Loading to Breakthrough**

- 5.1.6.1 If the enclosure is used for the determination of the breakthrough (see 5.1.4.2) the vehicle must be placed, with the engine shut off, in the evaporative emission enclosure.
- 5.1.6.2 The evaporative emission canister must be prepared for the canister loading operation. The canister must not be removed from the vehicle, unless access to it in its normal location is so restricted that loading can only reasonably be accomplished by removing the canister from the vehicle. Special care must be taken during this step to avoid damage to the components and the integrity of the fuel system.
- 5.1.6.3 The canister is loaded with a mixture composed of 50% butane and 50% nitrogen by volume at a rate of 40 grams butane per hour.
- 5.1.6.4 As soon as the canister reaches breakthrough, the vapour source must be shut off,
- 5.1.6.5 The evaporative emission canister must then be reconnected and the vehicle restored to its normal operating condition.

### **5.1.7 Fuel Drain and Refill**

- 5.1.7.1 The fuel tank(s) of the vehicle(s) is (are) emptied using the fuel tank drain(s). This must be done so as not to abnormally purge or abnormally load the evaporative control devices fitted to the vehicle. Removal of the fuel cap is normally sufficient to achieve this.
- 5.1.7.2 The fuel tank(s) is (are) refilled with test fuel at a temperature of between  $291^0 \text{ K} \pm 8^0 \text{ K}$  ( $18 \pm 8^0 \text{ C}$ ) to  $40 \pm 2\%$  of the tank's normal volumetric capacity. The fuel cap(s) of the vehicle must be fitted at this point.

## **5.2 Preconditioning Drive**

- 5.2.1 Within one hour from the completing of canister loading in accordance with 5.1.5 or 5.1.6 the vehicle is placed on the chassis dynamometer and is driven through one Part One and

two Part Two driving cycles of Type I test as specified in Annex III. Exhaust emissions are not sampled during this operation.

### **5.3 Soak**

5.3.1 Within five minutes of completing the preconditioning operation specified in 5.2.1 the engine bonnet must be completely closed and the vehicle driven off the chassis dynamometer and parked in the soak area. The vehicle is parked for a minimum of 12 hours and a maximum of 36 hours. The engine oil and coolant temperatures must have reached the temperature of the area of within  $\pm 3^0$  K of it at the end of the period.

### **5.4 Dynamometer Test**

5.4.1 After conclusion of the soak period the vehicle is driven through a complete Type I test drive as described in Annex III (cold start urban and extra urban test). Then the engine is shut off. Exhaust emissions may be sampled during this operation and the results must not be used for the purpose of exhaust emission type-approval.

5.4.2 Within two minutes of completing the Type I test drive specified in 5.4.1 the vehicle is driven a further conditioning drive consisting of one urban test cycle (hot start) of a Type I test. Then the engine is shut off again. Exhaust emissions need not be sampled during this operation.

### **5.5 Hot Soak Evaporative Emission Test**

5.5.1 Before the completion of the conditioning drive the measuring chamber must be purged for several minutes until a stable hydrocarbon background is obtained. The enclosure mixing fan(s) must also be turned on at this time.

5.5.2 The hydrocarbon analyzer must be zeroed and spanned immediately prior to the test.

5.5.3 At the end of the conditioning drive the engine bonnet must be completely closed and all connections between the vehicle and the test stand disconnected. The vehicle is then driven to the measuring chamber with a minimum use of the accelerator pedal. The engine must be turned off before any part of the vehicle enters the measuring chamber. The time at which the engine is switched off is recorded on the evaporative emission measurement data recording system and temperature recording begins. The vehicle's windows and

luggage compartments must be opened at this stage, if not already opened.

- 5.5.4 The vehicle must be pushed or otherwise moved into the measuring chamber with the engine switched off.
- 5.5.5 The enclosure doors are closed and sealed gas-tight within two minutes of the engine being switched off and within seven minutes of the end of the conditioning drive.
- 5.5.6 The start of a  $60 \pm 0.5$  minutes hot soak period begins when the chamber is sealed. The hydrocarbon concentration, temperature and barometric pressure are measured to give the initial readings  $C_{HC, i}$ ,  $P_i$  and  $T_i$  for the hot soak test. These figures are used in the evaporative emission calculation, Section 6. The ambient SHED temperature  $T$  must not be less than  $296^0$  K and not more than  $304^0$  K during the 60-minute hot soak period.
- 5.5.7 The hydrocarbon analyzer must be zeroed and spanned immediately before the end of the  $60 \pm 0.5$  minute test period.
- 5.5.8 At the end of the  $60 \pm 0.5$  minute test period the hydrocarbon concentration in the chamber must be measured. The temperature and the barometric pressure are also measured. These are the final readings  $C_{HC, f}$ ,  $P_f$  and  $T_f$  for the hot soak test used for the calculation in Section 6.

