

Informal Document to Amendment 3 to UN GTR No. 19 (Evaporative emission test procedure for the Worldwide harmonized Light vehicles Test Procedure (WLTP EVAP))

I. Statement of technical rationale and justification

A. Introduction

1. The compliance with emission standards is a central issue of vehicle certification worldwide. Emissions comprise criteria pollutants having a direct (mainly local) negative impact on health and environment, as well as pollutants having a negative environmental impact on a global scale. Regulatory emission standards typically are complex documents, describing measurement procedures under a variety of well-defined conditions, setting limit values for emissions, but also defining other elements such as the durability and on-board monitoring of emission control devices.

2. Most manufacturers produce vehicles for a global clientele or at least for several regions. Albeit vehicles are not identical worldwide since vehicle types and models tend to cater to local tastes and living conditions, the compliance with different emission standards in each region creates high burdens from an administrative and vehicle design point of view. Vehicle manufacturers, therefore, have a strong interest in harmonizing vehicle emission test procedures and performance requirements as much as possible on a global scale. Regulators also have an interest in global harmonization since it offers more efficient development and adaptation to technical progress, potential collaboration at market surveillance and facilitates the exchange of information between authorities.

3. As a consequence, stakeholders launched the work on the Worldwide harmonized Light vehicle Test Procedure (WLTP) which aims at harmonizing emission-related test procedures for light duty vehicles to the extent this is possible. One of the aspects covered within the mandate for WLTP is the evaporative emission test procedure.

4. Evaporative emissions from vehicles is a complex phenomenon which depends on multiple factors, that range from climate conditions to fuel properties, from driving and parking patterns to the technology used to control these emissions.

5. Evaporative emissions from a vehicle can be defined, in a very generic way, as Volatile Organic Compounds (VOCs) emitted by the vehicle itself in different operating conditions but not directly derived from the combustion process. In petrol vehicles the most important potential source of evaporative emissions is the loss of fuel through the evaporation and permeation mechanisms from the fuel storing system. Fuel-related evaporative emissions may occur during any vehicle operation including parking events, normal driving and vehicle refuelling.

6. VOCs may also be emitted by specific components of the vehicle such as tyres, interior trim, plastics or by other fluids (e.g. windshield washer fluid). These non-fuel related emissions are usually quite low, not dependent on how the vehicle is used or on the quality of the fuel, and tend to decrease over time. Evaporative emissions in general do not represent a significant problem for diesel vehicles due to the very low vapour pressure of diesel fuel.

7. During parking events, the fuel temperature in the fuel tank system increases due to rising ambient temperature and solar radiation. As a result of the increased temperature and consequent evaporation of the fuel, as well as expansion of the air/fuel vapour mixture, the pressure inside the fuel tank system increases significantly. This may lead the evaporation of the lightest petrol fractions with a corresponding increase of the pressure inside the fuel tank system. In non-sealed fuel tank systems, which are mostly used in conventional vehicles, the increase of the pressure inside the system is limited by the high probability of purging vapours inside the fuel tank system, and the pressure is vented mainly to the carbon canister(s). The canister adsorbs and stores hydrocarbons (HC). However, this canister has a limited adsorbing capacity (depending on several factors of which the most important are the

carbon quality, mass, and fuel specification as well as the ambient temperature) and must be periodically purged to desorb the stored hydrocarbons. This occurs during vehicle driving events since part of the combustion air flows through the canister removing the adsorbed hydrocarbons which are then burned inside the engine.

8. Due to the potentially limited operation time of the combustion engine in hybrid electric vehicles, the use of sealed fuel tank systems is one of the alternative solutions to the system described above to control evaporative emissions. A sealed fuel tank system is by design a closed system that can store fuel vapours inside the system up to the fuel tank relief pressure. In this case, no fuel vapour is vented to the canister nor to the atmosphere. However, the sealed fuel tank systems must be depressurised. This depressurisation is generally achieved by opening a pressure relief valve before refuelling to ensure a safe operation. The mixture of air and vapours released through the pressure relief valve are stored in the canister(s) which are then purged when the combustion engine runs.

9. In the case of very hot temperature conditions, the pressure inside the fuel tank system might exceed the fuel tank relief pressure which is designed to avoid the risk of a rupture of the sealed fuel tank system.

10. A technological option to limit the pressure increase inside the sealed fuel tank system due to a rising ambient temperature is insulating the tank itself. This means that the temperature of the fuel will remain lower than the ambient temperature. This option has been taken into account when developing the test procedure.

11. In normal vehicle driving conditions, in addition to the ambient air and solar radiation, the temperature of the fuel in the tank may increase as a consequence of the heat coming from other sources (hot engine and exhaust system, fuel pump, fuel return if present, road surface that may be significantly hotter than the ambient air). The balance between the fuel evaporation rate, the amount of fuel being pumped to the engine and the purge flow rate through the canister will determine the carbon canister loading which could lead to excessive emissions due to breakthrough/saturation. These emissions are known as running losses.

12. Hydrocarbons also escapes the vehicle's fuel system by permeation through the plastic and rubber components; e.g., hoses, seals, and in vehicles with a non-metallic tank, the fuel tank itself. Permeation does not occur through an opening; instead individual fuel molecules penetrate (i.e. they effectively mix with) the walls of the various components and eventually find their way to the outside. Fuel permeation is significant mainly for plastic or elastomeric materials, depends strongly on the temperature and is generally independent of vehicle operating conditions.

13. Another important source of evaporative emissions is the refuelling operation. When liquid fuel is delivered into the tank the air/petrol vapour mixture present in the tank is displaced and may be released into the atmosphere. Refuelling emissions are partially controlled through the maximum allowed fuel vapour pressure by reducing its value during the hot season. In addition, evaporative emissions during the refuelling operation can be controlled in two different ways. One method is the so-called "Stage II" vapour recovery system. The fuel nozzle is designed to draw the air/petrol vapour mixture displaced by the liquid fuel entering the tank and route it to the underground petrol storage tank of the service station. An alternative method is an "On-board Vapour Recovery System" (ORVR), which forces the displaced vapours to be routed to the carbon canister instead of escaping from the refuelling port.

14. An unintended source of HC emissions may occur from leaks in the system. Leaks may occur in the vapour and/or the liquid system as a result of deterioration and/or faulty operations. Examples of deterioration are corrosion of metallic components (e.g. fuel lines, tanks), cracking of rubber hoses, hardening of seals, mechanical failures. On-board diagnostic systems have been developed to check the integrity of the fuel system and are required in some regions.

15. In the existing regional type approval procedures, the various situations that can lead to significant evaporative emissions have been addressed either by developing different tests or by adopting different measures. As an example, in certain regions refuelling emissions are

controlled by mandating the use of the Stage II vapour recovery system while in other regions the ORVR approach has been chosen.

16. The need to represent real driving conditions as much as possible to make the performance of vehicles at certification and in real life comparable puts therefore some limitations on the level of harmonization to be achieved since, for instance, ambient temperatures vary widely on a global scale while other potential sources of evaporative emissions are addressed in different ways across the regions (e.g. refuelling emissions or potential leaks).

17. At this time, the WLTP EVAP test procedure focuses only on the evaporative emissions that can occur during parking events. Running losses and refuelling emissions are out of the scope of the current WLTP EVAP procedure. However, the venting of vapour from a sealed tank immediately prior to refuelling (also known as depressurisation puff loss emissions) is within the scope of this procedure.

18. The purpose of a UN Global Technical Regulation (UN GTR) is its implementation into regional legislation by as many Contracting Parties as possible. However, the scope of regional legislations in terms of vehicle categories concerned depends on regional conditions and cannot be predicted for the time being. On the other hand, according to the rules of the 1998 Agreement, Contracting Parties implementing a UN GTR must include all equipment falling into the formal UN GTR scope. Care must be taken so that an unduly large formal scope of the UN GTR does not prevent its regional implementation. Therefore, the formal scope of this UN GTR is kept mainly for light duty vehicles. However, this limitation of the formal UN GTR scope does not indicate that it could not be applied to a larger group of vehicle categories by regional legislation. In fact, Contracting Parties are encouraged to extend the scope of regional implementations of this UN GTR if this is technically, economically and administratively appropriate.

B. Procedural background and future development of the WLTP EVAP

19. In its November 2007 session, the World Forum for Harmonization of Vehicle Regulations (WP.29) decided to set up an Informal Working Group (IWG) under the Working Party on Pollution and Energy (GRPE) to prepare a road map for the development of WLTP. After various meetings and intense discussions, WLTP presented in June 2009 a first road map consisting of three phases, which was subsequently revised a number of times and contains the following main tasks:

(a) Phase 1 (2009–2014): Development of the worldwide harmonized light duty driving cycle and associated test procedure for the common measurement of criteria compounds, CO₂, fuel and energy consumption;

(b) Phase 2 (2014–2018): Low temperature/high altitude test procedure, durability, in-service conformity, technical requirements for On-Board Diagnostics (OBD), Mobile Air-Conditioning (MAC) system energy efficiency, off-cycle/real driving emissions, and evaporative emission;

(c) Phase 3 (2018-...): Emission limit values and OBD threshold limits, definition of reference fuels, comparison with regional requirements.

20. It should be noted that since the beginning of the WLTP process, the European Union had a strong political objective set by its own legislation (Regulations (EC) 715/2007 and 692/2008) to review the test procedure for evaporative emissions to ensure that these are effectively limited throughout the normal life of the vehicles under normal conditions of use.

21. The IWG on WLTP presented at the GRPE January 2016 session an updated road map for the Phase 2 including a proposal for the development of the WLTP test procedure for evaporative emissions. A strong desire of the Contracting Parties to develop the UN GTR by January 2017 was announced.

22. The WLTP EVAP Task Force started its work in February 2016 with the first meeting of experts. Work in developing this UN GTR ended in September 2016 with the submission of the initial text. Development of the procedure for sealed fuel tank systems started in late

2016 and ended its work in September 2017. The work to improve the regulatory text started in April 2018 and ended in September 2018. With this, the calibration requirements and intervals for test equipment, and the equation for the variable-volume enclosures were included. Also, improvements to clarify the requirements were made.

23. In October 2019 further work has been undertaken to amend the scope to include all vehicles fuelled with petrol and to add a new Optional Annex for the COP method. At this same timing, the previous cross-references to technical requirements in UN Regulation No.83 07 series have been replaced with the full text of those requirements.

C. Background on test procedures

23. For the development of the WLTP EVAP test procedure, the EVAP Task Force took into account existing legislation as well as the recent review and revision of the European evaporative emission test procedure.

24. The WLTP evaporative emission test procedure focuses only on evaporative emissions that can occur during parking events from vehicles with petrol-fuelled engines (including bi-fuel gas vehicles and hybrid vehicles combining an electric motor with a petrol-fuelled engine).

25. The WLTP evaporative emission test procedure is designed to measure evaporative emissions from a parked vehicle using a sealed housing for evaporative emissions determination (SHED). Two specific situations are considered:

(a) Evaporative emissions occurring immediately after the end of a trip due to residual fuel tank heating and the high temperatures of the engine and fuel system (hot soak test);

(b) Evaporative emissions occurring during a simulated extended parking event (48 hours) while the vehicle is exposed to temperature fluctuations according to a specific profile. This is intended to represent the temperature profile of a hot day (diurnal test). The result of the diurnal test is represented by the total amount of VOCs released in the SHED over a 48 hour period.

For sealed fuel tank systems, two other situations are addressed by the WLTP evaporative emission test procedure:

(c) Evaporative emissions that may occur if there is the need to depressurise the fuel tank system before refuelling to ensure a safe operation. In order to reduce the pressure inside the tank, the air/fuel vapours mixture released through the pressure relief valve are stored in the canister(s). This operation should also avoid excessive evaporative emissions through the filler neck when the fuel cap/fuel lid is opened. This latter aspect requires that inside the tank there is very limited overpressure compared to the ambient pressure when the fuel cap (or any alternative system used to close the filler neck) is opened.

