AUTOMOTIVE INDUSTRY STANDARD

Document on Test Method, Testing Equipment and Related Procedures for Testing Type Approval and Conformity of Production (COP) of Vehicles for Emission as per CMV Rules 115, 116 and 126 PART 2 (3 wheelers)

Status chart of the Standard to be used by the purchaser for updating the record

Sr. No.	Corrigenda	Amendment	Revision	Date	Remark	Misc.

General Remarks:

INTRODUCTION

The Government of India felt the need for a permanent agency to expedite the Publication of standards and development of test facilities in parallel when the work on the preparation of the standards is going on, as the development of improved safety critical parts can be undertaken only after the publication of the Standard and commissioning of test facilities. To this end, the erstwhile Ministry of Surface Transport (MoST) has constituted a permanent Automotive Industry Standards Committee (AISC) vide order No. RT-11028/11/97-MVL dated September 15, 1997. The standards prepared by AISC will be approved by the Permanent CMVR Technical Standing Committee (CTSC).

International Centre for Automotive Technology (ICAT), Manesar, being the secretariat of 2W and 3W committee , has formulated this standard.

The Automotive Research Association of India, (ARAI), Pune, being the secretariat of the AIS Committee, has published this standard.

While preparing this part, considerable assistance has been taken from following:

- EU regulation Nos: -
  o 168/2013 of 15th Jan 2013
  o 134/2014 of 16th December 2013
  o 44/2014 of 21st November 2013
  o 901/2014 of 18th July 2014.

- AIS-007 - Technical specification
- Global Technical Regulation No.17 - Crankcase and evaporative emissions of L-category vehicles**.**
- TAP/115/116 document issue 4 for BS IV emission norms compliance.

- The AISC panel responsible for formulation of this standard is given in chapter: (To be included)
- The Automotive Industry Standards Committee (AISC) responsible for Approval of this standard is given in Chapter : (To be included)

	Appendix 1	Functional Aspects of OBD system-OBD II
	Appendix 2	Essential characteristics of the vehicle family -OBD II
Chapter 3W-VIII		Vehicle propulsion family with regard to environmental performance demonstration tests.
Chapter 3W-IX		Test type VII requirements: CO 2 emissions, fuel consumption, electric energy consumption and electric range
	Appendix 1	Method of measuring carbon dioxide emissions and fuel consumption of vehicles powered by a combustion engine only
	Appendix 2	Method of measuring the electric energy consumption of a vehicle powered by an electric powertrain only
	Appendix 3	Method of measuring the carbon dioxide emissions, fuel consumption, electric energy consumption and driving range of vehicles powered by a hybrid electric powertrain
	Appendix 3.1	Electrical energy/power storage device State Of Charge (SOC) profile for an Externally chargeable Hybrid Electric Vehicle (OVC HEV) in a type VII test
	Appendix 3.2	Method for measuring the electricity balance of the battery of OVC and NOVC HEV
	Appendix 3.3	Method of measuring the electric range of vehicles powered by an electric powertrain only or by a hybrid electric powertrain and the OVC range of vehicles powered by a hybrid electric powertrain

Chapter 3W- I
Overall Requirements

1	**SCOPE**
1.1	This part of the standard is applicable for three wheeled motor vehicles of category L5 as defined in AIS-053:2005 / IS 14272: 2011 as amended from time to time, equipped with Positive Ignition engines (Petrol, CNG and LPG) and Compression Ignition Engines (Diesel) for Bharat Stage VI. DAC vehicles should comply with the CMV Rules as amended from time to time.
1.2	This part shall be read in conjunction with Govt. Gazette Notification G.S.R. 889 (E) dated 16th Sep, 2016 for BS VI. Unless otherwise specified in this Part, wherever words "the notification" has been used, shall mean this final gazette notification.
2	**REFERENCE STANDARDS:**
	Following standards and documents as amended from time to time are necessary adjuncts to this standard.
2.1	AIS-053:2005 – Automotive Vehicles – Types – Terminology. IS – 14272:2011 – Automotive vehicles – types – Terminology.
2.2	AIS-000 –Administrative Procedure to deal with Corrigendum, Amendments or Revisions to AIS, TAP 115 /116, CMVR Notifications, IS and ISO standards, which are notified under CMVR.
2.3	AIS-17:2000-Procedure for Type Approval and Certification of Vehicles for Compliance to Central Motor Vehicles Rules.
2.4	IS: 2-1960 – Rules for rounding off numerical values.
2.5	IS: 9211-2003 - Specification for Terms and Definitions of Weights of Road Vehicles.
2.6	IS 14785- 2000 - Automotive Vehicles - Determination of Road-load Constants by Coast down Test Method.
3	**DEFINITIONS**
	For the purposes of this Part the following definitions shall apply:
3.1.1	**'actuator'** means a converter of an output signal from a control unit into motion, heat or other physical state in order to control the powertrain, engine(s) or drive train;
3.1.2	**'boost control'** means a device to control the boost level produced in the induction system of a turbocharged or supercharged engine;

3.1.3	**'Power take-off unit**' means an engine-driven output provision for the purposes of powering auxiliary, vehicle mounted, and equipment.
3.1.4	**'air intake system**' means a system composed of components allowing the fresh air charge or air-fuel mixture to enter the engine and includes, if fitted, the air filter, intake pipes, resonator(s), the throttle body and the intake manifold of an engine;
3.1.5	**'alternative fuel vehicle**' means a vehicle designed to run on at least one type of fuel that is either gaseous at atmospheric temperature and pressure, or substantially non- mineral oil derived;
3.1.6	**'Calculated load value**' means referring to an indication of the current airflow divided by peak airflow, where peak airflow is corrected for altitude, if available. This definition provides a dimensionless number that is not engine specific and provides the service technician with an indication of the proportion of engine capacity being used (with wide open throttle as 100 %);
3.1.7	**'carburettor**' means a device that blends fuel and air into a mixture that can be combusted in a combustion engine;
3.1.8	**'catalytic converter**' means an emission pollution control device which converts toxic by-products of combustion in the exhaust of an engine to less toxic substances by means of catalyzed chemical reactions;
3.1.9	**'catalytic convekrter type**' means a category of catalytic converters that do not differ as regards the following: a) number of coated substrates, structure and material; b) type of catalytic activity (oxidizing, three-way, or of another type of catalytic activity); c) volume, ratio of frontal area and substrate length; d) catalytic converter material content; e) catalytic converter material ratio; f) cell density; g) dimensions and shape; h) thermal protection; i) an inseparable exhaust manifold, catalytic converter and muffler integrated in the exhaust system of a vehicle or separable exhaust system units that can be replaced.
3.1.10	**'compression ignition engine'** or 'CI engine' means a combustion engine working according to the principles of the 'Diesel' cycle;
3.1.11	**'conformity of production**' (CoP) means the ability to ensure that each series of products produced is in conformity with the specification, performance and marking requirements in the type-approval;

3.1.12	**'defeat device'** means any element of design which senses temperature, vehicle speed, engine speed and/or load, transmission gear, manifold vacuum or any other parameter for the purpose of activating, modulating, delaying or deactivating the operation of any part of the emission control and exhaust after-treatment system and that reduces the effectiveness of the emission control system under conditions which may reasonably be expected to be encountered in normal vehicle operation and use; Such an element of design may not be considered a defeat device if 1. The need of the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle, or 2. The device does not function beyond the requirements of engine starting or, 3. Conditions are substantially included in the Type I test procedure
3.1.13	**'drive train'** means the part of the powertrain downstream of the output of the propulsion unit(s) that consists if applicable of the torque converter clutches, the trans- mission and its control, either a drive shaft or belt drive or chain drive, the differentials, the final drive, and the driven wheel tyre (radius);
3.1.14	**'drive train control unit'** means the on-board computer that partly or entirely controls the drive train of the vehicle;
3.1.15	**'durability'** means the ability of components and systems to last so that the environmental performance as laid down in the notification for type I tests can still be met after a mileage as defined in Chapter 3W-V, if the vehicle is used under normal or intended circumstances and serviced in accordance with the manufacturer's recommendations;
3.1.16	**'emission control system'** means the electronic engine management controller and any emission-related component in the exhaust or evaporative system which supplies an input to or receives an output from this controller;
3.1.17	**'engine capacity'** means: (a) for reciprocating piston engines, the nominal engine swept volume; (b) for rotary-piston (Wankel) engines, double the nominal engine swept volume;
3.1.18	**'engine control unit'** means the on-board computer that partly or entirely controls the engine or engines of the vehicle;
3.1.19	**'engine misfire'** means a lack of combustion in the cylinder of a positive-ignition engine due to the absence of spark, poor fuel metering, poor compression or any other cause; In terms of OBD monitoring, it is that percentage of misfires out of a total number of firing events (as declared by the manufacturer) that would result in emissions exceeding the limits given in the applicable Gazette Notification under CMVR or that percentage that could lead to an exhaust catalyst, or catalysts, overheating causing irreversible damage.

3.1.20	**'exhaust emissions'** means tailpipe emissions of gaseous pollutants and particulate matter;
3.1.21	**'exhaust system'** means the combination of the exhaust pipe, the expansion box, the exhaust silencer and pollution control device(s), as applicable;
3.1.22	**'Fuel trim'** refers to feedback adjustments to the base fuel schedule.
3.1.23	**'flex fuel H$_2$NG vehicle'** means a flex fuel vehicle designed to run on different mixtures of hydrogen and natural gas or bio-methane;
3.1.24	**'fuel cell'** means a converter of chemical energy from hydrogen into electric energy for propulsion of the vehicle;
3.1.25	**'fuel feed system'** means the set of components including and between fuel storage and air-fuel blending or injecting device(s);
3.1.26	**'SCR system'** means a system capable of converting gaseous pollutants into harmless or inert gases by injecting a consumable reagent, which is a reactive substance to reduce tailpipe emissions and which is adsorbed onto a catalytic converter;
3.1.27	**'gaseous pollutant'** means the exhaust gas emissions of carbon monoxide (CO), oxides of nitrogen (NOx) expressed in nitrogen dioxide (NO2) equivalent, and hydro- carbons (HC);
3.1.28	**'inlet conduit'** means the combination of the inlet passage and the intake pipe;
3.1.29	**'inlet passage'** means the passage for the intake of air within the cylinder, cylinder-head or crankcase;
3.1.30	**'intake pipe'** means a part connecting the carburettor or air-control system and the cylinder, cylinder-head or crankcase;
3.1.31	**'intake system'** means the combination of the inlet conduit and the intake silencer;
3.1.32	**'long-term fuel trim'** refers to much more gradual adjustments to the fuel calibration schedule which compensate for vehicle differences and gradual changes that occur over time;
3.1.33	**'mass of the optional equipment'** means the mass of the equipment which may be fitted to the vehicle in addition to the standard equipment, in accordance with the manufacturer's specifications;
3.1.34	**'maximum net power'** means the maximum output for that power measured under full engine load.
3.1.35	**'maximum torque'** means the maximum torque value measured under full engine load.

3.1.36	**'mesh size'** means the number of openings per (linear) inch of mesh
3.1.37	**'mileage accumulation'** means a representative test vehicle or a fleet of representative test vehicles driving a predefined distance as set out in the notification in accordance with the test requirements of **Chapter 3W-V** to this standard;
3.1.38	**'net power'** means the power obtained on the test bench at the end of the crankshaft or its equivalent at the speed laid down by the manufacturer, together with the accessories listed in AIS-137 Part 5. If the power can be measured only when a gearbox is attached to the engine, the efficiency of the gearbox shall be taken into account.
3.1.39	**'optional equipment'** means features that are not included in the standard equipment and may be fitted to a vehicle under the responsibility of the manufacturer;
3.1.40	**'parent vehicle'** means a vehicle that is representative of a propulsion family set out in Chapter 3W-VIII;
3.1.41	**'particulate filter'** means a filtering device fitted in the exhaust system of a vehicle to reduce particulate matter from the exhaust flow;
3.1.42	**'particulate matter'** means components of the exhaust gas which are removed from the diluted exhaust gas at a maximum temperature of 52°C by means of the filters described in the test procedure for verifying average tailpipe emissions;
3.1.43	**'periodically regenerating system'** means a pollution control device such as a catalytic converter, particulate filter or any other pollution control device that requires a periodical regeneration process in less than 4000 km of normal vehicle operation;
3.1.44	**'pollution control device'** means those components of a vehicle that control or reduce tailpipe and/or evaporative emissions;
3.1.45	**'pollution control device type'** means a category of pollution-control devices that are used to control pollutant emissions and that do not differ in their essential environmental performance and design characteristics;
3.1.46	**'positive ignition engine'** or **'PI engine'** means a combustion engine working according to the principles of the 'Otto' cycle;
3.1.47	**'powertrain control unit'** means a combined control unit of combustion engine(s), electric traction motors or drive train unit systems including the transmission or the clutch;
3.1.48	**'Software'** of the powertrain / engine or drive train control units means a set of algorithms concerned with the operation of powertrain, engine or drive train data processing systems, containing an ordered sequence of instructions that change the state of the powertrain, engine or drive train control unit;
3.1.49	**'Calibration'** of the powertrain / engine or drive train control unit means the application of specific set of data maps and parameters used by the control unit's software to tune the vehicle's powertrain / engine or drive train;

3.1.50	'**properly maintained and used**' means that when selecting a test vehicle it satisfies the criteria with regard to a good level of maintenance and normal use according to the recommendations of the vehicle manufacturer for acceptance of such a test vehicle;
3.1.51	'**propulsion**' means a combustion engine, an electric motor, any hybrid application or a combination of those engine types or any other engine type;
3.1.52	'**reference mass**' means the kerb mass determined in accordance with IS 9211 : 2003 increased by a uniform figure of 150kg and if applicable plus the mass of the propulsion battery;
3.1.52.1	'**unladen Mass (kerb mass)**' means the mass of the vehicle in running order without crew, passengers or load, but with the fuel tank 90 % full and the usual set of tools and spare wheel on board where applicable. In the case of 3 wheeled tractors, designed for coupling to a semi-trailer, the unladen mass will be that of the drawing vehicle.
3.1.52.2.	'**Gross Vehicle Weight (GVW)**' Means the technically permissible maximum weight declared by the vehicle manufacturer. In case of the 3 wheeled vehicles designed to be coupled to a semi-trailer, the mass GVW to be taken into consideration when classifying that vehicle, shall be the maximum weight of the tractor in running order, plus the weight transferred to the tractor by the laden semi-trailer in static condition.
3.1.53	'**scavenging port**' means a connector between crankcase and combustion chamber of a two-stroke engine through which the fresh charge of air, fuel and lubrication oil mixture enters the combustion chamber;
3.1.54	'**secondary air**' means air introduced into the exhaust system by means of a pump or aspirator valve or other means intended to aid in the oxidation of HC and CO contained in the exhaust gas flow;
3.1.55	'**self-testing**' means the performance of tests in its own facilities, the registration of the test results and the submission of a report, including conclusions, to the test agency by a manufacturer that has been designated as a test agency in order to assess compliance with certain requirements;
3.1.56	'**sensor**' means a converter that measures a physical quantity or state and converts it into an electric signal that is used as input to a control unit;
3.1.57	"**Series mounted equipment**" means all equipment intended by the manufacturer for a specific application.
3.1.58	'**short-term fuel trim**' refers to dynamic or instantaneous adjustments to the base fuel schedule;
3.1.59	'**significant reduction of propulsion torque**' means a propulsion torque less than or equal to 90 % of torque in normal operation mode;
3.1.60	'**spark delivery of the ignition system**' means all the characteristics of the spark generated in the ignition system of a positive ignition '(PI)' engine used to ignite the air-fuel mixture, such including timing, level and positioning;

3.1.61	**'standard equipment**' means the basic configuration of a vehicle equipped with all the features required under the regulatory acts referred to in CMVR, including all features that are fitted without giving rise to any further specifications on configuration or equipment level;
3.1.62	**'stop-start system'** means automatic stop and start of the propulsion unit to reduce the amount of idling, thereby reducing fuel consumption, pollutant and CO2 emissions of the vehicle
3.1.63	**'super-charger'** means an intake air compressor used for forced induction of a combustion engine, thereby increasing propulsion unit performance;
3.1.64	**'tailpipe emissions**' means the emission of gaseous pollutants and particulate matter at the tailpipe of the vehicle;
3.1.65	**'torque'** means the torque measured under the conditions specified in **AIS-137 Part 5.**
3.1.66	'**turbocharger**' means an exhaust gas turbine-powered centrifugal compressor boosting the amount of air charge into the combustion engine, thereby increasing propulsion unit performance;
3.1.67	**'vehicle propulsion unit family'** for the purpose of this part of the standard means a manufacturers grouping of vehicles which, through their design as defined in **Chapter 3W-VIII** of this standard, have similar Environmental and Propulsion Unit Performance characteristics.
3.1.68	**'warm-up cycle**' means vehicle operation whereby the coolant temperature rises by at least 22 ℃ from engine start-up to at least 70 ℃;
3.1.69	**'opacity meter'** means an Instrument for continuous measurement of the light absorption coefficient of the exhaust gases emitted by vehicles
3.1.70	**'smoke density'** means the light absorption coefficient of the exhaust gases emitted by the vehicle expressed in terms of m^{-1} or in other units such as Bosch, Hartridge, % opacity etc.
3.1.71	**'Free acceleration test'** means the test conducted by abruptly but not violently, accelerating the vehicle from idle to full speed with the vehicle stationary in neutral gear.
3.1.72	**'crankcase emissions'** means emissions from spaces in or external to an engine which are connected to the oil sump crankcase by internal or external ducts through which gases and vapour can escape;
3.1.73	**'engine crankcase'** means the spaces in or external to an engine which are connected to the oil sump by internal or external ducts through which gases and vapour can escape;
3.1.74	**'eaporative emissions'** means the hydrocarbon vapours lost from the fuel system of a vehicle other than those from exhaust emissions meaning the hydrocarbon vapours lost from the fuel tank and fuel supply system of a motor vehicle and not those from tailpipe emissions;
3.1.75	**'Fuel tank breathing losses'** means hydrocarbon emissions caused by temperature changes in the fuel tank;

3.1.76	**'Fuel tank'** means a type of energy storage system that stores the fuel;
3.1.77	**'Hot soak losses'** means hydrocarbon emissions arising from the fuel system of a stationary vehicle after a period of driving (assuming a ratio of $C_1H_{2.20}$)
3.1.78	**'Non-exposed type of fuel tank'** means that the fuel tank, except the fuel tank cap, is not directly exposed to radiation of sunlight;
3.1.79	**'SHED test'** means a vehicle test in a sealed house for evaporation determination, in which a special evaporative emission test is conducted;
3.1.80	**'Permanent default mode'** refers to a case where the engine management controller permanently switches to a setting that does not require an input from a failed component or system;
3.1.81	**'variable cam phasing or lift'** means allowing the lift, the opening and closing duration or timing of the intake or exhaust valves to be modified while the engine is in operation;
3.1.82	**'communication protocol'** means a system of digital message formats and rules for messages exchanged in or between computing systems or units;
3.1.83	**'common rail'** means a fuel supply system to the engine in which a common high pressure is maintained;
3.1.84	**'intercooler'** means a heat exchanger that removes waste heat from the compressed air by a charger before entering into the engine, thereby improving volumetric efficiency by increasing intake air charge density;
3.1.85	**'electronic throttle control'** (ETC) means the control system consisting of sensing of rider input via the accelerator pedal or handle, data processing by the control unit(s), resulting actuation of the throttle and throttle position feedback to the control unit in order to control the air charge to the combustion engine;
3.1.86	**'Useful life for evaporative system'** means the relevant period of distance and/or time over which compliance with the evaporative total hydrocarbon emission limits has to be assured. **'Useful life for OBD'** means the relevant period of distance and/or time over which compliance with the OBD system has to be assured.
3.1.87	**'lean NOx adsorber'** means a storage of NO_X fitted into the exhaust system of a vehicle which is purged by the release of a reactant in the exhaust flow;
3.1.88	**'cold-start device'** means a device that temporarily enriches the air/fuel mixture of the engine, thus assisting the engine to start;
3.1.89	**'starting aid'** means a device which assists engine start up without enrichment of the air/fuel mixture such as glow plugs, injection timing and spark delivery adaptations;
3.1.90	**'exhaust gas recirculation (EGR) system'** means part of the exhaust gas flow led back to or remaining in the combustion chamber of an engine in order to lower the combustion temperature;
3.1.91	**'On-Board Diagnostic system (OBD)'** means an electronic system fitted on-board of a vehicle that has the capability of identifying the likely area of malfunction by means of fault codes stored in a computer memory which can be accessed by means of a generic scan tool;

3.1.92	**'Vehicle type for OBD'** means a category of power-driven vehicles, which do not differ in such essential engine and OBD system characteristics as defined in Appendix 2 of Chapter 3W-VI and VII.
3.1.93	**'Vehicle family**' means a manufacturer's grouping of vehicles, which through their design, are expected to have similar exhaust emission and OBD system characteristics. Each engine of this family must have complied with the requirements of this part .
3.1.94	**'Malfunction indicator (MI)**' means a visible or audible indicator that clearly informs the driver of the vehicle in the event of a malfunction of any emission related component connected to the OBD system, or the OBD system itself.
3.1.95	"**Malfunction**" means the failure of an emission-related component or system that would result in emissions exceeding the limits in the applicable Gazette Notification under CMVR or if the OBD system is unable to fulfill the basic monitoring requirements of Chapter 3W VI.
3.1.96	**'A driving cycle'** consists of engine start-up, driving mode where a malfunction would be detected if present, and engine shut-off.
3.1.97	**'A warm-up cycle'** means sufficient vehicle operation such that the coolant temperature has risen by a least 22 K / 22 degree C from engine starting and reaches a minimum temperature of 343 K (70 degrees C).
3.1.98	**'Permanent emission default mode'** refers to a case where the engine management controller permanently switches to a setting that does not require an input from a failed component or system where such a failed component or system would result in an increase in emissions from the vehicle to a level above the limits given in the applicable Gazette Notification under CMVR.
3.1.99	**'Access'** means the availability of all emission-related OBD data including all fault codes required for the inspection, diagnosis, servicing or repair of emissions related parts of the vehicle, via the serial interface for the standard diagnostic connection .
3.1.100	**'Unrestricted'** means:- access not dependent on an access code obtainable only from the manufacturer, or a similar device, or - access allowing evaluation of the data produced without the need for any unique decoding information, unless that information itself is standardized information.
3.1.101	**'Standardised data'** means that all data stream information, including all fault codes used, shall be produced only in accordance with industry standards which, by virtue of the fact that their format and their permitted options are clearly defined, provide for a maximum level of harmonisation in the motor vehicle industry, and whose use is expressly permitted in this part.
3.1.102	**'Circuit discontinuity'(CD)** means disconnection of only those components (sensors/actuators) which are monitored by EMS/ECU/Computer, by physically removing corresponding connector or cutting / separating wire(s) of corresponding sensor or actuator.

3.1.103	**'Deficiency'** means, in respect of vehicle OBD systems, that up to two separate components or systems that are monitored contain temporary or permanent operating characteristics that impair the otherwise efficient OBD monitoring of those omponents or systems or do not meet all of the other detailed requirements for OBD. Vehicles may be type-approved, registered and sold with such deficiencies according to the requirements of Para 4 of this Chapter 3W-VII (OBD II)
3.1.104	**"Hybrid vehicle (HV)"** means a vehicle with at least two different energy converters and two different energy storage systems (on vehicle) for the purpose of vehicle propulsion.
3.1.105	*"Hybrid electric vehicle (HEV)"** means a vehicle that, including vehicles which draw energy from a consumable fuel only for the purpose of recharging the electrical energy/power storage device that, for the purpose of mechanical propulsion, draws energy from both of the following on-vehicle sources of stored energy/power: a) A consumable fuel; b) A battery, capacitor, flywheel/generator or other electrical energy/ power storage device
3.1.106	**"Mono-fuel vehicle"** means a vehicle that is designed to run primarily on one type of fuel;
3.1.107	**"Mono-fuel gas vehicle"** means a vehicle that is designed primarily for permanent running on LPG or NG/bio methane or hydrogen, but may also have a petrol system for emergency purposes or starting only, where the petrol tank does not contain more than 5 litres of petrol.
3.1.108	**"Bi-fuel vehicle"** means a vehicle with two separate fuel storage systems that is designed to run on only one fuel at a time. The simultaneous use of both fuels is limited in amount and duration
3.1.109	**"Bi-fuel gas vehicle"** means a bi fuel vehicle that can run on petrol and also on either LPG, NG/bio methane or hydrogen (gas mode).
3.1.110	**"Flex fuel vehicle"** means a vehicle with one fuel storage system that can run on different mixtures of two or more fuels.
3.1.111	**"Flex fuel biodiesel vehicle"** means a flex fuel vehicle that can run on mineral diesel or a mixture of mineral diesel and biodiesel.
3.1.112	**"Flex fuel ethanol vehicle**" means a flex fuel vehicle that can run on petrol or a mixture of petrol and ethanol up to an 85/100 per cent ethanol blend (E85/E100).
3.2	For definitions related to Type Approval terminologies i.e. base vehicle, vehicle type, variant(s) and version(s) etc. the definitions given in AIS 017:2000 shall apply.

4	**REQUIREMENTS**
	This part of the standard establishes the administrative and technical requirements for the type-approval of new types of vehicles, systems, components and separate technical units referred to in 1. above.
4.1	Applicability of tests for each type of vehicle shall be as mentioned in the Notification. However, the requirements are not applicable in petrol mode for a vehicle in the scope of this part that is designed primarily for permanent running on gaseous fuel, having a petrol system, with a petrol fuel tank capacity not exceeding three liters in the case of vehicles of L5 category, intended for emergency purposes or starting only.
4.2	The vehicles shall be manufactured to comply with the requirements specified in BSVI emission norms throughout the useful life specified therein when maintained as per the recommendations of the vehicle manufacturer. This requirement shall be deemed to be satisfied when the vehicles are tested for specified tests as per the procedures mentioned in Chapters to this Part.
4.3	For CNG and LPG vehicles, the provisions of CMV Rule 115(B) and CMV Rule 115(C), as amended from time to time shall apply respectively.
4.4	The **AIS- 137 Part 5** specifies the method for measurement of performance such as net power at full load of an internal combustion engines used for automotive vehicles as a function of engine speed. This method can be used to verify specific performance parameter against that claimed by manufacturers, as required for statutory purposes as part of type approval.
5	**APPLICATION FOR TYPE APPROVAL**
	Application for Type Approval shall be submitted to the test agency along with following:-
5.1	Information to be submitted at the time of applying for type approval shall be as given in AIS-007 as amemned from time to time. **Note:** If the above information is submitted in a consolidated form for type approval of the whole vehicle as per AIS-007 as amended from time to time, it is not necessary to submit this information again.
5.2	Number of vehicles to be submitted for Type approval shall be worked out by the manufacturer based on the family definition mentioned in Chapter 3W-VIII.
5.3	This may also necessitate submission of vehicles of different variant (s) / version (s) for each test.
5.4	A copy of Owner's manual and service station manual shall be submitted. **Note:** In case these publications are not available at the time of submitting the prototype vehicle, they shall be submitted by the manufacturer as and when they are ready but before first CoP. In case these publications are not available at the time of prototype testing, the relevant information required by the Testing Agency, shall be provided by the manufacturer.

6	TYPE APPROVAL
6.1	If the vehicle submitted for approval pursuant to this part of the standard meets all the specified requirements, approval of that vehicle type shall be granted in the form as mentioned in AIS-017:2000
7	**EXTENSION OF TYPE APPROVAL**
7.1	Every functional modification in technical specifications pertaining to Environmental and Propulsion performance of vehicle declared in AIS-007 for BS VI provisions, shall be intimated to the test agency.
	Test agency may then consider, whether,
7.1.1	Vehicle with modifications complies with specified requirements,or,
7.1.2	any testing is required.
7.2	For considering whether testing is required or not, guidelines given in Chapter 3W-VIII shall be followed.
7.2.1	Changes other than those listed in Chapter 3W-VIII are considered to have no adverse effect on Environmental and Propulsion performance of vehicle after modification.
7.3	In case of 7.1.2, checks for those parameters which are affected by the modifications only need to be carried out.
7.4	In the event of 7.1.1 or in the case of 7.1.2 after successful compliance to requirements, the certificate of compliance shall be extended for the modified version.
7.5	In case these changes necessitate amendments in the Owners' manual and Service station manual, the amended copies shall be submitted to test agency.
7.6	Any changes to the procedure of PDI and running in concerning emission shall also be intimated to the test agency by the vehicle manufacturer, whenever such changes are carried out.
8	**TRANSITORY PROVISIONS (SEE AIS- 000)**
8.1	At the request of the applicant, type approvals for compliance to BS VI norms as per CMVR no 115 (20) shall be granted by test agencies from date of the Notification. Such type approvals shall be deemed to be compliance to BS IV norms as per CMVR no 115 (17).
8.1.1	However, in such cases the extension of approval for design changes and Conformity of Production, if applicable, shall be as per BS VI norms as per CMVR no 115 (20).

8.2	At the request of applicant, type approval to BS IV norms as per CMVR no 115 (17) shall be granted up to the notified date of implementation of BS VI norms as per CMVR no 115 (20) of the notification.
8.3	Type approvals issued for compliance to BS IV norms as per CMVR No 115 (17) shall be extended for design changes till implementation date of BS VI norms as per CMVR no 115 (20) subject to satisfactory compliance.
8.4	Type approvals granted to OBD stage I as per CMVR no 115 (20) shall be extended for design changes till implementation date of OBD stage II.
9	**ESSENTIAL CHARACTERISTICS OF THE VEHICLE AND ENGINE AND INFORMATION CONCERNING THE CONDUCT OF TESTS:**
9.1	Information shall be provided as per Tables in AIS 007 as amended time to time as applicable to the vehicle type.

Chapter 3W- II
Type I Test: Tailpipe emission after Cold Start

1	**INTRODUCTION**
1.1	This Chapter sets out the procedure for Type I testing of L5 Category vehicles as defined in AIS- 053:2005 / IS 14272:2011 as amended from time to time, for verifying compliance to tailpipe emission norms for BS VI.
2	**GENERAL REQUIREMENTS:**
2.1	The components liable to affect the emission of gaseous pollutants, carbon dioxide emissions and fuel consumption shall be so designed, constructed and assembled as to enable the vehicle in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Chapter.
2.2	Any hidden strategy that 'optimises' the powertrain of the vehicle running the relevant emission laboratory test cycle in an advantageous way, reducing tailpipe emissions and running significantly differently under real-world conditions, is considered a defeat strategy and is prohibited, unless the manufacturer has documented and declared it to the satisfaction of the test agency.
3	**PERFORMANCE REQUIREMENTS**
3.1	The vehicle shall comply with the limits as specified in the notification.
4	**TEST CONDITIONS**
4.1	Test room and soak area
4.1.1	Test room The test room with the chassis dynamometer and the gas sample collection device shall have a temperature of $298.2 \pm 5K$ ($25 \pm 5°C$). The room temperature shall be measured in the vicinity of the vehicle cooling blower (fan) before and after the type I test. The absolute humidity (H) of either the air in the test cell or the intake air of the engine shall be such that $5.5 < H < 12.2$ g of H_2O/kg dry air.
4.1.2	Soak area The soak area shall have a temperature of $298.2K \pm 5K$ ($25°C \pm 5°C$) and be such that the test vehicle to be preconditioned can be parked in accordance with following sub clauses.
4.1.2.1	**Test vehicle preconditioning**
4.1.2.1.1	The test vehicle shall be moved to the test area and the following operations performed: - The fuel tanks shall be drained through the drains of the fuel tanks provided and charged with the test fuel as specified in the notification to half the capacity of the tanks. - The test vehicle shall be placed, either by being driven or pushed, on a dynamometer and operated through the applicable test cycle as specified in Appendix 6 of this chapter. The vehicle need not be cold, and may be used to set dynamometer power.
4.1.2.1.2	Practice runs over the prescribed driving schedule may be performed at test points, provided an emission sample is not taken, for the purpose of finding the minimum throttle action to maintain the proper speed-time relationship, or to permit sampling system adjustments.