## **5.6 Soak**

- 5.6.1 The test vehicle must be pushed or otherwise moved to the soak area without use of the engine and soaked for not less than 6 hours and not more than 36 hours between the end of the hot soak test and the start of the diurnal emission test. For at least 6 hours of this period the vehicle must be soaked at  $293^0$  K  $\pm$   $2^0$  K ( $20^0$  C  $\pm$   $2^0$ C)

## **5.7 Diurnal Test**

- 5.7.1 The test vehicle must be exposed to one cycle of ambient temperature according to the profile specified in Appendix 2 with a maximum deviation of  $\pm 2^0$  K at any time. The average temperature deviation from the profile, calculated using the absolute value of each measured deviation, must not exceed  $1^0$  K. Ambient temperature must be measured at least every minute. Temperature cycling begins when time  $t_{start} = 0$ , as specified in 5.7.6.
- 5.7.2 The measuring chamber must be purged for several minutes immediately before the test until a stable background is

obtainable. The chamber mixing fan(s) must also be switched on at this time.

- 5.7.3 The test vehicle, with the engine shut off and the test vehicle windows and luggage compartment(s) opened must be moved into the measuring chamber. The mixing fan(s) must be adjusted in such a way as to maintain a minimum air circulation of 8 km/h under the fuel tank of the test vehicle.
- 5.7.4 The hydrocarbon analyzer must be zeroed and spanned immediately before the test.
- 5.7.5 The enclosure doors must be closed and gas-tight sealed.
- 5.7.6 Within 10 minutes of closing and sealing the doors, the hydrocarbon concentration, temperature and barometric pressure are measured to give the initial readings  $C_{HC,i}$ ,  $P_i$  and  $T_i$  for the diurnal test. This is the point where time  $t_{start} = 0$ .
- 5.7.7 The hydrocarbon analyzer must be zeroed and spanned immediately before the end of the test.
- 5.7.8 The end of the emission sampling period occurs 24 hours  $\pm$  6 minutes after the beginning of the initial sampling, as specified in 5.7.6. The time elapsed is recorded. The hydrocarbon concentration, temperature and barometric pressure are measured to give the final readings  $C_{HC,f}$ ,  $P_f$  and  $T_f$  for the diurnal test used for the calculation in Section 6. This completes the evaporative emission test procedure.

## 6 CALCULATION

- 6.1 The evaporative emission tests described in Section 5 allow the hydrocarbon emissions from the diurnal and hot soak phases to be calculated. Evaporative losses from each of these phases is calculated using the initial and final hydrocarbon concentrations, temperatures and pressures in the enclosure, together with the net enclosure volume.

The formula below is used :

$$M_{HC} = k \cdot V \cdot 10^{-4} \cdot \left( \frac{C_{HC,f} \cdot P_f}{T_f} - \frac{C_{HC,i} \cdot P_i}{T_i} \right) + M_{HC,out} - M_{HC,i}$$

where:

$M_{HC}$  = hydrocarbon mass in grams

$M_{HC,out}$  = mass of hydrocarbon exiting the enclosure, in the case of fixed-volume enclosures for diurnal emission testing (grams)

$M_{HC,i}$  = mass of hydrocarbon entering the enclosure, in the case of fixed-volume enclosures for diurnal emission testing (grams)

$C_{HC}$  = measured hydrocarbon concentration in the enclosure (ppm (volume)  $C_1$  equivalent)

- V = net enclosure volume in cubic metres corrected for the volume of the vehicle, with the windows and the luggage compartment open. If the volume of the vehicle is not determined a volume of 1,42 m<sup>3</sup> is subtracted.
- T = ambient chamber temperature, °K,
- P = barometric pressure in kPa,
- H/C = hydrogen to carbon ratio,
- k = 1.2 x (12 + H/C);

where:

- i is the initial reading,
- f is the final reading,
- H/C is taken to be 2.33 for diurnal test losses,
- H/C is taken to be 2.20 for hot soak losses.