(d) Evaporative emissions that may occur when the pressure inside the system exceed the fuel tank relief pressure. The pressure relief valve opens to avoid the risk of a rupture of the system. In these conditions the emissions could be uncontrolled in the case of a fully saturated canister. This has been taken in to account when developing the test procedure in order to reduce the frequency of this possibility or, alternatively, to control these emissions by means of the carbon canister.

26. The performance of the evaporative emission control system strongly depends on the initial condition of the carbon canister which is expected to adsorb the vapours generated in the tank. In order to simulate realistic conditions, prior to starting the hot soak and diurnal tests, the carbon canister is loaded to breakthrough and then purged by driving the vehicle over a specific combination of WLTC sections (conditioning drive). The conditioning drive cycle was extensively assessed and discussed also on the basis of real world activity data to take into account that the most critical conditions are represented by short trips in urban areas. For this reason, the conditioning drive for Class 2 and 3 vehicles includes one low phase, two medium phases and one high phase. The extra-high phase was excluded. The conditioning drive for Class 1 vehicles includes four low phases, two medium phases.

27. The test procedure also includes specific provisions to take into account the potential deterioration of the evaporative emission control system efficiency especially in the presence of ethanol in the fuel. The evaporative emission test is carried out with a carbon canister aged both mechanically and chemically according to a specific procedure. In addition, a permeation factor is used to take into account the potential increase over time of the full permeation rate through the tank walls.

28. As far as the fuel is concerned, its vapour pressure and composition (especially ethanol content) have a large effect on evaporative emissions and need therefore to be clearly specified. However, due to regional differences in the market specifications of fuels and in the measurement methods of their relevant properties, regionally different reference fuels need to be recognised. Contracting Parties may select their reference fuels either according to Annex 3 to UN GTR No. 15 or according to Annex 2 of this UN GTR.

D. Technical feasibility, anticipated costs and benefits

29. In designing and validating the WLTP EVAP procedure, strong emphasis has been put on its practicability, which is ensured by a number of measures explained above.

30. In general, the WLTP EVAP test procedure has been defined taking into account the technology available for evaporative emission control as well as the existing test facilities.

31. The best available technology performance significantly exceeds the stricter requirements on evaporative emissions which will be introduced in some regions as a result of the adoption of the WLTP EVAP procedure. In general, compared to the technology needed to comply with the requirements based on the 24-hour diurnal test still in force in many regions, the additional cost per vehicle is considered quite limited and eventually compensated by the emission reduction and the fuel savings.

32. Performing a test according to the WLTP EVAP test procedure and complying with the emission limits should not represent a major issue in most cases. Since in many regions the current evaporative test procedure is based on the 24-hour diurnal test, limited upgrades to existing SHEDs might be required to run the 48-hour diurnal test. In other cases, additional SHEDs might be necessary to take into account the longer time needed to complete evaporative emission tests. Nevertheless, 48-hour diurnal tests are already being performed by most of the car manufacturers since 48-hour and 72-hour diurnal test are already required for some markets.

33. For a more accurate assessment, costs and benefits would have to be quantified on a regional level since they largely depend on the local conditions (climate, fleet composition, fuel quality, ...).

34. As pointed out in the technical rationale and justification, the principle of a globally harmonized light duty vehicle test procedure offers potential cost reductions for vehicle manufacturers. The design of vehicles can be better unified on a global scale and administrative procedures may be simplified. The monetary quantification of these benefits depends largely on the extent and timing of implementations of the WLTP in regional legislation.

II. Text of the global technical regulation

1. Purpose

This UN Global Technical Regulation (UN GTR) aims at providing a worldwide harmonized method to determine the levels of evaporative emission from light-duty vehicles in a repeatable and reproducible manner designed to be representative of real world vehicle operation. The results will provide the basis for the regulation of these vehicles within regional type approval and certification procedures.

2. Scope and application

This UN GTR applies to vehicles of categories 1-2 and 2, both having a technically permissible maximum laden mass not exceeding 3,500 kg, with engines fuelled with petrol¹, and to all vehicles of category 1-1 with engines fuelled with petrol^{1,2}. At the option of the Contracting Party, mono-fuel gas vehicles may be excluded.

3. Definitions

- 3.1. Test equipment
 - 3.1.1. "*Accuracy*" means the difference between a measured value and a reference value, traceable to a national standard and describes the correctness of a result.
 - 3.1.2. "*Calibration*" means the process of setting a measurement system's response so that its output agrees with a range of reference signals.
- 3.2. Hybrid electric vehicles
 - 3.2.1. "*Charge-depleting operating condition*" means an operating condition in which the energy stored in the Rechargeable Electric Energy Storage System (REESS) may fluctuate but decreases on average while the vehicle is driven until transition to charge-sustaining operation.
 - 3.2.2. "*Charge-sustaining operating condition*" means an operating condition in which the energy stored in the REESS may fluctuate but, on average, is maintained at a neutral charging balance level while the vehicle is driven.
 - 3.2.3. "*Not off-vehicle charging hybrid electric vehicle*" (NOVC-HEV) means a hybrid electric vehicle that cannot be charged from an external source.
 - 3.2.4. "*Off-vehicle charging hybrid electric vehicle*" (OVC-HEV) means a hybrid electric vehicle that can be charged from an external source.
 - 3.2.5. "*Hybrid electric vehicle*" (HEV) means a hybrid vehicle where one of the propulsion energy converters is an electric machine.
 - 3.2.6. "*Hybrid vehicle*" (HV) means a vehicle equipped with a powertrain containing at least two different categories of propulsion energy converters and at least two different categories of propulsion energy storage systems.
- 3.3. Evaporative emission
 - 3.3.1. "*Fuel tank system*" means the devices which allow storing the fuel, comprising the fuel tank, the fuel filler, the filler cap and the fuel pump when it is fitted in or on the fuel tank.

¹ See Annex 2 - Reference fuels

² ECE/TRANS/WP.29/1045, as amended by Amends. 1 and 2 (Special Resolution No. 1, www.unece.org/trans/main/wp29/wgs/wp29gen/wp29resolutions.html)

- 3.3.2. "*Fuel system*" means the components which store or transport fuel on board the vehicle and comprise the fuel tank system, all fuel and vapour lines, any non-tank mounted fuel pumps and the activated carbon canister.
- 3.3.3. "*Butane working capacity*" (BWC) means the mass of butane which a carbon canister can adsorb.
- 3.3.4. "*BWC300*" means the butane working capacity after 300 cycles of fuel ageing cycles experienced.
- 3.3.5. "*Permeability Factor*" (PF) means the factor determined from hydrocarbon losses over a period of time and used to determine the final evaporative emissions.
- 3.3.6. "*Monolayer non-metal tank*" means a fuel tank constructed with a single layer of non-metal material including fluorinated/sulfonated materials.
- 3.3.7. "*Multilayer tank*" means a fuel tank constructed with at least two different layered materials, one of which is a hydrocarbon barrier material.
- 3.3.8. "*Sealed fuel tank system*" means a fuel tank system where the fuel vapours do not vent during parking over the 24-hour diurnal cycle defined in Appendix 2 to Annex 7 to the 07 series of amendments to UN Regulation No. 83 when performed with a reference fuel defined in Annex 2 of this UN GTR.
- 3.3.9. "*Evaporative emissions*" means in the context of this UN GTR the hydrocarbon vapours lost from the fuel system of a motor vehicle during parking and immediately before refuelling of a sealed fuel tank.
- 3.3.10. "*Mono-fuel gas vehicle*" means a mono-fuel vehicle that is designed primarily for permanent running on LPG or NG/biomethane or hydrogen, but may also have a petrol system for emergency purposes or starting only, where the nominal capacity of the petrol tank does not exceed 15 litres.
- 3.3.11. "*Depressurisation puff loss*" means hydrocarbons venting from a sealed fuel tank system pressure relief exclusively through the carbon canister allowed by the system.
- 3.3.12. "*Depressurisation puff loss overflow*" are the depressurisation puff loss hydrocarbons that pass through the carbon canister during depressurisation.
- 3.3.13. "*Fuel tank relief pressure*" is the minimum pressure value at which the sealed fuel tank system starts venting in response only to pressure inside the tank.
- 3.3.14. "*2 gram breakthrough*" shall be considered accomplished when the cumulative quantity of hydrocarbons emitted from the activated carbon canister equals 2 grams.

4. Abbreviations

General abbreviations

BWC	Butane working capacity
PF	Permeability factor
APF	Assigned permeability factor
OVC-HEV	Off-vehicle charging hybrid electric vehicle
NOVC-HEV	Not off-vehicle charging hybrid electric vehicle
WLTC	Worldwide light-duty test cycle
REESS	Rechargeable electric energy storage system
CoP	Conformity of production

5. General requirements

- 5.1. The vehicle and its components liable to affect the evaporative emissions shall be designed, constructed and assembled so as to enable the vehicle in normal use and under normal conditions of use such as humidity, rain, snow, heat, cold, sand, dirt, vibrations, wear, etc. to comply with the provisions of this UN GTR during its useful life determined by Contracting Parties.
 - 5.1.1. This shall include the security of all hoses, joints and connections used within the evaporative emission control systems.
 - 5.1.2. For vehicles with a sealed fuel tank system, this shall also include having a system which, just before refuelling, releases the tank pressure exclusively through a carbon canister which has the sole function of storing fuel vapour. This ventilation route shall also be the only one used when the tank pressure exceeds its safe working pressure.
- 5.2. The test vehicle shall be selected in accordance with paragraph 5.5.2. of this UN GTR.
- 5.3. Vehicle testing condition
 - 5.3.1. The types and amounts of lubricants and coolant for emissions testing shall be as specified for normal vehicle operation by the manufacturer.
 - 5.3.2. The type of fuel for testing shall be as specified in Annex 2 to this UN GTR.
 - 5.3.3. All evaporative emissions controlling systems shall be in working order.
 - 5.3.4. The use of any defeat device is prohibited.
- 5.4. Provisions for electronic system security
 - 5.4.1. Any vehicle with an evaporative emission control computer, including when integrated in an exhaust emissions control computer, shall include features to deter modification, except as authorised by the manufacturer. The manufacturer shall authorise modifications if these modifications are necessary for the diagnosis, servicing, inspection, retrofitting or repair of the vehicle. Any reprogrammable computer codes or operating parameters shall be resistant to tampering and afford a level of protection at least as good as the provisions in ISO 15031-7 (March 15, 2001). Any removable calibration memory chips shall be potted, encased in a sealed container or protected by electronic algorithms and shall not be changeable without the use of specialized tools and procedures.
 - 5.4.2. Computer-coded engine operating parameters shall not be changeable without the use of specialized tools and procedures (e.g. soldered or potted computer components or sealed (or soldered) enclosures).
 - 5.4.3. Manufacturers may seek approval from the responsible authority for an exemption to one of these requirements for those vehicles that are unlikely to require protection. The criteria that the responsible authority will evaluate in considering an exemption shall include, but are not limited to, the current availability of performance chips, the high-performance capability of the vehicle and the projected sales volume of the vehicle.
 - 5.4.4. Manufacturers using programmable computer code systems shall deter unauthorised reprogramming. Manufacturers shall include enhanced tamper protection strategies and write-protect features requiring electronic access to an off-site computer maintained by the manufacturer. Methods giving an adequate level of tamper protection will be approved by the responsible authority.