4.1.2.1.3	Within five minutes of completion of preconditioning, the test vehicle shall be removed from the dynamometer and may be driven or pushed to the soak area to be parked. The vehicle shall be stored for between 6 and 36 hours prior to the cold start type I test or until the engine oil temperature (T_O) or the coolant temperature (T_C) or the sparkplug seat/gasket temperature (T_P) (only for air-cooled engine) equals the air temperature of the soak area within $\pm 2K(\pm 2\ °C)$.
4.1.2.1.4	For the purpose of measuring particulates, between 6 and 36 hours before testing, the test cycle from Appendix 6 of this chapter shall be used. The technical details of the test cycle are laid down in Appendix 6 of this chapter and the test cycle shall also be used for vehicle pre-conditioning. six consecutive cycles shall be driven. The dynamometer setting shall be indicated as in point 4.4.5. or 5.2.2 as applicable.
4.1.2.1.5	After this preconditioning, and before testing, vehicles shall be kept in a room in which the temperature remains relatively constant between 293.2 K (20°C) and 303.2 K (30°C). This conditioning shall be carried out for at least 6 hours and continue until the engine oil temperature and coolant, if any, are within $\pm 2K$ ($\pm 2\ °C$) of the temperature of the room.
	If the manufacturer so requests, the test shall be carried out not later than 30 hours after the vehicle has been run and is at its normal temperature.
4.1.2.1.6	Vehicles equipped with a positive-ignition engine, fueled with LPG, NG/biomethane, H_2NG, hydrogen or so equipped that they can be fueled with either petrol, LPG, NG/biomethane, H_2NG or hydrogen between the tests on the first gaseous reference fuel and the second gaseous reference fuel, shall be preconditioned before the test on the second reference fuel. At the manufacturer's request and with the agreement of the test agency, this preconditioning may be extended. The dynamometer setting shall be as indicated in point 4.4.5 or 5.2.2 of this chapter as applicable.
4.2	**Test vehicle**
4.2.1	**General**
	All components of the test vehicle shall conform to those of the production series or, if the vehicle is different from the production series, a full description shall be given in the test report. In selecting the test vehicle, the manufacturer shall agree to the satisfaction of the test agency which tested parent vehicle is representative of the related vehicle propulsion family as laid down in Chapter 3W-VIII.
4.2.2	**Run-in**
	The vehicle shall be presented in good mechanical condition, properly maintained and used. In case of type approval vehicle shall have been run-in at least 1000 km before the test. The engine, drive train and vehicle shall be properly run in, in accordance with the manufacturer's requirements.
	Note: If the manufacturer has carried out the run-in on a chassis dynamometer where the odometer does not get operated, a declaration by the manufacturer will be sufficient for the compliance to this clause. However, the test agency may seek for log data by the manufacturer.

4.2.3	**Adjustments**
	The test vehicle shall be adjusted in accordance with the manufacturer's requirements, e.g. as regards the viscosity of the oils, or, if it differs from the production series, a full description shall be given in the test report.
4.2.4	**Test mass and load distribution**
	The test mass, including the masses of the driver and the instruments, shall be measured before the beginning of the tests. The load shall be distributed across the wheels as specified by the manufacturer.
4.2.5	**Tyres**
	The tyres shall be of a type specified as original equipment by the vehicle manufacturer. The tyre pressures shall be adjusted to the specifications of the manufacturer or to those where the speed of the vehicle during the road test and the vehicle speed obtained on the chassis dynamometer are equalized. The tyre pressure may be increased by up to 50 % from the manufacturer's recommended setting in the case of a two roller dynamometer. The tyre pressure shall be indicated in the test report.
4.3	**Specification of the reference fuel**
	The reference fuel as prescribed in the notification shall be used. If the engine is lubricated by a fuel oil mixture, the oil added to reference fuel shall comply to the grade and quantity as per the manufacturer's recommendation.
4.4	**Type I test**
4.4.1	Following types of Specifications and settings.
4.4.2	**Test bench specifications and settings**
4.4.2.1	The chassis dynamometer may have one or two rollers/long single roller in the case of vehicle with ywinned wheel, the roller diameter shall not be less than 400 mm. The dynamometer setting shall be as indicated in point 5.2.2 or point 4.4.5 of this Chapter.
4.4.2.2	The roller shall be fitted with a revolution counter with reset facility to measure the distance actually covered.
4.4.2.3	It shall be equipped with means to simulate inertia and load. These simulators shall be connected to the front roller, in the case of a two roller dynamometer.
4.4.2.4	The dynamometer rollers shall be clean, dry and free from anything which might cause the tyres to slip.
4.4.2.5.	The dynamometer shall be capable of simulating road load with adjustable load curve, i.e. a dynamometer with at least two road load parameters that can be adjusted to shape the load curve.
4.4.2.6.	The setting of the dynamometer shall not be affected by the lapse of time. It shall not produce any vibrations perceptible to the vehicle and likely to impair the vehicle's normal operations.

4.4.2.7	**Cooling fan specifications as follows:**
4.4.2.7.1	Throughout the test, a variable-speed cooling blower (fan) shall be positioned in front of the vehicle so as to direct the cooling air onto it in a manner that simulates actual operating conditions. The blower speed shall be such that, within the operating range of 10 to 50 km/h, the linear velocity of the air at the blower outlet is within ± 5 km/h of the corresponding roller speed. At the range of over 50 km/h, the linear velocity of the air shall be within ± 10% . At roller speeds of less than 10 km/h, air velocity may be zero.
4.4.2.7.2	The air velocity referred to in point 4.4.2.7.1 shall be determined as an averaged value of nine measuring points which are located at the centre of each rectangle dividing the whole of the blower outlet into nine areas (dividing both horizontal and vertical sides of the blower outlet into three equal parts). The value at each of the nine points shall be within 10 % of the average of the nine values.
4.4.2.7.3	The blower outlet shall have a cross-section area of at least 0.4 m^2 and the bottom of the blower outlet shall be between 5 cm and 20 cm above floor level. The blower outlet shall be perpendicular to the longitudinal axis of the vehicle, between 30 cm and 45 cm in front of its front wheel. The device used to measure the linear velocity of the air shall be located at between 0 cm and 20 cm from the air outlet.
4.4.2.8	The detailed requirements regarding test bench specifications are listed in Appendix 3 of this chapter.
4.4.3	Exhaust gas measurement system
4.4.3.1	The gas-collection device shall be a closed-type device that can collect all exhaust gases at the vehicle exhaust outlets on condition that it satisfies the backpressure condition of ± 125 mm of H_2O. An open system may be used if it is confirmed that all the exhaust gases are collected. The gas collection shall be such that there is no condensation which could appreciably modify the nature of exhaust gases at the test temperature. An example of a gas-collection device is illustrated in Figure 2-1:
	 Figure 2-1 Equipment for sampling the gases and measuring their volume

4.4.3.2.	A connecting tube shall be placed between the device and the exhaust gas sampling system. This tube and the device shall be made of stainless steel, or of some other material which does not affect the composition of the gases collected and which withstands the temperature of these gases.
4.4.3.3.	A heat exchanger capable of limiting the temperature variation of the diluted gases in the pump intake to $\pm$ 5 K ($\pm$ 5 ºC) shall be in operation throughout the test. This exchanger shall be equipped with a preheating system capable of bringing the exchanger to its operating temperature (with the tolerance of $\pm$ 5 K ($\pm$ 5 ºC)) before the test begins.
4.4.3.4.	A positive displacement pump shall be used to draw in the diluted exhaust mixture. This pump shall be equipped with a motor with several strictly controlled uniform speeds. The pump capacity shall be large enough to ensure the intake of the exhaust gases. A device using a critical-flow venturi (CFV) may also be used.
4.4.3.5.	A device (T) shall be used for the continuous recording of the temperature of the diluted exhaust mixture entering the pump.
4.4.3.6.	Two gauges shall be used, the first to ensure the pressure depression of the dilute exhaust mixture entering the pump relative to atmospheric pressure, and the second to measure the dynamic pressure variation of the positive displacement pump.
4.4.3.7.	A probe shall be located near to, but outside, the gas-collecting device, to collect samples of the dilution air stream through a pump, a filter and a flow meter at constant flow rates throughout the test.
4.4.3.8.	A sample probe pointed upstream into the dilute exhaust mixture flow, upstream of the positive displacement pump, shall be used to collect samples of the dilute exhaust mixture through a pump, a filter and a flow meter at constant flow rates throughout the test. The minimum sample flow rate in the sampling devices shown in Figure 2-1 and in point 4.4.3.7 shall be at least 150 litre/hour.
4.4.3.9.	Three-way valves shall be used on the sampling system described in points 4.4.3.7 and 4.4.3.8 to direct the samples either to their respective bags or to the outside throughout the test.
4.4.3.10.	Gas-tight collection bags
4.4.3.10.1.	For dilution air and dilute exhaust mixture the collection bags shall be of sufficient capacity not to impede normal sample flow and shall not change the nature of the pollutants concerned.
4.4.3.10.2.	The bags shall have an automatic self-locking device and shall be easily and tightly fastened either to the sampling system or the analyzing system at the end of the test.
4.4.3.11.	A revolution counter shall be used to count the revolutions of the positive displacement pump throughout the test.

	Note: Attention shall be paid to the connecting method and the material or configuration of the connecting parts, because each section (e.g. the adapter and the coupler) of the sampling system can become very hot. If the measurement cannot be performed normally due to heat damage to the sampling system, an auxiliary cooling device may be used as long as the exhaust gases are not affected.
	Note: With open type devices, there is a risk of incomplete gas collection and gas leakage into the test cell. There shall be no leakage throughout the sampling period.
4.4.3.12.	**Particular requirements for compression ignition engines**
4.4.3.12.1.	A heated sample line for a continuous HC-analysis with the heated flame ionization detector (HFID), including recorder (R) shall be used.
4.4.3.12.2.	The average concentration of the measured hydrocarbons shall be determined by integration. Throughout the test, the temperature of the heated sample line shall be controlled at (463.2K ± 10 K) 190 °C ± 10 °C. The heated sampling line shall be fitted with a heated filter (Fh) 99% efficient with particle ≥ 0.3 μm to extract any solid particles from the continuous flow of gas required for analysis.
4.4.3.12.3.	The sampling system response time (from the probe to the analyser inlet) shall be not more than 4 s.
4.4.3.12.4.	The HFID shall be used with a constant flow (heat exchanger) system to ensure a representative sample, unless compensation for varying CFV or CFO flow is made.
4.4.3.12.5.	The particulate sampling unit consists of a dilution tunnel, a sampling probe, a filter unit, a partial flow pump, and a flow rate regulator and measuring unit. The particulate sampling part flow is drawn through two series mounted filters. The sampling probe for the test gas flow for particulates shall be so arranged within the dilution tract that a representative sample gas flow can be taken from the homogenous air / exhaust mixture and an air / exhaust gas mixture temperature of 325.2 K(52 °C) shall not exceed immediately before the particulate filter. The temperature of the gas flow in the flow meter shall not fluctuate more than ± 3 K (± 3 °C), nor the mass flow rate shall fluctuate more than ± 5%. If the volume of flow changes unexpectedly as a result of excessive filter loading, the test should be stopped. When it is repeated, the rate of flow shall be decreased and / or larger filter shall be used. The filters shall be removed from the chamber not earlier than an hour before the test begins.
4.4.3.12.6.	The necessary particulate filters should be conditioned (as regards temperature and humidity) in an open dish which shall be protected against dust ingress for at least 8 hours and not more than 56 hours before the test in an air-conditioned chamber. After this conditioning, the uncontaminated filters shall be weighed and stored until they are used in a dust free and vibration proof chamber. The temperature of the chamber (or room) in which particulate filters are conditioned and weighed shall be maintained to within 295.2 K ± 3K (22°C ± 3°C) during all filters conditioning and weighing. The humidity shall be maintained to a dew point of 282.7 K ± 3 K (9.5°C ± 3°C) and a relative humidity of 45% ± 8%.

4.4.3.12.7.	If the filters are not used within 1 hour of their removal from the weighing chamber, then they shall be re-weighed. The 1hour limit shall be replaced by an 8 hour limit if one or both of the following conditions are met: - A stabilized filter is placed and kept in a sealed filter holder assembly with the ends plugged, or - A stabilized filter is placed in a sealed filter holder assembly which is then immediately placed in a sample line through which there is no flow.
4.4.3.13.	Additional sampling unit for the testing of vehicles equipped with a compression ignition engine.
4.4.3.13.1.	The particulate sampling system consist of a sampling probe in the dilution tunnel and two series-mounted filters. Quick-acting are located both up and downstream of the two filters in the direction of flow. The configuration of the sample probe shall be as indicated in Figure 2-6.
4.4.3.13.2.	The particulate sampling probe shall be arranged as follows:
4.4.3.13.2.1.	The sample probe shall be installed near the tunnel centre line between 10 and 20 tunnel diameters downstream of the exhaust gas inlet to the tunnel and have an internal diameter of at least 12 mm. If more than one simultaneous sample is drawn from a single sample probe, the flow drawn from that probe shall be split into identical sub-flows to avoid sampling artefacts. If multiple probes are used, each probe shall be sharp-edged, open-ended and facing directly into the direction of flow. Probes shall be equally spaced at least 5 cm apart around the central longitudinal axis of the dilution tunnel.
4.4.3.13.2.2.	The sample probe shall deliver the particle-size classification performance described in point 4.4.3.13.2.3. It is recommended that this performance be achieved by the use of a sharp-edged, open-ended probe facing directly in the direction of flow, plus a pre-classifier (cyclone impactor, etc.). An appropriate sampling probe, such as that indicated in Figure 2-6, may alternatively be used provided it achieves the pre-classification performance described in point 4.4.3.13.2.3.
4.4.3.13.2.3.	The pre-classifier (e.g. cyclone, impactor, etc.) shall be located upstream of the filter holder assembly. The pre-classifier 50 % cut point particle diameter shall be between 2.5 μm and 10 μm at the volumetric flow rate selected for sampling particulate mass emissions. The pre-classifier shall allow at least 99 % of the mass concentration of 1 μm particles entering the pre-classifier to pass through the exit of the pre-classifier at the volumetric flow rate selected for sampling particulate mass emissions. However, a sampling probe, used as an appropriate size-classification device, such as that shown in Figure 2-6, is acceptable as an alternative to a separate pre-classifier.
4.4.3.13.2.4.	The distance from the sampling tip to the filter mount shall be at least 5 probe diameters, but shall not exceed 1020 mm.
4.4.3.13.3.	**Sample and flow meter** The sample gas flow measurement unit shall consist of pumps, gas flow regulators and flow measuring units.
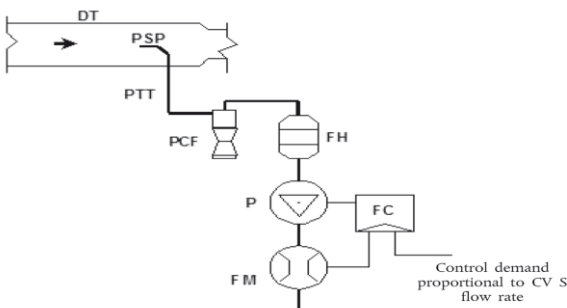
4.4.3.13.4.	The hydrocarbon sampling system consists of a heated sampling probe, line, filter and pump. The sampling probe shall be installed in such a way, at the same distance from the exhaust gas inlet as the particulate sampling probe that neither interferes with samples taken by the other. It shall have a minimum internal diameter of 4 mm.
4.4.3.13.5.	All heated parts shall be maintained at a temperature of 463.2K ± 10 K (190 °C ± 10 °C) by heating system.
4.4.3.13.6.	If it is not possible to compensate for variations in the flow rate, there shall be a heat exchanger and a temperature control device shall be used, so as to ensure that the flow rate in the system is constant and the sampling rate is accordingly proportional.
4.4.3.13.7	Sample pump and flow meter
4.4.3.13.7.1	The sample gas flow measurement unit shall consist of pumps, gas flow regulators and flow measuring units.
4.4.3.13.7.2	The temperature of the gas flow in the flow meter may not fluctuate by more than ±3K (± 3 °C), except during regeneration tests on vehicles equipped with periodically regenerating after-treatment devices. In addition, the sample mass flow rate shall remain proportional to the total flow of diluted exhaust gas to within a tolerance of ± 5% of the particulate sample mass flow rate. Should the volume of flow change unacceptably as a result of excessive filter loading, the test shall be stopped. When the test is repeated, the rate of flow shall be decreased.
4.4.3.13.8	Filter and filter holder
4.4.3.13.8.1	A valve shall be located downstream of the filter in the direction of flow. The valve shall be responsive enough to open and close within one second of the start and end of the test.
4.4.3.13.8.2	It is recommended that the mass collected on the 47 mm diameter filter (Pe) is ≥ 20 μg and that the filter loading is maximized in line with the requirements of points 4.4.3.12.6 and 4.4.3.12.7.
4.4.3.13.8.3	For a given test, the gas filter face velocity shall be set to a single value within the range 20 cm/s to 80 cm/s, unless the dilution system is being operated with sampling flow proportional to CVS flow rate.
4.4.3.13.8.4	Fluorocarbon coated glass fibre filters or fluorocarbon membrane filters are required. All filter types shall have a 0.3 μm DOP (di-octylphthalate) or PAO (poly-alpha-olefin) CS 68649-12-7 or CS 68037- 01-4 collection efficiency of at least 99 % at a gas filter face velocity of 5.33 cm/s.
4.4.3.13.8.5	The filter holder assembly shall be of a design that provides an even flow distribution across the filter stain area. The filter stain area shall be at least 1075 mm^2.
4.4.3.13.9	Filter weighing chamber and balance
4.4.3.13.9.1	The microgram balance used to determine the weight of a filter shall have a precision standard deviation) of 2 μg and resolution of 1 μg or better. It is recommended that the microbalance be checked at the start of each weighing session by weighing one reference weight of 50 mg. This weight shall be weighed three times and the average result recorded. The weighing session and balance are considered valid if the

<table>
<tr><td></td><td>average result of the weighing is within ± 5 μg of the result from the previous weighing session.

The weighing chamber (or room) shall meet the following conditions during all filter conditioning and weighing operations:

- Temperature maintained at 295.2 ± 3 K (22 °C ± 3 °C);

- Relative humidity maintained at 45 ± 8 %;

- Dew point maintained at 282.7 ± 3 K (9.5 °C ± 3 °C).
  It is recommended that temperature and humidity conditions be recorded along with sample and reference filter weights.</td></tr>
<tr><td>4.4.3.13.9.2</td><td>**Buoyancy correction**</td></tr>
<tr><td></td><td>All filter weights shall be corrected for filter buoyancy in air.

The buoyancy correction depends on the density of the sample filter medium, the density of air, and the density of the calibration weight used to calibrate the balance. The density of the air is dependent on the pressure, temperature and humidity.

It is recommended that the temperature and dew point of the weighing environment be controlled to 295.2 K ± 1 K (22 °C ± 1 °C) and 282.7 ± 1 K (9.5 °C ± 1 °C) respectively. However, the minimum requirements stated in point 4.4.3.13.9.1. will also result in an acceptable correction for buoyancy effects. The correction for buoyancy shall be applied as follows:</td></tr>
<tr><td></td><td>**Equation 2-1**

$$m_{corr} = m_{uncorr} * (1 - ((\rho_{air})/(\rho_{weight})))/(1 - ((\rho_{air})/(\rho_{media})))$$

where:

m_{corr} = PM mass corrected for buoyancy

m_{uncorr} = PM mass uncorrected for buoyancy

ρ_{air} = density of air in balance environment

ρ_{weight} = density of calibration weight used to span balance

ρ_{media} = density of PM sample medium (filter) with filter medium Teflon coated glass fibre (e.g.TX40):

ρ_{media} = 2.300kg/m3

ρ_{air} can be calculated as follows:</td></tr>
</table>

	Equation 2 -2 $$\rho_{air} = \frac{P_{abs} * M_{mix}}{R * T_{amb}}$$ where: P_{abs} = absolute pressure in balance environment M_{mix} = molar mass of air in balance environment (28.836 gmol^{-1}) R = molar gas constant (8.314 Jmol^{-1}K^{-1}) T_{amb} = absolute ambient temperature of balance environment The chamber (or room) environment shall be free of any ambient contaminants (such as dust) that would settle on the particulate filters during their stabilisation. Limited deviations from weighing room temperature and humidity specifications shall be allowed provided their total duration does not exceed 30 minutes in any one filter conditioning period. The weighing room shall meet the required specifications prior to personal entrance into the weighing room. No deviations from the specified conditions are permitted during the weighing operation. The effects of static electricity shall be nullified. This may be achieved by grounding the balance through placement on an antistatic mat and neutralization of the particulate filters prior to weighing using a Polonium neutralizer or a device of similar effect. Alternatively, nullification of static effects may be achieved through equalization of the static charge.
4.4.3.13.9.3	A test filter shall be removed from the chamber no earlier than an hour before the test begins.
4.4.3.14.	**Recommended system description for Particulate Sampling** Figure 2-2 is a schematic drawing of the recommended particulate sampling system. Since various configurations can produce equivalent results, exact conformity with this figure is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and coordinate the functions of component systems. Further components that are not needed to maintain accuracy with other system configurations may be excluded if their exclusion is based on good engineering judgment. Figure 2-2 **Particulate sampling system**
	A sample of the diluted exhaust gas is taken from the full flow dilution tunnel (DT) through

	the particulate sampling probe (PSP) and the particulate transfer tube (PTT) by means of the pump (P). The sample is passed through the particle size pre-classifier (PCF) and the filter holders (FH) that contain the particulate sampling filters. The flow rate for sampling is set by the flow controller (FC).
4.4.4.	**Driving schedules**
4.4.4.1.	**Test cycles** Test cycle for the type I test is described in Appendix 6 of this chapter. General Conditions under which the cycle is carried out: preliminary testing cycles should be carried out if necessary to determine how best to actuate the accelerator and brake controls so as to achieve a cycle approximately to the theoretical cycle within the prescribed limits
4.4.4.2.	**Vehicle speed and time tolerances**
4.4.4.2.1.	A tolerance of ± 1 km/h shall be allowed between the indicated speed and the theoretical speed during acceleration, during steady speed and during deceleration, when the vehicle's brakes are used. If the vehicle decelerates more rapidly without the use of the brakes, then the timing of the theoretical cycle shall be restored by constant speed or idling period merging into the following operation. Speed tolerances greater than those prescribed shall be accepted, during phase changes provided that the tolerances are never exceeded for more than 0.5 second on any one occasion.
4.4.4.2.2.	Time tolerances of ± 0.5 second shall be allowed. The above tolerances shall apply equally at the beginning and at the end of each gear changing period. The speed and time tolerances shall be combined as indicated in Figure 2-3.
	Figure 2-3. **Operating cycle with speed and time tolerances**

4.4.4.2.3	**Use of the Gear Box:**.
	The use of the gearbox in case of testing on chassis dynamometer shall be in accordance with Para 4.4.4.2.3.1 of this Chapter
4.4.4.2.3.1	Vehicles which do not attain the acceleration and maximum speed values required in the operating cycle shall be operated with the accelerator control fully depressed until they once again reach the required operating curve. Deviations from the operating cycle shall be recorded in the test report. The use of the gear box shall be as specified by the manufacturer.
	However, in the absence of such instructions, the following points shall be taken into account:
4.4.4.2.3.1.1	**Manual Change Gear Box:**
4.4.4.2.3.1.1.1.	During each phase at constant speed, the rotating speed of the engine shall be, if possible, between 50 % and 90% of the speed corresponding to the maximum power of the engine. When this speed can be reached in two or more gears, the vehicle shall be tested with the higher gear engaged.
4.4.4.2.3.1.1.2.	During acceleration, the vehicle shall be tested in whichever gear is appropriate to the acceleration imposed by the cycle. A higher gear shall be engaged at the latest when the rotating speed is equal to 110% of the speed corresponding to the maximum power of the engine.
4.4.4.2.3.1.1.3	During deceleration, a lower gear shall be engaged before the engine starts to idle roughly, at the latest when the engine revolutions are equal to 30% of the speed corresponding to the maximum power of the engine. No change down to first gear shall be effected during deceleration.
4.4.4.2.3.1.1.4	Vehicles equipped with an overdrive arrangement if fitted, which the driver can actuate shall be tested with the overdrive out of action.
4.4.4.2.3.1.1.5.	When it is not possible to adhere to the cycle, the operating cycle will be modified for gear change points, allowing 2 seconds time interval at constant speed for each gear change keeping the total time constant. Figure Ap 6-1 in Appendix 6 of this Chapter shows the operating cycle with recommended gear positions.
4.4.4.2.3.1.2	**Automatic Gear Box:**
	Vehicles equipped with automatic shift gear boxes shall be tested with the highest gear (drive) engaged. The accelerator shall be used in such a way as to obtain the steadiest acceleration possible, enabling the various gears to be engaged in the normal order.
4.4.5.	**Dynamometer settings**
	A full description of the chassis dynamometer and instruments shall be provided in accordance with Appendix 3 of this chapter. Measurements shall be taken to the accuracies specified in point **4.4.6.** The running resistance force for the chassis dynamometer settings can be derived either from on-road coast-down measurements or from a running resistance table, with reference to Appendix 5 of this chapter.
4.4.5.1.	**Chassis dynamometer setting derived from on-road coast-down measurements**

	To use this alternative, on-road coast-down measurements shall be carried out as specified in Appendix 7 of this chapter.
4.4.5.1.1.	**Requirements for the equipment** The instrumentation for the speed and time measurement shall have the accuracies specified in point **4.4.6.**
4.4.5.1.2.	**Inertia mass setting**
4.4.5.1.2.1.	The equivalent inertia mass m_i for the chassis dynamometer shall be the flywheel equivalent inertia mass, m_{fi}, closest to the sum of the kerb mass of the vehicle and uniform increase of 150 kg. Alternatively, the equivalent inertia mass mi can be derived from Appendix 5 and 7 of this chapter.
4.4.5.1.2.2.	If the reference mass mref cannot be equalized to the flywheel equivalent inertia mass mi, to make the target running resistance force F* equal to the running resistance force FE (which is to be set to the chassis dynamometer), the corrected coast-down time ΔTE may be adjusted in accordance with the total mass ratio of the target coast-down time ΔTroad in the following sequence: **Equation 2-3** $$\Delta T_{road} = \frac{1}{3.6}(m_a + m_{r1})\frac{2\Delta v}{F^*}$$ **Equation 2-4** $$\Delta T_E = \frac{1}{3.6}(m_i + m_{r1})\frac{2\Delta v}{F_E}$$ **Equation 2-5** $$F_E = F^*$$ **Equation 2-6** $$\Delta T_E = \Delta T_{road} * \frac{m_i + m_{r1}}{m_a + m_{r1}}$$ $$0.95 < \frac{m_i + m_{r1}}{m_a + m_{r1}} < 1.05$$ where m_{r1} may be measured or calculated, in kilograms, as appropriate. As an alternative, m_{r1} may be estimated as f percent of m.

4.4.5.2.	**Running resistance force derived from a running resistance table**
4.4.5.2.1.	The chassis dynamometer may be set by the use of the running resistance table instead of the running resistance force obtained by the coast-down method. In this table method, the chassis dynamometer shall be set by the reference mass regardless of particular vehicle characteristics. Note: Care shall be taken when applying this method to vehicles with extraordinary characteristics
4.4.5.2.2.	The flywheel equivalent inertia mass mfi shall be the equivalent inertia mass mi specified in Appendix 5 and 7 of this chapter where applicable. The chassis dynamometer shall be set by the rolling resistance of the non-driven wheels: (a) and the aero drag coefficient (b) specified in Appendix 5 of this chapter or determined in accordance with the procedures set out in Appendix 7 of this chapter respectively.
4.4.5.2.3.	The running resistance force on the chassis dynamometer F_E shall be determined using the following equation: Equation 2-7: $$F_E = F_T = a + b * v^2$$
4.4.5.2.4.	The target running resistance force F^* shall be equal to the running resistance force obtained from the running resistance table F_T, because the correction for the standard ambient conditions is not necessary.
4.4.6.	**Measurement accuracies**
	Measurements shall be taken using equipment that fulfils the accuracy requirements in: **Table 2-1** **Required accuracy of measurements**

Measurement items	At measured value	Resolution
(a) Running resistance force, F	+ 2 %	—
(b) Vehicle speed (v1, v2)	± 1 %	0.2 km/h
(c) Coast-down speed interval (2Δv = v1 - v2)	± 1 %	0.1 km/h
(d) Coast-down time (Δt)	± 0 %	0.01 s
(e) Total vehicle mass (m_{ref})	± 0.5 %	1.0 kg
(f) Wind speed	± 10 %	0.1 m/s
(g) Wind direction	—	5 deg.

	(h) Temperatures	± 1 K	1 K
	(i) Barometric pressure	—	0.2 kPa
	(j) Distance	± 0.1 %	1 m
	(k) Time	± 0.1 s	0.1 s

5	**Test procedures**
5.1.	**Description of the Type I Test**
	The test vehicle shall be subjected to test type I requirements as specified in the following sub-clauses.
5.1.1	**Type I test (verifying the average emission of gaseous pollutants, CO_2 emissions and fuel consumption in a characteristic driving cycle)**
5.1.1.1.	The test shall be carried out by the method described in point **5.2.** The gases shall be collected and analysed by the prescribed methods. During the test the exhaust gases shall be diluted with air and a proportional sample collected in one or more bags. The contents of the bags will be analyzed at the end of the test. The total volume of the diluted exhaust shall be measured. Carbon monoxide (CO), hydrocarbon (HC) and nitrogen oxide emissions (NO_X), and in addition particulate matter (PM) in the case of vehicles equipped with compression ignition engines shall be recorded. Carbon dioxide (CO_2) shall also be recorded for the purpose of calculation of fuel consumption.
5.1.1.2.	**Number of tests.**
5.1.1.2.1.	A test lasting a total of 648 seconds and comprising of 6 cycles as described in Appendix 6 of this Chapter shall be carried out, without interruption, with a modification that the exhaust gas sampling should start at initiation (T=0) as per test cycle mentioned in Appendix 6. Vehicles that are fueled with LPG or NG/biomethane, flex fuel H_2NG or hydrogen shall be tested for the type I test as per procedure set out in Appendix 8 of this chapter.
5.1.1.2.2.	The number of tests shall be determined as shown in figure 2-4. R_i1 to R_i3 describe the final measurement results for the first (No 1) test to the third (No 3) test. Nevertheless, for each of the pollutants one of the three results obtained may exceed by not more than 10% of the applicable limits prescribed for the vehicle concerned, provided the arithmetical mean of the three results is not exceeding the prescribed limit. Where the prescribed limits are exceeded for more than one pollutant, it shall be immaterial whether this occurs in the same test or in different tests.
5.1.1.2.3.	The number of tests prescribed in Para 5.1.1.2.2 above shall be reduced in the conditions hereinafter defined, where R_i1 is the result of the first test and R_i2 the result of the second test for each of the pollutants referred to in Para 5.1.1.1 above.
5.1.1.2.3.1.	Only one test shall be performed if the result obtained for each pollutant is less than or equal to 0.7 L i.e. $R_i1 \leq 0.70$ L.

5.1.1.2.3.2.	If the requirements of 5.1.1.2.3.1 is not satisfied, only two tests are performed if for each pollutant the following requirements are met. $R_i1 \le 0.85\ L$ and $R_i1 + R_i2 \le 1.7\ L$ and $R_i2 < L$. Subject to the provisions of the paragraphs 5.1.1.2.2 & 5.1.1.2.3, the test shall be repeated three times, the test results shall be multiplied by appropriate deterioration factors as notified in CMVR/notification. The resulting masses of gaseous emission and, in the case of vehicles equipped with compression-ignition engines, the mass of particulates obtained in each test shall not exceed the applicable limits.
5.1.1.2.4	Manufacturers shall ensure that type-approval requirements for verifying durability requirements for CO, NOx, HC+NOx and if applicable, PM are met. At the choice of the manufacturer, one of the following durability test procedures shall be used to provide evidence to the test agency that the environmental performance of a type-approved parent vehicle is durable. The final results shall be rounded off to nearest (mg) as per IS 2:1960.
5.1.1.2.4.1	Fixed DF (Mathematical Durability Procedure) : For each emission constituent, the product of the deterioration factor set out in notification and the environmental test result of Type I test shall be lower than the emission limits set out in notification.
5.1.1.2.4.2	Actual Durability Test with Full Mileage Accumulation: The test vehicles shall physically accumulate the full distance set out in notification and shall be tested in accordance with the procedure laid down in test type V. The emission test results up to and including the full distance shall be lower than the emission limits set out in notification.
5.1.1.2.4.3	Actual Durability Test with Partial Mileage Accumulation: The test vehicles shall physically accumulate a minimum of 50 % of the full distance set out in notification and shall be tested in accordance with the procedure laid down in test type V. As specified in the procedure, the test results shall be extrapolated up to the full distance set out in notification. Both the test results and the extrapolated results shall be lower than the emission limits set out in notification.
5.1.1.2.4.4	**DF requirements for Type Approval of New Variant/Vehicle of same family of Type V test:** The test shall be carried out on a run-in vehicle. At the choice of the manufacturer, one of the following durability test procedures shall be used to provide evidence to the test agency that the environmental performance of a type-approved family vehicle is durable.