## 6.2 Overall Results of Test

The overall hydrocarbon mass emission for the vehicle is taken to be :

$$M_{\text{total}} = M_{\text{DI}} + M_{\text{HS}}$$

where:

- M<sub>total</sub> = overall mass emissions of the vehicle (grams),
- M<sub>DI</sub> = hydrocarbon mass emission for diurnal test (grams),
- M<sub>HS</sub> = hydrocarbon mass emission for the hot soak (grams).

## 7 CONFORMITY OF PRODUCTION

- 7.1 For routine end-of-production-line testing, the holder of the approval may demonstrate compliance by sampling vehicles, which shall meet the following requirements.

### 7.2 Test for leakage

- 7.2.1 Vents to the atmosphere from the emission control system shall be isolated.
- 7.2.2 A pressure of 370 ± 10 mm of H<sub>2</sub>O must be applied to the fuel system.
- 7.2.3 The pressure must be allowed to stabilize prior to isolating the fuel system from the pressure source.
- 7.2.4 Following isolation of the fuel system, the pressure must not drop by more than 50 mm of H<sub>2</sub>O in five minutes.

### 7.3 Test for venting

- 7.3.1 Vents to the atmosphere from the emission control must be isolated.

- 7.3.2 A pressure of  $370 \pm 10$  mm of H<sub>2</sub>O must be applied to the fuel system.
- 7.3.3 The pressure must be allowed to stabilize prior to isolating the fuel system from the pressure source.
- 7.3.4 The venting outlets from the emission control system to the atmosphere must be reinstated to the production condition.
- 7.3.5 The pressure of the fuel system must drop to below 100 mm of H<sub>2</sub>O in not less than 30 seconds but within two minutes.
- 7.3.6 At the request of the manufacturer the functional capacity for venting can be demonstrated by equivalent alternative procedure. The specific procedure should be demonstrated by the manufacturer to the technical service during the type approval procedure.

#### **7.4 Purge test**

- 7.4.1 Equipment capable of detecting an airflow rate of 1,0 litres in one minutes must be attached to the purge inlet and a pressure vessel of sufficient size to have negligible effect on the purge system must be connected via a switching valve to the purge inlet, or alternatively.
- 7.4.2 The manufacturer may use a flow meter of his own choice, if acceptable to the competent authority.
- 7.4.3 The vehicle must be operated in such a manner that any design feature of the purge system that could restrict purge operation is detected and the circumstances noted.
- 7.4.4 Whilst the engine is operating within the bounds noted in 7.4.3, the air flow must be determined by either :
  - 7.4.4.1 the device indicated in 7.4.1. being switched in. A pressure drop from atmospheric to a level indicating that a volume of 1,0 litres of air has flowed into the evaporative emission control system within one minutes must be observed; or
  - 7.4.4.2 if an alternative flow measuring device is used, a reading of no less than 1.0, litres per minutes must be detectable.
  - 7.4.4.3 At the request of the manufacturer an alternative purge test procedure can be used, if the procedure has been presented to and has been accepted by the technical service during the type approval procedure.



- 7.5 The competent authority which has granted type-approval may at any time verify the conformity control methods applicable to each production unit.
- 7.5.1 The inspector must take a sufficiently large sample from the series.
- 7.5.2 The inspector may test these vehicles by application of either 7.1.4. or 7.1.5 of Annex. I.
- 7.5.3 If in pursuance of Section 7.1.5 of Annex. I the vehicle's test result falls outside the agreed limits of Section 5.3.4.2. of Annex I, the manufacturer may request that the approval procedure referred to in 7.1.4 of Annex I be applied.
- 7.5.3.1 The manufacturer must not be allowed to adjust, repair or modify any of the vehicles, unless they failed to comply with the requirements of Section 7.1.4 of Annex I and unless such work is documented in the manufacturer's vehicle assembly and inspection procedures.
- 7.5.3.2 The manufacturer may request a single re-test for a vehicle whose evaporative emission characteristics are likely to have changed due to his actions under 7.5.3.1
- 7.6 If the requirements of 7.5 are not met, the competent authority must ensure that all necessary steps are taken to re-establish conformity of production as rapidly as possible.