- 5.5. Evaporative emission family
- 5.5.1. Only vehicles that are identical with respect to the characteristics listed in (a), (d) and (e), technically equivalent with respect to the characteristics listed in (b) and (c) and similar or, where applicable, within the stated tolerance regarding the characteristics listed in (f) and (g), may be part of the same evaporative emission family:
- (a) Fuel tank system material and construction;
 - (b) Vapour hose material;
 - (c) Fuel line material and connection technique;
 - (d) Sealed tank or non-sealed tank system;
 - (e) Fuel tank relief valve setting (air ingestion and relief);
 - (f) Carbon canister butane working capacity (BWC300) within a 10 per cent range of the highest value (for carbon canisters with the same type of charcoal, the volume of charcoal shall be within 10 per cent of that for which the BWC300 was determined);
 - (g) Purge control system (for example, type of valve, purge control strategy).
- The manufacturer shall demonstrate the technical equivalence of points (b) and (c) to the responsible authority.
- 5.5.2. The vehicle shall be considered to produce worst-case evaporative emissions and shall be used for testing if it has the largest ratio of fuel tank capacity to BWC300 within the family. The vehicle selection shall be agreed in advance with the responsible authority.
- 5.5.3. The use of any innovative system calibration, configuration, or hardware related to the evaporative control system shall place the vehicle model in a different family.
- 5.6. The responsible authority shall not grant type approval if the information provided is insufficient to demonstrate that the evaporative emissions are effectively limited during the normal use of the vehicle.
- 5.7. Conformity of production
- At the option of the Contracting Party, the procedure for checking the conformity of a vehicle for the Type 4 test is specified in Annex 3 to this UN GTR.

6. Performance requirements

- 6.1. Limit values
- The following limit values shall apply:
- (a) For Contracting Parties which adopt the calculation defined in paragraph 7.2. of Annex 1, the limit value shall be 2.0 g/test;
 - (b) For Contracting Parties which adopt the alternative calculation defined in paragraph 7.3. of Annex 1, the limit value shall be determined by the Contracting Party.

Annex 1

Type 4 test procedures and test conditions

1. Introduction

This annex describes the procedure for the Type 4 test which determines the evaporative emission of vehicles.
2. Technical requirements
 - 2.1. The procedure includes the evaporative emissions test and two additional tests, one for the ageing of carbon canisters, as described in paragraph 5.1. of this annex, and one for the permeability of the fuel tank system, as described in paragraph 5.2. of this annex. The evaporative emissions test (Figure A1/4) determines hydrocarbon evaporative emissions as a consequence of diurnal temperature fluctuations and hot soaks during parking.
 - 2.2. In the case that the fuel system contains more than one carbon canister, all references to the term "carbon canister" in this UN GTR will apply to each carbon canister.
3. Vehicle

The vehicle shall be in good mechanical condition and have been run-in and driven at least 3,000 km before the test. For the purpose of the determination of evaporative emissions, the mileage and the age of the vehicle used for certification shall be recorded. The evaporative emission control system shall be connected and functioning correctly during the run-in period. The aged carbon canister shall not be installed during the run-in period.

A carbon canister aged according to the procedure described in paragraphs 5.1. to 5.1.3.1.3. inclusive of this annex shall not be installed until the start of the fuel drain and refill procedure specified in paragraph 6.5.1. of this annex.
4. Test equipment, calibration requirements and intervals

Unless stated otherwise in this paragraph, equipment used for testing shall be calibrated before its initial use and at appropriate service intervals thereafter. An appropriate service interval shall be either equipment manufacturer recommendation or according to good engineering practice.

 - 4.1. Chassis dynamometer

The chassis dynamometer shall meet the requirements of paragraphs 2. to 2.4.2. inclusive of Annex 5 to UN GTR No. 15.
 - 4.2. Evaporative emission measurement enclosure

The evaporative emission measurement enclosure shall be a gas-tight rectangular measuring chamber able to contain the vehicle under test. The vehicle shall be accessible from all sides and the enclosure when sealed shall be gas-tight in accordance with paragraph 4.2.3.3. of this annex. The inner surface of the enclosure shall be impermeable and non-reactive to hydrocarbons. The temperature conditioning system shall 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 1 °C over the duration of the test.

The control system shall 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 shall not be less than 5 °C nor more than 55 °C at any time during the diurnal emission test.

Wall design shall be such as to promote good dissipation of heat. Interior surface temperatures shall not be below 20 °C, nor above 52 °C for the duration of the hot soak rest.

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 bags 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 shall maintain the integrity of the enclosure as specified in paragraph 4.2.3. of this annex over the specified temperature range.

Any method of volume accommodation shall limit the differential between the enclosure internal pressure and the barometric pressure to a maximum value of ± 0.5 kPa.

The enclosure shall be capable of latching to a fixed volume. A variable volume enclosure shall be capable of accommodating a +7 per cent change from its "nominal volume" (see paragraph 4.2.3.1.1. of this annex,) taking into account temperature and barometric pressure variation during testing.

4.2.2. Fixed-volume enclosure

The fixed-volume enclosure shall be constructed with rigid panels that maintain a fixed enclosure volume and meet the requirements below.

4.2.2.1. The enclosure shall 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. Inlet air shall be filtered with activated carbon to provide a relatively constant hydrocarbon level. Any method of volume accommodation shall maintain the differential between the enclosure internal pressure and the barometric pressure between 0 and -0.5 kPa.

4.2.2.2. The equipment shall 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 analyser and integrated with the flow measurements to provide a continuous record of the mass hydrocarbon removal.

4.2.3. Calibration of the enclosure

4.2.3.1. Initial determination of internal volume of the enclosure

4.2.3.1.1. Before its initial use, the internal volume of the chamber shall 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 shall be latched to a fixed volume when the enclosure is held at an ambient temperature of 30 °C or at the choice of the manufacturer 29 °C. This nominal volume shall be repeatable within ± 0.5 per cent of the reported value.

- 4.2.3.1.2. The net internal volume is determined by subtracting 1.42 m³ 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 m³.
- 4.2.3.1.3. The chamber shall be checked as in paragraph 4.2.3.3. of this annex. If the propane mass does not correspond to the injected mass to within ± 2 per cent, then corrective action is required.
- 4.2.3.2. Determination of chamber background emissions
- This operation determines that the chamber does not contain any materials that emit significant amounts of hydrocarbons. The check shall 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.
- 4.2.3.2.1. Variable-volume enclosures may be operated in either latched or unlatched volume configuration, as described in paragraph 4.2.3.1.1. of this annex, ambient temperatures shall be maintained at $35\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$, or at the choice of the manufacturer $36\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$, throughout the 4-hour period mentioned below.
- 4.2.3.2.2. Fixed volume enclosures shall be operated with the inlet and outlet flow streams closed. Ambient temperatures shall be maintained at $35\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$, or at the choice of the manufacturer $36\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ throughout the 4-hour period mentioned below.
- 4.2.3.2.3. The enclosure may be sealed and the mixing fan operated for a period of up to 12 hours before the 4-hour background sampling period begins.
- 4.2.3.2.4. The analyser (if required) shall be calibrated, then zeroed and spanned.
- 4.2.3.2.5. The enclosure shall be purged until a stable hydrocarbon reading is obtained, and the mixing fan turned on if not already on.
- 4.2.3.2.6. The chamber is then sealed and the background hydrocarbon concentration, temperature and barometric pressure are measured. These are the initial readings C_{HCl} , P_i , T_i used in the enclosure background calculation.
- 4.2.3.2.7. The enclosure is allowed to stand undisturbed with the mixing fan on for a period of four hours.
- 4.2.3.2.8. At the end of this time the same analyser 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_{HCl} , P_f , T_f .
- 4.2.3.2.9. The change in mass of hydrocarbons in the enclosure shall be calculated over the time of the test in accordance with paragraph 4.2.3.4. of this annex and shall not exceed 0.05 g.
- 4.2.3.3. 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 paragraph 4.2.3.1. of this annex and also measures any leak rate. The enclosure leak rate shall 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.
- 4.2.3.3.1. The enclosure shall 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.
- 4.2.3.3.2. On variable-volume enclosures, the enclosure shall be latched to the nominal volume position. On fixed-volume enclosures the outlet and inlet flow streams shall be closed.

- 4.2.3.3.3. The ambient temperature control system is then turned on (if not already on) and adjusted for an initial temperature of 35 °C, or at the choice of the manufacturer 36 °C.
- 4.2.3.3.4. When the enclosure stabilises at 35 °C ± 2 °C, or at the choice of the manufacturer 36 °C ± 2 °C, the enclosure is sealed and the background concentration, temperature and barometric pressure measured. These are the initial readings C_{HCi} , P_i , T_i used in the enclosure calibration.
- 4.2.3.3.5. A quantity of approximately 4 grams of propane is injected into the enclosure. The mass of propane shall be measured to an accuracy and precision of ±2 per cent of the measured value.
- 4.2.3.3.6. The contents of the chamber shall be allowed to mix for five minutes and then the hydrocarbon concentration, temperature and barometric pressure are measured. These are the readings C_{HCf} , P_f , T_f for the calibration of the enclosure as well as the initial readings C_{HCi} , P_i , T_i for the retention check.
- 4.2.3.3.7. Based on the readings taken according to paragraphs 4.2.3.3.4. and 4.2.3.3.6. of this annex and the formula in paragraph 4.2.3.4. of this annex, the mass of propane in the enclosure is calculated. This shall be within ±2 per cent of the mass of propane measured in paragraph 4.2.3.3.5. of this annex.
- 4.2.3.3.8. For variable-volume enclosures the enclosure shall be unlatched from the nominal volume configuration. For fixed-volume enclosures, the outlet and inlet flow streams shall be opened.
- 4.2.3.3.9. The process is then begun of cycling the ambient temperature from 35 °C to 20 °C and back to 35 °C, or at the choice of the manufacturer 35.6 °C to 22.2 °C and back to 35.6 °C, over a 24-hour period according to the profile, or the alternative profile, specified in paragraph 6.5.9. of this annex within 15 minutes of sealing the enclosure. (Tolerances as specified in paragraph 6.5.9.1. of this annex.)
- 4.2.3.3.10. 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_{HCf} , P_f , T_f for the hydrocarbon retention check.
- 4.2.3.3.11. Using the formula in paragraph 4.2.3.4. of this annex, the hydrocarbon mass is then calculated from the readings taken in paragraphs 4.2.3.3.6. and 4.2.3.3.10. of this annex. The mass may not differ by more than 3 per cent from the hydrocarbon mass given in paragraph 4.2.3.3.7. of this annex.

4.2.3.4. 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.

The calculation shall be undertaken in accordance in paragraph 7. of this annex, using the following value for V .

V is the net enclosure volume, m^3 .

4.3. Analytical systems

The analytical systems shall meet the requirements of paragraphs 4.3.1. to 4.3.3. of this annex.

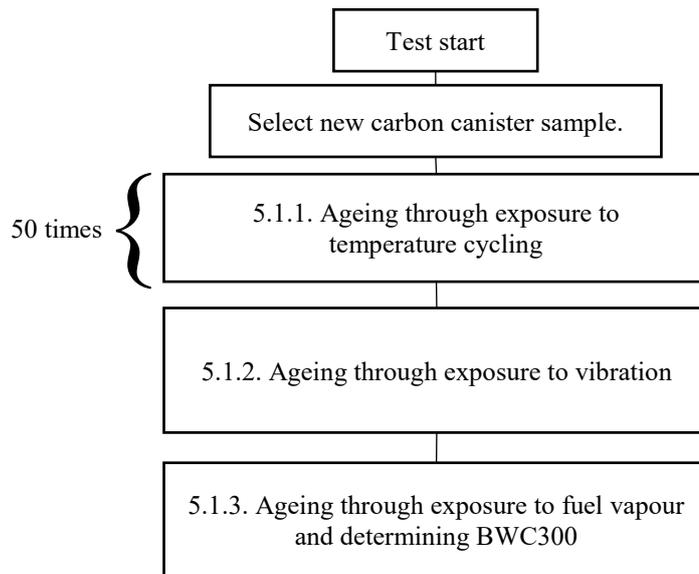
Continuous measuring of hydrocarbons is not mandatory unless the fixed volume type enclosure is used.