5.1.1.2.4.4.1	Fixed DF (Mathematical Durability Procedure) :
	For each emission constituent, the product of the deterioration factor set out in notification and the environmental test result of Type I test shall be lower than the emission limits set out in notification.
5.1.1.2.4.4.2	Actual Durability Test with Full Mileage Accumulation done for parent vehicle:
	In case the manufacturer has followed durability test procedure as per Clause 5.1.1.2.4.2 for parent vehicle, then:
	a) the product of the deterioration factor calculated as per Clause 3.2.4.6 of Chapter 3W-V and the environmental test result of Type I test shall be lower than the emission limits set out in notification; or
	b) Fully aged Golden component shall be used and environmental test result of Type I test shall be lower than the emission limits set out in notification. Deterioration factor to be calculated as per Clause 3.2.4.6 of Chapter 3W-V.
5.1.1.2.4.4.3	Actual Durability Test with Partial Mileage Accumulation done for parent vehicle:
	In case the manufacturer has followed durability test procedure as per Clause 5.1.1.2.4.3 for parent vehicle, then:
	a) the product of the deterioration factor calculated as per Clause 3.2.4.7 of Chapter 3W-V and the environmental test result of Type I test shall be lower than the emission limits set out in notification; or
	b) Partially aged Golden component shall be used and the product of the D.F for remaining portion of durability distance calculated as per Clause 3.2.4.8 of Chapter 3W-V and environmental test result of Type I test shall be lower than the emission limits set out in notification;
	c) Using the Emission results of Parent vehicle and the emission result of test vehicle (fitted with partial aged golden pollution control devices) at partial mileage, the test results shall be extrapolated up to the full distance set out in the notification. Both the test results and the extrapolated results shall be lower than the emission limits set out in the notification.
5.1.1.2.4.5	DF requirements for COP test shall be as follows:
	DF for COP of a variant/parent model shall be the DF being used for type approval of the variant/parent model. If the type approval test has been done by actual mileage accumulation, then applicable DF referred in 5.1.1.2.4.4.2 (a) and 5.1.1.2.4.4.3 (a), (b) shall be used.
	For 5.1.1.2.4.4.2 (b), DF for COP shall be the DF calculated as per clause 3.2.4.6 of Chapter 3W-V.
	For 5.1.1.2.4.4.3 (c), DF for COP shall be the DF calculated as per clause 3.2.4.7 of Chapter 3W-V using Parent vehicle results.
	For each emission constituent, the product of the deterioration factor and the environmental test result of Type I test shall be lower than the emission limits set out in notification.

5.1.1.2.4.6	At the choice of the manufacturer one of the following durability test procedures as described in below table shall be used for type approval:
	The emission test results multiplied by applicable D.F shall be lower than emission limits set out in notification.
	If the actual mileage accumulation (full) has been carried out, none of the emission values shall exceed these limits.

Table No 2-5					
	Option		D.F to be applied		Relative Clause
Option No.	Condition of Vehicle for Type-I test.	Condition of Pollution control devices.	Applicable D.F. for Type Approval	D.F. Calculation	
1	New vehicle, run-in	Degreened by Running-In	Fixed D.F	As per the Notification	5.1.1.2.4.1, 5.1.1.2.4.4.1
2[(1)]	Aged	Full mileage accumulation done as per Chapter 3W-V	No D.F to be applied	3.2.4.6 of Chapter 3W-V [Only calculation]	5.1.1.2.4.2
3[(1)]	Partially aged	Partial mileage accumulation done as per Chapter 3W-V	No D.F to be applied	i. 3.2.4.7 and ii. 3.2.4.8 of Chapter 3W-V [Only calculation]	5.1.1.2.4.3
4	New vehicle, run-in	Degreened by Running-In	D.F. calculated in Option No. 2 of table	--	5.1.1.2.4.4.2 (a)
			D.F. calculated in Option No. 3 i. of table	--	5.1.1.2.4.4.3 (a)
5	New vehicle, run-in	Using fully aged golden pollution control	No D.F to be applied		5.1.1.2.4.4.2 (b)

		devices			
6	New Vehicle, run-in	Using partially aged golden pollution control devices	D.F. calculated in Option No. 3 i. of table	--	5.1.1.2.4.4.3 (b)
			No D.F to be applied	--	5.1.1.2.4.4.3 (c)
(1)	Test vehicle is the parent vehicle for options 4, 5 and 6.				

5.2.	**Type I tests**
5.2.1.	**Overview**
5.2.1.1.	The type I test consists of prescribed sequences of dynamometer preparation, fueling, parking, and-driving cycle as described in Appendix 6 of this chapter.
5.2.1.2.	The test is designed to determine combined hydrocarbon+oxides of nitrogen, carbon monoxide, oxides of nitrogen, particulate matter mass emissions if applicable and fuel consumption. The test consists of engine start-ups and vehicle operation on a chassis dynamometer, through a specified driving cycle. A proportional part of the diluted exhaust emissions is collected continuously for subsequent analysis, using a constant volume (variable dilution) sampler (CVS).
5.2.1.3.	Except in cases of component malfunction or failure, all emission-control systems installed on or incorporated in a tested vehicle shall be functioning during all procedures.
5.2.1.4	Background concentrations are measured for all emission constituents for which emissions measurements are taken. For exhaust testing, this requires sampling and analysis of the dilution air.
5.2.1.5	**Background particulate mass measurement:** The particulate background level of the dilution air may be determined by passing filtered dilution air through the particulate filter. This shall be drawn from the same point as the particulate matter sample, if a particulate mass measurement is applicable. One measurement may be performed prior to or after the test. Particulate mass measurements may be corrected by subtracting the background contribution from the dilution system. The permissible background contribution shall be ≤ 1 mg/km (or equivalent mass on the filter). If the background contribution exceeds this level, the default figure of 1 mg/km (or equivalent mass on the filter) shall be used. Where subtraction of the background contribution gives a negative result, the particulate mass result shall be considered to be zero.

5.2.2.	**Dynamometer Load and Inertia setting:**
5.2.2.1.	Dynamometer with adjustable load curve: the load simulator shall be adjusted in order to absorb the power exerted on the driving wheels at various steady speeds of 50, 40, 30 and 20 km/h.
5.2.2.2.	The means by which these loads are determined and set are described in Appendix 7 of this Chapter.
5.2.2.2.1.	**Load and Inertia Setting Load Determined with Vehicle Road Test**
	The dynamometer shall be adjusted so that the total inertia of the rotating masses will simulate the inertia and other road load forces acting on the vehicle when driving on the road. The means by which this load is determined is described in clause 4. Load and Inertia adjustment to be carried out with vehicle mounting on the chassis dynamometer with proper vehicle warm up as per manufacturer recommendation before vehicle preconditioning cycle. Derived load set values to be used for vehicle preconditioning and for mass emission test. At the end of the test, road load verification to be carried out with vehicle and shall lie within ±5 %.
5.2.2.3.	Chassis Dynamometers with electrical inertia simulation shall be demonstrated to be equivalent to mechanical inertia systems. The means by which equivalence is established is described in Appendix 3 of this Chapter.
5.2.2.4	**Chassis Dynamometer Calibration**
	The chassis dynamometer system shall comply with the calibration and verification methods laid down in Appendix 3 of this chapter.
5.2.2.4.1.	The dynamometer should be calibrated periodically as recommended by the manufacturer of the chassis dynamometer and then calibrated as required. The calibration shall consist of the manufacturers' recommended procedure and a determination of the dynamometer frictional power absorption at 40 km/h when being used for testing of L5 Category vehicles. One method for determining this is given in Appendix 3 of this chapter. Other methods may be used if they are proven to yield equivalent results.
5.2.2.4.2.	The performance check consists of conducting dynamometer coast down time at one or more inertia power setting and comparing the coast down time to that recorded during the last calibration. If the coast down time differs by more than 1 second, a new calibration is required.
5.2.3.	**Calibration of Gas analysis system**
5.2.3.1.	Establishment of Calibration Curve
5.2.3.1.1.	The analyser calibration curve shall be established by at least five calibration points, spaced as uniformly as possible. The nominal concentration of the calibration gas of the highest concentration shall be at least equal to 80% of the full scale.

5.2.3.1.2.	The calibration curve is calculated by the least square method. If the degree of the polynomial resulting from the curve is greater than 3, the number of calibration points shall be at least equal to this polynomial degree plus 2.
5.2.3.1.3.	The calibration curve shall not differ by more than 2% from the nominal value of calibration gas of each calibration point.
5.2.3.1.4.	The different characteristic parameters of the analyser, particularly, the scale, the sensitivity, the zero point and the date of carrying out the calibration should be indicated on the calibration curve.
5.2.3.1.5.	It can be shown to the satisfaction of the test agency, that alternative technology e.g. computer, electronically controlled range switch etc., can give equivalent accuracy, then these alternatives may be used.
5.2.3.2	**Verification of Calibration**
5.2.3.2.1.	The calibration procedure shall be carried out as often as necessary and in any case within one month preceding the type approval emission test and once in six months for verifying conformity of production.
5.2.3.2.2.	The verification should be carried out using standard gases. The same gas flow rates shall be used as when sampling exhaust.
5.2.3.2.3.	A minimum of two hours shall be allowed for warming up the analysers.
5.2.3.2.4.	The NDIR analyser shall be tuned, where appropriate, and the flame combustion of the FID analyser optimized.
5.2.3.2.5.	Using purified dry air (or nitrogen), the CO and NOx analysers shall be set at zero; dry air shall be purified for the HC analyser. Using appropriate calibrating gases mentioned in 5.2.5.3 of this Chapter, the analysers shall be reset.
5.2.3.2.6.	The zero setting shall be rechecked and the procedure described in Para 5.2.3.2.4 and 5.2.3.2.5 above repeated, if necessary.
5.2.3.2.7.	The calibration curves of the analysers should be verified by checking at least at five calibration points, spaced as uniformly as possible. The nominal concentration of the calibration gas of the highest concentration shall be at least equal to 80% of the full scale. It should meet the requirement of para 5.2.3.1.3 above.
5.2.3.2.8.	If it does not meet, the system should be checked, fault, if any, corrected and a new calibration curve should be obtained.
5.2.3.3.	**Pre & Post-test Checks**
5.2.3.3.1.	**Pre- test Checks**
5.2.3.3.1.1	A minimum of two hours shall be allowed for warming up the infra-red NDIR analyser, but it is preferable that power be left on continuously in the analysers. The chopper motors may be turned off when not in use.
5.2.3.3.1.2	Each normally used operating range shall be checked prior to each analysis.
5.2.3.3.1.3.	Using purified dry air (or nitrogen), the CO and NOx analysers shall be set at zero; dry air shall be purified for the HC analyser.
5.2.3.3.1.4.	Span gas having a concentration of the constituent that will give a 75-95% full-scale deflection shall be introduced and the gain set to match the calibration curve. The same flow rate shall be used for calibration, span and exhaust sampling to avoid correction for sample cell pressure.

5.2.3.3.1.5.	The nominal value of the span calibration gas used shall remain within ± 2% of the calibration curve.
5.2.3.3.1.6.	If it does not, but it remains within ± 5% of the calibration curve, the system parameters such as gain of the amplifier, tuning of NDIR analysers, optimisation of FID analysers etc. may be adjusted to bring within ± 2%.
5.2.3.3.1.7.	If the system does not meet the requirement of 5.2.3.3.1.5 and 5.2.3.3.1.6 above, the system should be checked, fault, if any corrected and a new calibration curve should be obtained.
5.2.3.3.1.8.	Zero shall be checked and the procedures described in para 5.2.3.3.1.4 above repeated, if required.
5.2.3.3.2.	**Post-test Checks** After testing, zero gas and the span gas shall be used for re-checking. The analysis is considered acceptable if the difference between two measuring results is less than 2%.
5.2.3.4.	**Check for FID Hydrocarbon Response**
5.2.3.4.1.	**Detector response optimization** The FID shall be adjusted according to the manufacturer's specifications. To optimize the response, propane in air shall be used on the most common operating range.
5.2.3.4.2.	**Response factors of different hydrocarbons and recommended limits** The response factor (R_f) for a particular hydrocarbon species is the ratio of the FID C_1 reading to the gas cylinder concentration, expressed as ppm C_1. The concentration of the test gas shall be at a level to give a response of approximately 80 % of full-scale deflection for the operating range. The concentration shall be known to an accuracy of ± 2 % in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder shall be pre-conditioned for 24 hours at a temperature of between 293.2 K (20°C) and 303.2 K (30°C). Response factors shall be determined when introducing an analyser into service and thereafter at major service intervals. The test gases to be used and the recommended response factors are: Methane and purified air: $1.00 < R_f < 1.15$ or $1.00 < R_f < 1.05$ for NG/biomethane fueled vehicles Propylene and purified air: $0.90 < R_f < 1.00$ Toluene and purified air: $0.90 < R_f < 1.00$ These are relative to a response factor (Rf) of 1.00 for propane and purified air.

5.2.3.4.3.	**Oxygen interference check and recommended limits** The response factor shall be determined as described in 5.2.3.4.2. The test gas to be used and recommended response factor range are : Propane and nitrogen $\quad 0.95 \leq R_f \leq 1.05$,
5.2.3.5.	**Efficiency Test of the NOx Converter :**
5.2.3.5.1	The efficiency of the converter used for the conversion of NO_2 into NO is tested as follows :
5.2.3.5.1.1.	Using the test set up shown in Figure 2- 5 and the procedure described below, the efficiency of converters can be tested by means of an ozonator.
	  Figure 2 -5 **Schematic of Set-up for checking the efficiency of NOx converter**
5.2.3.5.2.	Calibrate the CLA analyser in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which should amount to about 80 % of the operating range and the NO_2 concentration of the gas mixture shall be less than 5 % of the NO concentration). The NO_x analyser shall be in the NO mode so that span gas does not pass through the converter. Record the indicated concentration.
5.2.3.5.3.	Via a T-fitting, oxygen or synthetic air is added continuously to the gas flow until the concentration indicated is about 10 % less than the indicated calibration concentration given in paragraph 5.2.3.4.2 above. Record the indicated concentration (c). The ozonator is kept deactivated throughout this process.

5.2.3.5.4.	The ozonator is now activated to generate enough ozone to bring the NO concentration down to 20 % (minimum 10 %) of the calibration concentration given in 5.2.3.5.2. Record the indicated concentration (d).
5.2.3.5.5.	The NOx analyser is then switched to the NOx mode which means that the gas mixture (consisting of NO, NO_2, O_2 and N_2) now passes through the converter. Record the indicated concentration (a).
5.2.3.5.6.	The ozonator is now deactivated. The mixture of gases described in paragraph 5.2.3.5.3 above passes through the converter into the detector. Record the indicated concentration (b).
5.2.3.5.7.	With the ozonator deactivated, the flow of oxygen or synthetic air is also shut off. The NOx reading of the analyser shall then be no more than 5 % above the figure in paragraph 5.2.3.5.2
5.2.3.5.8.	The efficiency of the NOx converter is calculated as follows : $$\text{Efficiency (\%)} = \left(1 + \frac{(a-b)}{(c-d)}\right) * 100$$
5.2.3.5.9.	The efficiency of the converter shall not be less than 95%.
5.2.3.5.10	The efficiency of the converter shall be tested at least once a week.
5.2.3.6.	**System Leak Test :**
	A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyser pump shall be switched on. After an initial stabilisation period all flow meters and pressure gauges should read zero. If not, the sampling line(s) shall be checked and the fault corrected.
5.2.3.7.	**Calibration and verification procedures of the particulate mass emissions measurement equipment**
5.2.3.7.1.	**Flow meter calibration** The test agency shall check that a calibration certificate has been issued for the flow meter demonstrating compliance with a traceable standard within a 12-month period prior to the test, or since any repair or change which could influence calibration.
5.2.3.7.2.	**Microbalance calibration** The test agency shall check that a calibration certificate has been issued for the microbalance demonstrating compliance with a traceable standard within a 12-month period prior to the test.
5.2.3.7.3	**Reference filter weighing** To determine the specific reference filter weights, at least two unused reference filters shall be weighed within eight hours of, but preferably at the same time as, the sample filter weighing. Reference filters shall be of the same size and material as the sample filter. If the specific weight of any reference filter changes by more than $\pm$ 5 μg between sample filter weighings, the sample filter and reference filters shall be reconditioned in

the weighing room and then reweighed.

This shall be based on a comparison of the specific weight of the reference filter and the rolling average of that filter's specific weights.

The rolling average shall be calculated from the specific weights collected in the period since the reference filters were placed in the weighing room. The averaging period shall be between one day and 30 days.

Multiple reconditioning and re-weighings of the sample and reference filters are permitted up to 80 hours after the measurement of gases from the emissions test.

If, within this period, more than half the reference filters meet the $\pm$ 5 µg criterion, the sample filter weighing can be considered valid.

If, at the end of this period, two reference filters are used and one filter fails to meet the $\pm$ 5 µg criterion, the sample filter weighing may be considered valid provided that the sum of the absolute differences between specific and rolling averages from the two reference filters is no more than 10 µg.

If fewer than half of the reference filters meet the $\pm$ 5 µg criterion, the sample filter shall be discarded and the emissions test repeated. All reference filters shall be discarded and replaced within 48 hours.

In all other cases, reference filters shall be replaced at least every 30 days and in such a manner that no

sample filter is weighed without comparison with a reference filter that has been in the weighing room for at least one day.

If the weighing room stability criteria outlined in point 4.4.3.13.9.1 are not met but the

reference filter weighings meet the criteria listed in point 5.2.3.7.3, the vehicle

manufacturer has the option of accepting the sample filter weights or voiding the

tests, fixing the weighing room control system and re- running the test.

(*) Minimum internal diameter
Wall thickness ~ 1 mm - Material: stainless steel

Figure 2-6
Particulate sampling probe configuration

5.2.4.	**Analytical Equipment**
5.2.4.1.	Pollutant gases shall be analysed with the following instruments :
5.2.4.1.1.	**Carbon monoxide (CO) and carbon dioxide (CO₂) analysis** The carbon monoxide and carbon dioxide analysers shall be of the Non-Dispersive Infra Red (NDIR) absorption type.
5.2.4.1.2.	**Hydrocarbon (HC) analysis** Gasoline Vehicles: The hydrocarbons analyser shall be of the Flame ionisation (FID) type calibrated with propane gas expressed equivalent to carbon atoms.
5.2.4.1.3.	**Hydrocarbons (HC) analysis** Diesel Vehicles: The hydrocarbon analyser shall be of the Flame ionisation type Detector with valves, pipe work etc. heated to 190 °C ± 10 °C (HFID). It shall be calibrated with propane gas expressed equivalent to carbon atoms (C_1).
5.2.4.1.4.	**Nitrogen oxide (NOx) analysis.** The nitrogen oxide analyser shall be of the Chemiluminescent (CLA) type with a NOx-NO converter or by NDUVR (non- dispersive ultraviolet resonance absorption) type analyser.
5.2.4.1.5.	**Particulates:** Gravimetric determination of the particulates collected. These particulates are in each case collected by two series mounted filters in the sample gas flow. The quantity of particulates collected by each pair of filters shall be as follows : **Equation 2-8** $$M = \frac{(V_{mix} * m)}{(V_{ep} * d)} \quad \text{or}$$ **Equation 2-9** $$m = \frac{(M * d * V_{ep})}{V_{mix}}$$ Where V_{ep}: Flow through filters. V_{mix}: Flow through tunnel. M : Particulate mass (g/km) M_{limit} : Limit mass of particulates (limit mass in force, g/km) m : Mass of particulates collected by filters (g)

	d : Actual distance corresponding to the operating cycle (km)
	The particulate sample rate (V_{ep} / V_{mix}) will be adjusted so that for M = M_{limit} $1 \leq m \leq 5$ mg (when 47mm diameter filters are used).
	The filter surface consist of a material that is hydrophobic and inert towards the components of exhaust gas (flurocarbon coated glass fibre filters or equivalent)
5.2.4.1.6.	**Accuracy** The analysers shall have a measuring range compatible with the accuracy required to measure the concentrations of the exhaust gas sample pollutants. Measurements error shall not exceed ± 2% (intrinsic error of analyser) disregarding the true value for the calibration gases. For concentration of less than 100 ppm the measurement error shall not exceed ± 2 ppm. The ambient air sample shall be measured on the same analyser with an appropriate range. The microgram balance used to determine the weight of all filters shall have an accuracy of 5 μg and readability of 1 μg.
5.2.4.1.7.	**Ice-trap** No gas-drying device shall be used before the analysis unless it is shown that it has no effect on the pollutant content of the gas stream.
5.2.4.2.	**Calibration**
5.2.4.2.1.	Each analyzer shall be calibrated as often as necessary and in any case in the month before type approval testing and at least once every six months for verifying conformity of production.
5.2.4.2.2.	The calibration method that shall be used is described in 5.2.3 of this Chapter for the analyzers indicated in para 5.2.4.1 above.
5.2.5.	**Volume measurement :**
5.2.5.1.	The method of measuring total dilute exhaust volume incorporated in the constant Volume sampler shall be such that measurement is accurate to within ± 2 per cent.
5.2.5.2.	**Constant Volume Sampler Calibration**
5.2.5.2.1.	The Constant Volume Sampler system volume measurement device shall be Calibrated by a suitable method to ensure the prescribed accuracy and at a frequency sufficient to maintain such accuracy.
5.2.5.2.2.	An example of a calibration procedure which will give the required accuracy is given in Appendix 4 of this Chapter. The method shall utilize a flow-metering device Which is dynamic and suitable for the high flow rate encountered in Constant Volume Sampler testing. The devices shall be of certified accuracy traceable to an approved national or international standard.

5.2.5.3.	**Reference gases**
5.2.5.3.1	**Pure gases** The following pure gases shall be available, if necessary, for calibration and operation: Purified nitrogen: (purity: ≤ 1 ppm C1, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO); Purified synthetic air: (purity: ≤ 1 ppm C1, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO); oxygen content between 18 and 21 % by volume; Purified oxygen: (purity > 99.5 % vol. O_2); Purified hydrogen (and mixture containing helium): (purity ≤ 1 ppm C1, ≤ 400 ppm CO_2); Carbon monoxide: (minimum purity 99.5 %) Propane: (minimum purity 99.5 %.)
5.2.5.3.2	**Calibration and span gases** Mixtures of gases with the following chemical compositions shall be available: a) C_3H_8 and purified synthetic air, (see point 5.2.3.7.1.); b) CO and purified nitrogen; c) CO_2 and purified nitrogen; d) NO and purified nitrogen (the amount of NO_2 contained in this calibration gas shall not exceed 5 % of the NO content). The true concentration of a calibration gas shall be within ± 2 % of the stated figure.
5.2.5.3.3.	**Calibration and verification of the dilution system** The dilution system shall be calibrated and verified and shall comply with the requirements of Appendix 4 of this chapter.
5.2.6	**Emissions tests**
5.2.6.1.	**Engine starting and restarting**
5.2.6.1.1.	The engine shall be started up by means of the devices provided for this purpose according to the manufacturer's instructions, as incorporated in the owner's manual of production vehicles.
5.2.6.1.2	During the idling phase, the operator may use choke, throttling etc., where necessary to keep the engine running.
5.2.6.1.3.	If, during the cold start, the test vehicle does not start after 10 seconds of cranking or 10 cycles of the manual starting mechanism, cranking shall cease and the reason for failure to start shall be determined. The revolution counter on the constant volume sampler shall be turned off and the sample solenoid valves placed in the 'standby' position during this diagnostic period. In addition, either the CVS blower shall be turned off or the exhaust tube disconnected from the tailpipe during the diagnostic period.

5.2.6.1.4.	If failure to start is caused by vehicle malfunction, corrective action (following the unscheduled maintenance provisions) lasting less than 30 minutes may be taken and the test continued (During the corrective action sampling system shall be deactivated). The sampling system shall be reactivated at the same time cranking is started. The driving schedule timing sequence shall begin when the engine starts. If failure to start is caused by vehicle malfunction and the vehicle cannot be started, the test shall be avoided, the vehicle removed from the dynamometer, corrective action taken (following the unscheduled maintenance provisions) and the vehicle rescheduled for test from a cold start. The reason for the malfunction (if determined) and the corrective action taken shall be reported. If failure to start is an operational error, the test vehicle shall be rescheduled for testing from a cold start.
5.2.6.1.5.	If the engine 'false starts', the operator shall repeat the recommended starting procedure (such as resetting the choke, etc.)
5.2.6.2.	**Stalling**
5.2.6.2.1.	If the engine stalls during an idle period, it shall be restarted immediately and the test continued. If it cannot be started soon enough to allow the vehicle to follow the next acceleration as prescribed, the driving schedule indicator shall be stopped. When the vehicle restarts, the driving schedule indicator shall be reactivated.
5.2.6.2.2.	If the engine stalls beyond speed tolerance during some operating mode other than idle, the test shall be considered void.
5.2.6.2.3.	If the test vehicle will not restart within one minute, the test shall be voided, the vehicle removed from the dynamometer, corrective action taken and the vehicle rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.
5.2.6.3.	**Idling**
5.2.6.3.1	**Manual-shift or semi-automatic gear-box**
5.2.6.3.1.1.	During periods of idling, the clutch shall be engaged and gears in neutral.
5.2.6.3.1.2.	To enable the accelerations to be performed according to normal cycle the vehicle shall be placed in first gear, with clutch disengaged, 5 seconds before the Acceleration following the idling period considered of the driving cycle as per Appendix 6 of this chapter.
5.2.6.3.1.3.	The first idling period at the beginning of the cycle shall consist of 16 seconds of idling in neutral with the clutch engaged and 5 seconds in first gear with the clutch disengaged.
5.2.6.3.2.	Automatic-shift gear-box: After initial engagement, the selector shall not be operated at any time during the test except in accordance with paragraph 5.2.6.4.3 below.

5.2.6.4.	**Accelerations**
5.2.6.4.1.	Manual Shift Gear Box :Accelerations shall be so performed that the rate of acceleration shall be as constant as possible throughout the phase.
5.2.6.4.2.	If an acceleration cannot be carried out in the prescribed time, the extra time required is, if possible, deducted from the time allowed for changing gear, but otherwise from the subsequent steady speed period.
5.2.6.4.3.	Automatic-shift gear-boxes: If an acceleration cannot be carried out in the prescribed time the gear selector shall be operated in accordance with requirements for manual shift gear-boxes**.**
5.2.6.5.	**Decelerations:**
5.2.6.5.1.	All decelerations shall be effectedby closing the throttle completely. The clutch shall be disengaged, at around a speed of 10 km/hr. If the period of deceleration is longer than that prescribed for the corresponding phase, the vehicle's brakes shall be used to enable the timing of the cycle to be abided by.
5.2.6.5.2.	If the period of deceleration is shorter than that prescribed for the corresponding phase, the timing of theoretical cycle shall be restored by constant speed or idling period merging into the following operation
5.2.6.6.	**Steady Speeds:**
5.2.6.6.1.	"Pumping" or the closing of the throttle shall be avoided when passing from acceleration to the following steady speed.
5.2.6.6.2.	Periods of constant speed shall be achieved by keeping the accelerator position fixed.
5.2.7.	**Drive instructions**
5.2.7.1.	The test vehicle shall be driven with minimum throttle movement to maintain the desired speed. No simultaneous use of brake and throttle shall be permitted.
5.2.7.2.	If the test vehicle cannot accelerate at the specified rate, it shall be operated with the throttle fully opened until the roller speed reaches the value prescribed for that time in the driving schedule
5.2.8.	**Dynamometer test runs**
5.2.8.1.	The complete dynamometer test consists of test cycle as described in point Appendix 6 of this chapter.
5.2.8.2.	During the test, the speed can be recorded against time so that the correctness of the cycle performed can be assessed.
6.	**Analysis of results**
6.1.	**Type I Test**
6.1.1.	**Exhaust emission analysis**

6.1.1.1.	**Procedure for Sampling and Analysis :**
6.1.1.1.1	**Sampling:** Sampling for all vehicles shall begin at start of the driving cycle (T_0) defined in Appendix 6 of this chapter.
6.1.1.1.2.	**Analysis :**
6.1.1.1.2.1.	The exhaust gases contained in the bag shall be analysed as soon as possible and in any event not later than 20 minutes after the end of the test cycles. The spent particulate filters shall be taken to the chamber no later than 1 hour after conclusion of the test on the exhaust gases and shall be conditioned for between 2 and 36 hours and then be weighed.
6.1.1.1.2.2.	Prior to each sample analysis the analyser range to be used for each pollutant shall be set to zero with the appropriate zero gas.
6.1.1.1.2.3.	The analysers shall then be set to the calibration curves by means of span gases of nominal concentrations of 70 to 100 % of the range.
6.1.1.1.2.4.	The analysers' zeros shall then be re-checked. If the reading differs by more than 2 % of range from that set in paragraph 6.1.1.1.2.2 above, the procedure shall be repeated.
6.1.1.1.2.5.	The samples shall then be analysed.
6.1.1.1.2.6.	After the analysis zero and span points shall be re-checked using the same gases. If these re-checks are within 2 % those in paragraph 6.1.1.1.2.3, then the analysis shall be considered acceptable.
6.1.1.1.2.7.	For all the points in this section, the flow rates and pressure of the various gases shall be the same as those used during calibration of the analysers.
6.1.1.1.2.8.	The figure adopted for the content of the gases in each of the pollutants measured shall be that read off after stabilization of the measuring device. Diesel hydrocarbon mass emissions shall be calculated from the integrated HFID reading corrected for varying flow, if necessary as shown in this part.
6.1.1.2.	**Measuring the distance covered**. The distance (S) actually covered for a test cycle shall be calculated by multiplying the number of revolutions read from the cumulative counter by the circumference of the roller. This distance shall be expressed in km.
6.1.1.3.	**Determination of the Quantity of Gaseous Pollutants Emitted** The reported results of all emission tests shall be rounded, using the 'rounding-off method' in IS 2: 1960 to the number of decimal places indicated by expressing the applicable standard to three significant figures.
6.1.1.3.1.	**The volume considered:** The volume to be considered shall be corrected to conform to the conditions of 101.3 kPa and 273.2 K (0°C).

6.1.1.3.2.	**Total Mass of Gaseous Pollutants Emitted:**
	The mass, M, of each pollutant emitted by the vehicle during the test shall be determined by obtaining the product of the voluminal concentration and the volume of the gas in question, with due regard for the following densities at the above mentioned reference condition.
	$$= \frac{9{,}104 \cdot A + 136}{1524{,}152 - 0{,}583 \cdot A} \cdot 10^6 \ mg/m^3 \text{ for } H_2NG \text{ (with A = NG/biomethane quantity within the } H_2NG \text{ mixture in (volume \%)).}$$
	$d = 631 * 10^3 \ mg/m^3$ for petrol (E5) $(C_1H_{1.89}O_{0.016})$;
	$= 932 * 10^3 \ mg/m^3$ for ethanol (E85) $(C_1H_{2.74}O_{0.385})$;
	$= 649 * 10^3 \ mg/m^3$ for LPG $(C_1H_{2.525})$;
	$= 714 * 10^3 \ mg/m^3$ for NG/biogas (C_1H_4);
	$= 623 * 10^3 \ mg/m^3$ for diesel (B7) $(C_1H_{1.86}O_{0.007})$
	• in the case of nitrogen oxides (NO_x): $d = 2.05 * 10^6 \ mg/m^3$
	• in the case of Carbon Dioxides (CO_2): $d = 1.964 * 10^3 \ g/m^3$
	• in the case of Carbon monoxide (CO): $d = 1.25 * 10^6 \ mg/m^3$
	The mass 'm' of particulate pollutant emissions from the vehicle during the test is defined by weighing the mass of particulates collected by two filters, 'm1' by the first filter, 'm2' by the second filter.
	- if $0.95 \ (m1 + m2) \leq m1$, $m = m1$,
	- if $0.95 \ (m1 + m2) > m1$, $m = m1 + m2$,
	- if $m2 > m1$, the test shall be cancelled.
6.1.1.4.	The mass emission of pollutants are calculated by means of the following formula

	Equation 2-10 $$M_i = \frac{V_{mix} * Q_i * k_H * C_i * 10^{-6}}{d}$$ Where Mi = Mass emission of the pollutant i in g/km Vmix = Volume of the diluted exhaust gas expressed in m^3/test and corrected to standard conditions 273.2 K (0 ºC) and 101.3 kPa Q_i = Density of the pollutant i in kg/m^3 at 273.2 K (0 ºC) temperature and pressure 101.3 kPa) K_H = Humidity correction factor used for the calculation of the mass emissions of oxides of nitrogen. There is no humidity correction for HC and CO. C_i = Concentration of the pollutant i in the diluted exhaust gas expressed in ppm and corrected by the amount of the pollutant i contained in the dilution air. d = distance covered in km

6.1.1.5.	**Volume Determination**
6.1.1.5.1.	Calculation of the volume when a variable dilution device with constant flow control by orifice or venturi is used. Record continuously the parameters showing the volumetric flow, and calculate the total volume for the duration of the test.
6.1.1.5.2.	**Calculation of volume when a positive displacement pump is used.** The volume of diluted exhaust gas in systems comprising a positive displacement pump is calculated with the following formula:
	Equation 2-11 V = Vo * N where, V = Volume of diluted exhaust gas expressed in m^3/test (prior to correction) Vo = Volume of gas delivered by the positive displacement pump on testing conditions, in m^3/rev. N = Number of revolutions per test.