**Annexure 2**  
**CALIBRATION OF EQUIPMENT FOR EVAPORATIVE EMISSION TESTING**

**1. CALIBRATION FREQUENCY AND METHODS**

- 1.1 All equipment must be calibrated before its initial use and then calibrated as often as necessary and in any case in the month before type-approval testing. The calibration methods to be used are described in this Appendix.
- 1.2 Normally the series of temperatures which are mentioned firstly must be used. The series of temperatures within square brackets may alternatively be used.

**2. CALIBRATION OF ENCLOSURE**

**2.1 Initial Determination of Enclosure Internal Volume**

- 2.1.1 Before its initial use, the internal volume of the chamber must be determined as follows. The internal dimensions of the chamber are carefully measured, allowing for any irregularities such as bracing struts. The internal volume of the chamber is determined from these measurements.

For variable-volume enclosures, the enclosure must be latched to a fixed volume when the enclosure is held at an ambient temperature of 303<sup>0</sup> K (30<sup>0</sup> C) [(302<sup>0</sup> K (29<sup>0</sup> C)]. This nominal volume must be repeatable within ± 0.5 % of the reported value.

- 2.1.2 The net internal volume is determined by subtracting 1.42 m<sup>3</sup> from the internal volume of the chamber. Alternatively the volume of the test vehicle with the luggage compartment and windows open may be used instead of the 1.42 m<sup>3</sup>.
- 2.1.3 The chamber must be checked as in 2.3. If the propane mass does not agree with the injected mass to within ± 2% then corrective action is required.

**2.2 Determination of Chamber Background Emissions**

This operation determines that the chamber does not contain any materials that emit significant amounts of hydrocarbons. The check must be carried out at the enclosure's introduction to service, after any operations in the enclosure which may affect background emissions and at a frequency of at least once per year.

- 2.2.1 Variable-volume enclosures may be operated in either latched or unlatched volume configuration, as described in 2.1.1.

Ambient temperatures must be maintained at  $308^0 \text{ K} \pm 2^0 \text{ K}$  ( $35 \pm 2^0 \text{ C}$ ) [ $309^0 \text{ K} \pm 2^0 \text{ K}$  ( $36 \pm 2^0 \text{ C}$ )], throughout the 4-hour period mentioned below.

- 2.2.2 Fixed volume enclosures must be operated with inlet and outlet flow streams closed. Ambient temperatures must be maintained at  $308^0 \text{ K} \pm 2^0 \text{ K}$  ( $35^0 \pm 2^0 \text{ C}$ ) [ $309^0 \text{ K} \pm 2^0 \text{ K}$  ( $36^0 \pm 2^0 \text{ C}$ )] throughout the four-hour period mentioned below.
- 2.2.3 The enclosure may be sealed and the mixing fan operated for a period of up to 12 hours before the four-hour background sampling period begins.
- 2.2.4 The analyzer (if required) must be calibrated, then zeroed and spanned.
- 2.2.5 The enclosure must be purged until a stable hydrocarbon reading is obtained, and the mixing fan turned on if not already on.
- 2.2.6 The Chamber is then sealed and the background hydrocarbon concentration, temperature and barometric pressure are measured. These are the initial readings  $C_{\text{HC},i}$ ,  $P_i$  and  $T_i$  used in the enclosure background calculation.
- 2.2.7 The enclosure is allowed to stand undisturbed with the mixing fan on for a period of four hours.
- 2.2.8 At the end of this time the same analyzer is used to measure the hydrocarbon concentration in the chamber. The temperature and the barometric pressure are also measured. These are the final readings  $C_{\text{HC},f}$ ,  $P_f$  and  $T_f$ .
- 2.2.9 The change in mass of hydrocarbons in the enclosure must be calculated over the time of the test in accordance with 2.4 and must not exceed 0.05 g.

### 2.3. Calibration and Hydrocarbon Retention Test of the Chamber

The calibration and hydrocarbon retention test in the chamber provides a check on the calculated volume in 2.1 and also measures any leak rate. The enclosure leak rate must be determined at the enclosure's introduction to service, after any operations in the enclosure which may affect the integrity of the enclosure, and at least monthly thereafter. If six consecutive monthly retention checks are successfully completed without corrective action, the enclosure leak rate may be determined quarterly thereafter as long as no corrective action is required.