- 4.3.1. Hydrocarbon analyser
- 4.3.1.1. The atmosphere within the chamber is monitored using a hydrocarbon detector of the FID type. Sample gas shall be drawn from the mid-point of one side wall or roof of the chamber and any bypass flow shall be returned to the enclosure, preferably to a point immediately downstream of the mixing fan.
- 4.3.1.2. The hydrocarbon analyser shall have a response time to 90 per cent of final reading of less than 1.5 seconds. Its stability shall be better than 2 per cent of full scale at zero and at 80 ± 20 per cent of full scale over a 15-minute period for all operational ranges.
- 4.3.1.3. The repeatability of the analyser expressed as one standard deviation shall be better than ± 1 per cent of full scale deflection at zero and at 80 ± 20 per cent of full scale on all ranges used.
- 4.3.1.4. The operational ranges of the analyser shall 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 analyser shall 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 shall have operating characteristics at least equivalent to the signal being recorded and shall provide a permanent record of results. The record shall 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).
- 4.3.3. Checking of FID hydrocarbon analyser
- 4.3.3.1. Detector response optimisation
- The FID shall be adjusted as specified by the instrument manufacturer. Propane in air should be used to optimise the response on the most common operating range.
- 4.3.3.2. Calibration of the hydrocarbon analyser
- The analyser should be calibrated using propane in air and purified synthetic air. See paragraph 6.2. of Annex 5 to UN GTR 15.
- Each of the normally used operating ranges are calibrated in accordance with paragraphs 4.3.3.2.1. to 4.3.3.2.4. of this annex.
- 4.3.3.2.1. 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 per cent of the full scale.
- 4.3.3.2.2. 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 shall be at least the number of the polynomial degree plus 2.
- 4.3.3.2.3. The calibration curve shall not differ by more than 2 per cent from the nominal value of each calibration gas.
- 4.3.3.2.4. Using the coefficients of the polynomial derived from paragraph 5. of Annex 5 to UN GTR 15, a table of indicated reading against true concentration shall be drawn up in steps of no greater than 1 per cent of full scale. This is to be carried out for each analyser range calibrated. The table shall also contain other relevant data such as:
- (a) Date of calibration, span and zero potentiometer readings (where applicable);
 - (b) Nominal scale;

- (c) Reference data of each calibration gas used;
 - (d) The actual and indicated value of each calibration gas used together with the percentage differences;
 - (e) FID fuel and type;
 - (f) FID air pressure.
- 4.3.3.2.5. If it can be shown to the satisfaction of the responsible authority that alternative technology (e.g. computer, electronically controlled range switch) can give equivalent accuracy, then those alternatives may be used.
- 4.4. Temperature recording system
- The temperature recording system shall meet the requirements of paragraphs 4.4.1. to 4.4.5. of this annex.
- 4.4.1. 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 centre line of each side wall at a height of 0.9 ± 0.2 m.
- 4.4.2. The temperatures of the fuel tank(s) are recorded by means of the sensor positioned in the fuel tank as in paragraph 6.1.1. of this annex in the case of use of the gasoline canister load option (paragraph 6.5.5.3. of this annex).
- 4.4.3. Temperatures shall, throughout the evaporative emission measurements, be recorded or entered into a data processing system at a frequency of at least once per minute.
- 4.4.4. The accuracy of the temperature recording system shall be within ± 1.0 °C and the temperature shall be capable of being resolved to ± 0.4 °C.
- 4.4.5. The recording or data processing system shall be capable of resolving time to ± 15 seconds.
- 4.5. Pressure recording system
- The pressure recording system shall meet the requirements of paragraphs 4.5.1. to 4.5.3 of this annex.
- 4.5.1. The difference Δp between barometric pressure within the test area and the enclosure internal pressure shall, throughout the evaporative emission measurements, be recorded or entered into a data processing system at a frequency of at least once per minute.
- 4.5.2. The accuracy of the pressure recording system shall be within ± 0.3 kPa and the pressure shall be capable of being resolved to ± 0.025 kPa.
- 4.5.3. The recording or data processing system shall be capable of resolving time to ± 15 seconds.
- 4.6. Fans
- The fans shall meet the requirements of paragraphs 4.6.1. and 4.6.2. of this annex.
- 4.6.1. By the use of one or more fans or blowers with the Sealed Housing Evaporative Determination (SHED) door(s) open, it shall be possible to reduce the hydrocarbons concentration in the chamber to the ambient hydrocarbon level.
- 4.6.2. The chamber shall have one or more fans or blowers of like capacity 0.1 to 0.5 m³/sec. with which to thoroughly mix the atmosphere in the enclosure. It shall be possible to attain an even temperature and hydrocarbon concentration in the chamber during measurements. The vehicle in the enclosure shall not be subjected to a direct stream of air from the fans or blowers.

- 4.7. Calibration gases
- The gases shall meet the requirements of paragraphs 4.7.1. and 4.7.2. of this annex.
- 4.7.1. The following pure gases shall be available for calibration and operation:
- Purified synthetic air: (purity < 1 ppm C₁ equivalent,
≤ 1 ppm CO, ≤ 400 ppm CO₂, ≤ 0.1 ppm NO);
- Oxygen content between 18 and 21 per cent by volume.
- Hydrocarbon analyser fuel gas: (40 ± 2 per cent hydrogen, and balance helium with less than 1 ppm C₁ equivalent hydrocarbon, less than 400 ppm CO₂),
- Propane (C₃H₈): 99.5 per cent minimum purity.
- Butane (C₄H₁₀): 98 per cent minimum purity.
- Nitrogen (N₂): 98 per cent minimum purity.
- 4.7.2. Calibration and span gases shall be available containing mixtures of propane (C₃H₈) and purified synthetic air. The true concentrations of a calibration gas shall be within 2 per cent of the stated figures. The accuracy of the diluted gases obtained when using a gas divider shall be to within ±2 per cent of the true value. The concentrations specified in paragraphs 4.2.3. and 4.3.3. of this annex may also be obtained by the use of a gas divider using synthetic air as the dilutant gas.
- 4.8. Carbon canister weighing scale for depressurisation puff loss overflow measurement
- The carbon canister weighing scale shall have an accuracy of ±0.02 g.
- 4.9. Fuel tank heating (only applicable for gasoline canister load option)
- 4.9.1. The fuel in the vehicle tank(s) shall be heated by a controllable source of heat; for example a heating pad of 2,000 W capacity is suitable. The heating system shall apply heat evenly to the tank walls beneath the level of the fuel so as not to cause local overheating of the fuel. Heat shall not be applied to the vapour in the tank above the fuel.
- 4.9.2. The tank heating device shall make it possible to heat the fuel in the tank evenly by 14 °C from 16 °C within 60 minutes, with the temperature sensor position as in paragraph 4.9.3. of this annex. The heating system shall be capable of controlling the fuel temperature to ±1.5 °C of the required temperature during the tank heating process.
- 4.9.3. The fuel tank of the vehicle shall, without introducing any leaks, 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 per cent of its capacity. 5. Procedure for carbon canister bench ageing and PF determination
- 5.1. Carbon canister bench ageing
- Before performing the hot soak and diurnal losses sequences, the carbon canister shall be aged according to the procedure described in Figure A1/1.

Figure A1/1

Carbon canister bench ageing procedure

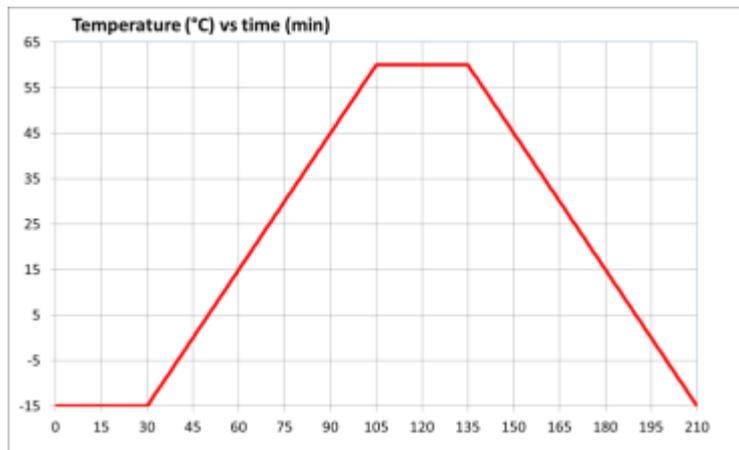
5.1.1. Ageing through exposure to temperature cycling

The carbon canister shall be cycled between temperatures from -15 °C to 60 °C in a dedicated temperature enclosure with 30 minutes of stabilisation at -15 °C and 60 °C. Each cycle shall last 210 minutes (see Figure A1/2).

The temperature gradient shall be as close as possible to 1 °C/min. No forced air flow should pass through the carbon canister.

The cycle shall be repeated 50 times consecutively. In total, this procedure lasts 175 hours.

Figure A1/2

Temperature conditioning cycle

5.1.2. Ageing through exposure to vibration

Following the temperature ageing procedure, the carbon canister shall be shaken vertically with the carbon canister mounted as per its orientation in the vehicle with an overall Grms (root mean square acceleration) > 1.5 m/sec² with a frequency of 30 ±10 Hz. The test shall last 12 hours.

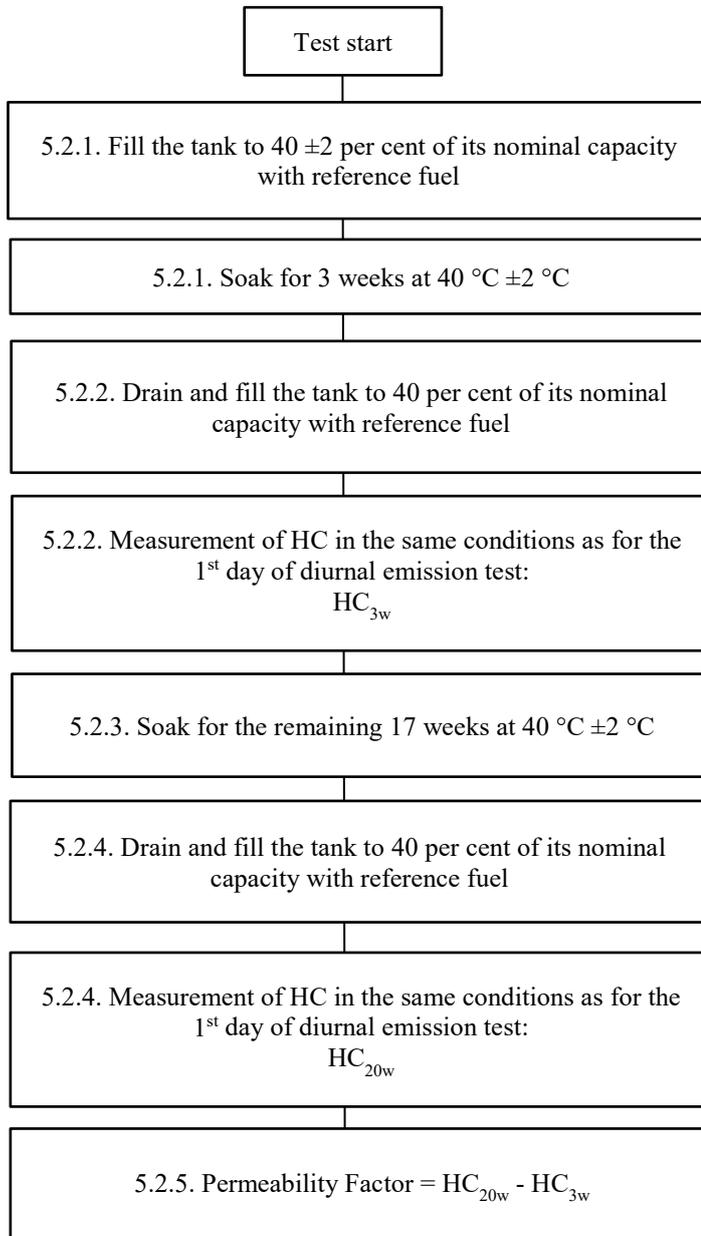
5.1.3. Ageing through exposure to fuel vapour and determining BWC300