6.1.1.5.3.	**Correction of the diluted exhaust gas volume to standard conditions. The diluted exhaust gas volume is corrected by means of the following formula** :
	Equation 2-12 $$V_{mix} = V * K_1 * \frac{P_B - P_1}{T_P}$$ In which $K_1 = 273K/101.3kPa = 2.6949$ (K*kPa^{-1}) Where P_B = Barometric pressure in the test room in kPa P_1 = Vacuum at the inlet to the positive displacement pump in kPa relative to the ambient barometric pressure. T_P = Average temperature of the diluted exhaust gas entering the positive displacement pump during the test (K).
6.1.1.6.	**Calculation of the Corrected Concentration of Pollutants in the Sampling Bag**
	Equation 2-13 $$C_i = C_e - C_d \left(1 - \frac{1}{DiF}\right)$$ where: C_i = Concentration of the pollutant i in the diluted exhaust gas, expressed in ppm and corrected by the amount of i contained in the dilution air. C_e = Measured concentration of pollutant i in the diluted exhaust gas, expressed in ppm. C_d = Measured concentration of pollutant i in the air used for dilution, expressed in ppm. DiF = Dilution factor
	The dilution factor is calculated as follows: For each reference fuel, except hydrogen: Equation 2-14 $$DiF = \frac{X}{C_{co_2} + (C_{HC} + C_{CO}) \times 10^{-4}}$$ For a fuel of composition $C_X H_y O_z$, the general formula is: Equation 2-15 For H_2NG, the formula is:

$$X = 100 * \cfrac{x}{x + \cfrac{y}{2} + 3.76 \times \left(x + \cfrac{y}{4} - \cfrac{z}{2} \right)}$$

Equation 2-16

For hydrogen, the dilution factor is calculated as follows:

$$DiF = \frac{X}{C_{H_2O} - C_{H_2O-DA} + C_{H_2} \times 10^{-4}}$$

Equation 2-17

$$X = \frac{65,4 \cdot A}{4,922 \cdot A + 195,84}$$

For H2NG, the formula is

For the reference fuels contained in Appendix X, the values of 'X' are as follows:

Table 2-3

Factor 'X' in formulae to calculate DF

Fuel	X
Petrol (E5)	13.4
Diesel (B5)/(B7)	13.5
LPG	11.9
NG/biomethane	9.5
Ethanol (E85)	12.5
Hydrogen	35.03

In these equations:

C_{CO_2} =concentration of CO_2 in the diluted exhaust gas contained in the sampling bag, expressed in percent by volume,

C_{HC}=concentration of HC in the diluted exhaust gas contained in the sampling bag, expressed in ppm carbon equivalent,

C_{CO}=concentration of CO in the diluted exhaust gas contained in the sampling bag, expressed in ppm

C_{H_2O}=concentration of H_2O in the diluted exhaust gas contained in the sampling bag, expressed in percent by volume,

C_{H_2O-DA} =concentration of H_2O in the air used for dilution, expressed in percent by volume,

C_{H_2}=concentration of hydrogen in the diluted exhaust gas contained in the sampling bag, expressed in ppm,

A=quantity of NG/biomethane in the H_2NG mixture, expressed in percent by volume.

6.1.1.7.	**Determination of the NOx Humidity Correction Factor**
	In order to correct the influence of humidity on the results of oxides of nitrogen, the following calculations are applied:
	Equation 2-18
	$$k_H = \frac{1}{1 - 0.0329(H - 10.71)}$$ in which : $$H = \frac{6.211 * R_a * P_d}{P_B - P_d * R_a * 10^{-2}}$$
	where: H= Absolute humidity expressed in grams of water per kg of dry air Ra=Relative humidity of the ambient air expressed in percentage Pd=Saturation vapour pressure at ambient temperature expressed in kPa P$_B$=Atmospheric pressure in the room, expressed in kPa
6.1.1.8.	**Special provision relating to vehicles equipped with compression-ignition engines**
6.1.1.8.1.	**HC measurement for compression-ignition engines**
	The average HC concentration used in determining the HC mass emissions from compression-ignition engines is calculated with the aid of the following formula:
	Equation 2-19
	$$C_e = \frac{\int_{t_1}^{t_2} C_{HC} \, .dt}{t_2 - t_1}$$
	Where $\int_{t1}^{t2} C_{HC} .dt$ =Integral of the recording of the heated FID over the test (t$_2$- t$_1$) Ce= concentration of HC measured in the diluted exhaust in ppm of Ci C$_1$ is substituted directly for C$_{HC}$ in all relevant equations.

6.1.1.8.2.	**Determination of particulates**
	Particulate emission Mp (mg/km) is calculated by means of the following equation:

Equation 2-20

$$M_P = \left[\frac{P_a}{V_{ap}} - \left(\frac{P_a}{V_{ap}} + \left(1 - \frac{1}{DiF} \right) \right) \right] - \frac{(V_{mix} + V_{ap})}{d}$$

Where exhaust gases are vented outside tunnel.

Equation 2-21

$$M_P = \left[\frac{P_a}{V_{ap}} - \left(\frac{P_a}{V_{ap}} + \left(1 - \frac{1}{DiF} \right) \right) \right] - \frac{(V_{mix})}{d}$$

Where exhaust gases are returned to the tunnel.

where:

V_{mix}:volume of diluted exhaust gases (see Equation 2-12) under standard conditions.
V_{ap}:volume of exhaust gas flowing through particulate filter under standard conditions.
P_a:particulate mass collected by filters.
d:actual distance corresponding to the operating cycle in km.
DiF:dilutuion factor as determined in clause 6.1.1.6.

M_p:particulate emission in mg/km

'Where correction for the particulate background level from the dilution system has been used, this shall be determined in accordance with point 5.2.1.5. In this case, the particulate mass (mg/km) shall be calculated as follows:

$$M_P = \left[\frac{P_a}{V_{ap}} - \left(\frac{P_a}{V_{ap}} \cdot \left(1 - \frac{1}{DF} \right) \right) \right] \cdot \frac{(V_{mix} + V_{ap})}{d}$$

where exhaust gases are vented outside the tunnel;

$$M_P = \left[\frac{P_a}{V_{ap}} - \left(\frac{P_a}{V_{ap}} \cdot \left(1 - \frac{1}{DF} \right) \right) \right] \cdot \frac{V_{mix}}{d}$$

where exhaust gases are returned to the tunnel;

6.1.2.	**Fuel Consumption Analysis** where: Vap=volume of tunnel air flowing through the background particulate filter under standard conditions; Pa=particulate mass collected by background filter; DF=dilution factor as determined in point 6.1.1.6. Where application of a background correction results in a negative particulate mass (in mg/km), the result shall be considered to be zero mg/km particulate mass.
6.1.2.1.	**Calculation of fuel consumption**
6.1.2.1.1.	The fuel consumptions are calculated by carbon balance method using measured emissions of carbon dioxide (CO_2) and other carbon related emissions (hydrocarbons - HC, carbon monoxide - CO)
6.1.2.1.2.	The fuel consumption is calculated by means of following formulae: - For vehicles with a positive ignition engine fueled with petrol (E5):: Equation 2-22 $FC = (0.118/D) * ((0.848 * HC) + (0.429 * CO) + (0.273 * CO_2))$ - For vehicles with a positive ignition engine fueled with LPG: Equation 2-23 $FC_{norm} = (0.1212/0.538) * ((0.825 * HC) + (0.429 * CO) + (0.273 * CO_2))$. If the composition of the fuel used for the test differs from the composition that is assumed for the calculation of the normalised consumption, on the manufacturer's request a correction factor cf may be applied, as follows: Equation 2-24 $FC_{norm} = (0.1212/0.538) * (cf) * ((0.825 * HC) + (0.429 * CO) + (0.273 * CO_2))$. The correction factor cf, which may be applied, is determined as follows: Equation 2-25 $cf = 0.825 + 0.0693 * n_{actual}$ where: n_{actual} = the actual H/C ratio of the fuel used. - For vehicles with a positive ignition engine fueled with NG/biomethane Equation 2-26 $FC_{norm} = (0.1336/0.654) * ((0.749 * HC) + (0.429 * CO) + (0.273 * CO_2))$ - For vehicles with a compression ignition engine fueled with diesel (B5): Equation 2-27

$$FC = (0.116/D) * ((0.861 * HC) + (0.429 * CO) + (0.273 * CO_2))$$

- For vehicles with a compression ignition engine fueled with diesel (B7):

Equation 2-28

$$FC = (0.116/D) * ((0.859 * HC) + (0.429 * CO) + (0.273 * CO_2))$$

- For Vehicles with a positive ignition engine fueled by H_2NG:

Equation 2-29

$$FC = \left(\frac{910.4 \cdot A + 13.600}{44.655 \cdot A^2 + 667.08 \cdot A} \right) \cdot \left(\left(\frac{7.848 \cdot A}{9.104 \cdot A + 136} \right) \cdot HC + 0.429 \cdot CO + 0.273 \cdot CO_2 \right)$$

- For vehicles fueled with gaseous hydrogen

Equation 2-30

$$FC = 0.024 \frac{V}{d} \left[\frac{1}{Z_1} \frac{p_1}{T_1} - \frac{1}{Z_2} \frac{p_2}{T_2} \right]$$

- For vehicles fueled with gaseous or liquid hydrogen, the manufacturer may alternatively, with the prior agreement of the test agency, choose either the formula:

Equation 2-31

$$FC = 0.1 * (0.1119 * H_2O + H_2)$$

or a method in accordance with standard protocols such as SAE J2572.

- For vehicles with a positive ignition engine fueled with ethanol (E85):

Equation 2-32

$$FC = (0.1742/D) * ((0.574 * HC) + (0.429 * CO) + (0.273 * CO_2)).$$

- For vehicles with a compression ignition engine fueled with diesel (B7):

Equation 2-33

$$FC = (0.116/D) * ((0.859 * HC) + (0.429 * CO) + (0.273 * CO_2)).$$

	In these formulae:
	FC=the fuel consumption in litres per 100 km in the case of petrol, ethanol, LPG, diesel (B5/B7) or biodiesel, in m^3 per 100 km in the case of natural gas and H_2NG or in kg per 100 km in the case of hydrogen.
	HC=the measured emission of hydrocarbons in mg/km
	CO=the measured emission of carbon monoxide in mg/km
	CO_2=the measured emission of carbon dioxide in mg/km
	H2O=the measured emission of water (H2O) in mg/km
	H2=the measured emission of hydrogen (H2) in mg/km
	A=the quantity of NG/biomethane in the H2NG mixture, expressed in percent by volume
	D=the density of the test fuel.
	In the case of gaseous fuels, D is the density at 288.2K (15 °C) and at 101.3 kPa ambient pressure: d=theoretical distance covered by a vehicle tested under the type I test in km
	P1=pressure in gaseous fuel tank before the operating cycle in Pa
	P2=pressure in gaseous fuel tank after the operating cycle in Pa
	T1=temperature in gaseous fuel tank before the operating cycle in K
	T2=temperature in gaseous fuel tank after the operating cycle in K
	Z1=compressibility factor of the gaseous fuel at P1 and T1
	Z2=compressibility factor of the gaseous fuel at P2 and T2
	V=inner volume of the gaseous fuel tank in m3
6.1.2.1.3.	For the purpose of these calculations, the fuel consumption shall be expressed in appropriate units and the following fuel characteristics shall be used,
	a) Density: measured on the test fuel according to EN ISO 12185 or an equivalent method. For petrol and diesel fuel density measured at 15° C will be used; for LPG and natural gas a reference density will be used, as follows:
	0.538 kg/liter for LPG
	[0.654] kg/m3 for NG*/
	*/ Mean value of G20, [G23] and G25 reference fuels at 15 °C.
	0.084 kg/m^3 for hydrogen
	For H2NG (with A being the quantity of NG/ biomethane in H2NG mixture, expressed in percent by volume for H2NG)

$$\frac{1{,}256 \cdot A + 136}{0{,}654 \cdot A}$$

b) Hydrogen -carbon ratio: fixed values will be used which are:

1.89 for E5 petrol

1.86 for diesel fuel (B5 and B7)

2.74 for ethanol (E 85)

2.525 for LPG

4.00 for NG

Table 2-4
Compressibility factor Z x of the gaseous fuel

	T (K)									
	5	100	200	300	400	500	600	700	800	900
p (bar) 33	0.859	1.051	1.885	2.648	3.365	4.051	4.712	5.352	5.973	6.576
53	0.965	0.922	1.416	1.891	2.338	2.765	3.174	3.57	3.954	4.329
73	0.989	0.991	1.278	1.604	1.923	2.229	2.525	2.81	3.088	3.358
93	0.997	1.042	1.233	1.47	1.711	1.947	2.177	2.4	2.617	2.829
113	1	1.066	1.213	1.395	1.586	1.776	1.963	2.146	2.324	2.498
133	1.002	1.076	1.199	1.347	1.504	1.662	1.819	1.973	2.124	2.271
153	1.003	1.079	1.187	1.312	1.445	1.58	1.715	1.848	1.979	2.107
173	1.003	1.079	1.176	1.285	1.401	1.518	1.636	1.753	1.868	1.981
193	1.003	1.077	1.165	1.263	1.365	1.469	1.574	1.678	1.781	1.882
213	1.003	1.071	1.147	1.228	1.311	1.396	1.482	1.567	1.652	1.735
233	1.004	1.071	1.148	1.228	1.312	1.397	1.482	1.568	1.652	1.736
248	1.003	1.069	1.141	1.217	1.296	1.375	1.455	1.535	1.614	1.693
263	1.003	1.066	1.136	1.207	1.281	1.356	1.431	1.506	1.581	1.655
278	1.003	1.064	1.13	1.198	1.268	1.339	1.409	1.48	1.551	1.621
293	1.003	1.062	1.125	1.19	1.256	1.323	1.39	1.457	1.524	1.59
308	1.003	1.06	1.12	1.182	1.245	1.308	1.372	1.436	1.499	1.562
323	1.003	1.057	1.116	1.175	1.235	1.295	1.356	1.417	1.477	1.537
338	1.003	1.055	1.111	1.168	1.225	1.283	1.341	1.399	1.457	1.514
353	1.003	1.054	1.107	1.162	1.217	1.272	1.327	1.383	1.438	1.493

Note: - In the case that the needed input values for p and T are not indicated in the table, the compressibility factor shall be obtained by linear interpolation between the compressibility factors indicated in the table, choosing the ones that are the closest to the sought value.

7.0	**Records required**
	The following information shall be recorded with respect to each test:
	a) Test number,
	b) System or device tested (brief description),
	c) Date and time of day for each part of the test schedule,
	d) Instrument operator,
	e) Rider or operator,
	f) Test vehicle: make, vehicle identification number, model year, transmission type, odometer reading at initiation of preconditioning, engine displacement, engine family, emission control system, recommended engine speed at idle, nominal fuel tank capacity, inertial loading, actual curb mass recorded at 0 kilometre, and drive wheel tyre pressure.
	g) Dynamometer serial number: as an alternative to recording the dynamometer serial number, a reference to a vehicle test cell number may be used, with the advance approval of the Administration, provided the test cell records show the pertinent instrument information.
	h) All pertinent instrument information such as tuning-gain-serial number- detector number-range. As an alternative, a reference to a vehicle test cell number may be used, with the advance approval of the Administration, provided test cell calibration records show the pertinent instrument information.
	i) Recorder charts: Identify zero, span, exhaust gas, and dilution air sample traces.
	j) Test cell barometric pressure, ambient temperature and humidity.
	Note: A central laboratory barometer may be used; provided, that individual test cell barometric pressures are shown to be within ± 0.1 per cent of the barometric pressure at the central barometer location.
	k) Pressure of the mixture of exhaust and dilution air entering the CVS metering device, the pressure increase across the device, and the temperature at the inlet. The temperature shall be recorded continuously or digitally to determine temperature variations.
	l) The number of revolutions of the positive displacement pump accumulated during each test phase while exhaust samples are being collected. The number of standard cubic meters metered by a critical flow venturi (CFV) during each test phase would be the equivalent record for a CFV-CVS.
	m) The humidity of the dilution air.
	Note: If conditioning columns are not used this measurement can be deleted. If the conditioning columns are used and the dilution air is taken from the test cell, the ambient humidity can be used for this measurement.
	n) The driving distance for each part of the test, calculated from the measured roll or shaft revolutions.
	o) The actual roller speed pattern of the test.
	p) The gear use schedule of the test.
	q) The emissions results of the Type I test for each part of the test.
	r) The second by second emission values of the Type I tests, if necessary.
	s) The emissions results of the Type II test.

	Table Ap 1-1	
Symbol	Definition	Unit
A	Coefficient of polygonal function	—
a_T	Rolling resistance force of front wheel	N
B	Coefficient of polygonal function	—
b_T	Coefficient of aerodynamic function	$N/(km/h)^2$
C	Coefficient of polygonal function	—
C_{CO}	Concentration of carbon monoxide	% vol.
C_{COcorr}	Corrected concentration of carbon monoxide	% vol.
CO_{2c}	Carbon dioxide concentration of diluted gas, corrected to take account of diluent air	%
CO_{2d}	Carbon dioxide concentration in the sample of diluent air collected in bag B	%
CO_{2e}	Carbon dioxide concentration in the sample of diluent air collected in bag A	%
CO_{2m}	Mass of carbon dioxide emitted during the test part	g/km
CO_c	Carbon monoxide concentration of diluted gas, corrected to take account of diluent air	ppm
CO_d	Carbon monoxide concentration in the sample of diluent air, collected in bag B	ppm
CO_e	Carbon monoxide concentration in the sample of diluent air, collected in bag A	ppm
CO_m	Mass of carbon monoxide emitted during the test part	mg/km
d_0	Standard ambient relative air density	—
d_{CO}	Density of carbon monoxide	mg/m^3
d_{CO2}	Density of carbon dioxide	mg/m^3
DiF	Dilution factor	—
d_{HC}	Density of hydrocarbon	mg/m^3
S / d	Distance driven in a cycle part	km
d_{NOX}	Density of nitrogen oxide	mg/m^3
d_T	Relative air density under test condition	—
Δt	Coast-down time	s
Δt_{ai}	Coast-down time measured in the first road test	S
Δt_{bi}	Coast-down time measured in the second road test	s
ΔT_E	Coast-down time corrected for the inertia mass	s
Δt_E	Mean coast-down time on the chassis dynamometer at the	s

	reference speed	
ΔT_i	Average coast-down time at specified speed	s
Δt_i	Coast-down time at corresponding speed	s
ΔT_j	Average coast-down time at specified speed	s
ΔT_{road}	Target coast-down time	s
$\overline{\Delta t}$	Mean coast-down time on the chassis dynamometer without absorption	S
Δv	Coast-down speed interval ($2\Delta v = v1 - v2$)	km/h
E	Chassis dynamometer setting error	%
F	Running resistance force	N
F*	Target running resistance force	N
$F^*_{(v0)}$	Target running resistance force at reference speed on chassis dynamometer	N
$F^*_{(vi)}$	Target running resistance force at specified speed on chassis dynamometer	N
Symbol	Definition	Unit
f^*_0	Corrected rolling resistance in the standard ambient condition	N
f^*_2	Corrected coefficient of aerodynamic drag in the standard ambient condition	$N/(km/h)^2$
F^*_j	Target running resistance force at specified speed	N
f_0	Rolling resistance	N
f_2	Coefficient of aerodynamic drag	$N/(km/h)^2$
F_E	Set running resistance force on the chassis dynamometer	N
$F_{E(v0)}$	Set running resistance force at the reference speed on the chassis dynamometer	N
$F_{E(v2)}$	Set running resistance force at the specified speed on the chassis dynamometer	N
F_f	Total friction loss	N
$F_{f(v0)}$	Total friction loss at the reference speed	N
F_j	Running resistance force	N
$F_{j(v0)}$	Running resistance force at the reference speed	N
F_{pau}	Braking force of the power absorbing unit	N
$F_{pau(v0)}$	Braking force of the power absorbing unit at the reference speed	N
$F_{pau(vj)}$	Braking force of the power absorbing unit at the specified speed	N
F_T	Running resistance force obtained from the running resistance table	N

H	Absolute humidity	mg/km
HC_c	Concentration of diluted gases expressed in the carbon equivalent, corrected to take account of diluent air	ppm
HC_d	Concentration of hydrocarbons expressed in the carbon equivalent, in the sample of diluent air collected in bag B	ppm
HC_e	Concentration of hydrocarbons expressed in the carbon equivalent, in the sample of diluent air collected in bag A	ppm
HC_m	Mass of hydrocarbon emitted during the test part	mg/km
K_0	Temperature correction factor for rolling resistance	—
K_h	Humidity correction factor	—
L	Limit values of gaseous emission	mg/km
M	Test L5 -category vehicle mass	kg
m_{fi}	Flywheel equivalent inertia mass	kg
m_i	Equivalent inertia mass	kg
m_k	Kerb mass (L5-category vehicle)	kg
m_r	Equivalent inertia mass of all the wheels	kg
m_{ri}	Equivalent inertia mass of all the rear wheel and L5-category vehicle parts rotating with wheel	kg
m_{ref}	Reference mass of the L5-category vehicle plus uniform mass of 150 kg	kg
m_{rf}	Rotating mass of the front wheel	kg
m_{rid}	Rider mass	kg
N	Engine speed	min^{-1}
N	Number of data regarding the emission or the test	—
N	Number of revolution made by pump P	—
Ng	Number of forward gears	—
n_{idle}	Idling speed	min^{-1}
Symbol	Definition	Unit
NO_{xc}	Nitrogen oxide concentration of diluted gases, corrected to take account of diluent air	Ppm
NO_{xd}	Nitrogen oxide concentration in the sample of diluent air collected in bag B	ppm
NO_{xe}	Nitrogen oxide concentration in the sample of diluent air collected in bag A	ppm
NO_{xm}	Mass of nitrogen oxides emitted during the test part	mg/km
P_0	Standard ambient pressure	kPa
P_a	Ambient/atmospheric pressure	kPa
P_d	Saturated pressure of water at the test temperature	kPa

P_i	Average under-pressure during the test part in the section of pump P	kPa
P_n	Rated engine power	kW
P_T	Mean ambient pressure during the test	kPa
$\rho 0$	Standard relative ambient air volumetric mass	kg/m^3
$r(i)$	Gear ratio in gear i	—
R	Final test result of pollutant emissions, carbon dioxide emission or fuel consumption	mg/km,g/km, 1/100 km
R_{i1}	First type I test results of pollutant emissions	mg/km
R_{i2}	Second type I test results of pollutant emissions	mg/km
R_{i3}	Third type I test results of pollutant emissions	mg/km
S	Rated engine speed	min^{-1}
T_C	Temperature of the coolant	K
T_O	Temperature of the engine oil	K
T_P	Temperature of the spark-plug seat/gasket	K
T_0	Standard ambient temperature	K
T_p	Temperature of the diluted gases during the test part, measured in the intake section of pump P	K
T_T	Mean ambient temperature during the test	K
U	Humidity	%
V	Specified speed	
V	Total volume of diluted gas	m^3
v_{max}	Maximum design speed of test vehicle (L-category vehicle)	km/h
v0	Reference vehicle speed	km/h
V0	Volume of gas displaced by pump P during one revolution	m^3/rev.
v1	Vehicle speed at which the measurement of the coast-down time begins	km/h
v2	Vehicle speed at which the measurement of the coast-down time ends	km/h
Vi	Specified vehicle speed selected for the coast-down time measurement	km/h

Appendix 1 to Chapter 3W- II
Symbols and Acronyms

Table Ap1-2 : List of acronyms and symbols		
Item	**Unit**	**Term**
LPG	-	liquefied petroleum gas
NG	-	natural gas
H_2CNG	-	hydrogen-natural gas mixtures
CO	Ppm	carbon monoxide
NO	Ppm	nitric oxide
CO_2	Ppm	carbon dioxide
C_3H_8	Ppm	propane
T_f	°C	temperature of fuel
T_v	°C	temperature of fuel vapour
t	minutes	time from start of the fuel tank heat build
m_{HC}	grams	mass of hydrocarbon emitted over the test phase
C_{HC}	ppm C1	hydrocarbon concentration measured in the enclosure
T	K or °C	ambient chamber temperature
DF	mg/test	deterioration factor for SHED test
V	m^3	net enclosure volume corrected for the volume of the vehicle
p	kPa	barometric pressure
H/C	-	hydrogen to carbon ratio
m_{total}	grams	overall evaporative mass emissions of the vehicle
m_{TH}	grams	evaporative hydrocarbon mass emission for the fuel tank heat build
m_{HS}	grams	evaporative hydrocarbon mass emission for the hot soak
v_{max}	km/h	maximum vehicle speed
R_f	-	response factor for a particular hydrocarbon species
FID	-	flame ionisation detector
SHED	-	Sealed Housing for Evaporation Determination
r^2	-	regression correlation coefficient
HC	-	Hydrocarbon

Appendix 2 to Chapter 3W- II
Technical Specification of Reference Fuels

1	**Technical Specification of reference fuels**
1.1	Technical Specification of reference fuels shall be as per GSR 889(E) dated 26th September 2016 as amended form time to time.

Appendix 3 to Chapter 3W- II
Chassis Dynamometer System

1	**Specification**
1.1	General requirements
1.1.1	The dynamometer shall be capable of simulating road load within one of the following classifications: a) Dynamometer with fixed load curve, i.e. a dynamometer whose physical characteristics provide a fixed load curve shape; b) Dynamometer with adjustable load curve, i.e. a dynamometer with at least two road load parameters that can be adjusted to shape the load curve.
1.1.2	Dynamometers with electric inertia simulation shall be demonstrated to be equivalent to mechanical inertia systems. The means by which equivalence is established are described in point 4.
1.1.3	Where the total resistance to progress on the road cannot be reproduced on the chassis dynamometer between speeds of 10 km/h and 120 km/h, it is recommended that a chassis dynamometer with the characteristics defined in point 1.2 shall be used.
1.1.3.1	The load absorbed by the brake and the chassis dynamometer (internal frictional effects) between the speeds of 0 and 120 km/h is as follows: *Equation Ap3-1:* $$F = (a + b * v^2) \pm 0.1 * F_{80} \text{ (without being negative)}$$ where: F = total load absorbed by the chassis dynamometer (N); a = value equivalent to rolling resistance (N); b = value equivalent to coefficient of air resistance (N/(km/h)^2); v = vehicle speed (km/h); F_{80} = load at 80 km/h (N). Alternatively, for vehicles that cannot attain 80 km/h the load at the reference vehicle speeds v_j in Table Ap3- 1 shall be determined. **Table Ap3- 1** <table><tr><td>Category v_{max} (km/h)</td><td>Applicable reference speed, v_j (km/h)</td></tr><tr><td>70-80</td><td>50</td></tr><tr><td>45-70</td><td>40</td></tr><tr><td>25-45</td><td>30</td></tr><tr><td><25</td><td>15</td></tr></table>
1.2	**Specific requirements**
1.2.1	The setting of the dynamometer shall not be affected by the lapse of time. It shall not produce any vibrations perceptible to the vehicle and likely to impair the vehicles' normal operations.
1.2.2	The chassis dynamometer may have one roller or two rollers. In the case of a single roller, the roller diameter shall not be less than 400 mm.

1.2.3	It shall be possible to measure and read the indicated load to an accuracy of ± 5 %.
1.2.4	In the case of a dynamometer with a fixed load curve, the accuracy of the load setting at 80 km/h or of the load setting at the reference vehicle speeds (30 km/h, respectively 15 km/h) referred to in point 1.1.3.1 for vehicles that cannot attain 80 km/h, shall be ± 5 % . In the case of a dynamometer with adjustable load curve, the accuracy of matching dynamometer load to road load shall be ± 5 % for vehicle speeds > 20 km/h and ± 10 % for vehicle speeds ≤ 20 km/h. Below this vehicle speed, dynamometer absorption shall be positive.
1.2.5	The total inertia of the rotating parts (including the simulated inertia where applicable) shall be known and shall be within ± 10 kg of the inertia class for the test.
1.2.6	The speed of the vehicle shall be measured by the speed of rotation of the roller (the front roller in the case of a two-roller dynamometer). It shall be measured with an accuracy of ± 1 km/h at vehicle speeds over 10 km/h. The roller shall be fitted with a revolution counter with reset facility to measure the distance actually covered.
2	**Dynamometer calibration procedure**
2.1	**Introduction** The power absorbed by chassis dynamometer comprises the power absorbed by frictional effects and the power absorbed by the power absorption device. The chassis dynamometer is brought into operation beyond the range of test speeds. The device used for starting up the chassis dynamometer is then disconnected; the rotational speed of the driven rollers decreases. The kinetic energy of rollers is dissipated by the power absorption unit and by the frictional effects. This method disregards variations in the roller's internal frictional effects caused by rollers with or without the vehicle. The frictional effects of the rear roller shall be disregarded when this is free.
2.2	Calibration of the load indicator at 80 km/h or of the Power indicator referred to in point 1.1.3.1 for vehicles that cannot attain 80 km/h. The following procedure shall be used for calibration of the Power indicator to 80 km/h or the applicable Power indicator referred to in point 1.1.3.1 for vehicles that cannot attain 80 km/h, as a function of the Power absorbed (see also Figure Ap3-1):
2.2.1	Measure the rotational speed of the roller if this has not already been done. A fifth wheel, a revolution counter or some other method may be used.
2.2.2	Place the vehicle on the dynamometer or devise some other method for starting up the dynamometer.
2.2.3	Use the flywheel or any other system of inertia simulation for the particular inertia class to be used.

	Figure Ap3-1
	Power absorbed by the chassis dynamometer
	Legend:
	$\blacktriangle = F = a + b*v^2$ $\bullet = (a + b*v^2) - 0.1*F_{80}$
	$\square = (a + b*v^2) + 0.1*F_{80}$
2.2.4	Bring the dynamometer to a vehicle speed of 80 km/h or to the reference vehicle speed referred to in point 1.1.3.1 for vehicles that cannot attain 80 km/h.
2.2.5	Note the power indicated (Pi).
2.2.6	Bring the dynamometer to a speed of 90 km/h or to the respective reference vehicle speed referred to in to in point 1.1.3.1 plus 5 km/h for vehicles that cannot attain 80 km/h
2.2.7	Disconnect the device used to start up the dynamometer.
2.2.8	Note the time taken by the dynamometer to pass from a vehicle speed of 85 to 75 km/h, or for vehicles that cannot attain 80 km/h referred to in Table Ap3- 1 note the time between vj + 5 km/h to vj– 5 km/h.
2.2.9	Set the power-absorption device at a different level.
2.2.10	The requirements of points 2.2.4 to 2.2.9 shall be repeated sufficiently often to cover the range of road power used.
2.2.11	Calculate the Power absorbed using the formula:
	Equation Ap3-2
	$$P_a = M_i * \frac{V_1^2 - V_2^2}{2000t}$$
	where:
	Pa = Power absorbed in kW;
	m_i = equivalent inertia in kg (excluding the inertial effects of the free rear roller);

	V1 = initial speed in m/s
	V2 = final speed in m/s
	T = time taken by the roller to pass from 85 km/h to 75 km/h in s, or for vehicles that cannot attain 80 km/h, time taken by the roller to pass from 55km/h-45 km/h, 45-35 km/h, 35 – 25 km/h, respectively from 20 – 10 km/h in s.
2.2.12	Figure Ap3-2 shows the load indicated at 80 km/h in terms of load absorbed at 80 km/h. Figure Ap3-2 Load indicated at 80 km/h in terms of load absorbed at 80 km/h
2.2.13	The requirements laid down in points 2.2.3 to 2.2.11 shall be repeated for all inertia classes to be used.
2.3	**Calibration of the Power indicator at other speeds** The procedures described in point 2.2 shall be repeated as often as necessary for the chosen vehicle speeds.
2.4	**Calibration of force or torque** The same procedure shall be used for force or torque calibration.
3	**Verification of the Power Absorption curve**
3.1	**Procedure** The Power absorption curve of the dynamometer from a reference setting at a speed of 80 km/h or for vehicles that cannot attain 80 km/h at the respective reference vehicle speeds referred to in point 1.1.3.1, shall be verified as follows:
3.1.1	Place the vehicle on the dynamometer or devise some other method for starting up the dynamometer.
3.1.2	Adjust the dynamometer to the absorbed Power Pa at 80 km/h, or for vehicles that cannot attain 80 km/h to the absorbed power Fvj at the respective target vehicle speed vj referred to in point 1.1.3.1.
3.1.3	Note the Power absorbed at 120, 100, 80, 60, 40 and 20 km/h or for vehicles that cannot attain 80 km/h absorbed at the target vehicles speeds vj referred to in point 1.1.3.1.