- 2.3.1. The enclosure must be purged until a stable hydrocarbon concentration is reached. The mixing fan is turned on, if not

already switched on. The hydrocarbon analyser is zeroed, calibrated if required, and spanned.

- 2.3.2. On variable-volume enclosures the enclosure must be latched to the nominal volume position. On fixed-volume enclosures the outlet and inlet flow streams must be closed.
- 2.3.3. The ambient temperature control system is then turned on (if not already on) and adjusted for an initial temperature of 308°K (35°C) [309°K (36°C)].
- 2.3.4. When the enclosure stabilizes at 308°K  $\pm$  2°K (35°  $\pm$  2°C) [309°K  $\pm$  2°K (36°  $\pm$  2°C)], the enclosure is sealed and the background concentration, temperature and barometric pressure measured. These are the initial readings  $C_{HC,i}$ ,  $P_i$  and  $T_i$  used in the enclosure calibration.
- 2.3.5. A quantity of approximately 4 grams of propane is injected into the enclosure. The mass of propane must be measured to an accuracy and precision of  $\pm$  0.2 % of the measured value.
- 2.3.6. The contents of the chamber must be allowed to mix for five minutes and then the hydrocarbon concentration, temperature and barometric pressure are measured. These are the final readings  $C_{HC,f}$ ,  $P_f$  and  $T_f$  for the calibration of the enclosure as well as the initial readings  $C_{HC,i}$ ,  $P_i$  and  $T_i$  for the retention check.
- 2.3.7. On the basis of the readings taken in 2.3.4 and 2.3.6 and the formula in 2.4, the mass of propane in the enclosure is calculated. This must be within  $\pm$  2 % of the mass of propane measured in 2.3.5..
- 2.3.8. For variable-volume enclosures the enclosure must be unlatched from the nominal volume configuration. For fixed-volume enclosures, the outlet and inlet flow streams must be opened.
- 2.3.9. The process is then begun of cycling the ambient temperature from 308°K (35°C) to 293°K (20°C) and back to 308°K (35°C) [308.6°K (35.6°C) to 295.2°K (22.2°C) and back to 308.6°K (35.6°C)] over a 24-hour period according to the profile [alternative profile] specified in Table 1 within 15 minutes of sealing the enclosure. (Tolerances as specified in section 5.7.1 of Annex VI).
- 2.3.10. At the completion of the 24-hour cycling period, the final hydrocarbon concentration, temperature and barometric pressure are measured and recorded. These are the final readings  $C_{HC,f}$ ,  $T_f$  and  $P_f$  for the hydrocarbon retention check.

2.3.11. Using the formula in 2.4, the hydrocarbon mass is then calculated from the readings taken in 2.3.10 and 2.3.6. The mass may not differ by more than 3 % from the hydrocarbon mass given by 2.3.7.

## 2.4 Calculations

The calculation of net hydrocarbon mass change within the enclosure is used to determine the chamber's hydrocarbon background and leak rate. Initial and final readings of hydrocarbon concentration, temperature and barometric pressure are used in the following formula to calculate the mass change.

$$M_{HC} = k \cdot V \cdot 10^{-4} \cdot \left( \frac{C_{HC,f} \cdot P_f}{T_f} - \frac{C_{HC,i} \cdot P_i}{T_i} \right) + M_{HC,out} - M_{HC,i}$$

where:

- $M_{HC}$  = hydrocarbon mass in grams
- $M_{HC,out}$  = mass of hydrocarbon exiting the enclosure, in the case of fixed-volume enclosures for diurnal emission testing (grams)
- $M_{HC,i}$  = mass of hydrocarbon entering the enclosure, in the case of fixed-volume enclosures for diurnal emission testing (grams)
- $C_{HC}$  = measured hydrocarbon concentration in the enclosure (ppm (volume)  $C_1$  equivalent)
- $V$  = net enclosure volume in cubic metres corrected for the volume of the vehicle, with the windows and the luggage compartment open. If the volume of the vehicle is not determined a volume of 1,42 m<sup>3</sup> is subtracted.
- $T$  = ambient chamber temperature, °K,
- $P$  = barometric pressure in kPa,
- $H/C$  = hydrogen to carbon ratio,
- $k$  = 17.6" for "k= 1.2 × (12 + H/C )

where:

- $i$  is the initial reading,
- $f$  is the final reading,
- $H/C$  is taken to be 2.33 for diurnal test losses,
- $H/C$  is taken to be 2.20 for hot soak losses.