5.1.3.1. Ageing shall consist of repeatedly loading with fuel vapour and purging with laboratory air.

- 5.1.3.1.1. After temperature and vibration ageing, the carbon canister shall be further aged with a mixture of market fuel as specified in paragraph 5.1.3.1.1.1. of this annex and nitrogen or air with a 50 ± 15 per cent fuel vapour volume. The fuel vapour fill rate shall be 60 ± 20 g/h.
- The carbon canister shall be loaded to 2 gram breakthrough. Alternatively, loading shall be considered to be completed when the hydrocarbon concentration level at the vent outlet reaches 3,000 ppm.
- 5.1.3.1.1.1. The market fuel used for this test shall fulfil the same requirements as a reference fuel with respect to:
- (a) Density at 15 °C;
 - (b) Vapour pressure;
 - (c) Distillation (70 °C, 100 °C, 150 °C);
 - (d) Hydrocarbon analysis (olefins, aromatics, benzene only);
 - (e) Oxygen content;
 - (f) Ethanol content.
- 5.1.3.1.2. The carbon canister shall be purged between 5 and 60 minutes after loading with 25 ± 5 litres per minute of emission laboratory air until 300 bed volume exchanges are reached.
- 5.1.3.1.3. The procedures set out in paragraphs 5.1.3.1.1. and 5.1.3.1.2. of this annex shall be repeated 300 times after which the carbon canister shall be considered to be stabilised.
- 5.1.3.1.4. The procedure to measure the butane working capacity (BWC) with respect to the evaporative emission family in paragraph 5.5. of this UN GTR shall consist of the following.
- (a) The stabilised carbon canister shall be loaded to 2 gram breakthrough and subsequently purged a minimum of 5 times. Loading shall be performed with a mixture composed of 50 per cent butane and 50 per cent nitrogen by volume at a rate of 40 grams butane per hour.
 - (b) Purging shall be performed according to paragraph 5.1.3.1.2. of this annex.
 - (c) The BWC shall be recorded after each loading.
 - (d) BWC₃₀₀ shall be calculated as the average of the last 5 BWCs.
- 5.1.3.2. If the aged carbon canister is provided by a supplier, the vehicle manufacturer shall inform the responsible authority in advance of the ageing process to enable the witnessing of any part of that process.
- 5.1.3.3. The manufacturer shall provide the responsible authority a test report including at least the following elements:
- (a) Type of activated carbon;
 - (b) Loading rate;
 - (c) Fuel specifications.

5.2. Determination of the PF of the fuel tank system (see Figure A1/3)

Figure A1/3

Determination of the PF

5.2.1. The fuel tank system representative of a family shall be selected and mounted on a rig in a similar orientation as in the vehicle. The tank shall be filled to 40 ± 2 per cent of its nominal capacity with reference fuel at a temperature of $18 \text{ °C} \pm 2 \text{ °C}$. The rig with the fuel tank system shall be placed in a room with a controlled temperature of $40 \text{ °C} \pm 2 \text{ °C}$ for 3 weeks.

5.2.2. At the end of the third week, the tank shall be drained and refilled with reference fuel at a temperature of $18 \text{ °C} \pm 2 \text{ °C}$ to 40 ± 2 per cent of its nominal capacity.

Within 6 to 36 hours, the rig with the fuel tank system shall be placed in an enclosure. The last 6 hours of this period shall be at an ambient temperature of $20 \text{ °C} \pm 2 \text{ °C}$. In the enclosure, a diurnal procedure shall be performed over the first 24-hour period of the procedure described in paragraph 6.5.9. of this annex. The fuel vapour in the tank shall be vented to the outside of the enclosure to eliminate the possibility of the tank venting emissions being

counted as permeation. The HC emissions shall be measured and the value shall be recorded as HC_{3W}.

5.2.3. The rig with the fuel tank system shall be placed again in a room with a controlled temperature of 40 °C ±2 °C for the remaining 17 weeks.

5.2.4. At the end of the seventeenth week, the tank shall be drained and refilled with reference fuel at a temperature of 18 °C ±2 °C to 40 ±2 per cent of its nominal tank capacity.

Within 6 to 36 hours, the rig with the fuel tank system shall be placed in an enclosure. The last 6 hours of this period shall be at an ambient temperature of 20 °C ±2 °C. In the enclosure, a diurnal procedure shall be performed over a first period of 24 hours of the procedure described according to paragraph 6.5.9. of this annex. The fuel tank system shall be vented to the outside of the enclosure to eliminate the possibility of the tank venting emissions being counted as permeation. The HC emissions shall be measured and the value shall be recorded in this case as HC_{20W}.

5.2.5. The PF is the difference between HC_{20W} and HC_{3W} in g/24h calculated to 3 significant digits using the following equation:

$$PF = HC_{20W} - HC_{3W}$$

5.2.6. If the PF is determined by a supplier, the vehicle manufacturer shall inform the responsible authority in advance of the determination to allow witness check in the supplier's facility.

5.2.7. The manufacturer shall provide the responsible authority with a test report containing at least the following:

- (a) A full description of the fuel tank system tested, including information on the type of tank tested, whether the tank is metal, monolayer non-metal or multilayer, and which types of materials are used for the tank and other parts of the fuel tank system;
- (b) The weekly mean temperatures at which the ageing was performed;
- (c) The HC measured at week 3 (HC_{3W});
- (d) The HC measured at week 20 (HC_{20W});
- (e) The resulting permeability factor (PF).

5.2.8. As an alternative to paragraphs 5.2.1. to 5.2.7. inclusive of this annex, a manufacturer using multilayer tanks or metal tanks may choose to use an Assigned Permeability Factor (APF) instead of performing the complete measurement procedure mentioned above:

$$APF \text{ multilayer/metal tank} = 120 \text{ mg /24 h}$$

Where the manufacturer chooses to use an APF, the manufacturer shall provide the responsible authority with a declaration in which the type of tank is clearly specified as well as a declaration of the type of materials used.

6. Test procedure for the measurement of hot soak and diurnal losses

6.1. Vehicle preparation

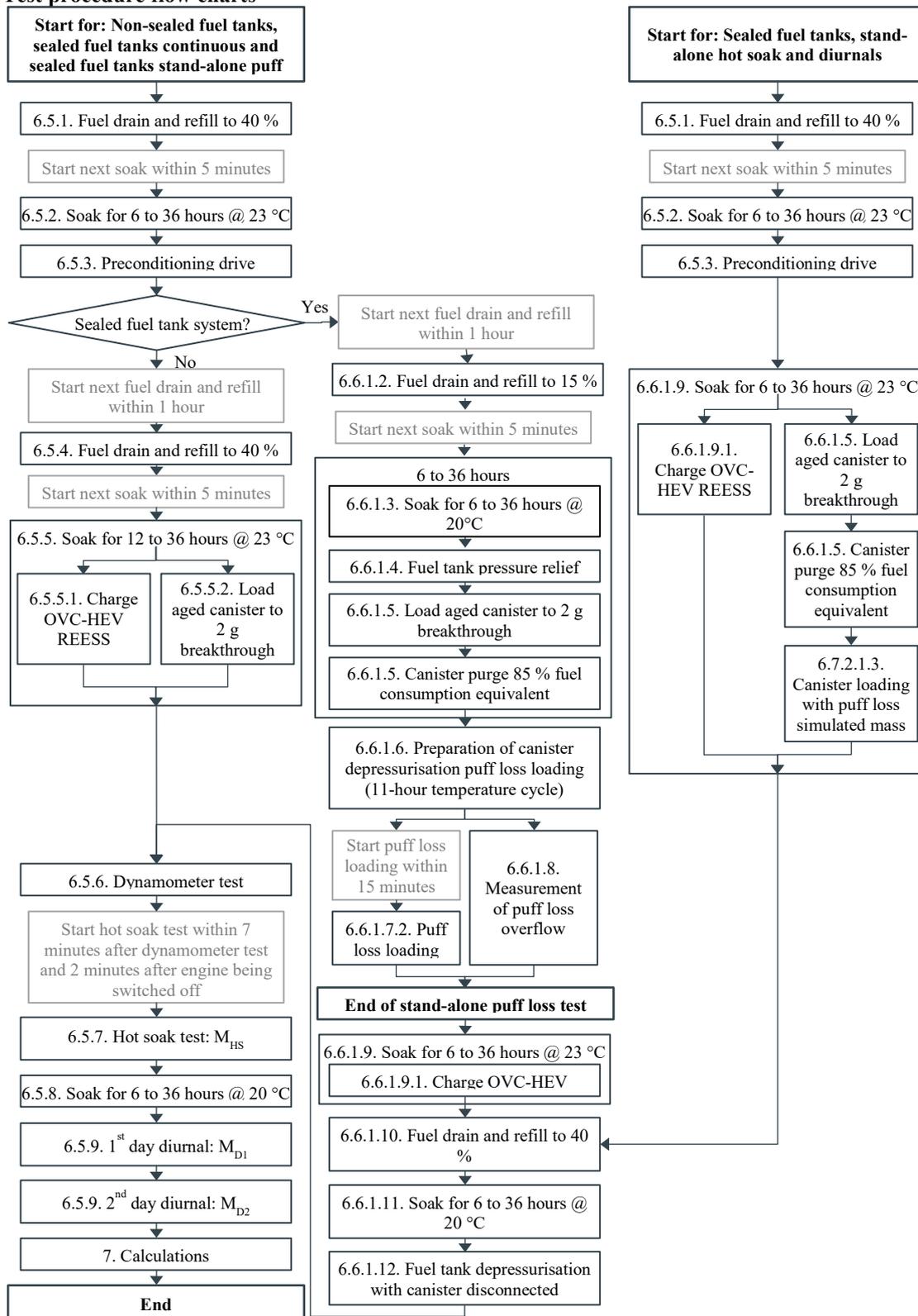
The vehicle shall be prepared in accordance with paragraphs 6.1.1. and 6.1.2. of this annex. At the request of the manufacturer and with approval of the responsible authority, non-fuel background emission sources (e.g. paint, adhesives, plastics, fuel/vapour lines, tyres, and other rubber or polymer components) may be reduced to typical vehicle background levels before testing (e.g. baking of tyres at temperatures of 50 °C or higher for appropriate periods, baking of the vehicle, draining washer fluid).

For a sealed fuel tank system, the vehicle carbon canisters shall be installed so that access to carbon canisters and connection/disconnection of carbon canisters can be done easily.

- 6.1.1. The vehicle shall be mechanically prepared before the test as follows:
- (a) The exhaust system of the vehicle shall not exhibit any leaks;
 - (b) The vehicle may be steam-cleaned before the test;
 - (c) In the case of use of the gasoline canister load option (paragraph 6.5.5.3. of this annex) the fuel tank of the vehicle shall 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 per cent of its capacity;
 - (d) 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;
 - (e) 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.
- 6.1.2. The vehicle is taken into the test area where the ambient temperature is between 20 and 30 °C.
- 6.2. Mode selections and gear shift prescriptions
- 6.2.1. For vehicles with manual shift transmissions, the gear shift prescriptions specified in Annex 2 to UN GTR No. 15 shall apply.
- 6.2.2. In the case of conventional Internal Combustion Engine (ICE) vehicles, the mode shall be selected according to Annex 6 to UN GTR No. 15.
- 6.2.3. In the case of NOVC-HEVs and OVC-HEVs, the mode shall be selected according to Appendix 6 to Annex 8 of UN GTR No. 15.
- 6.2.4. Upon request of the responsible authority, the selected mode may be different from that described in paragraphs 6.2.2. and 6.2.3. of this annex.
- 6.3. Test conditions
- The tests included in this UN GTR shall be performed using the test conditions specific to interpolation family vehicle H with the highest cycle energy demand of all the interpolation families included in the evaporative emission family being considered.
- Otherwise, at the request of the responsible authority, any cycle energy representative of a vehicle in the family may be used for the test.
- 6.4. Flow of the test procedure
- The test procedure for non-sealed and sealed tank systems shall be followed according to the flow chart described in Figure A1/4.
- The sealed fuel tank systems shall be tested with one of 2 options. One option is to test the vehicle with one continuous procedure. Another option, called the 'stand-alone test procedure', is to test the vehicle with two separate procedures which will allow repeating the dynamometer test and the diurnal tests without repeating the tank depressurisation puff loss overflow test and the depressurisation puff loss measurement.