3.1.4	Draw the curve Pa versus V and verify that it corresponds to the requirements of point 1.1.3.1.
3.1.5	Repeat the procedure set out in points 3.1.1 to 3.1.4 for other values of Power Pa at 80 km/h and for other values of inertia.
4	**Verification of simulated inertia**
4.1	Object
	The method described in this Appendix makes it possible to check that the simulated total inertia of the dynamometer is carried out satisfactorily in the running phase of the operating cycle. The manufacturer of the chassis dynamometer shall specify a method for verifying the specifications according to point 4.3.
4.2	Principle
4.2.1	Drawing-up working equations
	Since the dynamometer is subjected to variations in the rotating speed of the roller(s), the force at the surface of the roller(s) can be expressed by:
	Equation Ap3-3:
	$F = I * \gamma = IM * \gamma + F1$
	where:
	F is the force at the surface of the roller(s) in N;
	I is the total inertia of the dynamometer (equivalent inertia of the vehicle);
	IM is the inertia of the mechanical masses of the dynamometer;
	γ is the tangential acceleration at roller surface;
	F1 is the inertia force.
	Thus, total inertia is expressed as follows:
	Equation Ap3-4:
	$I = Im + F1 / \gamma$
	where:
	Im can be calculated or measured by traditional methods;
	F1 can be measured on the dynamometer;
	γ can be calculated from the peripheral speed of the rollers.
	The total inertia (I) will be determined during an acceleration or deceleration test with values no lower than those obtained on an operating cycle.
4.2.2	Specification for the calculation of total inertia
	The test and calculation methods shall make it possible to determine the total inertia I with a relative error ($\Delta I/I$) of less than $\pm 2 \%$.

4.3	Specification
4.3.1	The mass of the simulated total inertia I shall remain the same as the theoretical value of the equivalent inertia (see Appendix 5 of this chapter) within the following limits:
4.3.1.1	± 5 % of the theoretical value for each instantaneous value;
4.3.1.2	± 2 % of the theoretical value for the average value calculated for each sequence of the cycle. The limit specified in point 4.3.1.1 is brought to ± 50 % for one second when starting and, for vehicles with manual transmission, for two seconds during gear change
4.4	Verification procedure
4.4.1	Verification is carried out during each test throughout the test cycles defined in Appendix 6 of this chapter.
4.4.2	However, if the requirements laid clown in point 4.3 are met with instantaneous accelerations which are at least three times greater or smaller than the values obtained in the sequences of the theoretical cycle, the verification described in point 4.4.1 will not be necessary.
5	**Technical Note:**
5.1	Explanation of drawing up working equations:
5.1.1.	Equilibrium of the forces on the road, *Equation Ap3-5:* $$CR = k_1 J r_1 \frac{d\theta_1}{dt} + k_2 J r_2 \frac{d\theta_2}{dt} + k_3 M \gamma r_1 + k_3 F_s r_1$$
5.1.2.	Equilibrium of the forces on dynamometer with mechanical simulated inertias *Equation Ap3-6:* $$C_m = k_1 J r_1 \frac{d\theta 1}{dt} + k_3 \frac{J R_m \frac{dW_m}{dt}}{R_m} r_1 + k_3 F_s r_1$$ $$= k_1 J r_1 \frac{d\theta 1}{dt} + k_3 I \gamma r_1 + k_3 F_s r_1$$
5.1.3.	Equilibrium of the forces of dynamometer with non-mechanically simulated inertias *Equation Ap3-7:* $$C_e = k_1 J r_1 \frac{d\theta_1}{dt} + \left(k_3 \frac{J R_e \frac{dW_e}{dt}}{R_e} r_1 + \frac{C_1}{R_e} r_1 \right) + k_3 F_s r_1$$ $$= k_1 J r_1 \frac{d\theta_1}{dt} + k_3 (I_M \gamma + F_1) r_1 + k_3 F_s r_1$$

	Where:		
	CR	=	engine torque on the road
	C_m	=	engine torque on the chassis dynamometer with mechanically simulated inertias
	C_e	=	engine torque on the chassis dynamometer with electrically simulated inertias
	J_{r1}	=	Moment of inertia of the vehicle transmission brought back to the driving wheels
	J_{r2}	=	Moment of inertia of the non-driving wheels
	JR_m	=	Moment of inertia of the bench with mechanically simulated inertias
	JR_e	=	Moment of mechanical inertia of the chassis dynamometer with electrically simulated inertias
	M	=	Mass of the vehicle on the road
	I	=	Equivalent inertia of the chassis dynamometer with electrically simulated inertias
	IM	=	Mechanical Inertia of the chassis dynamometer with electrically simulated inertia.
	F_s	=	Resultant force at stabilized speed.
	C_1	=	Resultant torque from electrically simulated inertias
	F_1	=	Resultant force from electrically simulated inertias
	$d\theta_1 / dt$	=	Angular acceleration of the driving wheels
	$d\theta_2 / dt$	=	Angular acceleration of the non-driving wheels
	dW_m / dt	=	Angular acceleration of the mechanical chassis dynamometer
	dW_e / dt	=	Angular acceleration of the electrical chassis dynamometer
	γ	=	Linear acceleration
	r_1	=	Radius under load of the driving wheels
	r_2	=	Radius under load of the non-driving wheels
	R_m	=	Radius of the rollers of the mechanical chassis dynamometer
	R_e	=	Radius of the rollers of the electrical chassis dynamometer
	k_1	=	Coefficient dependent on the gear reduction ratio and the various inertias of transmission and "efficiency"
	k_2	=	Ratio transmission $* (r_1/r_2) *$ "efficiency"
	k_3	=	Ratio transmission $*$ "efficiency"

5.1.4	Supposing the two types of bench (Paragraphs 5.1.2 and 5.1.3 above) are made equal and simplified, one obtains :
	Equation Ap3-8:
	$k_3 * (IM * \gamma + F1) * r_1 = k3 * I * \gamma * r_1$
	where –
	$I = IM + (F1 / \gamma)$.

Appendix 4 to Chapter 3W- II
Exhaust Dilutions System

1	System specification
1.1	**System overview**
	A full-flow exhaust dilution system shall be used. This requires that the vehicle exhaust be continuously diluted with ambient air under controlled conditions. The total volume of the mixture of exhaust and dilution air shall be measured and a continuously proportional sample of the volume shall be collected for analysis. The quantities of pollutants are determined from the sample concentrations, corrected for the pollutant content of the ambient air and the totalised flow over the test period. The exhaust dilution system shall consist of a transfer tube, a mixing chamber and dilution tunnel, a dilution air conditioning, a suction device and a flow measurement device. Sampling probes shall be fitted in the dilution tunnel as specified in this appendix. The mixing chamber described in this point shall be a vessel, such as those illustrated in Figures Ap4-1 and Ap4-2, in which vehicle exhaust gases and the dilution air are combined so as to produce a homogeneous mixture at the chamber outlet.
1.2	**General requirements**
1.2.1	The vehicle exhaust gases shall be diluted with a sufficient amount of ambient air to prevent any water condensation in the sampling and measuring system under any conditions which may occur during a test.
1.2.2	The mixture of air and exhaust gases shall be homogeneous at the point where the sampling probe is located (see point 1.3.3). The sampling probe shall extract a representative sample of the diluted exhaust gas.
1.2.3	The system shall enable the total volume of the diluted exhaust gases to be measured.
1.2.4	The sampling system shall be gas-tight. The design of the variable dilution sampling system and the materials that go to make it up shall be such that they do not affect the pollutant concentration in the diluted exhaust gases. Should any component in the system (heat exchanger, cyclone separator, blower, etc.) change the concentration of any of the pollutants in the diluted exhaust gases and the fault cannot be corrected, sampling for that pollutant shall be carried out upstream from that component.
1.2.5	All parts of the dilution system that are in contact with raw and diluted exhaust gas shall be designed to minimise deposition or alteration of the particulates or particles. All parts shall be made of electrically conductive materials that do not react with exhaust gas components and shall be electrically grounded to prevent electrostatic effects.
1.2.6	If the vehicle being tested is equipped with an exhaust pipe comprising several branches, the connecting tubes shall be connected as near as possible to the vehicle without adversely affecting its operation.
1.2.7	The variable-dilution system shall be designed so as to enable the exhaust gases to be sampled without appreciably changing the back-pressure at the exhaust pipe outlet.
1.2.8	The connecting tube between the vehicle and dilution system shall be so designed as to minimise heat loss.
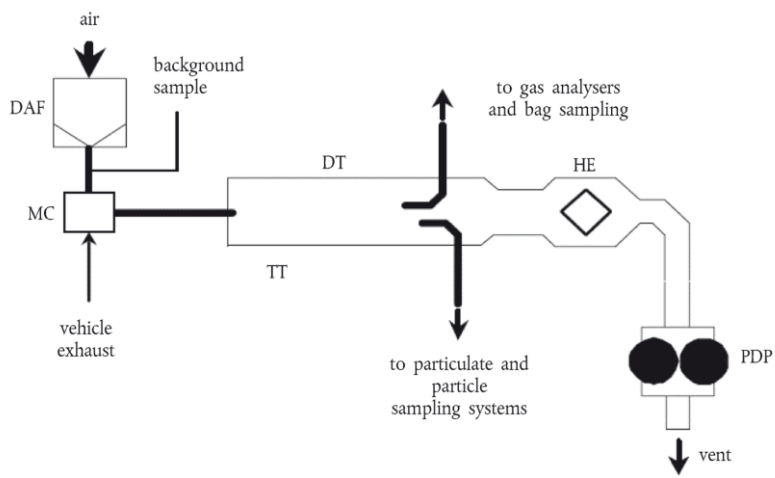
1.3	**Specific requirements**
1.3.1	Connection to vehicle exhaust The connecting tube between the vehicle exhaust outlets and the dilution system shall be as short as possible and satisfy the following requirements: a) the tube shall be less than 3.6 m long, or less than 6.1 m long if heat insulated. Its internal diameter may not exceed 105 mm; b) it shall not cause the static pressure at the exhaust outlets on the test vehicle to differ by more than $\pm$ 0.75 kPa at 50 km/h, or more than $\pm$ 1.25 kPa for the whole duration of the test, from the static pressures recorded when nothing is connected to the vehicle exhaust outlets. The pressure shall be measured in the exhaust outlet or in an extension having the same diameter, as near as possible to the end of the pipe. Sampling systems capable of maintaining the static pressure to within $\pm$ 0.25 kPa may be used if a written request from a manufacturer to the test agency substantiates the need for the closer tolerance; c) it shall not change the nature of the exhaust gas; d) any elastomeric connectors employed shall be as thermally stable as possible and have minimum exposure to the exhaust gases.
1.3.2	**Dilution air conditioning**
	The dilution air used for the primary dilution of the exhaust in the CVS tunnel shall be passed through a medium capable of reducing particles in the most penetrating particle size of the filter material by $\geq$ 99.95 %, or through a filter of at least class H13 of EN 1822:1998. This represents the specification of High Efficiency Particulate Air (HEPA) filters. The dilution air may be charcoal scrubbed before being passed to the HEPA filter. It is recommended that an additional coarse particle filter is situated before the HEPA filter and after the charcoal scrubber, if used. At the vehicle manufacturer's request, the dilution air may be sampled according to good engineering practice to determine the tunnel contribution to background particulate mass levels, which can then be subtracted from the values measured in the diluted exhaust.
1.3.3	**Dilution tunnel**
	Provision shall be made for the vehicle exhaust gases and the dilution air to be mixed. A mixing orifice may be used. In order to minimise the effects on the conditions at the exhaust outlet and to limit the drop in pressure inside the dilution-air conditioning device, if any, the pressure at the mixing point shall not differ by more than $\pm$ 0.25 kPa from atmospheric pressure. The homogeneity of the mixture in any cross-section at the location of the sampling probe shall not vary by more than $\pm$2 % from the average of the values obtained for at least five points located at equal intervals on the diameter of the gas stream. For particulate and particle emissions sampling, a dilution tunnel shall be used which: a) shall consist of a straight tube of electrically-conductive material, which shall be earthed; b) shall be small enough in diameter to cause turbulent flow (Reynolds number $\geq$ 4000) and of sufficient length to cause complete mixing of the exhaust and dilution air; c) shall be at least 200 mm in diameter; d) may be insulated.

1.3.4	**Suction device**
	This device may have a range of fixed speeds to ensure sufficient flow to prevent any water condensation. This result is generally obtained if the flow is either: a) twice the maximum flow of exhaust gas produced by accelerations of the driving cycle; or b) sufficient to ensure that the CO_2 concentration in the dilute exhaust sample bag is less than 3 % by volume for petrol and diesel, less than 2.2 % by volume for LPG and less than 1.5 % by volume for NG/biomethane.
1.3.5	**Volume measurement in the primary dilution system**
	The method for measuring total dilute exhaust volume incorporated in the constant volume sampler shall be such that measurement is accurate to ± 2 % under all operating conditions. If the device cannot compensate for variations in the temperature of the mixture of exhaust gases and dilution air at the measuring point, a heat exchanger shall be used to maintain the temperature to within ± 6 K (± 6 ℃) of the specified operating temperature. If necessary, some form of protection for the volume measuring device may be used, e.g. a cyclone separator, bulk stream filter, etc. A temperature sensor shall be installed immediately before the volume measuring device. This sensor shall have an accuracy and a precision of ±1K (±1 ℃) and a response time of 0.1 s at 62 % of a given temperature variation (value measured in silicone oil). The difference from atmospheric pressure shall be measured upstream and, if necessary, downstream from the volume measuring device. The pressure measurements shall have a precision and an accuracy of ± 0.4 kPa during the test.
1.3.6.	**Gas sampling**
1.3.6.1.	**Dilute exhaust gases**
1.3.6.1.1.	The sample of dilute exhaust gases is taken before the suction devices but after the conditioning devices (if any).
1.3.6.1.2	The flow-rate shall not deviate by more than ± 2% from the average.
1.3.6.1.3	The sampling rate shall not fall below 5 litres per minute and shall not exceed 0.2% of the flow-rate of the dilute exhaust gases
1.3.6.1.4	An equivalent limit applies to constant-mass sampling systems.
1.3.6.2.	**Dilution air**
1.3.6.2.1	A sample of the dilution air is taken at a constant flow-rate near the ambient air inlet (after the filter if one is fitted).
1.3.6.2.2	The air shall not be contaminated by exhaust gases from the mixing area.
1.3.6.2.3	The sampling rate for the dilution air shall be comparable to that used in the case of the dilute exhaust gases.
1.3.6.3.	**Sampling operations**
1.3.6.3.1	The materials used for the sampling operations shall be such that they do not change the pollutant concentration.
1.3.6.3.2	Filters may be used in order to extract the solid particles from the sample.

1.3.6.3.3	Pumps are required in order to convey the sample to the sampling bag(s).
1.3.6.3.4	Flow control valves and flow-meters are needed in order to obtain the flow-rates required for sampling.
1.3.6.3.5	Quick fastening gas-tight connections may be used between the three-way valves and the sampling bags, the connections sealing themselves automatically on the bag side. Other systems may be used for conveying the samples to the analyzer (three-way stop valves, for example).
1.3.6.3.6	The various valves used for directing the sampling gases shall be of the quick-adjusting and quick-acting type.
1.3.6.4	Storage of the sample The gas samples are collected in sampling bags of adequate capacity so as not to reduce the sampling rate. The bags shall be made of such a material as will not change the concentration of synthetic pollutant gases by more than ± 2 % after 20 minutes.
1.4	**Recommended system descriptions**
	Figure Ap 4-1 and Figure Ap 4-2 are schematic drawings of two types of recommended exhaust dilution systems that meet the requirements of this Chapter. Since various configurations can produce accurate results, exact conformity with these figures is not essential. Additional components such as instruments, valves, solenoids and switches may be used to provide additional information and coordinate the functions of the component system.
1.4.1	Full-flow dilution system with positive displacement pump
	  Figure Ap4-1 **Positive displacement pump dilution system**

	The positive displacement pump (PDP) full-flow dilution system satisfies the requirements of this Chapter by metering the flow of gas through the pump at constant temperature and pressure. The total volume is measured by counting the revolutions of the calibrated positive displacement pump. The proportional sample is achieved by sampling with pump, flow meter and flow control valve at a constant flow rate. The collecting equipment consists of:
1.4.1.1	A filter (refer to DAF in Figure Ap 4-1) for the dilution air shall be installed, which can be preheated if necessary.
	This filter shall consist of the following filters in sequence: an optional activated charcoal filter (inlet side) and a high efficiency particulate air (HEPA) filter (outlet side). It is recommended that an additional coarse particle filter is situated before the HEPA filter and after the charcoal filter, if used. The purpose of the charcoal filter is to reduce and stabilise the hydrocarbon concentrations of ambient emissions in the dilution air.
1.4.1.2	A transfer tube (TT) by which vehicle exhaust is admitted into a dilution tunnel (DT) in which the exhaust gas and dilution air are mixed homogeneously.
1.4.1.3	The positive displacement pump (PDP), producing a constant-volume flow of the air/exhaust-gas mixture. The PDP revolutions, together with associated temperature and pressure measurement, are used to determine the flow rate;
1.4.1.4	A heat exchanger (HE) of a capacity sufficient to ensure that throughout the test the temperature of the air/exhaust-gas mixture measured at a point immediately upstream of the positive displacement pump is within 6 K (6 ºC) of the average operating temperature during the test. This device shall not affect the pollutant concentrations of diluted gases taken off afterwards for analysis.
1.4.1.5	A mixing chamber (MC) in which exhaust gas and air are mixed homogeneously and which may be located close to the vehicle so that the length of the transfer tube (TT) is minimised.
1.4.2	**Full-flow dilution system with critical-flow venture**
	The use of a critical-flow venturi (CFV) for the full-flow dilution system is based on the principles of flow mechanics for critical flow. The variable mixture flow rate of dilution and exhaust gas is maintained at sonic velocity which is directly proportional to the square root of the gas temperature. Flow is continually monitored, computed and integrated throughout the test. The use of an additional critical-flow sampling venturi ensures the proportionality of the gas samples taken from the dilution tunnel. As pressure and temperature are both equal at the two venturi inlets, the volume of the gas flow diverted for sampling is proportional to the total volume of diluted exhaust-gas mixture produced and thus the requirements of this Chapter are met. The collecting equipment consists of:
1.4.2.1	A filter (DAF) for the dilution air which can be preheated if necessary. This filter shall consist of the following filters in sequence: an optional activated charcoal filter (inlet side) and a high efficiency particulate air (HEPA) filter (outlet side). It is recommended that an additional coarse particle filter is situated before the HEPA filter and after the charcoal filter, if used. The purpose of the charcoal filter is to reduce and stabilize the hydrocarbon concentrations of ambient emissions in the dilution air;

1.4.2.2	A mixing chamber (MC) in which exhaust gas and air are mixed homogeneously and which may be located close to the vehicle so that the length of the transfer tube (TT) is minimized;
1.4.2.3	A dilution tunnel (DT) from which particulates and particles are sampled;
1.4.2.4	Some form of protection for the measurement system may be used, e.g. a cyclone separator, bulk stream filter, etc.;
1.4.2.5	A measuring critical-flow venturi tube (CFV) to measure the flow volume of the diluted exhaust gas;
1.4.2.6	A blower (BL) of sufficient capacity to handle the total volume of diluted exhaust gas.
2	**CVS calibration procedure**
2.1	**General requirements**
	The CVS system shall be calibrated by using an accurate flow-meter and a restricting device. The flow through the system shall be measured at various pressure readings and the control parameters of the system measured and related to the flows. The flow-meter shall be dynamic and suitable for the high flow-rate encountered in CVS testing. The device shall be of certified accuracy traceable to an approved national or international standard.
2.1.1	Various types of flow-meter may be used, e.g. calibrated venturi, laminar flow-meter, calibrated turbine-meter, provided that they are dynamic measurement systems and can meet the requirements of point 1.3.5 of this Appendix.
2.1.2	The following points give details of methods of calibrating PDP and CFV units, using a laminar flow-meter which gives the required accuracy, together with a statistical check on the calibration validity.
2.2	**Calibration of the positive displacement pump (PDP)**
2.2.1	The following calibration procedure outlines the equipment, the test configuration and the various parameters that are measured to establish the flow-rate of the CVS pump. All the parameters relating to the pump are simultaneously measured with the parameters relating to the flow-meter which is connected in series with the pump. The calculated flow rate (given in m3/min at pump inlet, absolute pressure and temperature) can then be plotted against a correlation function that is the value of a specific combination of pump parameters. The linear equation that relates the pump flow and the correlation function is then determined. If a CVS has a multiple speed drive, a calibration shall be performed for each range used.
2.2.2	This calibration procedure is based on the measurement of the absolute values of the pump and flow-meter parameters that relate to the flow rate at each point. Three conditions shall be maintained to ensure the accuracy and integrity of the calibration curve:
2.2.2.1	The pump pressures shall be measured at tappings on the pump rather than at the external piping on the pump inlet and outlet. Pressure taps that are mounted at the top centre and bottom centre of the pump drive head plate are exposed to the actual pump cavity pressures and therefore reflect the absolute pressure differentials;

2.2.2.2	Temperature stability shall be maintained during the calibration. The laminar flow-meter is sensitive to inlet temperature oscillations which cause the data points to be scattered. Gradual changes of ± 1 K (± 1 ºC) in temperature are acceptable as long as they occur over a period of several minutes;
2.2.2.3	All connections between the flow-meter and the CVS pump shall be free of any leakage.
2.2.3	During an exhaust emission test, the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.
2.2.4	Figure Ap 4-3 of this Appendix shows one possible test set-up. Variations are permissible, provided that the test agency approves them as being of comparable accuracy. If the set-up shown in Figure Ap 4-3 is used, the following data shall be found within the limits of precision given:
	Barometric pressure (corrected) (Pb) ± 0.03 kPa
	Ambient temperature (T) ± 0.2 K(± 0.2 °C)
	Air temperature at LFE (ETI) ± 0.15 K (± 0.15 °C)
	Pressure depression upstream of LFE (EPI) ± 0.01 kPa
	Pressure drop across the LFE matrix (EDP) ± 0.0015 kPa
	Air temperature at CVS pump inlet (PTI) ± 0.2 K (± 0.2 °C)
	Air temperature at CVS pump outlet (PTO) ± 0.2 K (± 0.2 °C)
	Pressure depression at CVS pump inlet (PPI) ± 0.22 kPa
	Pressure head at CVS pump outlet (PPO) ± 0.22 kPa
	Pump revolutions during test period (n) ± 1 min-1
	Elapsed time for period (minimum 250 s) (t) ± 0.1 s
	  Figure Ap4-3
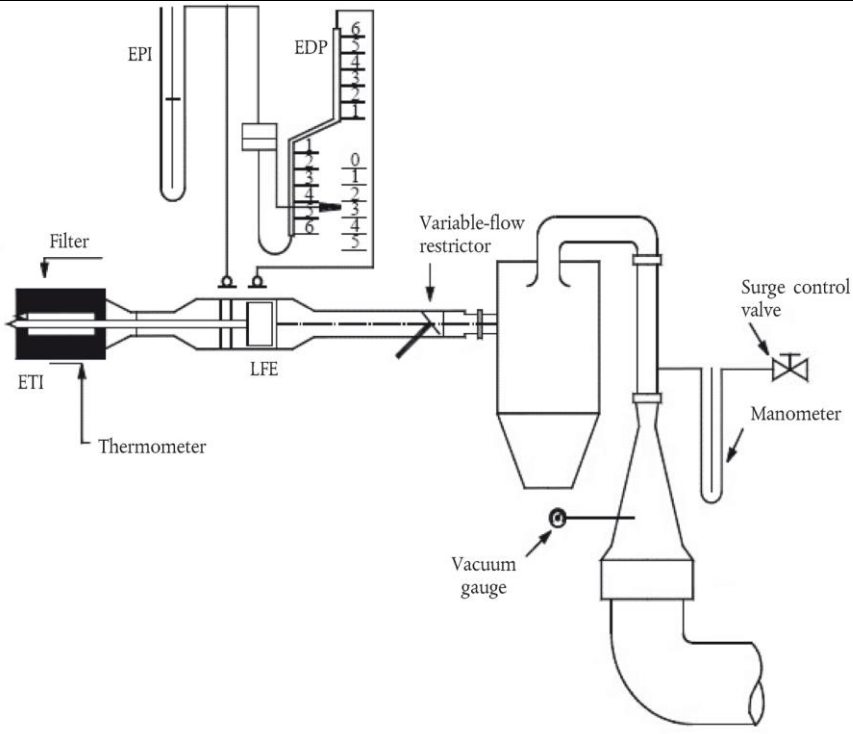
		PDP calibration configuration
2.2.5		After the system has been connected as shown in Figure Ap 4-3, set the variable restrictor in the wide-open position and run the CVS pump for 20 minutes before starting the calibration.
2.2.6		Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression (about 1 kPa) that will yield a minimum of six data points for the total calibration. Allow the system to stabilise for three minutes and repeat the data acquisition.
2.2.7		The air flow rate (Qs) at each test point is calculated in standard m3/min from the flow-meter data using the manufacturer's prescribed method.
2.2.8		The air flow-rate is then converted to pump flow (V_0) in m^3/rev at absolute pump inlet temperature and pressure.
		Equation Ap 4-1: $$V_0 = \frac{Q_s}{n} \cdot \frac{T_p}{273,2} \cdot \frac{101,33}{P_p}$$
		where: V_0 = pump flow rate at T_p and P_p (m^3/rev); Q_s = air flow at 101.33 kPa and 273.2 K($0\ ^oC$) (m^3/min); T_p = pump inlet temperature (K); P_p = absolute pump inlet pressure (kPa); n = pump speed (min^{-1}).
2.2.9		To compensate for the interaction of pump speed pressure variations at the pump and the pump slip rate, the correlation function (x0) between the pump speed (n), the pressure differential from pump inlet to pump outlet, and the absolute pump outlet pressure is calculated as follows: *Equation Ap 4-2:* $$x_0 = \frac{1}{n}\sqrt{\frac{\Delta P_p}{P_e}}$$ where: x_0 = correlation function; ΔP_p = pressure differential from pump inlet to pump outlet (kPa); P_e = absolute outlet pressure (PPO + P_b) (kPa).

2.2.9.1	A linear least-square fit is performed to generate the calibration equations which have the formula:
	Equation Ap 4-3:
	$V_0 = D_0 — M* (x_0)$
	$n = A — B*(\Delta P_p)$
	D0, M, A and B are the slope-intercept constants describing the lines
2.2.10.	A CVS system that has multiple speeds shall be calibrated on each speed used. The calibration curves generated for the ranges shall be approximately parallel and the intercept values (D0) shall increase as the pump flow range decreases.
2.2.11	If the calibration has been performed carefully, the calculated values from the equation will be within 0.5 % of the measured value of V0.Values of M will vary from one pump to another. Calibration is performed at pump start-up and after major maintenance.
2.3	**Calibration of the critical-flow venturi (CFV)**
2.3.1	Calibration of the CFV is based on the flow equation for a critical-flow venturi:
	Equation Ap 4-4: $$Q_s = \frac{K_v P}{\sqrt{T}}$$ where: Q_S = flow; K_V = calibration coefficient; P = absolute pressure (kPa); T = absolute temperature (K). Gas flow is a function of inlet pressure and temperature. The calibration procedure described in points 2.3.2 to 2.3.7 shall establish the value of the calibration coefficient at measured values of pressure, temperature and air flow.
2.3.2	The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.
2.3.3	Measurements for flow calibration of the critical-flow venturi are required and the following data shall be found within the limits of precision given: Barometric pressure (corrected) (Pb) ± 0.03 kPa LFE air temperature, flow-meter (ETI) ± 0.15 °K (± 0.15 °C) Pressure depression upstream of LFE (EPI) ± 0.01 kPa Pressure drop across (EDP) LFE matrix ± 0.0015 kPa

	Air flow (Qs) ± 0.5 % CFV inlet depression (PPI) ± 0.02 kPa Temperature at venturi inlet (Tv) ± 0.2 K (± 0.2 °C).
2.3.4	The equipment shall be set up as shown in Figure Ap 4-4 and checked for leaks. Any leaks between the flow- measuring device and the critical-flow venturi will seriously affect the accuracy of the calibration.
	  Figure Ap4-4 **CFV calibration configuration**
2.3.5	The variable-flow restrictor shall be set to the open position, the blower shall be started and the system stabilized. Data from all instruments shall be recorded.
2.3.6	The flow restrictor shall be varied and at least 8 readings shall be taken across the critical flow range of the venturi.
2.3.7	The data recorded during the calibration shall be used in the following calculations. The air flow-rate (Qs) at each test point is calculated from the flow-meter data using the manufacturer's prescribed method. Calculate values of the calibration coefficient Equation Ap 4-5: $$K_v = \frac{Q_s \sqrt{T_v}}{P_v}$$ (K_V) for each test point: Q_s = flow-rate in m^3 /min at 273.2 K (0 °C) and 101.3 kPa T_v = temperature at the venturi inlet (K);

	P_V = absolute pressure at the venturi inlet (kPa). Plot K_V as a function of venturi inlet pressure. For sonic flow, K_V will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_V decreases. The resultant Kv changes are not permissible. For a minimum of eight points in the critical region, calculate an average K_V and the standard deviation. If the standard deviation exceeds 0.3% of the average K_V, take corrective action.
3	**System verification procedure**
3.1	**General requirements**
	The total accuracy of the CVS sampling system and analytical system shall be determined by introducing a known mass of a pollutant gas into the system while it is being operated as if during a normal test and then analysing and calculating the pollutant mass according to the formula in point 4, except that the density of propane shall be taken as 1.967 grams per litre at standard conditions. The two techniques described in points 3.2 and 3.3 are known to give sufficient accuracy. The maximum permissible deviation between the quantity of gas introduced and the quantity of gas measured is 5 %.
3.2	**CFO method**
3.2.1	Metering a constant flow of pure gas (CO or C3H8) using a critical-flow orifice device
3.2.2	A known quantity of pure gas (CO or C3H8) is fed into the CVS system through the calibrated critical orifice. If the inlet pressure is high enough, the flow-rate (q), which is adjusted by means of the critical-flow orifice, is independent of orifice outlet pressure (critical flow). If deviations exceeding 5 % occur, the cause of the malfunction shall be determined and corrected. The CVS system is operated as in an exhaust emission test for about five to ten minutes. The gas collected in the sampling bag is analysed by the usual equipment and the results compared to the concentration of the gas samples which was known beforehand.
3.3	**Gravimetric method**
3.3.1	Metering a limited quantity of pure gas (CO or C3H8) by means of a gravimetric technique
3.3.2	The following gravimetric procedure may be used to verify the CVS system. The weight of a small cylinder filled with either carbon monoxide or propane is determined with a precision of $\pm$ 0.01 g. For about five to ten minutes, the CVS system is operated as in a normal exhaust emission test, while CO or propane is injected into the system. The quantity of pure gas involved is determined by means of differential weighing. The gas accumulated in the bag is analysed using the equipment normally used for exhaust-gas analysis. The results are then compared to the concentration figures computed previously

Appendix 5 to Chapter 3W- II
Classification Equivalent inertia mass and running resistance

1	Classification of equivalent inertia mass and running resistanceThe chassis dynamometer can be set using the Power absorption table instead of the running resistance force obtained by the coast-down methods set out in Appendix 7 of this chapter. With the manufacturer's agreement, the following method may be used. The brake is adjusted so as to absorb the load exerted at the driving wheels at constant speed of 50 km/h in accordance with table Ap5-I . In this table method, the chassis dynamometer shall be set by the reference mass regardless of particular vehicle characteristics.
	Classification of equivalent inertia mass and running resistance
	The chassis dynamometer can be set using the Power absorption table instead of the running resistance force obtained by the coast-down methods set out in Appendix 7 of this chapter. With the manufacturer's agreement, the following method may be used. The brake is adjusted so as to absorb the load exerted at the driving wheels at constant speed of 50 km/h in accordance with table Ap5-I . In this As per table Ap5-1 method, the chassis dynamometer shall be set by the reference mass regardless of particular vehicle characteristics.
2.	The flywheel equivalent inertia mass m_{ref} shall be the equivalent inertia mass m_i specified in point 4.4.5.1.2 of Chapter 3W - II.

Table Ap5-1
Power setting for L5 Category Vehicles.