## 3. CHECKING OF FID HYDROCARBON ANALYSER

### 3.1 Detector response optimization

The FID must be adjusted as specified by the instrument manufacturer. Propane in air should be used to optimize the response on the most common operating range.

### 3.2 Calibration of the HC analyzer

The analyzer should be calibrated using propane in air and purified synthetic air. See Section 4.5.2 of Annex III (Calibration and span gases).

Establish a calibration curve as described in Sections 4.1 to 4.5 of this Appendix.

### 3.3 Oxygen interference check and recommended limits

The response factor ( $R_f$ ) for a particular hydrocarbon species is the ratio of the FID  $C_1$  reading to the gas cylinder concentration, expressed as ppm  $C_1$ .

The concentration of the test must be a level to give a response of approximately 80% of full scale deflection, for the operating range. The concentration must be known, to an accuracy of  $\pm 2\%$  in reference to a gravimetric standard expressed in volume. In addition the gas cylinder must be preconditioned for 24 hours at a temperature between 293 K and 303 K ( $20^0$  and  $30^0C$ ).

Response factors should be determined when introducing an analyzer into service and thereafter at major service intervals. The reference gas to be used is propane with balance purified air which is taken to give a response factor of 1,00.

The test gas to be used for oxygen interference and the recommended response factor range are given below :

Propane and nitrogen 0,95 #  $R_f$  # 1,05.

## 4 CALIBRATION OF THE HYDROCARBON ANALYZER

Each of the normally used operating ranges are calibrated by the following procedure:

- 4.1 Establish the calibration curve by at least five calibration points spaced as evenly as possible over the operating range. The nominal concentration of the calibration gas with the highest concentrations to be at least 80% of the full scale.
- 4.2 Calculate the calibration curve by the method of least squares. If the resulting polynomial degree is greater than 3, then the number of calibration points must be at least the number of the polynomial degree plus 2..
- 4.3 The calibration curve must not differ by more than 2% from the nominal value of each calibration gas.
- 4.4 Using the coefficients of the polynomial derived from 3.2, a table of indicated reading against true concentration shall be drawn up in steps of no greater than 1% of full scale. This is to be carried out for each

analyzer range calibrated. The table shall also contain other relevant data such as :

Date of calibration,

Span and zero potentiometer reading (where applicable),

Nominal scale,

Reference data of each calibration gas used,

The actual and indicated value of each calibration gas used together with the percentage differences,

FID fuel and type,

FID air pressure.

- 4.5 It can be shown to the satisfaction of the Regulatory Agency that alternative technology (e.g. computer, electronically controlled range switch) can give equivalent accuracy, then those alternatives may be used.

**Table 1**

Diurnal ambient temperature profile for the calibration of the enclosure and the diurnal emission test		
Time (hours)		Temperature (°C <sub>i</sub> )
Calibration	Test	
13	0/24	20
14	1	20,2
15	2	20,5
16	3	21,2
17	4	23,1
18	5	25,1
19	6	27,2
20	7	29,8
21	8	31,8
22	9	33,3
23	10	34,4
24/0	11	35
1	12	34,7
2	13	33,8
3	14	32
4	15	30
5	16	28,4
6	17	26,9
7	18	25,2
8	19	24
9	20	23
10	21	22
11	22	20,8
12	23	20,2

Alternative diurnal ambient temperature profile for the calibration of the enclosure in accordance with Chapter 3, sections 1.2 and 2.3.9	
Time (hours)	Temperature (°C <sub>i</sub> )
0	35,6
1	35,3
2	34,5
3	33,2
4	31,4
5	29,7
6	28,2
7	27,2
8	26,1
9	25,1
10	24,3
11	23,7
12	23,3
13	22,9
14	22,6
15	22,2
16	22,5
17	24,2
18	26,8
19	29,6
20	31,9
21	33,9
22	35,1
23	35,4
24	35,6