Figure A1/4

Test procedure flow charts



6.5. Continuous test procedure for non-sealed fuel tank systems

6.5.1. Fuel drain and refill

The fuel tank of the vehicle shall be emptied. This shall 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. The

fuel tank shall be refilled with reference fuel at a temperature of $18\text{ °C} \pm 2\text{ °C}$ to 40 ± 2 per cent of its nominal capacity.

6.5.2. Soak

Within 5 minutes after completing the fuel drain and refill, the vehicle shall be soaked for a minimum of 6 hours and a maximum of 36 hours at $23\text{ °C} \pm 3\text{ °C}$.

6.5.3. Preconditioning drive

The vehicle shall be placed on a chassis dynamometer and driven over the following phases of the cycle described in Annex 1 of UN GTR No. 15:

- (a) For Class 1 vehicles:
low, medium, low, low, medium, low
- (b) For Class 2 and 3 vehicles: low, medium, high, medium.

For OVC-HEVs, the preconditioning drive shall be performed under the charge-sustaining operating condition as defined in paragraph 3.3.6. of UN GTR No. 15. Upon the request of responsible authority, any other mode may be used.

6.5.4. Fuel drain and refill

Within one hour after the preconditioning drive, the fuel tank of the vehicle shall be emptied. This shall 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. The fuel tank shall be refilled with test fuel at a temperature of $18\text{ °C} \pm 2\text{ °C}$ to 40 ± 2 per cent of its nominal capacity.

6.5.5. Soak

Within five minutes of completing fuel drain and refill, the vehicle shall be parked for a minimum of 12 hours and a maximum of 36 hours at $23\text{ °C} \pm 3\text{ °C}$.

During soaking, the procedures described in paragraphs 6.5.5.1. and 6.5.5.2. of this annex may be performed either in the order of first paragraph 6.5.5.1. followed by paragraph 6.5.5.2. or in the order paragraph 6.5.5.2. followed by paragraph 6.5.5.1. The procedures described in paragraphs 6.5.5.1. and 6.5.5.2. may also be performed simultaneously.

6.5.5.1. REESS charge

For OVC-HEVs, the REESS shall be fully charged according to the charging requirements described in paragraph 2.2.3. of Appendix 4 to Annex 8 to UN GTR No.15.

6.5.5.2. Carbon canister loading

The carbon canister aged according to the sequence described in paragraph 5.1. to 5.1.3.1.3. inclusive of this annex shall be loaded to 2 gram breakthrough according to the procedure described in paragraph 6.5.5.2.1. of this annex.

One of the methods specified in paragraphs 6.5.5.3. and 6.5.5.4. of this annex shall be used to precondition the evaporative canister. For vehicles with multiple canisters, each canister shall be preconditioned separately.

6.5.5.2.1. 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.

6.5.5.2.2. Breakthrough may be verified using the evaporative emission enclosure as described in paragraphs 6.5.5.3. and 6.5.5.4. of this annex. Alternatively, breakthrough may be determined using an auxiliary evaporative canister connected downstream of the vehicle's canister. The auxiliary canister shall be well purged with dry air prior to loading.

- 6.5.5.2.3. The measuring chamber shall be purged for several minutes immediately before the test until a stable background is obtained. The chamber air mixing fan(s) shall be switched on at this time.

The hydrocarbon analyser shall be zeroed and spanned immediately before the test.

- 6.5.5.3. Canister loading with repeated heat builds to breakthrough

- 6.5.5.3.1. The fuel tank(s) of the vehicle(s) is (are) emptied using the fuel tank drain(s). This shall 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.

- 6.5.5.3.2. The fuel tank(s) is (are) refilled with test fuel at a temperature of between 10 to 14 °C to 40 ± 2 per cent of the tank's normal volumetric capacity. The fuel cap(s) of the vehicle shall be fitted at this point.

- 6.5.5.3.3. Within one hour of being refuelled the vehicle shall 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 shall be properly positioned with respect to the fuel tank(s) and connected to the temperature controller. The heat source is specified in paragraph 4.9. of this annex. In the case of vehicles fitted with more than one fuel tank, all the tanks shall be heated in the same way as described below. The temperatures of the tanks shall be identical to within ±1.5 °C.

- 6.5.5.3.4. The fuel may be artificially heated to the starting diurnal temperature of 20 °C ± 1 °C.

- 6.5.5.3.5. When the fuel temperature reaches at least 19 °C, the following steps shall be taken immediately: the purge blower shall be turned off; enclosure doors closed and sealed; and measurement initiated of the hydrocarbon level in the enclosure.

- 6.5.5.3.6. When the fuel temperature of the fuel tank reaches 20 °C a linear heat build of 15 °C begins. The fuel shall be heated in such a way that the temperature of the fuel during the heating conforms to the function below to within ±1.5 °C. The elapsed time of the heat build and temperature rise is recorded.

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

Where:

T_r = required temperature (K),

T_o = initial temperature (K),

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

- 6.5.5.3.7. As soon as break-through occurs or when the fuel temperature reaches 35 °C, whichever occurs first, the heat source is turned off, the enclosure doors unsealed and opened, and the vehicle fuel tank cap(s) removed. If break-through has not occurred by the time the fuel temperature 35 °C, the heat source is removed from the vehicle, the vehicle removed from the evaporative emission enclosure and the entire procedure outlined in paragraph 6.6.1.2. of this annex repeated until break-through occurs.

- 6.5.5.4. Butane loading to breakthrough

- 6.5.5.4.1. If the enclosure is used for the determination of the break-through (see paragraph 6.5.5.2.2. of this annex) the vehicle shall be placed, with the engine shut off, in the evaporative emission enclosure.

- 6.5.5.4.2. The evaporative emission canister shall be prepared for the canister loading operation. The canister shall 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 shall be taken during this step to avoid damage to the components and the integrity of the fuel system.

- 6.5.5.4.3. The canister is loaded with a mixture composed of 50 per cent butane and 50 per cent nitrogen by volume at a rate of 40 grams butane per hour.
- 6.5.5.4.4. As soon as the canister reaches breakthrough, the vapour source shall be shut off.
- 6.5.5.4.5. The evaporative emission canister shall then be reconnected and the vehicle restored to its normal operating condition.
- 6.5.6. Dynamometer test
- The test vehicle shall be pushed onto a dynamometer and shall be driven over the cycles described in paragraph 6.5.3.(a) or paragraph 6.5.3.(b) of this annex. OVC-HEVs shall be operated in charge-depleting operating condition. The engine shall be subsequently shut off. Exhaust emissions may be sampled during this operation and the results may be used for the purpose of exhaust emission and fuel consumption type approval if this operation meets the requirement described in Annex 6 or Annex 8 of UN GTR No.15.
- 6.5.7. Hot soak evaporative emissions test
- Within 7 minutes after the dynamometer test and within 2 minutes of the engine being switched off, the hot soak evaporative emissions test shall be performed in accordance with paragraphs 6.5.7.1. to 6.5.7.8. of this annex. The hot soak losses shall be calculated according to paragraph 7.1. of this annex and recorded as M_{HS} .
- 6.5.7.1. Before the completion of the test run the measuring chamber shall be purged for several minutes until a stable hydrocarbon background is obtained. The enclosure mixing fan(s) shall also be turned on at this time.
- 6.5.7.2. The hydrocarbon analyser shall be zeroed and spanned immediately prior to the test.
- 6.5.7.3. At the end of the driving cycle the engine bonnet shall 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 shall 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 shall be opened at this stage, if not already opened.
- 6.5.7.4. The vehicle shall be pushed or otherwise moved into the measuring chamber with the engine switched off.
- 6.5.7.5. 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.
- 6.5.7.6. The start of a 60 ± 0.5 minute hot soak period begins when the chamber is sealed. The hydrocarbon concentration, temperature and barometric pressure are measured to give the initial readings C_{HCi} , P_i and T_i for the hot soak test. These figures are used in the evaporative emission calculation, paragraph 6. The ambient temperature T of the enclosure shall not be less than $23\text{ }^{\circ}\text{C}$ and no more than $31\text{ }^{\circ}\text{C}$ during the 60-minute hot soak period.
- 6.5.7.7. The hydrocarbon analyser shall be zeroed and spanned immediately before the end of the 60 ± 0.5 minute test period.
- 6.5.7.8. At the end of the 60 ± 0.5 minute test period, the hydrocarbon concentration in the chamber shall be measured. The temperature and the barometric pressure

are also measured. These are the final readings C_{HCF} , P_f and T_f for the hot soak test used for the calculation in paragraph 6. of this annex.

6.5.8. Soak

After the hot soak evaporative emissions test, the test vehicle shall be 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 the last 6 hours of this period the vehicle shall be soaked at $20\text{ °C} \pm 2\text{ °C}$.

6.5.9. Diurnal testing

6.5.9.1. The test vehicle shall be exposed to two cycles of ambient temperature in accordance with the profile specified in Table A1/1 with a maximum deviation of $\pm 2\text{ °C}$ at any time. The average temperature deviation from the profile, calculated using the absolute value of each measured deviation, shall not exceed $\pm 1\text{ °C}$. Ambient temperature shall be measured and recorded at least every minute. Temperature cycling shall begin at time $T_{\text{start}} = 0$, as specified in paragraph 6.5.9.6. of this annex.

Table A1/1
Diurnal ambient temperature profiles

<i>Diurnal ambient temperature profile for the calibration of the enclosure and the diurnal emission test</i>			<i>Alternative diurnal ambient temperature profile for the calibration of the enclosure</i>	
<i>Time (hours)</i>		<i>Temperature (°C_i)</i>	<i>Time (hours)</i>	<i>Temperature (°C_i)</i>
<i>Calibration</i>	<i>Test</i>			
13	0/24	20.0	0	35.6
14	1	20.2	1	35.3
15	2	20.5	2	34.5
16	3	21.2	3	33.2
17	4	23.1	4	31.4
18	5	25.1	5	29.7
19	6	27.2	6	28.2
20	7	29.8	7	27.2
21	8	31.8	8	26.1
22	9	33.3	9	25.1
23	10	34.4	10	24.3
24/0	11	35.0	11	23.7
1	12	34.7	12	23.3
2	13	33.8	13	22.9
3	14	32.0	14	22.6
4	15	30.0	15	22.2
5	16	28.4	16	22.5
6	17	26.9	17	24.2
7	18	25.2	18	26.8
8	19	24.0	19	29.6
9	20	23.0	20	31.9
10	21	22.0	21	33.9

11	22	20.8	22	35.1
12	23	20.2	23	3.4
			24	35.6

- 6.5.9.2. The enclosure shall be purged for several minutes immediately before the test until a stable background is obtained. The chamber mixing fan(s) shall also be switched on at this time.
- 6.5.9.3. The test vehicle, with the powertrain shut off and the test vehicle windows and luggage compartment(s) opened, shall be moved into the measuring chamber. The mixing fan(s) shall be adjusted in such a way as to maintain a minimum air circulation speed of 8 km/h under the fuel tank of the test vehicle.
- 6.5.9.4. The hydrocarbon analyser shall be zeroed and spanned immediately before the test.
- 6.5.9.5. The enclosure doors shall be closed and sealed gas-tight.
- 6.5.9.6. Within 10 minutes of closing and sealing the doors, the hydrocarbon concentration, temperature and barometric pressure shall be measured to give initial readings of hydrocarbon concentration in the enclosure (C_{HCi}), barometric pressure (P_i) and ambient chamber temperature (T_i) for the diurnal testing. $T_{start} = 0$ starts at this time.
- 6.5.9.7. The hydrocarbon analyser shall be zeroed and spanned immediately before the end of each emission sampling period.
- 6.5.9.8. The end of the first and second emission sampling period shall occur at 24 hours ± 6 minutes and 48 hours ± 6 minutes, respectively, after the beginning of the initial sampling, as specified in paragraph 6.5.9.6. of this annex. The elapsed time shall be recorded.
- At the end of each emission sampling period, the hydrocarbon concentration, temperature and barometric pressure shall be measured and used to calculate the diurnal test results using the equation in paragraph 7.1. of this annex. The result obtained from the first 24 hours shall be recorded as M_{D1} . The result obtained from the second 24 hours shall be recorded as M_{D2} .
- 6.6. Continuous test procedure for sealed fuel tank systems
- 6.6.1. In the case that the fuel tank relief pressure is greater than or equal to 30 kPa
- 6.6.1.1. The test shall be performed as described in paragraphs 6.5.1. to 6.5.3. inclusive of this annex.
- 6.6.1.2. Fuel drain and refill
- Within one hour after the preconditioning drive, the fuel tank of the vehicle shall be emptied. This shall 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, otherwise the carbon canister shall be disconnected. The fuel tank shall be refilled with reference fuel at a temperature of $18\text{ }^\circ\text{C} \pm 2\text{ }^\circ\text{C}$ to 15 ± 2 per cent of the tank's nominal capacity. The operations described in paragraphs 6.6.1.3., 6.6.1.4. and 6.6.1.5. of this annex shall be completed within a total of 36 hours and for the operations described in paragraphs 6.6.1.4. and 6.6.1.5. the vehicle shall not be exposed to temperatures above $25\text{ }^\circ\text{C}$.
- 6.6.1.3. Soak
- Within 5 minutes after completing fuel drain and refill, the vehicle shall be soaked for stabilisation for at least 6 hours at an ambient temperature of $20\text{ }^\circ\text{C} \pm 2\text{ }^\circ\text{C}$.