Reference Mass of Vehicle m_{ref} (kg)		Equivalent Inertia m_i (kg)	Absorbed power at 50 km/h (kW)
Exceeding	Up to		
300	330	310	1.21
330	360	340	1.26
360	395	380	1.33
395	435	410	1.37
435	480	450	1.44
480	540	510	1.50
540	600	570	1.56
600	650	620	1.61
650	710	680	1.67
710	770	740	1.74
770	820	800	1.81
820	880	850	1.89
880	940	910	1.99
940	990	960	2.05
990	1050	1020	2.11
1050	1110	1080	2.18
1110	1160	1130	2.24
1160	1220	1190	2.30
1220	1280	1250	2.37

Classification Equivalent inertia mass and running resistance

1280	1330	1300	2.42
1330	1390	1360	2.49
1390	1450	1420	2.54
1450	1500	1470	2.57
1500	1560	1530	2.62
1560	1620	1590	2.67
1620	1670	1640	2.72
1670	1730	1700	2.77
1730	1790	1760	2.83

1.	**Introduction**
1.1	This Appendix describe the Driving cycle and gear shifting procedure need to be followed for type I test as per procedure laid down in 3W Chapter II.
2.	**Driving Cycle**
2.1	Break down of the operating cycle used for the type I test is mentioned in following Table Ap6 -1
3.	**Gear shifting procedure**
	Operating cycle with recommended gear position is mentioned in Figure Ap6-1 and
	As per cluase 4.4.4.2.3.1, 4.4.4.2.3.1.1 and 4.4.4.2.3.1.2. of Chapter 3W-II

Table Ap6-1

OPERATING CYCLE ON THE CHASSIS DYNAMOMETER (Indian Driving Cycle)

No. of operation		Acceleration (m/sec^2)	Speed (km/h)	Duration of each operation (S)	Cumulative time(s)
01.	Idling	--	—	16	16
02.	Acceleration	0.65	0-14	6	22
03.	Acceleration	0.56	14-22	4	26
04.	Deceleration	-0.63	22-13	4	30
05.	Steady speed	-	13	2	32
06.	Acceleration	0.56	13-23	5	37
07.	Acceleration	0.44	23-31	5	42
08.	Deceleration	-0.56	31-25	3	45
09.	Steady speed	-	25	4	49
10.	Deceleration	-0.56	25-21	2	51
11.	Acceleration	0.45	21-34	8	59
12.	Acceleration	0.32	34-42	7	66
13.	Deceleration	-0.46	42-37	3	69
14.	Steady speed	-	37	7	76
15.	Deceleration	-0.42	37-34	2	78
16.	Acceleration	0.32	34-42	7	85
17.	Deceleration	-0.46	42-27	9	94
18.	Deceleration	-0.52	27-14	7	101
19.	Deceleration	-0.56	14-00	7	108

Appendix 6 to Chapter 3W- II
Driving cycles & Gearshift procedure for Type I test
Table Ap6 - 2

A: BREAK DOWN BY PHASES

Sr. No.	Particulars	Time(s)	Percentage
1	Idling	1-6	14.81
2	Steady speed periods	13	12.04
3	Accelerations	42	38.89
4	Deceleration's	37	34.26
		108	100

B: AVERAGE SPEED DURING TEST: 21.93 km/h;

C: THEORETICAL DISTANCE COVERED PER CYCLE: 0.658 km;

D: EQUIVALENT DISTANCE FOR THE TEST (6 cycles): 3.948 km.

Figure Ap6 -1

Operating cycle with recommended gear position

GEAR CHANGE

DE-CLUTCHING

Appendix 7 to Chapter 3W- II
Road tests of L5-category vehicles equipped with two or more wheels on the powered axles for the determination of test bench settings

1.	Definition of the road
1.1	The road shall be level and sufficiently long to enable the measurements specified below to be made. The longitudinal slope shall not exceed 1.5% and shall be constant within ± 0.1 % over the measuring strip.
2	Atmospheric Conditions
2.1	**Wind:** Testing shall be limited to wind speeds averaging less than 3 m/s with peak speeds less than 5 m/s. In addition, the vector component of the wind speed across the test road shall be less than 2 m/s. Wind velocity should be measured 0.7 m above the road surface.
2.2	**Humidity: The road shall be dry.**
2.3	**Pressure - Temperature** : Air density at the time of the test shall not deviate by more than ±7.5 % from the reference conditions: P = 100 kPa & T = 20 °C/ 293.20K
3	**Vehicle Preparation :**
3.1.	Verifications : The following verifications shall be made in accordance with the manufacturer's specifications for the use considered : -wheel, wheel rims, tyres (make, type, pressure), -front axle geometry, -brake adjustment (elimination of parasitic drag) -lubrication of front and rear axles, -adjustment of the suspension and vehicle level, etc.
3.2.	**Preparation for the test**: The vehicle shall be loaded to its reference mass. The level of the vehicle shall be that obtained when the centre of gravity of the load is situated midway between the "R" points of the front outer seats and on a straight line passing through those points.
3.2.1	In case of road tests, the windows of the vehicle shall be closed. Any covers of air climatisation systems, headlamps, etc., shall be in the non-operating position.
3.2.2	The vehicle shall be clean.
3.2.3	Immediately prior to the test the vehicle shall be brought to normal running temperature in an appropriate manner.
4	**Methods for chassis dynamometer with adjustable load curve**
4.1	**Energy variation during coast-down method :**
4.1.1.	On the road
4.1.1.1.	Accuracies of test equipment Time shall be measured accurate to within 0.1 second. Speed shall be measured accurate to within 2 % .
4.1.1.2.	Test procedure
4.1.1.2.1	Accelerate the vehicle to a speed of 10 km/h greater than the chosen test speed, V.

Appendix 7 to Chapter 3W- II
Road tests of L5-category vehicles equipped with two or more wheels on the
powered axles for the determination of test bench settings

4.1.1.2.2	Place the gear box in "neutral" position.
4.1.1.3.	Measure the time taken (t1)for the vehicle to decelerate from $V_2 = V + \Delta V$ km/h to $V_1 = V - \Delta V$ km/h : with $V \leq 5$ km/h
4.1.1.4.	Perform the same test in the opposite direction : t_2
4.1.1.5.	Take the average T, of the two times t_1 and t_2.
4.1.1.6.	Repeat these tests several times such that the statistical accuracy (p) of the average Equation Ap7 -1 $$T = \frac{1}{n}\sum_{i=1}^{n} t_i$$ is not more than 2% ($p \leq 2\%$) The statistical accuracy (p) is defined by: Equation Ap7 − 2 $$p = \frac{t*s}{\sqrt{n}} * \frac{100}{T}$$ where, t = coefficient given by the table below s = standard deviation = $\sqrt{\sum \frac{(T_i - T)^2}{(n-1)}}$ n = number of tests

N	4	5	6	7	8	9	10	11	12	13	14	15
T	3.2	2.8	2.6	2.5	2.4	2.3	2.2	2.2	2.2	2.2	2.2	2.2
$\frac{t}{\sqrt{n}}$	1.6	1.25	1.06	0.94	0.85	0.77	0.73	0.66	0.64	0.61	0.59	0.57

4.1.1.7	Calculate the power by the formula: Equation Ap7-3 $$P = \frac{m * V * \Delta V}{500 * T}$$ where, P is expressed in kW V = speed of the test in m/s ΔV = speed deviation from speed V, in m/s m = reference mass in kg T = time in seconds
4.1.1.8	Alternatively, the coast down shall be carried out as per IS 14785- 2000 to establish "a" and "b" coefficients for setting on chassis dynamometer.
4.1.2	**On the chassis dynamometer :**
4.1.2.1	Measurement equipment and accuracy: The equipment shall be identical to that used on the road.
4.1.2.2	Test procedure:
4.1.2.2.1	Install the vehicle on the test dynamometer.
4.1.2.2.2	Adjust the tyre pressure (cold) of the driving wheels as required by the chassis dynamometer.
4.1.2.2.3	Adjust the equivalent inertia of the chassis dynamometer.
4.1.2.2.4	Bring the vehicle and chassis dynamometer to operating temperature in a suitable manner.
4.1.2.2.5	Carry out the following operations specified in paragraph 4.1.1.2 with the exception of paragraphs 4.1.1.2.4 and 4.1.1.2.5 and with changing m by I in the formula of paragraph 4.1.1.2.7 above.
4.1.2.2.6	Adjust the chassis dynamometer such that It shall be possible to measure and read the indicated load to an accuracy of $\pm$ 5 % .
4.2	**Torque measurements method at constant speed**
4.2.1.	On the road :
4.2.1.1	Measurement equipment and error Torque measurement shall be carried out with an appropriate measuring device, accurate to within 2 %. Speed measurement shall be accurate to within 2 %.

4.2.1.2	Test procedure
4.2.1.2.1.	Bring the vehicle to the chosen stabilised speed, V.
4.2.1.2.2.	Record the torque C(t) and speed over a period t (of at least 10 s) by means of class 1000 instrumentation meeting [ISO standard No. 970], over small intervals of time t.
4.2.1.2.3.	Differences in torque $C_{(t)}$, and speed relative to time shall not exceed 5% for each second of the measurement period. The torque C is the average torque derived from the following formula Equation Ap7-4 $$C_{t1} = \frac{1}{\Delta t} \int_{t}^{t+\Delta t} C(t)dt$$
4.2.1.2.4	Carry out the test in the opposite direction and find out the average torque i.e. C_t.
4.2.1.2.5	Determine the average of these torques C_{t1} and C_{t2} i.e. C_t.
4.2.2	**On the chassis dynamometer**
4.2.2.1	Measurement equipment and error: The equipment shall be identical to that used on the road.
4.2.2.2	Test procedure
4.2.2.2.1	Perform the operations specified in paragraphs 4.1.2.2.1 to 4.1.2.2.4 above.
4.2.2.2.2	Adjust the chassis dynamometer such that It shall be possible to measure and read the indicated load to an accuracy of ± 5 %.
4.3	**Integrated torque over vehicle driving pattern:**
4.3.1	This method is a non-obligatory complement to the constant speed method described in paragraph 4.2 above.
4.3.2	In this dynamic procedure the mean torque value M is determined. This is accomplished by integrating the actual torque values, M (t), with respect to time during operation of the test vehicle with a defined driving cycle. The integrated torque is then divided by the time difference $t_2 - t_1$, The result is : Equation Ap7-5 $$\bar{M} = \frac{1}{t_1 - t_2} \int_{t_1}^{t_2} M(t) * dt$$ (with M(t) > 0) M is calculated from six sets of results. It is recommended that the sampling rate of $\underline{M}$ be not less than two samples per second.

4.3.3	**Dynamometer setting:** The dynamometer load is set by the method described in paragraph 5.2 above. If M (dynamometer) does not match M (road) then the inertia setting shall be adjusted until the values are equal within ± 5 %. Note: This method can only be used for dynamometers with electrical inertia simulation or fine adjustment.
4.3.3.1	Acceptance criteria : Standard deviation of six measurements shall be less than or equal to 2 % of the mean value.
4.4	**Method by deceleration measurement by gyroscopic platform :**
4.4.1	On the road :
4.4.1.1	Measurement equipment and accuracy : - Speed shall be measured with an accuracy better than 2 %. - Deceleration shall be measured with an accuracy better than 1 %. - The slope of the road shall be measured with an accuracy better than 1%. - Time shall be measured with an accuracy better than 0.1 s. - The level of the vehicle is measured on a reference horizontal ground: as an alternative, it is possible to correct for the slope of the road (a1).
4.4.1.2	Test procedure :
4.4.1.2.1	Accelerate the vehicle to a speed 5 km/h greater than the chosen test speed V.
4.4.1.2.2	Record the deceleration between V + 0.5 km/h and V - 0.5 km/h.
4.4.1.2.3	Calculate the average deceleration attributed to the speed V by the formula: Equation Ap7-6 $$\overline{\gamma_1} = \frac{1}{t}\int_0^t \gamma_1(t)dt - (g.\sin \alpha_1)$$ <u>w</u>here: γ_1 = average deceleration value at the speed V in one direction of the road t = time between V + 0.5 km/h and V - 0.5 km/h $\gamma_1(t)$ = deceleration recorded with the time g = 9.81 m/s².
4.4.1.2.4	Perform the same test in the other direction γ_2

4.4.1.2.5	Calculate the average deceleration i.e. Equation Ap7-7 $$\gamma_i = \frac{\gamma_1 + \gamma_2}{2}$$ for test I
4.4.1.2.6.	Perform a sufficient number of tests as specified in paragraph 4.1.1.2.6 above replacing T by γ where Equation Ap7-8 $$\gamma = \frac{1}{n}\sum_{i=1}^{n}\gamma_i$$
4.4.1.2.7.	Calculate the average force absorbed F=m* γ , Where m =vehicle reference mass in kg & γ =average deceleration calculated as above.
4.4.2.	**On the chassis dynamometer :**
4.4.2.1.	Measuring equipment and accuracy The measurement instrumentation of the chassis dynamometer itself shall be used as defined in para 4.1.2.1 of this Appendix.
4.4.2.2.	Test procedure Adjustment of the force on the rim under steady speed. On chassis dynamometer, the total resistance is of the type: F_{total} = $F_{indicated}$ + $F_{driving\ axle\ rolling}$ with F_{total} = F_{road} $F_{indicated}$ = F_{road} - $F_{driving\ axle\ rolling}$ Where: F indicated is the force indicated on the force indicating device of the chassis dynamometer. F (road) is known. F driving axle rolling, can be measured on chassis dynamometer driving axle rolling able to work as generator. The test vehicle, gear box in neutral position, is driven by the dynamometer at the test speed; the rolling resistance, R_R, of the driving axle is then measured on the force indicating device of the chassis dynamometer. Determination on chassis dynamometer unable to work as a generator. For the two-roller chassis dynamometer, the R_R value is the one which is determined before on the road.

Appendix 7 to Chapter 3W- II
Road tests of L5-category vehicles equipped with two or more wheels on the
powered axles for the determination of test bench settings

	For the single-roller chassis dynamometer, the R_R value is the one which is determined on the road multiplied by a coefficient R which is equal to the ratio between the driving axle mass and the vehicle total mass. **Note:** R_R is obtained from the curve F = f (V).
4.4.2.2.1.	Calibrate the force indicator for the chosen speed of the roller bench as defined in Appendix 3 of this chapter.
4.4.2.2.2.	Perform the same operation as in paragraphs 4.1.2.2.1 to 4.1.2.2.4 above.
4.4.2.2.3.	Set the force, $F_A = F - F_R$ on the indicator for the speed chosen.
4.4.2.2.4.	Carry out a sufficient number of tests as indicated in paragraph 4.1.1.2.6 above, replacing T by F_A.
4.5.	**Deceleration Method applying coast-down techniques :**
4.5.1.	On the Road
4.5.1.1.	Accuracies of the test instrument shall be the same as specified in 4.1.1.1.
4.5.1.2.	Drive the vehicle at a constant speed of about 10 km/h more than the chosen test speed, V km/h, along a straight line.
4.5.1.3.	After this speed is held steady for a distance of at-least 100 m, disconnect the engine from the drive line by bringing the gear to neutral or by other means in the case of vehicle where manual shifting to neutral is not possible.
4.5.1.4.	Measure the time taken (t_1 sec) for the speed to drop from $V + \Delta V$ km/h to $V - \Delta V$ km/h. The value of ΔV shall not be less than 1 km/h or more than 5 km/h. However, same value of ΔV shall be used for all the tests.
4.5.1.5.	Repeat the test in the opposite direction and record the time (t_2 sec.).
4.5.1.6.	Repeat the test 10 times such that the statistical error of the time ti (arithmetic average of t_1 and t_2) is equal to or less than 2%.
4.5.1.7.	The statistical error 'p' is calculated as – Equation Ap7-9 $$p = \frac{24.24 * (t_i - t_m)^2}{t_m}$$ Where t = average time for each consecutive set of reading, $t_1 + t_{2/2}$ t_m = Arithmetic average of 10 such t_i.

4.5.1.8.	The basic equation of motion to calculate the road load resistance force, F, is
	Equation Ap7-10 $$F = \frac{(W + W_2) * V}{(3.6 * t_m * g)}$$ where, F - in N W - the weight of the test vehicle in N W_2 - equivalent inertia weight of rotating axle (0.035 x mass of the test vehicle) in N V - vehicle speed difference during the coast down, in km/h tm - coast down time, in seconds g - Acceleration due to gravity, 9.81 m/s².
4.5.1.9.	Using least square curve fitting method and values of F and V, the coefficient of rolling and aerodynamic resistance of the vehicle viz. a and b respectively are found from the following equation : Equation Ap7-11 $F = a + b* V^2$
4.5.2.	Chassis Dynamometer Setting :The values of a and b are set on the dynamometer.
4.6.	Alternative method :With the manufacturer's agreement, Power absorption table method provided in Appendix 5 of this chapter may be used.

Appendix 8 to Chapter 3W- II
Type I test procedure for vehicles fueled with LPG/NG/biomethane, H_2NG or hydrogen

1.0	**Introduction**
1.1.	This Appendix describes the special requirements as regards the testing of LPG, NG/biomethane, H_2NG or hydrogen gas for the approval of alternative fuel vehicles that run on those fuels or can run on petrol, LPG, NG/biomethane, H_2NG or hydrogen.
1.2.	The composition of these gaseous fuels, as sold on the market, can vary greatly and fueling systems shall adapt their fuelling rates accordingly. To demonstrate this adaptability, the parent vehicle equipped with a representative LPG, NG/biomethane or H_2NG fuel system shall be tested in type I tests on two extreme reference fuels.
1.3.	The requirements of this Appendix as regards hydrogen shall apply only to vehicles using hydrogen as a combustion fuel and not to those equipped with a fuel cell operating on hydrogen.
1.4	For CNG and LPG vehicles, the provisions of CMV Rule 115(B) and CMV Rule 115(C) as amended from time to time, shall apply.
1.5	Vehicles models and variants having option for Bi-fuel operation and fitted with limp-home gasoline tank of capacity not exceeding three litres on three wheelers shall be exempted from test in gasoline mode.
2.0	**Granting of type approval for an L5-category vehicle equipped with a gaseous fuel system**
	Type approval is granted subject to the following requirements:
2.1.	**Exhaust emissions approval of a vehicle equipped with a gaseous fuel system** It shall be demonstrated that the parent vehicle equipped with a representative LPG, NG/biomethane, H_2NG or hydrogen fuel system can adapt to any fuel composition that may appear on the market and comply with the following:
2.1.1.	In the case of LPG there are variations in C_3/C_4 composition (test fuel requirement A and B) and therefore the parent vehicle shall be tested on reference fuels A and B referred to in in the notification. Reference Fuel shall be used for Type Approval and Conformity of Production two year after the same is available to the test agencies. Till then, Commercial LPG fuel shall be used as per applicable Gazette Notification under CMVR.
2.1.2.	In the case of NG/biomethane there are generally two types of fuel, high calorific fuel (G20) and low calorific fuel (G25), but with a significant spread within both ranges; They differ significantly in Wobbe index. These variations are reflected in the reference fuels. The parent vehicle shall be tested on both reference fuels referred to in the notification . Reference Fuel shall be used for Type Approval and Conformity of Production two year after the same is available to the test agencies. Till then, Commercial CNG fuel shall be used as per applicable Gazette Notification under CMVR.
2.1.3.	In the case of a flex fuel H_2NG vehicle, the composition range may vary from 0 % hydrogen (L-gas) to a maximum percentage of hydrogen within the mixture (H-gas), as specified by the manufacturer. It shall be demonstrated that the parent vehicle can adapt to

	any percentage within the range specified by the manufacturer and the vehicle shall be tested in the type I test on 100 % H-gas and 100 % L-gas. It shall also be demonstrated that it can adapt to any NG/biomethane composition that may appear on the market, regardless of the percentage of hydrogen in the mixture.
2.1.4.	For vehicles equipped with hydrogen fuel systems, compliance shall be tested on the single hydrogen reference fuel referred to in notification.
2.1.5.	If the transition from one fuel to another is in practice aided through the use of a switch, this switch shall not be used during type-approval. In such cases, at the manufacturer's request and with the agreement of the test agency, the pre-conditioning cycle referred in point 4.1.2.1 of **Chapter 3W-II** may be extended.
2.1.6.	The ratio of emission results 'r' shall be determined for each pollutant as shown in Table Ap8-1 for LPG, NG/biomethane and H₂NG vehicles.
2.1.6.1.	In the case of LPG and NG/biomethane vehicles, the ratios of emission results 'r' shall be determined for each pollutant as follows:

TABLE Ap8-1

Calculation ratio 'r' for LPG and NG/biomethane vehicles

Type(s) of fuel	Reference fuels	Calculation of 'r'
LPG and petrol	Fuel A	
or LPG only	Fuel	$r = \dfrac{B}{A}$
NG/biomethane	fuel G20	
	fuel G25	

Note1: Limitation of exhaust emissions by the vehicle, evaporative emissions, crankcase emissions, durability of pollution control devices, cold start pollutant emissions and on-board diagnostics of vehicles fueled with unleaded petrol, or which can be fueled with either unleaded petrol and LPG (Approval B)

Note 2: Limitation of emissions of gaseous pollutants by the engine, crankcase emissions, durability of pollution control devices, cold start emissions and on-board diagnostics of vehicles fueled with LPG (Approval D).

2.1.6.2.	In the case of flex fuel H₂NG vehicles, two ratios of emission results 'r1' and 'r2' shall be determined for each pollutant as follows:

TABLE Ap 8-2

Look-up table ratio 'r' for NG/biomethane or H₂NG gaseous fuels

Type(s) of fuel	Reference fuels	Calculation of 'r'
NG/biomethane	fuel G20	$r_1 = \dfrac{G25}{G20}$
	fuel G25	
H₂NG	Mixture of hydrogen and G20 with the maximum percentage of hydrogen specified by the manufacturer	$r_2 = \dfrac{H_2G25}{H_2G20}$
	Mixture of hydrogen and G25 with the maximum percentage of hydrogen specified by the manufacturer	

2.2	**Exhaust emissions approval of a member of the propulsion family** For the type-approval of mono-fuel gas vehicles and bi-fuel vehicles operating in gas mode, fuelled by LPG, NG/biomethane, H₂NG or hydrogen, as a member of the propulsion family in Chapter VIIII, a type I test shall be performed with one gaseous reference fuel. For LPG, NG/biomethane and H₂NG vehicles, this reference fuel may be either of the reference fuels in as per notification.. The gas-fuelled vehicle is considered to comply if the following requirements are met:
2.2.1.	The test vehicle shall be selected based on definition of a propulsion family member in Chapter 3W-VIII.
2.2.2.	If the test fuel requirement is reference fuel A for LPG or G20 for NG/biomethane, the emission result shall be multiplied by the relevant factor 'r' if r > 1; if r < 1, no correction is needed.
2.2.3.	If the test fuel requirement is reference fuel B for LPG or G25 for NG/biomethane, the emission result shall be divided by the relevant factor 'r' if r < 1; if r > 1, no correction is needed.
2.2.4.	At the manufacturer's request, the type I test may be performed on both reference fuels, so that no correction is needed.
2.2.5.	The parent vehicle shall comply with the emission limits for relevant category set out in the notification and for both measured and calculated emissions.
2.2.6.	If repeated tests are conducted on the same engine, an average shall first be taken of the results on reference fuel G20, or A, and those on reference fuel G25, or B; the 'r' factor shall then be calculated from these averages.

2.2.7.	For the type approval of a flex fuel H$_2$NG vehicle as a member of a family, two type I tests shall be performed, the first test with 100 % of either G20 or G25, and the second test with the mixture of hydrogen and the same NG/biomethane fuel used during the first test, with the maximum hydrogen percentage specified by the manufacturer.
2.2.7.1.	If the NG/biomethane fuel is the reference fuel G20, the emission result for each pollutant shall be multiplied by the relevant factors (r1 for the first test and r2 for the second test) in point 2.1.6.if the relevant factor > 1; if the correspondent relevant factor < 1, no correction is needed.
2.2.7.2.	If the NG/biomethane fuel is the reference fuel G25, the emission result for each pollutant shall be divided by the corresponding relevant factor (r1 for the first test and r2 for the second test) calculated in accordance with point 2.1.6., if this is < 1; if the corresponding relevant factor is > 1, no correction is needed.
2.2.7.3.	At the manufacturer's request, the type I test shall be conducted with the four (4) possible combinations of reference fuels, in accordance with point 2.1.6., so that no correction is needed.
2.2.7.4.	If repeated tests are carried out on the same engine, an average shall first be taken of the results on reference fuel G20, or H$_2$G20, and those on reference fuel G25, or H$_2$G25 with the maximum hydrogen percentage specified by the manufacturer; The 'r1' and 'r2' factors shall then be calculated from these averages.
2.2.8.	During the type I test, the vehicle shall use only petrol for a maximum of 60 consecutive seconds directly after engine crank and start when operating in gas-fuelling mode. In the case of the use of LPG or CNG as a fuel, it is permissible that the engine is started on petrol and switched to LPG or CNG after a predetermined period of time which cannot be changed by the driver.

1.	**Introduction**
	This Appendix contains specific provisions regarding the type approval of vehicles equipped with a periodically regenerating system.
2.	Scope of the type approval for vehicles with a periodically regenerating system as regards type I tests
2.1.	L5 - category vehicles that are equipped with periodically regenerating systems shall comply with the requirements in this Appendix.
2.2.	Instead of carrying out the test procedures in the following point, a fixed K_i value of 1.05 may be used if the manufacturer sees no reason why this value could be exceeded and after approval of testing agency
2.3	During cycles where regeneration occurs, emission standards can be exceeded. If a regeneration of an anti- pollution device occurs at least once per Type I test and that has already regenerated at least once during the vehicle preparation cycle, it will be considered as a continuously regenerating system which does not require a special test procedure.
2.4.	"Periodically regenerating system" means an anti-pollution device (e.g. catalytic converter, particulate trap) that requires a periodical regeneration process in less than 4,000 km of normal vehicle operation. During cycles where regeneration occurs, emission standards can be exceeded. If a regeneration of an anti-pollution device occurs at least once per Type I test and that has already regenerated at least once during vehicle preparation cycle, it will be considered as a continuously regenerating system which does not require a special test procedure. This Appendix does not apply to continuously regenerating systems.
	At the request of the manufacturer, the test procedure specific to periodically regenerating systems will not apply to a regenerative device if the manufacturer provides data to the type approval authority that, during cycles where regeneration occurs, emissions remain below the standards given in the notification for the concerned vehicle category after agreement of the test agency.
3.	**Test procedure**
	The vehicle may be equipped with a switch capable of preventing or permitting the regeneration process provided that its operation has no effect on original engine calibration. This switch shall be used for the purpose of preventing regeneration only during loading of the regeneration system and during the pre-conditioning cycles. However, it shall not be used during the measurement of emissions in the regeneration phase; rather the emission test shall be carried out with the unchanged original equipment manufacturers powertrain control unit / engine control unit / drive train control unit if applicable and powertrain software.
3.1.	Measurement of carbon dioxide emission / fuel consumption and mass emissions between two cycles where regenerative phases occur.
3.1.1.	The average of carbon dioxide emission / fuel consumption and mass emissions between regeneration phases and during loading of the regenerative device shall be determined from the arithmetic mean of several approximately equidistant (if more than two) type I operating cycles.

	Carbon dioxide emission / fuel consumption and mass emissions shall be measured for at least two type I operating cycles: one immediately after regeneration (before new loading) and one as immediately as possible before a regeneration phase. All emissions measurements and calculations shall be carried out in accordance with Chapter 3W-II. Average emissions for a single regenerative system shall be determined in accordance with point 3.3 and for multiple regeneration systems in accordance with point 3.4.
3.1.2.	The loading process and K_i determination shall be carried out on a chassis dynamometer during the type I operating cycles. These cycles may be run continuously (i.e. without the need to switch the engine off between cycles). After any number of completed cycles, the vehicle may be removed from the chassis dynamometer and the test continued at a later time.
3.1.3.	The number of cycles (D) between two cycles in which regeneration phases occur, the number of cycles over which emissions measurements are taken (n) and each emissions measurement (M'_{sij}) shall be reported in test report.
3.2.	Measurement of carbon dioxide emission / fuel consumption and mass emissions during regeneration
3.2.1.	If necessary, the vehicle may be prepared for the emissions test during a regeneration phase using the preparation cycles in Appendix 6 of of this chapter.
3.2.2.	The test and vehicle conditions for the type I test described in Chapter 3W-II apply before the first valid emission test is carried out.
3.2.3.	Regeneration shall not occur during the preparation of the vehicle. This may be ensured by one of the following methods:
3.2.3.1	A 'dummy' regenerating system or partial system may be fitted for the pre-conditioning cycles;
3.2.3.2	Any other method agreed between the manufacturer and the testing agency.
3.2.4.	A cold start exhaust emission test including a regeneration process shall be carried out in accordance with the applicable type I operating cycle.
3.2.5.	If the regeneration process requires more than one operating cycle, subsequent test cycle(s) shall be driven immediately, without switching the engine off, until complete regeneration has been achieved (each cycle shall be completed). The time necessary to set up a new test shall be as short as possible (e.g. as required to change a particulate matter filter on the analyzing equipment). The engine shall be switched off during this period.
3.2.6.	The emission values, during regeneration (M_{ri}) shall be calculated in accordance with Type I test procedure described in Chapter 3W-II and point 3.3. The number of operating cycles (d) measured for complete regeneration shall be recorded.
3.3.	Calculation of the combined exhaust emissions of a single regenerative system: Equation Ap9-1

$$(1) \quad M_{si} = \frac{\sum_{j=1}^{n} M'_{sij}}{n} \qquad n \geq 2$$

Equation Ap9-2

$$(2) \quad M_{ri} = \frac{\sum_{j=1}^{d} M'_{rij}}{d}$$

Equation Ap 9-3

$$(3) \quad M_{pi} = \left\{ \frac{M_{si} * D + M_{ri} * d}{D + d} \right\}$$

Where for each pollutant (i) considered:

M'_{sij} = mass emissions of pollutant (i), mass emissions of CO2 in g/km / fuel consumption in l/100 km over one type I operating cycle without regeneration;

M'_{rij} = mass emissions of pollutant (i), mass emissions of CO2 in g/km / fuel consumption in l/100 km over one type I operating cycle during regeneration (when n > 1, the first type I test is run cold, and subsequent cycles are hot);

$K_i = M_{pi} / M_{si}$
the test agency. K_i may be determined following the completion of a single sequence.

M_{si}=mean mass emissions of pollutant (i) in mg/km or mean mass emissions of CO2 in g/km / fuel consumption in l/100 km over one part (i) of the operating cycle without regeneration;

M_{ri}=mean mass emissions of pollutant (i) in mg/km or mean mass emissions of CO2 in g/km / fuel consumption in l/100 km over one part (i) of the operating cycle during regeneration;

M_{pi}=mean mass emissions of pollutant (i) in mg/km or mean mass emissions of CO_2 in g/km / fuel consumption in l/100 km;

n=number of test points at which emissions measurements (Type I operating cycles) are taken be-tween two cycles where regenerative phases occur, ≥ 2

d=number of operating cycles required for regeneration.

D=number of operating cycles between two cycles where regenerative phases occur.
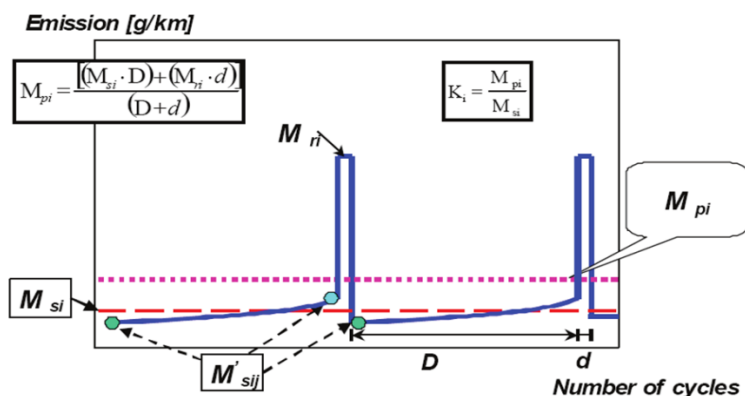
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FIGURE Ap9-1

Example of measurement parameters. Parameters measured during emissions or fuel consumption test during and between cycles in which regeneration occurs (schematic example – the emissions during 'D' may increase or decrease)

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3.3.1.	Calculation of the regeneration factor K for each pollutant (i), carbon dioxide emission / fuel consumption considered:
	Equation Ap9-4
	M_{si}, M_{pi} and K_i results shall be recorded in the test report delivered by

3.4.	Calculation of combined exhaust emissions, carbon dioxide emissions / fuel consumption of multiple periodic regenerating systems
	Equation Ap9-5
	$$(1) \quad M_{sik} = \frac{\sum\limits_{j=1}^{n_k} M'_{sik,j}}{n_k} \qquad n_k \geq 2$$
	Equation Ap 9-6
	$$(2) \quad M_{rik} = \frac{\sum\limits_{j=1}^{d_k} M'_{rik,j}}{d_j}$$
	Equation Ap 9-7
	$$(3) \quad M_{si} = \frac{\sum\limits_{k=1}^{x} M_{sik} \cdot D_k}{\sum\limits_{k=1}^{x} D_k}$$

Equation Ap 9-8

$$(4) \quad M_{ri} = \frac{\sum_{k=1}^{x} M_{rik} \cdot d_k}{\sum_{k=1}^{x} d_k}$$

Equation Ap 9 -9

$$(5) \quad M_{pi} = \frac{M_{si} \cdot \sum_{k=1}^{x} D_k + M_{ri} \cdot \sum_{k=1}^{x} d_k}{\sum_{k=1}^{x} (D_k + d_k)}$$

Equation Ap 9 -10

$$(6) \quad M_{pi} = \frac{\sum_{k=1}^{x} (M_{sik} \cdot D_k + M_{rik} \cdot d_k)}{\sum_{k=1}^{x} (D_k + d_k)}$$

Equation Ap 9 -11

$$(7) \quad K_i = \frac{M_{pi}}{M_{si}}$$

Where for each pollutant (i) considered:

M'_{sik}=mass emissions of event k of pollutant (i) in mg/km, mass emissions of CO_2 in g/km / fuel consumption in l/100 km over one type I operating cycle without regeneration;

M'_{rik}=mass emissions of event k of pollutant (i) in mg/km, mass emissions of CO_2 in g/km / fuel consumption in l/100 km over one type I operating cycle during regeneration (if d > 1, the first type I test is run cold, and subsequent cycles are hot);

$M'_{sik,j}$=mass emissions of event k of pollutant (i) in mg/km, mass emissions of CO_2 in g/km / fuel consumption in l/100 km over one type I operating cycle without regeneration measured at point j; $1 \le j \le n$;,

	$M'_{rik,j}$=mass emissions of event k of pollutant (i) in mg/km, mass emissions of CO_2 in g/km / fuel consumption in l/100 km over one type I operating cycle during regeneration (when j > 1, the first type I test is run cold, and subsequent cycles are hot) measured at operating cycle j; $1 \leq j \leq d$;,
	M_{si}=mass emission of all events k of pollutant (i) in mg/km, of CO_2 in g/km / fuel consumption in l/100 km without regeneration;
	M_{ri}=mass emission of all events k of pollutant (i) in mg/km, of CO_2 in g/km / fuel consumption in l/100 km during regeneration;.
	M_{pi}=mass emission of all events k of pollutant (i) in mg/km, of CO_2 in g/km / fuel consumption in l/100 km;,
	n_k=number of test points of event k at which emissions measurements (type I operating cycles) are taken between two cycles in which regenerative phases occur;
	d_k=number of operating cycles of event k required for regeneration ;
	D_k=number of operating cycles of event k between two cycles in which regenerative phases occur.
	FIGURE Ap9-2 **Parameters measured during emissions test during and between cycles in which regene ration occurs (schematic example)**
	For more details of the schematic process see Figure Ap9-3:

	FIGURE Ap9-3 **Parameters measured during emissions test during and between cycles where regeneration occurs (schematic example)**
	For application of a simple and realistic case, the following description gives a detailed explanation of the schematic example shown in Figure Ap9 -3:
	'Particulate Filter': regenerative, equidistant events, similar emissions (±15 percent) from event to event $D_k = D_k+1 = D_1$ $d_k = d_k+1 = d_1$ $M_{rik} - M_{sik} = M_{rik}+1 - M_{sik}+1$ $n_k = n$
	'DeNOx': the desulphurisation (SO_2 removal) event is initiated before an influence of sulphur on emissions is detectable (±15 percent of measured emissions) and in this example, for exothermic reasons, together with the last DPF regeneration event. $M'_{sik,j}=1 = constant \quad M_{sik} = M_{sik}+1 = M_{si2} \quad M_{rik} = M_{rik}+1 = M_{ri2}$ For SO_2 removal event: M_{ri2}, M_{si2}, d_2, D_2, $n_2 = 1$
	Complete system (DPF + DeNOx): Equation Ap 9-12 $$M_{si} = \frac{n \cdot M_{si1} \cdot D_1 + M_{si2} \cdot D_2}{n \cdot D_1 + D_2}$$ Equation Ap 9-13 $$M_{ri} = \frac{n \cdot M_{ri1} \cdot d_1 + M_{ri2} \cdot d_2}{n \cdot d_1 + d_2}$$ Equation Ap 9 -14
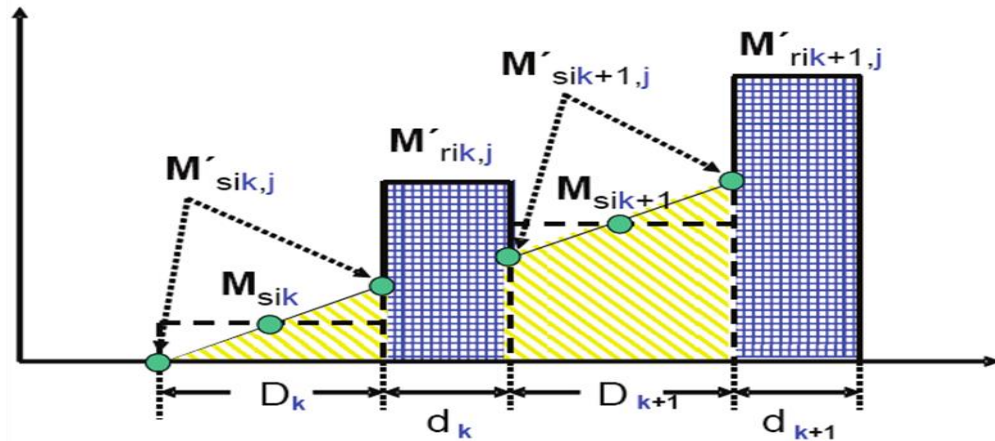
<table>
<tr>
<td></td>
<td>

$$M_{pi} = \frac{M_{si} + M_{ri}}{n \cdot (D_1 + d_1) + D_2 + d_2} = \frac{n \cdot (M_{si1} \cdot D_1 + M_{ri1} \cdot d_1) + M_{si2} \cdot D_2 + M_{ri2} \cdot d_2}{n \cdot (D_1 + d_1) + D_2 + d_2}$$

The calculation of the factor (K_i) for multiple periodic regenerating systems is possible only after a certain number of regeneration phases for each system. After performing the complete procedure (A to B, see Figure Ap 9-2), the original starting conditions A should be reached again.</td>
</tr>
<tr>
<td>3.4.1.</td>
<td>Extension of approval for a multiple periodic regeneration system</td>
</tr>
<tr>
<td>3.4.1.1.</td>
<td>If the technical parameters or the regeneration strategy of a multiple regeneration system for all events within this combined system are changed, the complete procedure including all regenerative devices shall be performed by measurements to update the multiple K_i – factor.</td>
</tr>
<tr>
<td>3.4.1.2.</td>
<td>If a single device of the multiple regeneration system is changed only in strategy parameters (i.e. such as 'D' or 'd' for DPF) and the manufacturer can provide the plausible technical data to the test agency and information demonstrating that:

a) There is no detectable interaction with the other device(s) of the system; and

b) The important parameters (i.e. construction, working principle, volume, location, etc.) are identical,

The necessary update procedure for k_i may be simplified.

In such cases, where agreed between the manufacturer and the test agency, only a single event of sampling/storage and regeneration shall be performed and the test results ('M_{si}', 'M_{ri}'), in combination with the changed parameters ('D' or 'd'), may be introduced into the relevant formula (e) to update the multiple K_i - factor mathematically by substituting the existing basic K_i - factor formula (e).</td>
</tr>
</table>

Appendix 10 to Chapter 3W- II
COP Procedure – Technical Requirements

1.	**Introduction**
	Every produced vehicle of the model approved under this CMV Rule 115 (20) shall conform, with regard to components affecting the emission of gaseous pollutants by the engine to the vehicle model type approved. The administrative procedure for carrying out conformity of production is given in Part 6 of AIS- 137.
2	**Type I Test: Verifying the average emission of gaseous pollutants:**
	For verifying the conformity of production in a Type I Test, the following procedure as per Option1 is adopted.
2.1	To verify the average tailpipe emissions of gaseous pollutants of low volume vehicles with Annual production less than 250 per 6 months, manufacture can choose from the Option 1 or Option 2 as listed below:
2.2	**Run-in**
	The vehicle shall be run in as per manufacturer's recommendation before the test.
3	**Option 1**
3.1	The vehicle samples taken from the series, as described in clause 1 of this appendix is subjected to the single Type-I test described in Chapter -3W-II. The results shall be multiplied by the deterioration factors applied at the time of type approval. The resultant masses of gaseous emissions and where specified in the notification, the mass of particulates obtained in the test shall not exceed the applicable limits.
3.2	Procedure for Conformity of Production as per Bharat Stage-VI for 3 Wheelers vehicles
3.2.1	Conformity of production shall be verified as per Bharat Stage VI emission norms for 3 wheeler vehicles as given in notification and with the procedure given below.
3.2.2	To verify the average tailpipe emissions of gaseous pollutants following procedure shall be adopted.
3.2.3	Minimum of three vehicles shall be selected randomly from the series with a sample lot size as defined in. Part 6 of AIS- 137.
3.2.4	After selection by the testing agency, the manufacturer shall not undertake any adjustments to the vehicles selected, except those permitted in Part 6 of AIS- 137.
3.2.5	All three randomly selected vehicles shall be tested for a Type -1 test as per Chapter 3W-II
3.2.6	Let X_{i1}, X_{i2} & X_{i3} are the test results for the vehicle Sample No.1, 2 & 3.
3.2.7	If the natural Logarithms of the measurements in the series are $X_1, X_2, X_3 .... X_j$ and L_i is the natural logarithm of the limit value for the pollutant, then define :

	$$d_j = X_j - L_i$$ $$\overline{d}_n = \frac{1}{n}\sum_{j=1}^{n} d_j$$ $$V_n^2 = \frac{1}{n}\sum_{j=1}^{n}(d_j - \overline{d}_n)^2$$
3.2.8	Table Ap10-1 of this Appendix shows values of the pass (An) and fail (Bn) decision numbers against current sample number. The test statistic is the ratio dn/Vn and shall be used to determine whether the series has passed or failed as follows : • Pass the series, if $\overline{dn}$ /V$_n$ < A$_n$ for all the pollutants • Fail the series if $\overline{dn}$/V$_n$ > B$_n$ for any one of the pollutants. • Increase the sample size by one, if A$_n$ < $\overline{dn}$ /V$_n$ < B$_n$ for any one of the pollutants. When a pass decision is reached for one pollutant, that decision will not be changed by any additional tests carried out to reach a decision for the other pollutants. • If no pass decision is reached for all the pollutants and no fail decision is reached for one pollutant, a test shall be carried out on another randomly selected sample till a pass or fail decision is arrived at
	Option I : COP Test Procedure as per Bharat Stage VI for 3 wheeler **Figure Ap10-1**

Table Ap10-1: Applicable for COP Procedure as per Bharat Stage VI for 3 Wheeler		
Sample Size	Pass Decision threshold (A_n)	Fail Decision threshold (B_n)
3	-0.80381	16.64743
4	-0.76339	7.68627
5	-0.72982	4.67136
6	-0.69962	3.25573
7	-0.67129	2.45431
8	-0.64406	1.94369
9	-0.61750	1.59105
10	-0.59135	1.33295
11	-0.56542	1.13566
12	-0.53960	0.97970
13	-0.51379	0.85307
14	-0.48791	0.74801
15	-0.46191	0.65928
16	-0.43573	0.58321
17	-0.40933	0.51718
18	-0.38266	0.45922
19	-0.35570	0.40788
20	-0.32840	0.36203
21	-0.30072	0.32078
22	-0.27263	0.28343
23	-0.24410	0.24943
24	-0.21509	0.21831
25	-0.18557	0.18970
26	-0.15550	0.16328
27	-0.12483	0.13880
28	-0.09354	0.11603
29	-0.06159	0.09480
30	-0.02892	0.07493
31	0.00449	0.05629
32	0.03876	0.03876

4	**Option 2**
4.1	Minimum of three vehicles shall be selected randomly from the series with a sample lot size.
4.2	After selection by the testing agency, the manufacturer shall not undertake any adjustments to the vehicles selected, except those permitted in Part 6 of AIS- 137.
4.3	First vehicle out of three randomly selected vehicles shall be tested for Type – I test as per Chapter 3W-II
4.4	Only one test (V1) shall be performed if the test results for all the pollutants meet 70 % of their respective limit values (i.e. V1 $\leq$ 0.7L & L being the COP Limit)

4.5	Only two tests shall be performed if the first test results for all the pollutants doesn't exceed 85% of their respective COP limit values (i.e. V1 ≤ 0.85L) and at the same time one of these pollutant value exceeds 70% of the limit (i.e. V1 > 0.7L) In addition, to reach the pass decision for the series, combined results of V1 & V2 shall satisfy such requirement that: (V1 + V2) < 1.70L and V2 ≤ L for all the pollutants.
4.6	Third Type - I (V3) test shall be performed if the para 4.11 doesn't satisfy and if the second test results for all pollutants are within the 110% of the prescribed COP limits, Series passes only if the arithmetical mean for all the pollutants for three type I tests do not exceed their respective limit value i.e. (V1 + V2 + V3)/3 ≤ L).
4.7	If one of the three test results obtained for any one of the pollutants exceed 10% of their respective limit values the test shall be continued on Sample No. 2 & 3 as given in the Figure Ap10- 2 of this Appendix, as the provision for extended COP and shall be informed by the test agency to the nodal agency
4.8	These randomly selected sample No.2 & 3 shall be tested for only one Type – I test as per Chapter -3W-II
4.9	Let X i2 & X i3 are the test results for the Sample No.2 & 3 and Xi1 is the test result of the Sample No.1 which is the arithmetical mean for the three type – I tests conducted on Sample No. **1**
4.10	If the natural Logarithms of the measurements in the series are X1, X2, X3...........Xj and Li is the natural logarithm of the limit value for the pollutant, then define: $$dj = Xj - Li$$ $$d_n = \frac{1}{n}\sum_{j=1}^{n} d_j$$ $$V_n^2 = \frac{1}{n}\sum_{j=1}^{n}(d_j - \overline{d_n})^2$$
4.11	Table Ap10-1 of this part shows values of the pass (A_n) and fail (B_n) decision numbers against current sample number. The test statistic is the ratio d_n / V_n and shall be used to determine whether the series has passed or failed as follows: - • Pass the series, $d_n /V_n \geq A_n$ for all the pollutants • Fail the series $d_n /V_n \geq B_n$ for any one of the pollutants. • Increase the sample size by one, if $A_n < d_n /V_n \leq B_n$ for any one of the pollutants.
4.12	When a pass decision is reached for one pollutant, that decision will not be changed by any additional tests carried out to reach a decision for the other pollutants.-
4.13	If no pass decision is reached for all the pollutants and no fail decision is reached for one pollutant, a test shall be carried out on another randomly selected sample till a pass or fail decision is arrived at.

5	These tests shall be conducted with the reference fuel as specified in the notification. However, at the manufacturer's request, tests may be carried out with commercial fuel.
6	**Type II Test: Carbon-monoxide and Hydrocarbons emission at idling speed:** When the vehicle taken from the series for the first type I test mentioned in para 2 above, subjected to the test described in **Chapter 3W-III** of this Part for verifying the carbon monoxide and hydrocarbon emission at idling speed shall meet the limit values specified in CMVR rule no. 115(2)(i)). If it does not, another 10 vehicles shall be taken from the series at random and shall be tested as per **Chapter 3W-III** of this Part. These vehicles can be same as those selected for carrying out Type I test. Additional vehicles if required, shall be selected for carrying out for Type II test. At least 9 vehicles shall meet the limit values specified in CMVR rule no. 115(2(i)). Then the series is deemed to conform.

Figure Ap 10-2

OPTION II:COP Test Procedure as per Bharat Stage VI for 3W
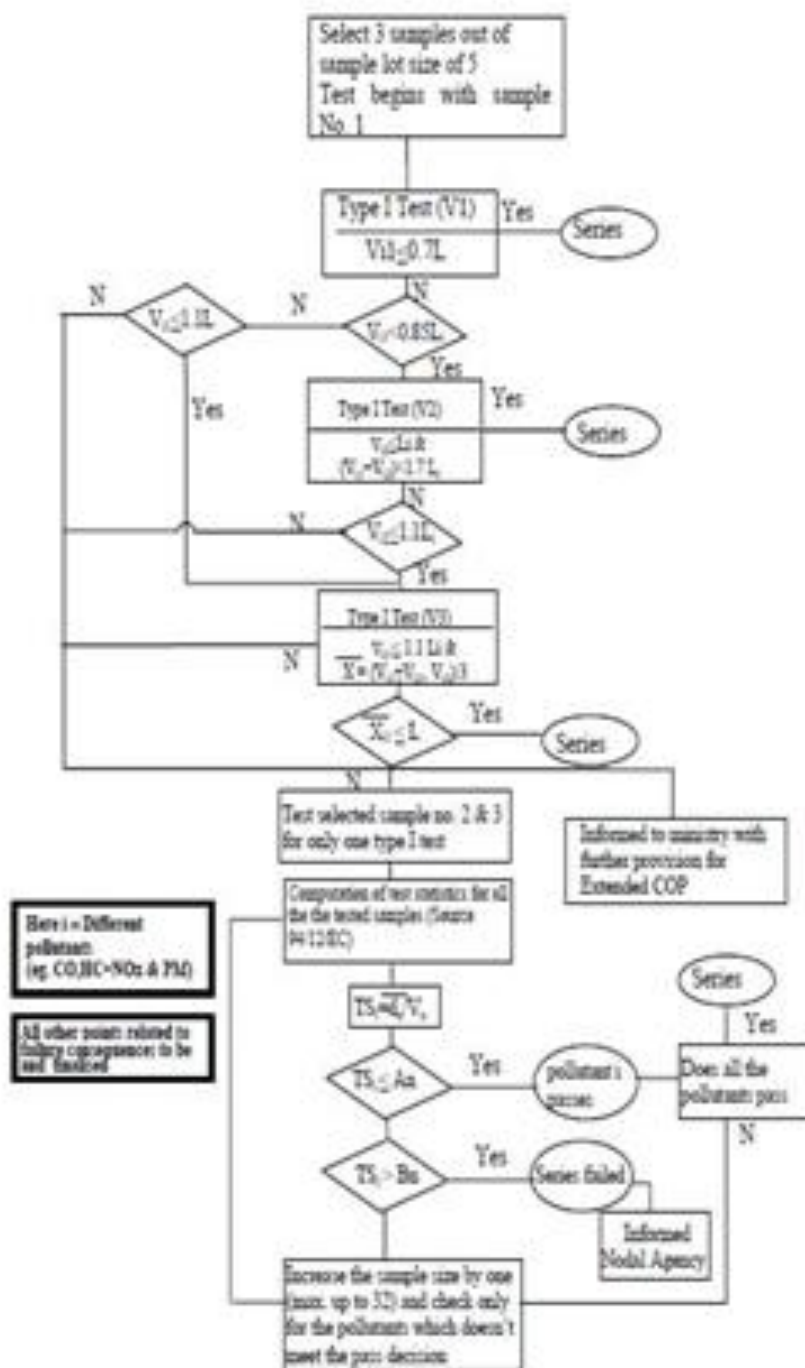
Appendix 11 to Chapter 3W- II
Type I test procedure for hybrid category vehicles

1.	**Introduction**
1.1.	This Appendix defines the specific provisions regarding type-approval of hybrid electric L5-category vehicles (HEV).
1.2.	In principle, for the environmental type I to VIII test, hybrid electric vehicles shall be tested in accordance with this part, unless otherwise provided for in this Appendix.
1.3	For the type I and type VII tests, off-vehicle charging (OVC) vehicles (as categorized in point 2) shall be tested according to Conditions A and B. Both sets of test results and the weighted values shall be reported in the test report.
1.4.	The emissions test results shall comply with the limits set-out the notification under all test conditions specified in this part.
2.	**Categories of hybrid vehicles**
	Table Ap12-1 **Hybrid vehicle categories** <table><tr><td>Vehicle charging</td><td colspan="2">Off-Vehicle Charging (1) (OVC)</td><td colspan="2">Not-off-vehicle Charging (2) (NOVC)</td></tr><tr><td>Operating mode switch</td><td>Without</td><td>With</td><td>Without</td><td>With</td></tr></table> (1) Also known as 'externally chargeable'. (2) Also known as 'not externally chargeable'.
3.	**Type I test methods**
	For the type I test, hybrid electric L5-category vehicles shall be tested according to the applicable procedure as per notification. For each test condition, the pollutant emission test result shall comply with the notified limits.
3.1.	Externally chargeable vehicles (OVC HEVs) without an operating mode switch
3.1.1.	Two tests shall be performed under the following conditions: a) condition A: the test shall be carried out with a fully charged electrical energy/power storage device (b) condition B: the test shall be carried out with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity). The profile of the state of charge (SOC) of the electrical energy/power storage device during different stages of the test is given in Appendix 3.1. to Chapter 2W- VIII.
3.1.2.	Condition A

3.1.2.1.	The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle while driving (on the test track, on a chassis dynamometer, etc.) in any of the following conditions
	(a) at a steady speed of 50 km/h until the fuel-consuming engine starts up;
	(b) if a vehicle cannot reach a steady speed of 50 km/h without the fuel-consuming engine starting up, the speed shall be reduced until it can run at a lower steady speed at which the fuel-consuming engine does not start up for a defined time or distance (to be determined by the test agency and the manufacturer);
	(c) in accordance with the manufacturer's recommendation.
	The fuel-consuming engine shall be stopped within ten seconds of being automatically started.
3.1.2.2.	Conditioning of vehicle
	The vehicle shall be conditioned by driving the applicable type I driving cycle as set out in Appendix 6.
3.1.2.3.	After this preconditioning and before testing, the vehicle shall be kept in a room in which the temperature remains relatively constant between 293,2 K and 303,2 K (20 °C and 30 °C). This conditioning shall be carried out for at least six hours and continue until the temperature of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room, and the electrical energy/power storage device is fully charged as a result of the charging prescribed in point 3.1.2.4
3.1.2.4.	During soak, the electrical energy/power storage device shall be charged with any of the following
	(a) the on-board charger if fitted:
	(b) an external charger recommended by the manufacturer and referred to in the user manual, using the normal overnight charging procedure set out in point 3.2.2.4. of Appendix 3 to Chapter 2W-IX.
	This procedure excludes all types of special charges that could be automatically or manually initiated, e.g. equalization or servicing charges
	The manufacturer shall declare that a special charge procedure has not occurred during the test;
	End-of-charge criterion.
	The end-of-charge criterion corresponds to a charging time of 12 hours, except where the standard instrumentation gives the driver a clear indication that the electrical energy storage device is not yet fully charged.
	In this case, the maximum time is = 3 times the claimed battery capacity (Wh) / mains power supply (W).

3.1.2.5.	Test procedure
3.1.2.5.1.	The vehicle shall be started up by the means provided to the driver for normal use. The first test cycle starts on the initiation of the vehicle start-up procedure.
3.1.2.5.2.	The test procedures described in points 3.1.2.5.2.1. or 3.1.2.5.2.2. shall be used in accordance with the type I test procedure set out in Appendix 6.
3.1.2.5.2.1.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period of the applicable type I test cycle (end of sampling (ES)).
3.1.2.5.2.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and continue over a number of repeat test cycles. It shall end on conclusion of the final idling period in the applicable type I test cycle during which the battery reached the minimum state of charge in accordance with the following procedure (end of sampling (ES)):
3.1.2.5.2.2.1.	the electricity balance Q (Ah) is measured over each combined cycle according to the procedure in Appendix 3.2. to chapter 2W- VIII and used to determine when the battery minimum state of charge has been reached;
3.1.2.5.2.2.2.	the battery minimum state of charge is considered to have been reached in combined cycle N if the electricity balance Q measured during combined cycle N+1 is not more than a 3 percent discharge, expressed as a percentage of the nominal capacity of the battery (in Ah) in its maximum state of charge, as declared by the manufacturer. At the manufacturer's request, additional test cycles may be run and their results included in the calculations in points 3.1.2.5.5. and 3.1.4.2, provided that the electricity balance Q for each additional test cycle shows less discharge of the battery than over the previous cycle;
3.1.2.5.2.2.3.	after each cycle, a hot soak period of up to ten minutes is allowed. The power train shall be switched off during this period.
3.1.2.5.3.	The vehicle shall be driven according to the provisions in Appendix 6
3.1.2.5.4.	The exhaust gases shall be analyzed according to the provisions in chapter 2W- II.
3.1.2.5.5.	The test results shall be compared with the limits set out in the notification and the average emission of each pollutant (expressed in mg per kilometer) for Condition A shall be calculated (M 1i). In the case of testing according to point 3.1.2.5.2.1., (M 1i) is the result of the single combined cycle run. In the case of testing according to point 3.1.2.5.2.2., the test result of each combined cycle run (M 1ia), multiplied by the appropriate deterioration factor and K i factors, shall be less than the limits in the notification. For the purposes of the calculation in point 3.1.4., M 1i shall be defined as: *Equation Ap12-1:* $$M_{li} = \frac{1}{N} \sum_{a=1}^{N} M_{lia}$$

	where: i: pollutant a: test cycle
3.1.3.	Condition B
3.1.3.1.	Conditioning of vehicle. The vehicle shall be conditioned by driving the applicable type I driving cycle as set out in Appendix 6.
3.1.3.2.	The electrical energy/power storage device of the vehicle shall be discharged while driving (on the test track, on a chassis dynamometer, etc.): (a) at a steady speed of 50 km/h until the fuel-consuming engine starts up, or (b) if a vehicle cannot reach a steady speed of 50 km/h without the fuel-consuming engine starting up, the speed shall be reduced until it can run a at lower steady speed at which the engine does not start up for a defined time or distance (to be determined by the test agency and the manufacturer), or (c) in accordance with the manufacturers' recommendation The fuel-consuming engine shall be stopped within ten seconds of being automatically started
3.1.3.3.	After this preconditioning and before testing, the vehicle shall be kept in a room in which the temperature remains relatively constant between 293.2 K and 303,2 K (20 °C and 30 °C). This conditioning shall be carried out for at least six hours and continue until the temperature of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room.
3.1.3.4.	Test procedure
3.1.3.4.1.	The vehicle shall be started up by the means provided to the driver for normal use. The first cycle starts on the initiation of the vehicle start-up procedure
3.1.3.4.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period of the applicable type I test cycle (end of sampling (ES)).
3.1.3.4.3.	The vehicle shall be driven according to the provisions of Appendix 6.
	3.1.3.4.4. The exhaust gases shall be analysed in accordance with Chapter 2W- II
3.1.3.5.	The test results shall be compared with the limits which is notified in the Notification and the average emission of each pollutant for Condition B shall be calculated (M_{2i}). The test results M_{2i}, multiplied by the appropriate deterioration and K i factors, shall be less than the limits prescribed in the notification.

3.1.4.	Test results
3.1.4.1.	Testing in accordance with point 3.1.2.5.2.1
	For reporting, the weighted values shall be calculated as follows
	Equation Ap12-2:
	$M_i = (D_e \cdot M_{1i} + D_{av} \cdot M_{2i})/(D_e + D_{av})$
	where:
	M_i = mass emission of the pollutant i in mg/km;
	M_{1i} = average mass emission of the pollutant i in mg/km with a fully charged electrical energy/power storage device, calculated in accordance with point 3.1.2.5.5
	M_{2i} = average mass emission of the pollutant i in mg/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), calculated in accordance with point 3.1.3.5
	D_e = electric range of the vehicle determined according to the procedure set out in Appendix 3.3. to Chapter 2W- VII, where the manufacturer shall provide the means for taking the measurement with the vehicle running in pure electric mode;
	D_{av} = average distance between two battery recharges, as follows
	—4 km for a vehicle with an engine capacity < 150 cm 3 ;
	— 6 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max < 130 km/h;
	— 10 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max ≥ 130 km/h.
3.1.4.2.	Testing in accordance with point 3.1.2.5.2.2.
	For communication, the weighted values shall be calculated as follows:
	Equation Ap12-3:
	$M_i = (D_{ovc} \cdot M_{1i} + D_{av} \cdot M_{2i})/(D_{ovc} + D_{av})$
	where:
	M_i = mass emission of the pollutant i in mg/km;
	M_{1i} = average mass emission of the pollutant i in mg/km with a fully charged electrical energy/power storage device, calculated in accordance with point 3.1.2.5.5.;
	M_{2i} = average mass emission of the pollutant i in mg/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), calculated in accordance with point 3.1.3.5.;
	D_{ovc} = OVC range established in accordance with the procedure in Appendix 3.3. to Chapter 2W-IX;
	D_{av} = average distance between two battery recharges, as follows:

	— 4 km for a vehicle with an engine capacity < 150 cm 3 ;
	— 6 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max < 130 km/h;
	— 10 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max ≥ 130 km/h.
3.2.	Externally chargeable vehicles (OVC HEVs) with an operating mode switch.
3.2.1.	Two tests shall be performed under the following conditions
3.2.1.1.	Condition A: the test shall be carried out with a fully charged electrical energy/power storage device.
3.2.1.2.	Condition B: the test shall be carried out with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity).
3.2.1.3.	The operating mode switch shall be positioned in accordance with the table Ap12-2.

Table Ap12-2

Look-up table to determine Condition A or B depending on different hybrid vehicle concepts and on the hybrid mode selection switch position

	Hybrid-modes -›	— Pure electric — Hybrid	— Pure fuel-consuming — Hybrid	— Pure electric — Pure fuel-consuming — Hybrid	— Hybrid mode n ([1]) — Hybrid mode m[1]
Battery state of charge		**Switch in position**	**Switch in position**	**Switch in position**	**Switch in position**
Condition A Fully charged		Hybrid	Hybrid	Most electric hybrid mode ([2])	Hybrid
Condition B Min.		Fuel-	Fuel-	Most fuel-consuming	Hybrid

			consuming	consuming	mode (^{3})	
	state of charge					

(^{1}) For instance: sport, economic, urban, extra-urban position, etc.

(^{2}) Most electric hybrid mode: the hybrid mode which can be proven to have the highest electricity consumption of all selectable hybrid modes when tested in accordance with condition A as per this appendix, to be established based on information provided by the manufacturer and in agreement with the test agency.

(^{3}) Most fuel-consuming mode: the hybrid mode which can be proven to have the highest fuel consumption of all selectable hybrid modes when tested in accordance with condition B of this appendix, to be established based on information provided by the manufacturer and in agreement with the test agency.

3.2.2.	Condition A
3.2.2.1.	If the pure electric range of the vehicle is higher than one complete cycle, the type I test may at the manufacturer's request be carried out in pure electric mode. In this case, the engine preconditioning prescribed in point 3.2.2.3.1. or 3.2.2.3.2. can be omitted
3.2.2.2.	The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle while driving with the switch in pure electric position (on the test track, on a chassis dynamometer, etc.) at a steady speed of 70 percent ± 5 percent of the maximum design speed of the vehicle, as per IS 10278.

Stopping the discharge occurs in any of the following conditions:

(a) when the vehicle is not able to run at 65 percent of the maximum thirty minutes speed;

(b) when the standard on-board instrumentation gives the driver an indication to stop the vehicle;

(c) after 100 km.

If the vehicle is not equipped with a pure electric mode, the electrical energy/power storage device shall be discharged by driving the vehicle (on the test track, on a chassis dynamometer, etc.) in any of the following conditions:

(a) at a steady speed of 50 km/h until the fuel-consuming engine of the HEV starts up;

(b) if a vehicle cannot reach a steady speed of 50 km/h without the fuel-consuming engine starting up, the speed shall be reduced until it can run at a lower steady speed at which the fuel-consuming engine does not start up for a defined time or distance (to be determined by the test agency and the manufacturer);

(c) in accordance with the manufacturers' recommendation

The fuel-consuming engine shall be stopped within ten seconds of being automatically started. By means of derogation if the manufacturer can prove to the test agency that the vehicle is physically not capable of achieving the thirty minutes |

	speed the maximum fifteen minute speed may be used instead.
3.2.2.3.	Conditioning of vehicle
3.2.2.4.	After this preconditioning and before testing, the vehicle shall be kept in a room in which the temperature remains relatively constant between 293,2 K and 303,2 K (20 °C and 3 °C). This conditioning shall be carried out for at least six hours and continue until the temperature of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room, and the electrical energy/power storage device is fully charged as a result of the charging prescribed in point 3.2.2.5.
3.2.2.5.	During soak, the electrical energy/power storage device shall be charged with any of the following chargers (a) the on-board charger if fitted; (b) an external charger recommended by the manufacturer, using the normal overnight charging procedure. This procedure excludes all types of special charges that could be automatically or manually initiated, e.g. equalization charges or servicing charges. The manufacturer shall declare that a special charge procedure has not occurred during the test (c) End-of-charge criterion The end-of-charge criterion corresponds to a charging time of 12 hours, except where the standard instrumentation gives the driver a clear indication that the electrical

	energy storage device is not yet fully charged In this case, the maximum time is = 3 × claimed battery capacity (Wh) / mains power supply (W).
3.2.2.6.	Test procedure
3.2.2.6.1.	The vehicle shall be started up by the means provided to the driver for normal use. The first cycle starts on the initiation of the vehicle start-up procedure.
3.2.2.6.1.1.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period of the applicable type I test cycle (end of sampling (ES)
3.2.2.6.1.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and continue over a number of repeat test cycles. It shall end on conclusion of the final idling period of the applicable type I test cycle during which the battery has reached the minimum state of charge in accordance with the following procedure (end of sampling (ES)
3.2.2.6.1.2.1.	The electricity balance Q (Ah) is measured over each combined cycle using the procedure in Appendix 3.2. to chapter 2W-IX and used to determine when the battery minimum state of charge has been reached;
3.2.2.6.1.2.2.	The battery minimum state of charge is considered to have been reached in combined cycle N if the electricity balance measured during combined cycle N+1 is not more than a 3 percent discharge, expressed as a percentage of the nominal capacity of the battery (in Ah) in its maximum state of charge, as declared by the manufacturer. At the manufacturer's request, additional test cycles may be run and their results included in the calculations in points 3.2.2.7. and 3.2.4.3., provided that the electricity balance for each additional test cycle shows less discharge of the battery than over the previous cycle;
3.2.2.6.1.2.3.	After each cycle, a hot soak period of up to ten minutes is allowed. The powertrain shall be switched off during this period
3.2.2.6.2.	The vehicle shall be driven according to the provisions of Appendix 6.
3.2.2.6.3.	The exhaust gases shall be analysed according to Chapter 2W- II.