6.6.1.4. Fuel tank depressurisation

The tank pressure shall be subsequently released so as not to abnormally raise the inside pressure of the fuel tank. This may be done by opening the fuel cap of the vehicle. Regardless of the method of depressurisation, the vehicle shall be returned to its original condition within 1 minute.

6.6.1.5. Carbon canister loading and purge

The carbon canister aged in accordance with the sequence described in paragraph 5.1. to 5.1.3.1.3. inclusive of this annex shall be loaded to 2 gram breakthrough according to the procedure described in paragraphs 6.5.5.4. to 6.5.5.4.5. inclusive of this annex, and shall be subsequently purged with 25 ± 5 litres per minute with emission laboratory air. The volume of purge air shall not exceed the volume determined in accordance with the requirements of paragraph 6.6.1.5.1. This loading and purging can be done either (a) using an on-board carbon canister at a temperature of 20 °C or optionally 23 °C, or (b) by disconnecting the carbon canister. In both cases, no further relief of the tank pressure is allowed.

6.6.1.5.1. Determination of maximum purge volume

The maximum purge amount Vol_{max} shall be determined by the following equation. In the case of OVC-HEVs, the vehicle shall be operated in charge-sustaining operating condition. This determination can also be done at a separate test or during the preconditioning drive.

$$Vol_{max} = Vol_{Pcycle} \times \frac{Vol_{tank} \times 0.85 \times \frac{100}{FC_{Pcycle}}}{Dist_{Pcycle}}$$

where:

Vol_{Pcycle} is the cumulative purge volume rounded to the nearest 0.1 litres measured using a suitable device (e.g. flowmeter connected to the vent of the carbon canister or equivalent) over the cold start preconditioning drive described in the paragraph 6.5.3. of this annex, l;

Vol_{tank} is the manufacturer's nominal fuel tank capacity, l;

FC_{Pcycle} is the fuel consumption over the single purge cycle described in paragraph 6.5.3. of this annex which may be measured in either warm or cold start condition, l/100 km. For OVC-HEVs and NOVC-HEVs, fuel consumption shall be calculated according to paragraph 4.2.1. of Annex 8 of UN GTR 15;

$Dist_{Pcycle}$ is the theoretical distance to the nearest 0.1 km of a single purge cycle described in paragraph 6.5.3. of this annex, km.

6.6.1.6. Preparation of carbon canister depressurisation puff loss loading

After completing carbon canister loading and purging, the test vehicle shall be moved into an enclosure, either a SHED or an appropriate climatic chamber. It shall be demonstrated that the system is leak-free and the pressurisation is performed in a normal way during the test or by a separate test (e.g. by means of pressure sensor on the vehicle). The test vehicle shall be subsequently exposed to the first 11 hours of the ambient temperature profile specified for the diurnal emission test in Table A1/1 with a maximum deviation of ± 2 °C at any time. The average temperature deviation from the profile, calculated using the absolute value of each measured deviation, shall not exceed ± 1 °C. The ambient temperature shall be measured and recorded at least every 10 minutes.

- 6.6.1.7. Carbon canister puff loss loading
- 6.6.1.7.1. Fuel tank depressurisation before refuelling
- The manufacturer shall ensure that the refuelling operation cannot be initiated before the sealed fuel tank system is fully depressurised to a pressure less than 2.5 kPa above ambient pressure in normal vehicle operation and use. At the request of the responsible authority, the manufacturer shall provide detailed information or demonstrate proof of operation (e.g. by means of pressure sensor on the vehicle). Any other technical solution may be allowed provided that a safe refuelling operation is ensured and that no excessive emissions are released to the atmosphere before the refuelling device is connected to the vehicle.
- 6.6.1.7.2. Within 15 minutes after the ambient temperature has reached 35 °C, the tank relief valve shall be opened to load the carbon canister. This loading procedure may be performed either inside or outside an enclosure. The carbon canister loaded according to this paragraph shall be disconnected and shall be kept in the soak area.
- 6.6.1.8. Measurement of depressurisation puff loss overflow
- The depressurisation puff loss overflow shall be measured using the process in either paragraph 6.6.1.8.1. or 6.6.1.8.2. of this annex.
- 6.6.1.8.1. The depressurisation puff loss overflow from the vehicle carbon canister may be measured by using an additional carbon canister identical to the vehicle's carbon canister but not necessarily aged. The additional carbon canister shall be fully purged with dry air prior to loading and shall be connected directly at the outlet of the vehicle's canister with the shortest possible tube. The additional carbon canister shall be weighed before and after the procedure described in paragraph 6.6.1.7. of this annex.
- 6.6.1.8.2. The depressurisation puff loss overflow from the vehicle carbon canister during its depressurisation may be measured using a SHED.
- Within 15 minutes after the ambient temperature has reached 35°C as described in paragraph 6.6.1.6. of this annex, the chamber shall be sealed and the measurement procedure shall be started.
- The hydrocarbon analyser shall be zeroed and spanned, after which the hydrocarbon concentration (C_{HCl}), temperature (T_i) and barometric pressure (P_i) shall be measured to give the initial readings C_{HCl} , P_i and T_i for the sealed tank depressurisation puff loss overflow determination.
- The ambient temperature T of the enclosure shall not be less than 25°C during the measurement procedure.
- At the end of the procedure described in paragraph 6.6.1.7.2. of this annex, the hydrocarbon concentration (C_{HCl}) in the chamber shall be measured after 300 ± 5 seconds. The temperature (T_f) and the barometric pressure (P_f) shall also be measured. These are the final readings C_{HCl} , P_f and T_f for the sealed tank depressurisation puff loss overflow.
- The sealed tank puff loss overflow result shall be calculated according to paragraph 7.1. of this annex and recorded.
- 6.6.1.8.3. There shall be no change in weight of the additional carbon canister when testing according to paragraph 6.6.1.8.1. of this annex or the result of the SHED measurement when testing according to paragraph 6.6.1.8.2. of this annex, within the tolerance of ± 0.5 gram.
- 6.6.1.9. Soak
- After completing puff loss loading the vehicle carbon canister shall be replaced with a dummy carbon canister (of the same specification as the original but not

necessarily aged), the vehicle shall then be soaked at 23 ± 2 °C for 6 to 36 hours to stabilise the vehicle temperature.

6.6.1.9.1. REESS charge

For OVC-HEVs, the REESS shall be fully charged in accordance with the charging requirements described in paragraph 2.2.3. of Appendix 4 to Annex 8 to UN GTR No.15 during the soaking described in paragraph 6.6.1.9. of this annex.

6.6.1.10. Fuel drain and refill

The fuel tank of the vehicle shall be drained and filled up to 40 ± 2 per cent of the tank's nominal capacity with reference fuel at a temperature of 18 °C ± 2 °C.

6.6.1.11. Soak

The vehicle shall be subsequently parked for a minimum of 6 hours to a maximum of 36 hours in the soak area at 20 °C ± 2 °C to stabilise the fuel temperature.

6.6.1.12. Fuel tank depressurisation

The tank pressure shall be subsequently released so as not to abnormally raise the inside pressure of the fuel tank. This may be done by opening the fuel cap of the vehicle. Regardless of the method of depressurisation, the vehicle shall be returned to its original condition within 1 minute. After this action, the vehicle carbon canister shall be connected again.

6.6.1.13. The procedures in paragraphs 6.5.6. to 6.5.9.8. inclusive of this annex shall be followed.

6.6.2. In the case that the fuel tank relief pressure is lower than 30 kPa

The test shall be performed as described in paragraphs 6.6.1.1. to 6.6.1.13. inclusive of this annex. However, in this case, the ambient temperature described in paragraph 6.5.9.1. of this annex shall be replaced by the profile specified in Table A1/2 of this annex for the diurnal emission test.

Table A1/2

Ambient temperature profile of the alternative sequence for sealed fuel tank system

<i>Time (hours)</i>	<i>Temperature (°C)</i>
0/24	20.0
1	20.4
2	20.8
3	21.7
4	23.9
5	26.1
6	28.5
7	31.4
8	33.8
9	35.6
10	37.1
11	38.0
12	37.7
13	36.4
14	34.2
15	31.9
16	29.9
17	28.2
18	26.2
19	24.7
20	23.5
21	22.3
22	21.0
23	20.2

- 6.7. Stand-alone test procedure for sealed fuel tank systems
- 6.7.1 Measurement of depressurisation puff loss loading mass
- 6.7.1.1. The procedures in paragraphs 6.6.1.1. to 6.6.1.7.2. inclusive of this annex shall be performed. The depressurisation puff loss loading mass is defined as the difference in weight of the vehicle carbon canister before paragraph 6.6.1.6. of this annex is applied and after paragraph 6.6.1.7.2. of this annex is applied.
- 6.7.1.2. The depressurisation puff loss overflow from the vehicle carbon canister shall be measured according to paragraphs 6.6.1.8.1. and 6.6.1.8.2. inclusive of this annex and fulfil the requirements of paragraph 6.6.1.8.3. in this annex.
- 6.7.2. Hot soak and diurnal breathing evaporative emissions test
- 6.7.2.1. In the case that the fuel tank relief pressure is greater than or equal to 30 kPa
- 6.7.2.1.1. The test shall be performed as described in paragraphs 6.5.1. to 6.5.3. and 6.6.1.9. to 6.6.1.9.1. inclusive of this annex.
- 6.7.2.1.2. The carbon canister shall be aged according to the sequence described in paragraph 5.1. to 5.1.3.1.3. inclusive of this annex and shall be loaded and purged according to paragraph 6.6.1.5. of this annex.

- 6.7.2.1.3. The aged carbon canister shall subsequently be loaded according to the procedure described in paragraphs 6.5.5.4. However, instead of loading to breakthrough as described in paragraph 6.5.5.4.4. the total loading mass shall be determined according to paragraph 6.7.1.1. of this annex. At the request of the manufacturer, the reference fuel may alternatively be used instead of butane. The carbon canister shall be disconnected.
- 6.7.2.1.4. The procedures in paragraphs 6.6.1.10. to 6.6.1.13. inclusive of this annex shall be followed.
- 6.7.2.2. In the case that the fuel tank relief pressure is lower than 30 kPa
The test shall be performed as described in paragraphs 6.7.2.1.1. to 6.7.2.1.4. inclusive of this annex. However, in this case, the ambient temperature described in 6.5.9.1. of this annex shall be modified in accordance with the profile specified in Table A1/1 of this annex for the diurnal emission test.
7. Calculation of evaporative test results
- 7.1. The evaporative emission tests described in paragraphs 6. to 6.7.2.2. inclusive of this annex allow the hydrocarbon emissions from the puff loss overflow, diurnal and hot soak tests to be calculated. Evaporative losses from each of these tests shall be calculated using the initial and final hydrocarbon concentrations, temperatures and pressures in the enclosure, together with the net enclosure volume.

The following equation shall be used:

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

where:

M_{HC} is the mass of hydrocarbons, grams;

$M_{HC,out}$ is the mass of hydrocarbons exiting the enclosure in the case of fixed volume enclosures for diurnal emission testing, grams;

$M_{HC,in}$ is the mass of hydrocarbon entering the enclosure in the case of fixed volume enclosures for diurnal emission testing, grams;

C_{HC} is the measured hydrocarbon concentration in the enclosure, ppm volume in C₁ equivalent;

V is the net enclosure volume corrected for the volume of the vehicle with the windows and the luggage compartment open, m³. If the volume of the vehicle is not known, a volume of 1.42 m³ shall be subtracted;

T is the ambient chamber temperature, K;

P is the barometric pressure, kPa;

H/C is the hydrogen to carbon ratio

where:

H/C is taken to be 2.33 for puff loss overflow measurement in SHED and diurnal test losses;

H/C is taken to be 2.20 for hot soak losses;

H/C is taken to be 2.67 for calibration;

k is $1.2 \times 10^{-4} \times (12 + H/C)$, in (g × K)/(m³ × kPa);

i is the initial reading;

f is the final reading.

- 7.1.1. As an alternative to the equation in paragraph 7.1. of this annex, for variable volume enclosures the following equation may be used at the choice of the manufacturer:

$$M_{HC} = k \times V \times \frac{P_i}{T_i} (C_{HCf} - C_{HCi})$$

where:

- M_{HC} is the mass of hydrocarbons, grams;
- C_{HC} is the measured hydrocarbon concentration in the enclosure, ppm volume in C_1 equivalent;
- V is the net enclosure volume corrected for the volume of the vehicle with the windows and the luggage compartment open, m^3 . If the volume of the vehicle is not known, a volume of $1.42 m^3$ shall be subtracted;
- T_i is the initial ambient chamber temperature, K;
- P_i is the initial barometric pressure, kPa;
- H/C is the hydrogen to carbon ratio;
- H/C is taken to be 2.33 for puff loss overflow measurement in SHED and diurnal test losses;
- H/C is taken to be 2.20 for hot soak losses;
- H/C is taken to be 2.67 for calibration;
- k is $1.2 \times 10^{-4} \times (12 + H/C)$, in $(g \times K/(m^3 \times kPa))$;
- i is the initial reading;
- f is the final reading.
- 7.2. The result of $(M_{HS} + M_{D1} + M_{D2} + (2 \times PF))$ shall be below the limit defined in paragraph 6.1.(a) of this UN GTR.
- 7.3. At the option of the Contracting Party, the following may be used:
The result of $(M_{HS} + M_{D_{max}} + PF)$ shall be below the limit defined in paragraph 6.1.(b) of this UN GTR. The $M_{D_{max}}$ shall be either M_{D1} or M_{D2} , whichever generates the higher emission.
8. Test report
- The test report shall contain at least the following:
- Description of the soak periods, including time and mean temperatures;
 - Description of aged carbon canister used and reference to exact ageing report;
 - Mean temperature during the hot soak test;
 - Measurement during hot soak test, HSL;
 - Measurement of first diurnal, DL1st day;
 - Measurement of second diurnal, DL2nd day;
 - Final evaporative test result, calculated according to paragraph 7. of this annex;
 - Declared fuel tank relief pressure of the system (for sealed tank systems);
 - Puff loss loading value (in the case of using 'stand-alone test procedure' described in paragraph 6.7. of this annex).

Annex 2

Reference fuels

1. As there are regional differences in the market specifications of fuels, regionally different reference fuels need to be recognised. Contracting Parties may select their reference fuels either according to Annex 3 to UN GTR No. 15. or according to paragraph 2. of this annex.
2. Specification of reference fuel for testing for mutual recognition
The reference fuel listed in Table A2/1 is designed to be used as the reference fuel for mutual recognition under the rules of the 1998 Agreement.
3. Specification of reference fuel for regional testing
The reference fuel listed in Annex 3 to UN GTR No. 15. may be used for this purpose.

Table A2/1
Evaporative emission test reference fuel for mutual recognition under the 1998 Agreement

Parameter	Unit	Limits		Test method
		Minimum	Maximum	
Research octane number, RON		95.0	98.0	EN ISO 5164 JIS K2280
Density at 15 °C	kg/m ³	743.0	756.0	EN ISO 12185 JIS K2249-1,2,3
Vapour pressure	kPa	56.0	60.0	EN 13016-1 JIS K2258-1,2
Distillation:				
– evaporated at 70 °C	% v/v	34.0	46.0	EN ISO 3405
– evaporated at 100 °C	% v/v	54.0	62.0	EN ISO 3405
– evaporated at 150 °C	% v/v	86.0	94.0	EN ISO 3405
Hydrocarbon analysis:				
– olefins	% v/v	6.0	13.0	EN 22854
– aromatics	% v/v	25.0	32.0	EN 22854
– benzene	% v/v	-	1.00	EN 22854 EN 238 JIS K2536-2,3,4
Oxygen content	% m/m	3.3	3.7	EN 22854 JIS K2536-2,4,6
Sulphur content	mg/kg	—	10	EN ISO 20846 EN ISO 20884 JIS K2541-1,2,6,7
Lead content	mg/l	Not detected		EN 237 JIS K2255
Ethanol	% v/v	9.0	10.0	EN 22854 JIS K2536-2,4,6

<i>Parameter</i>	<i>Unit</i>	<i>Limits</i>		<i>Test method</i>
		<i>Minimum</i>	<i>Maximum</i>	
MTBE		Not detected		JIS K2536-2,4,5,6 ^a
Methanol		Not detected		JIS K2536-2,4,5,6 ^a
Kerosene		Not detected		JIS K2536-2,4 ^a

^a Other method that is traceable to national or international standard may be used.

Annex 3 -Optional

CoP procedure for Type 4 test

1. Introduction

Every vehicle produced under a type approval according to this Regulation shall conform for the Type 4 test, in accordance with Table A3/1 to the vehicle type approved.

Table A3/1

Type 4 Applicable Type 4 CoP requirements for the different vehicle types

<i>Vehicle type</i>	<i>Evaporative emissions</i>
ICE	YES ⁽¹⁾
NOVC-HEV	YES ⁽¹⁾
OVC-HEV	YES ⁽¹⁾
PEV	Not Applicable
NOVC-FCHV	Not Applicable
OVC-FCHV	Not Applicable

⁽¹⁾ only for engines fuelled by petrol

2. CoP family

For the purposes of the manufacturer's conformity of production check on the Type 4 test, the family means the conformity of production (CoP) family, which shall be identical to the evaporative emissions family, as described in paragraph 5.5. of this UN GTR.

3. Test frequency

Once per year a vehicle shall be randomly taken from the CoP family described in paragraph 2 to this annex and subjected to the three tests described in paragraph 7 of this annex.

4. Test fuel

All these tests shall be conducted with reference fuel in accordance with the specifications in Annex 2.

5. Conformity check

5.1. The production shall be deemed to conform if the vehicle selected and tested according to paragraph 3. of this Annex meets the requirements of all of those tests.

5.2. If the vehicle tested does not satisfy the requirements of paragraph 5.1., a further random sample of four vehicles shall be taken from the same family without unjustified delay and subjected to the tests described in paragraph 7 of this annex.

The production shall be deemed to conform if the requirements are met for at least three of these vehicles within 6 months after the initial failed test has been detected.

- 5.3. If the vehicles tested do not satisfy the requirements of paragraph 5.2., a further random sample shall be taken from the same family without unjustified delay and subjected to the tests described in Annex 1.
- If the vehicle tested does not satisfy the requirements of Annex 1, a further random sample of four vehicles shall be taken from the same family and also subjected without unjustified delay to the tests described in Annex 1.
- On request of the manufacturer, for CoP tests described in Annex 1 the Permeability Factor (PF) derived at Type Approval or the Assigned Permeability Factor (APF) may be applied
- The production shall be deemed to conform if the requirements are met for at least three of these vehicles within 24 months after the initial failed test has been detected.
- 5.3.1. For CoP tests described in Annex 1 which are performed on a vehicle which has completed a mileage of less than 20,000 km a canister which has been aged according to paragraph 5.1. of Annex 1 shall be used. This can be the original canister from the test vehicle or another canister of identical specification. On request of the manufacturer for these tests either the Permeability Factor (PF) as defined in the paragraph 5.2 of Annex 1 which was established at Type Approval for the evaporative family or the Assigned Permeability Factor (APF) also defined in the paragraph 5.2 of Annex 1 shall be applied.
- 5.3.2. On request of the manufacturer, CoP tests described in Annex 1 may be carried out on a vehicle which has completed a minimum mileage of 20,000 km up to a maximum of 30,000 km with no modifications to the vehicle other than those described in the test procedure. When the test is carried out on a vehicle which has completed a mileage of between 20,000 km and 30,000 km, the canister aging shall be omitted and the Permeability Factor or Assigned Permeability Factor shall not be applied.
- Independent of the accumulated mileage of the vehicle, non-fuel background emission sources (e.g. paint, adhesives, plastics, fuel/vapour lines, tyres, and other rubber or polymer components) can be eliminated according to paragraph 6.1. of Annex 1.
6. [Reserved]
7. Conformity of production
- 7.1. In case of vehicles with a sealed fuel tank system, at the request of the manufacturer and in agreement with the responsible authority, alternative procedures to paragraphs 7.2. to 7.4 can be applied.
- When the manufacturer chooses to use any alternative procedure, all the details of the conformity test procedure shall be recorded in the type approval documentation.
- 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 3.70 kPa \pm 0.10 kPa shall be applied to the fuel system. At the request of manufacturer and with approval of the responsible authority, an alternative pressure can also be applied, taking into account the pressure range in use of the fuel system.
- 7.2.3. The pressure shall be allowed to stabilise prior to isolating the fuel system from the pressure source.

- 7.2.4. Following isolation of the fuel system, the pressure shall not drop by more than 0.50 kPa in five minutes.
- 7.2.5. At the request of the manufacturer and in agreement with the responsible authority the function for leakage can be demonstrated by an equivalent alternative procedure.
- 7.3. Test for venting
 - 7.3.1. Vents to the atmosphere from the emission control shall be isolated.
 - 7.3.2. A pressure of 3.70 kPa \pm 0.10 kPa shall be applied to the fuel system. At the request of manufacturer and with approval of the responsible authority, an alternative pressure can also be applied, taking into account the pressure range in use of the fuel system.
 - 7.3.3. The pressure shall be allowed to stabilise prior to isolating the fuel system from the pressure source.
 - 7.3.4. The venting outlets from the emission control systems to the atmosphere shall be reinstated to the production condition.
 - 7.3.5. The pressure of the fuel system shall drop to below a pressure less than 2.5 kPa above ambient pressure within one minute.
 - 7.3.6. At the request of the manufacturer and in agreement with the responsible authority the functional capacity for venting can be demonstrated, when applicable, by an equivalent alternative procedure.
- 7.4. Purge test
 - 7.4.1. Equipment capable of detecting an airflow rate of 1.0 litres in one minute shall be attached to the purge inlet and a pressure vessel of sufficient size to have negligible effect on the purge system shall 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 choosing, if acceptable to the responsible authority.
 - 7.4.3. The vehicle shall 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 paragraph 7.4.3. of this annex, the air flow shall be determined by either:
 - 7.4.4.1. The device indicated in paragraph 7.4.1. of this annex being switched in. A pressure drop from atmospheric to a level indicating that a volume of 1.0 litre of air has flowed into the evaporative emission control system within one minute shall be observed; or
 - 7.4.4.2. If an alternative flow measuring device is used, a reading of no less than 1.0 litre per minute shall be detectable.
 - 7.4.4.3. At the request of the manufacturer and in agreement with the responsible authority an equivalent alternative purge test procedure can be used.