3.2.2.7.	The test results shall be compared to the emission limits as notified and the average emission of each pollutant (expressed in mg/km) for Condition A shall be calculated (M_{1i}).
	The test result of each combined cycle run M_{1ia} , multiplied by the appropriate deterioration and K_i factors, shall be less than the emission limits as per notification. For the purposes of the calculation in point 3.2.4., M_{1i} shall be calculated according to Equation Ap12-1.
3.2.3.	Condition B
3.2.3.1.	Conditioning of vehicle.
	The vehicle shall be conditioned by driving the applicable type I driving cycle set out in Appendix 6.
3.2.3.2.	The electrical energy/power storage device of the vehicle shall be discharged in accordance with point 3.2.2.2.
3.2.3.3.	After this preconditioning, and before testing, the vehicle shall be kept in a room in which the temperature remains relatively constant between 293,2 K and 303,2 K (20 °C and 30 °C). This conditioning shall be carried out for at least six hours and continue until the temperature of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room.
3.2.3.4.	Test procedure
3.2.3.4.1.	The vehicle shall be started up by the means provided to the driver for normal use. The first cycle starts on the initiation of the vehicle start-up procedure.
3.2.3.4.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period of the applicable type I test cycle (end of sampling (ES)).
3.2.3.4.3.	The vehicle shall be driven in accordance with the provisions of Appendix
3.2.3.4.4.	The exhaust gases shall be analysed in accordance with the provisions in Chapter 2W-II.
3.2.3.5.	The test results shall be compared with the pollutant limits and the average emission of each pollutant for Condition B shall be calculated (M_{2i}). The test results M_{2i} , multiplied by the appropriate deterioration and K_i factors, shall be less than the notified limits.

3.2.4.	Test results
3.2.4.1.	Testing in accordance with point 3.2.2.6.2.1
	For communication, the weighted values shall be calculated as in Equation Ap12-2
	where:
	M_i = mass emission of the pollutant i in mg/km;
	M_{1i} = average mass emission of the pollutant i in mg/km with a fully charged electrical energy/power storage device, calculated in accordance with point 3.2.2.7
	M_{2i} = average mass emission of the pollutant i in mg/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), calculated in accordance with point 3.2.3.5;
	D_e = electric range of the vehicle with the switch in pure electric position, in accordance with Appendix 3.3. to Chapter 2W-IX. If there is not a pure electric position, the manufacturer shall provide the means for taking the measurement with the vehicle running in pure electric mode.
	D_{av} = average distance between two battery recharges, as follows:
	— 4 km for a vehicle with an engine capacity < 150 cm 3
	— 6 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max < 130 km/h;
	— 10 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max ≥ 130 km/h.
3.2.4.2.	Testing in accordance with point 3.2.2.6.2.2.
	For communication, the weighted values shall be calculated as in Equation Ap12-3
	where:
	M_i = mass emission of the pollutant i in mg/km;
	M_{1i} = average mass emission of the pollutant i in mg/km with a fully charged electrical energy/power storage device, calculated in accordance with point 3.2.2.7.;
	M_{2i} = average mass emission of the pollutant i in mg/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), calculated in accordance with point 3.2.3.5.;
	D_{ovc} = OVC range according to the procedure in Appendix 3.3. toChapter 2W- VIII;
	D_{av} = average distance between two battery recharges, as follows:
	— 4 km for a vehicle with an engine capacity < 150 cm 3
	— 6 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max < 130 km/h;
	— 10 km for a vehicle with an engine capacity ≥ 150 cm 3 and v max ≥ 130 km/h.

3.3.	Not externally chargeable vehicles (not-OVC HEVs) without an operating mode switch
3.3.1.	These vehicles shall be tested according to Appendix 6.
3.3.2.	For preconditioning, at least two consecutive complete driving cycles are carried out without soak.
3.3.3.	The vehicle shall be driven in accordance with to the provisions of Appendix 6.
3.4.	Not externally chargeable vehicles (not-OVC HEVs) with an operating mode switch
3.4.1.	These vehicles are preconditioned and tested in hybrid mode in accordance with Chapter 2W-II. If several hybrid modes are available, the test shall be carried out in the mode that is automatically set after the ignition key is turned (normal mode). On the basis of information provided by the manufacturer, the test agency shall ensure that the limit values are complied with in all hybrid modes
3.4.2.	For preconditioning, at least two consecutive complete applicable driving cycles shall be carried out without soak.
3.4.3.	The vehicle shall be driven in accordance with the provisions of Chapter 2W-II.

Chapter 3W- III
Test type II requirements Tailpipe emissions at idling and free acceleration

1.	Introduction
	This Chapter describes the test procedure for type II testing for verification of compliance to applicable provisions of CMVR Rule No. 115 (2).
2	**Scope**
2.1	Vehicles equipped with a propulsion type of which a positive ignition combustion engine forms a part shall be subject only to a type II emission test as set out in points 3, 4 and 5.
2.2	Vehicles equipped with a propulsion type of which a compression ignition combustion engine forms a part shall be subject only to a type II free acceleration emission test as set out in points 3 and 6. In this case point 3.8 is not applicable.
3	**General conditions of type II emission testing**
3.1	In general practice, Type II test shall be carried out immediately after Type I test, if not, A visual inspection of any emission control equipment shall be conducted prior to start of the type II emission test in order to check that the vehicle is complete, in a satisfactory condition and that there are no leaks in the fuel, air supply or exhaust systems. If the testing is done immediately after the Type I test, these inspections may not be carried out.
3.2	The fuel used to conduct the type II tests shall be the reference fuel, as specified in the notification. In case the engine is lubricated by mixing oil to the fuel, the quality and quantity of lubricating oil shall be as prescribed by the manufacturer.
3.3	During the test, the environmental temperature shall be between 293.2 K and 303.2 K (20 °C and 30 °C).
3.4	In the case of vehicles with manually-operated or semi-automatic-shift gearboxes, the test type II test shall be carried out with the gear lever in the 'neutral' position and the clutch engaged.
3.5	In the case of vehicles with automatic-shift gearboxes, the idle type II test shall be carried out with the gear selector in either the 'neutral' or the 'park' position. Where an automatic clutch is also fitted, the driven axle shall be lifted up to a point at which the wheels can rotate freely.
3.6	The type II emission test shall be conducted immediately after the type I emission test. In any event, if Type-II test is required to be conducted independent of Type-I test then the engine shall be warmed up to ensure the conditions as observed at the end of Type-I test.
3.7	The exhaust outlets shall be provided with an air-tight extension, so that the sample probe used to collect exhaust gases may be inserted at least 30 cm into the exhaust outlet without increasing the back pressure of more than 125 mm H_2O and without disturbing operation of the vehicle. This extension shall be so shaped as to avoid any appreciable dilution of exhaust gases in the air at the location of the sample probe. Where a vehicle is equipped with an exhaust system with multiple outlets, either these shall be joined to a common pipe or the pollutants shall be collected from each of them and an arithmetical average taken.

3.8	The emission test equipment and analysers to perform the type II testing shall be regularly calibrated and maintained. A flame ionisation detection or NDIR analyser may be used for measuring hydrocarbons.
3.9	The vehicles shall be tested with the fuel-consuming engine running.
3.9.1	The manufacturer shall provide a type II test 'service mode' that makes it possible to inspect the vehicle for Type II tests on a running fuel-consuming engine, in order to determine its performance in relation to the data collected. Where this inspection requires a special procedure, this shall be detailed in the service manual (or equivalent media). That special procedure shall not require the use of special equipment other than that provided with the vehicle.
4	**Test type II – description of test procedure to measure tailpipe emissions at idle and free acceleration** The test shall be carried out with the engine at normal idling speed as specified by the manufacturer. The type II idle test shall be considered acceptable if the values measured are within the applicable limits prescribed in CMV Rule No. 115 (2).
4.1	**Components for adjusting the idling speed**
4.1.1	Components for adjusting the idling speed for the purposes of this Chapter refer to controls for changing the idling conditions of the engine which may be easily operated by a mechanic using only the tools referred to in point 4.1.2. In particular, devices for calibrating fuel and air flows are not considered as adjustment components if their setting requires the removal of the set-stops, an operation which can normally be performed only by a Trained mechanic.
4.1.2	The tools which may be used to adjust the idling speed are screwdrivers (ordinary or cross-headed), spanners (ring, open-end or adjustable), pliers, Allen keys and a generic scan tool.
4.2	Determination of measurement points and type II idle test pass/fail criteria
4.2.1	First, a measurement is taken at the setting in accordance with the conditions fixed by the manufacturer
4.2.2	For each adjustment component with a continuous variation, a sufficient number of characteristic positions shall be determined. The test shall be carried out with the engine at normal idling speed and at 'high idle' speed. High idle engine speed is defined by the manufacturer but it must be higher than 2000 min $^{-1}$
4.2.3	The measurement of the carbon monoxide content of exhaust gases shall be carried out for all the possible positions of the adjustment components, but for components with a continuous variation only for the positions referred to in point 4.2.2.
4.2.4	The type II idle test shall be considered passed if the following condition is met:
4.2.4.1	The maximum pollutant content shall not exceed the notified limits.
4.2.5	The possible positions of the adjustment components shall be limited by any of the following:

4.2.5.1	the larger of the following two values: the lowest idling speed which the engine can reach; the speed recommended by the manufacturer, minus 100 revolutions per minute;
4.2.5.2	the smallest of the following three values:
	(a) the highest rotation speed which the crankshaft of the engine can attain by activation of the idling speed components;
	(b) the rotation speed recommended by the manufacturer, plus 250 revolutions per minute;
	(c) the cut-in rotation speed of automatic clutches
4.2.6	Settings incompatible with the correct running of the engine shall not be adopted as measurement settings. In particular, if the engine is equipped with several carburettors, all the carburettors shall have the same setting.
4.3	The following parameters shall be measured and recorded at normal idling speed and high idle Speed as per notification: a) The carbon monoxide (CO) content by volume of the exhaust gases emitted (in vol %); b) The carbon dioxide (CO_2) content by volume of the exhaust gases emitted (in vol %); c) hydrocarbons (HC) in ppm; d) the oxygen (O_2) content by volume of the exhaust gases emitted (in vol %) or lambda, as chosen by the manufacturer; e) the engine speed during the test, including any tolerances; f) the engine oil temperature at the time of the test. Alternatively, for liquid cooled engines, the coolant temperature shall be acceptable.
4.3.1	With respect to the parameters under point 4.3. (d) (O_2/lambda) the following shall apply
4.3.1.1	The measurement shall only be conducted at high idle engine speed;
4.3.1.2	Vehicles in the scope of this measurement are only those equipped with a closed loop fuel system
4.3.1.3	Exemptions for vehicle with:
4.3.1.3.1	Engines equipped with a mechanically-controlled (spring, vacuum) secondary air system;
4.3.1.3.2	two-stroke engines operated on a mix of fuel and lubrication oil.
5	**CO concentration calculation in the type II idle test**
5.1	The CO (C_{CO}) and CO_2 (C_{CO_2}) concentration shall be determined from the measuring instrument readings or recordings, by use of appropriate calibration curves.

5.2	The corrected concentration for carbon monoxide is: Equation 3-1:For four stroke engine: $$C_{CO_{corr}} = 15 \, X \, \frac{C_{CO}}{C_{CO} + C_{CO_2}}$$ Equation 3-2:For two stroke engine: $$C_{CO_{corr}} = 10 \, X \, \frac{C_{CO}}{C_{CO} + C_{CO_2}}$$ Note: During calculation if the correction factor is less than 1, then it will be treated as 1.
5.3	The C_{CO} concentration (see point 5.1.) shall be measured in accordance with the formulae in point 5.2 and does not need to be corrected if the total of the concentrations measured ($C_{CO} + C_{CO_2}$) is at least: a) For petrol(E5): 15 %; b) For LPG: 13.5%; c) For NG/bio methane: 11.5% .
6	**Test type II – free acceleration test procedure**
6.1	The combustion engine and any turbocharger or supercharger, if fitted, shall be running at idle before start of each free acceleration test cycle.
6.2	To initiate each free acceleration cycle, the throttle pedal/accelerator shall be applied gradually but not violently to reach full throttle operating condition within 5 seconds, so as to obtain maximum delivery from the fuel pump.
6.3	During each free acceleration cycle, the engine shall reach cut-off speed or, for vehicles with automatic transmissions, the speed specified by the manufacturer or, if this data is not available, two-thirds of the cut-off speed, before the throttle is released. This could be checked, for instance, by monitoring engine speed or by allowing at least two seconds elapsing between initial throttle depression and release.
6.4	For vehicles equipped with CVT and automatic clutch, the driven wheels may be lifted from the ground. For engines with safety limits in the engine control (e.g. max 1500 rpm without running wheels or without gear engaged), this maximum engine speed shall be reached.
6.5	The average concentration level of the opacity (in m^{-1}) in the exhaust flow (opacity) shall be measured during five free acceleration tests. Opacity means an optical measurement of the density of particulate matter in the exhaust flow of an engine, expressed in m^{-1}. Time duration between the two consecutive free accelerations tests shall be 5 to 20 seconds
7.	**Test type II – free acceleration test results and requirements**
7.1	The test value measured in accordance with point 6.5 shall be in compliance with the requirements laid down in CMV Rule No. 115 (2).
8	**COP procedure – Technical Requirements**
8.1	COP test procedure for Type II test shall be as per clause 6.0 of Appendix 10 to Chapter 2W-II.

Chapter 3W- IV
Type III tests- Emissions of Crankcase gases and Type IV tests – Evaporative Emissions.

1	**Purpose**
	This Chapter provides the test methods for the determination of crankcase gas emissions (Test Type III).
	This Chapter also provides test procedures to determine evaporative emissions (Test Type IV) owing to evaporation of fuel through the vehicle's fuel tank and fuel delivery system.
2	**Scope and application**
2.1	Three-wheeled Vehicles of L5 category with regard to the propulsion unit and fuel type in accordance with notification.
3	For Definitions refer clause 3 of overall requirements.
4.	**List of acronyms and symbols:** refer Table 2 of Appendix 1 Chapter 3W-II
5.	**General requirements**
5.1	Vehicles, systems, and components shall be so designed, constructed and assembled by the manufacturer, so as to enable the vehicle, in normal use and maintained according to the prescriptions of the manufacturer, to comply with the provisions of this Chapter during its useful life.
6.	**Test type III requirements:** emissions of crankcase gases
6.1	**Introduction**
6.1.1	Test type III shall be conducted in order to demonstrate that zero emissions from the crankcase and/or if applicable the crankcase ventilation system can escape directly into the atmosphere.
6.2	**General provisions**
6.2.1	Zero emissions from the crankcase and/or if applicable the crankcase ventilation system may escape directly into the atmosphere from any vehicle throughout its useful life. For this purpose it may require:
6.2.1.1	A written declaration from the vehicle manufacturer that the propulsion unit is equipped with a closed crankcase system preventing crankcase gas to be discharged directly into the ambient atmosphere. In this case the Type III test requirements may be waived.
6.2.2	The manufacturer shall provide the test agency with technical details and drawings to prove that the engine or engines are so constructed as to prevent vapour of any fuel, lubrication oil or crankcase gases from escaping to the atmosphere from the crankcase gas ventilation system.

6.2.3	A physical verification may be conducted that the crankcase breather is not let out into atmosphere but is connected to the Intake system.
6.2.4	Type III test is not applicable for vehicles equipped with a two-stroke engine containing a scavenging port between the crank case and the cylinder(s).
7.	**Test type IV requirements: Evaporative emissions**
7.1.	Introduction – evaporative emissions
7.1.1	The procedure laid down in Appendix 1 of this chapter sets out the evaporative hydrocarbon emission determination requirements of the whole vehicle.
7.2.	**Test fuel** The appropriate test fuel, as defined in notification shall be used.
7.2.1	If the combustion engine uses a petrol-lubrication oil mixture, the lubrication oil added to the reference fuel shall comply with the grade and quantity recommended by the manufacturer.
7.3.	**Documentation**
	The vehicle manufacturer shall fill out the information in accordance with the evaporative emission test parameters laid down in AIS- 007 and submit it to the test agency.

1	**Description of SHED test**

	The evaporative emission SHED test (Figure Ap1-1) consists of a conditioning phase and a test phase, as follows:
	
	(a) conditioning phase:
	
	      (i) driving cycle;
	
	      (ii) vehicle soak;
	
	(b) test phase:
	
	      (i) diurnal (breathing loss) test;
	
	      (ii) driving cycle;
	
	      (iii) hot soak loss test.
	
	Mass emissions of hydrocarbons from the tank breathing loss and the hot soak loss phases are added together to provide an overall result for the test.

	  Figure Ap1-1 **Flow Chart – SHED test procedure**
2	**Test vehicle requirement**
2.1.	Durability The SHED test shall be conducted at the choice of the manufacturer with one or more degreened test vehicle(s) equipped with aged evaporative emission control devices. The ageing test procedure set-out in Appendix 4 shall apply.
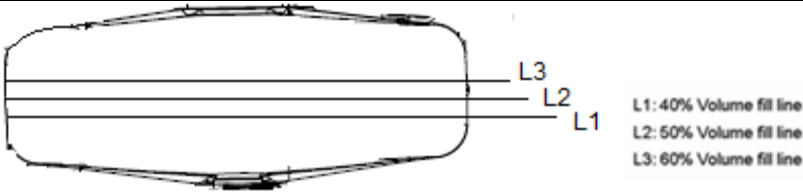
2.2.	**Test vehicles**
	The degreened test vehicle, which shall be representative of the vehicle type with regard to environmental performance to be approved, shall be in good mechanical condition and, before the evaporative test, have been run in and driven at least 1000 km after first start on the production line. The evaporative emission control system shall be connected and functioning correctly over this period and the carbon canister[1] and evaporative emission control valve subjected to normal use, undergoing neither abnormal purging nor abnormal loading. [1] Or the canister with HC absorbent material or other equivalent.
2.2.1	The ageing of the canister(s) has to be verified. This may be done by demonstrating that it has accumulated a minimum of 1000 km. If this demonstration is not given, Procedure prescribed in Appendix 2 of this chapter shall be used. In the case of a multiple canister system each canister must undergo the procedure separately.
3.	**Chassis dynamometer and evaporative emissions enclosure**
3.1.	The chassis dynamometer shall meet the requirements of Appendix 3 to **Chapter 3W-II** provided that the chassis dynamometer shall be capable of accommodating three-wheeled vehicles (e.g. two rollers, long single roller)
3.2.	**Evaporative emission measurement enclosure (SHED)**
	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 when inside and the enclosure when sealed shall be gas-tight. The inner surface of the enclosure shall be impermeable to hydrocarbons. At least one of the surfaces shall incorporate a flexible impermeable material or other device to allow the equilibration of pressure changes resulting from small changes in temperature. Wall design shall be such as to promote good dissipation of heat.
3.3.	**Analytical systems**
3.3.1.	Hydrocarbon analyzer
3.3.1.1.	The atmosphere within the chamber is monitored using a hydrocarbon detector of the flame ionization detector (FID) type. Sample gas shall be drawn from the midpoint of one side wall or the roof of the chamber and any bypass flow shall be returned to the enclosure, preferably to a point immediately downstream of the mixing fan.
3.3.1.2.	The hydrocarbon analyzer shall have a response time to 90% of final reading of less than 1.5 seconds. Its stability shall be better than 2 % of full scale at zero and at 80% ± 20% of full scale over a 15-minute period for all operational ranges.
3.3.1.3.	The repeatability of the analyzer expressed as one standard deviation shall be better than 1 % of full scale deflection at zero and at 80% ± 20% of full scale on all ranges used.
3.3.1.4.	The operational ranges of the analyzer shall be chosen to give best resolution over the measurement, calibration and leak-checking procedures.

3.3.2.	Hydrocarbon analyzer data recording system
3.3.2.1.	The hydrocarbon analyzer 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 fuel tank heating and hot soak periods together with the time elapsed between start and completion of each test.
3.4.	**Fuel tank heating**
3.4.1.	The fuel tank heating system shall consist of at least two separate heat sources with two temperature controllers. A typical heat source shall be a pair of heating pads. Other heat sources may be used as required by the circumstances at the request of the manufacturer to the satisfaction of the test agency. Temperature controllers may be manual, such as variable transformers, or they may be automated. Since vapour and fuel temperature are to be controlled separately, an automatic controller is recommended both for the fuel and the vapour.
3.4.2	The heating system shall not cause hot-spots on the wetted surface of the tank which would cause local overheating of the fuel. Heating pads, for the fuel if used, shall be located as low as practicable on the fuel tank and shall cover at least 10 % of the wetted surface. The centre line of the fuel heating strips if used, shall be below 30% of the fuel depth as measured from the bottom of the fuel tank, and approximately parallel to the fuel level in the tank. The centre line of the vapour heating strips, if used, shall be located at the approximate height of the centre of the vapour volume. The temperature controllers shall be capable of controlling the fuel and vapour temperatures to the heating function laid down in paragraph 4.3.1.6.
3.4.3	In order to ensure uniform and appropriate heating and measurement of temperature for fuel and vapour the following precautions or the manufacturer recommendations shall be followed: a) Separate heating pads for fuel and vapour shall cover as much area as possible; b) The pasting of heating pads on either side of fuel tank shall be symmetric for fuel and vapour heating; c) The position of fuel and vapour temperature sensors shall be as close to the area covered by heating pads respectively; d) No fuel heating pad shall be located above a 40% volume fill line from bottom. Likewise no vapour heating pad for the tank evaporative test shall be below the 60 % volume fill line from bottom.

L1: 40% Volume fill line
L2: 50% Volume fill line
L3: 60% Volume fill line

Figure Ap1-2

Example fuel tank with appropriate positioning of fuel tank heating pads to control fuel and vapour temperatures.

3.4.4	With temperature sensors positioned as in paragraph 3.5.2, the fuel heating device shall make it possible to evenly heat the fuel and fuel vapour in the tank in accordance with the heating function described in 4.3.1.6. The heating system shall be capable of controlling the fuel and vapour temperatures to $\pm$ 1.7 K ($\pm$ 1.7 °C) of the required temperature during the tank heating process.
3.4.5	Notwithstanding the requirements of paragraph 3.4.2, if a manufacturer is unable to meet the heating requirement specified, due to use of thick-walled plastic fuel tanks for example, then the closest possible alternative heat slope shall be used. Prior to the commencement of any test, manufacturers shall submit engineering data to the test agency to support the use of an alternative heat slope.
3.5.	**Temperature recording**
3.5.1.	The temperature in the chamber is recorded at two points by temperature sensors which are connected so as to show a mean value. The measuring points are extended approximately 0.1 m into the enclosure from the vertical centre line of each side wall at a height of 0.9 ± 0.2 m.
3.5.2.	The temperatures of the fuel and fuel vapour shall be recorded by means of sensors positioned in the fuel tank so as to measure the temperature of the prescribed test fuel at the approximate mid-volume of the fuel. In addition, the vapour temperature in the fuel tank shall be measured at the approximate mid-volume of the vapour.
3.5.3	When the fuel or vapour temperature sensors cannot be located in the fuel tank to measure the temperature of the prescribed test fuel or vapour at the approximate mid-volume, sensors shall be located at the approximate mid-volume of each fuel or vapour containing cavity. The average of the readings from these sensors shall constitute the fuel or vapour temperature. The fuel and vapour temperature sensors shall be located at least one inch away from any heated tank surface. The test agency may approve alternate sensor locations where the specifications above cannot be met or where tank symmetry provides redundant measurements.
3.5.4	Throughout the evaporative emission measurements, temperatures shall be recorded or entered into a data processing system at a frequency of at least once per minute.

3.5.5	The accuracy of the temperature recording system shall be within ± 1.7 K (± 1.7 °C) and capable of resolving temperatures to 0.5 K (0.5 °C.)
3.5.6	The recording or data processing system shall be capable of resolving time to ± 15 seconds.
3.6.	**Fans**
3.6.1.	It shall be possible to reduce the hydrocarbon concentration in the chamber to the ambient hydrocarbon level by using one or more fans or blowers with the SHED door(s) open.
3.6.2.	The chamber shall have one or more fans or blowers of likely capacity 0.1 to 0.5 m³/s with which it is possible 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.
3.7.	**Gases**
3.7.1.	The following pure gases shall be available for calibration and operation: a) purified synthetic air (purity: < 1 ppm C1 equivalent <1 ppm CO, < 400 ppm CO_2, 0.1 ppm NO); oxygen content between 18 and 21 % by volume; b) hydrocarbon analyzer fuel gas (40 ± 2 % hydrogen, and balance helium with less than 1 ppm C1 equivalent hydrocarbon, less than 400 ppm CO_2); c) propane (C_3H_8), 99.5 % minimum purity.
3.7.2.	Calibration and span gases shall be available containing mixtures of propane (C_3H_8) and purified synthetic air. The true concentrations of a calibration gas shall be within ± 2% of the stated figures. The accuracy of the diluted gases obtained when using a gas divider shall be to within ± 2% of the true value. The concentrations specified in paragraph 3.7.1 may also be obtained by the use of a gas divider using synthetic air as the diluting gas. The FID analyzer shall be calibrated using air/propane or air/hexane mixtures with nominal hydrocarbon concentrations equal to 50 % and 90 % of full scale.
3.8.	**Additional equipment**
3.8.1.	The relative humidity in the test area shall be measurable to within ± 5 %.
3.8.2.	The pressure within the test area shall be measurable to within ± 0.1 kPa.
3.9.	**Alternative equipment**
3.9.1.	At the request of the manufacturer and with the agreement of the test agency, the test agency may authorize the use of alternative equipment provided that it can be demonstrated that it gives equivalent results.

4.	**Test procedure**
4.1.	**Test preparation**
4.1.1.	The vehicle is 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) the fuel tank of the vehicle shall be equipped with temperature sensors so that the temperature of the fuel and fuel vapour in the fuel tank can be measured when it is filled to 50 % ± 2 % of its capacity declared by the manufacturer; d) additional fittings, adaptors or devices may optionally be fitted to allow a complete draining of the fuel tank. Alternatively, the fuel tank may be evacuated by means of a pump or siphon that prevents fuel spillage.
4.2.	**Conditioning phase**
4.2.1.	The vehicle shall be taken into the test area where the ambient temperature is between 293.2 K (20 °C) and 303.2 K(30 °C).
4.2.2.	Before switching off the engine, the test vehicle is placed on a chassis dynamometer and driven a single time through the applicable Type I test cycle as specified in Appendix 6 to **Chapter 3W-II.**
4.2.3.	The vehicle is parked in the test area for the minimum period stated in Table Ap1-1.
	Table Ap1-1 **SHED test – minimum and maximum soak periods**<table><tr><td>Engine capacity</td><td>Minimum (hours)</td><td>Maximum (hours)</td></tr><tr><td>< 170 cm³</td><td>6</td><td>36</td></tr><tr><td>170 cm³ ≤ engine capacity < 280 cm³</td><td>8</td><td>36</td></tr><tr><td>≥ 280 cm³</td><td>12</td><td>36</td></tr></table>
4.3.	**Test phases**
4.3.1.	**Tank breathing (diurnal) evaporative emission test**
4.3.1.1.	The measuring chamber shall be vented/purged for several minutes immediately before the test until a stable background is obtainable. The chamber mixing fan(s) shall be switched on at this time also.

4.3.1.2.	The hydrocarbon analyzer shall be set to zero and spanned immediately before the test.
4.3.1.3.	The fuel tank(s) shall be emptied as described in paragraph 4.1.1 and refilled with test fuel at a temperature of between 283.2 K (10 °C) and 287.2 K(14 °C) to 50 % ± 2% of the capacity declared by the manufacturer.
4.3.1.4.	The test vehicle shall be brought into the test enclosure with the engine switched off and parked in an upright position. The fuel tank sensors and heating device shall be connected, if necessary. Immediately begin recording the fuel temperature and the air temperature in the enclosure. If a venting/purging fan is still operating, it shall be switched off at this time.
4.3.1.5.	The fuel and vapour may be artificially heated to the starting temperatures of 288.7 K (15.5 °C) and 294.2 K ± 1 K (21.0 °C ± 1 °C) respectively. An initial vapour temperature up to 5 K (5 °C) above 294.2 K (21.0 °C) may be used. For this condition, the vapour shall not be heated at the beginning of the diurnal test. When the fuel temperature has been raised to 5.5 K(5.5 °C) below the vapour temperature by following the T_f function, the remainder of the vapour heating profile shall be followed.
4.3.1.6.	As soon as the fuel temperature reaches 287.2 K (14.0 °C): (1) Install the fuel filler cap(s); (2) Turn off the purge blowers, if not already off at that time; (3) Close and seal enclosure doors.
	As soon as the fuel reaches a temperature of 288.7 K ± 1K (15.5 °C ± 1 °C) the test procedure shall continue as follows: (a) the hydrocarbon concentration, barometric pressure and the temperature shall be measured to give the initial readings C_{HC}, i, p_i and T_i for the tank heat build test; (b) a linear heat build of 286.5 K (13.3 °C) or 293.2 K ± 0.5 (20 °C ± 0.5 °C) over a period of 60 ± 2 minutes shall begin. The temperature of the fuel and fuel vapour during the heating shall conform to the function below to within ± 1.7 K (± 1.7 °C), or the closest possible function as described in 3.4:
	For exposed type fuel tanks: Equations Ap1-1: $T_f = 0.3333 * t + 288.5$ K $T_v = 0.3333 * t + 294$ K
	For non-exposed type fuel tanks: Equations Ap1-2: $T_f = 0.2222 * t + 288.5$ K $T_v = 0.2222 * t + 294$ K

	where:
	T_f = required temperature of fuel (K);
	T_v = required temperature of vapour (K);
	t = time from start of the tank heat build in minutes.
4.3.1.7	The hydrocarbon analyzer is set to zero and spanned immediately before the end of the test.
4.3.1.8.	If the heating requirements in paragraph 4.3.1.6 have been met over the 60 ± 2 minute period of the test, the final hydrocarbon concentration in the enclosure is measured (C_{HC},f). The time or elapsed time of this measurement is recorded, together with the final temperature and barometric pressure T_f and p_f.
4.3.1.9.	The heat source is turned off and the enclosure door unsealed and opened. The heating device and temperature sensor are disconnected from the enclosure apparatus. The vehicle is now removed from the enclosure with the engine switched off.
4.3.1.10.	To prevent abnormal loading of the carbon canister, fuel tank caps may be removed from the vehicle during the period between the end of the diurnal test phase and the start of the driving cycle. The driving cycle shall begin within 60 minutes of the completion of the breathing loss test.
4.3.2.	**Driving cycle**
4.3.2.1.	Following the tank breathing losses test, the vehicle is pushed or otherwise maneuvered on to the chassis dynamometer with the engine switched off. It is then driven through the driving cycle specified in Appendix 6 to **Chapter 3W-II.**
4.3.3.	**Hot soak evaporative emissions test**
	The level of evaporative emissions is determined by the measurement of hydrocarbon emissions over a 60-minute hot soak period. The hot soak test shall begin within seven minutes of the completion of the driving cycle specified in point 4.2 and within two minutes of engine shutdown.
4.3.3.1.	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.
4.3.3.2.	The hydrocarbon analyzer shall be set to zero and spanned immediately prior to the test.
4.3.3.3.	The vehicle shall be pushed or otherwise moved into the measuring chamber with the engine switched off.
4.3.3.4.	The enclosure doors are closed and sealed gas-tight within seven minutes of the end of the driving cycle.
4.3.3.5.	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_{HC}, i, p_i and T_i for the hot soak test. These figures are used in the evaporative emission calculation laid down in paragraph 5.
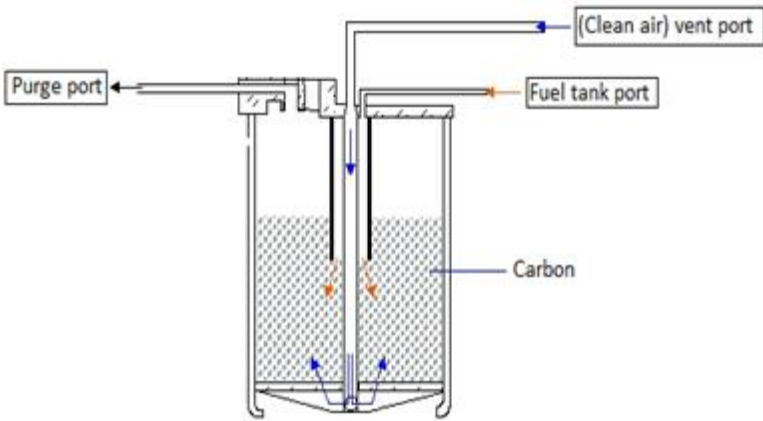
4.3.3.6.	The hydrocarbon analyzer shall be zeroed and spanned immediately before the end of the 60 ± 0.5 minute test period.
4.3.3.7.	At the end of the 60 ± 0.5 minute test period, measure the hydrocarbon concentration in the chamber. The temperature and the barometric pressure are also measured. These are the final readings C_{HC}, f. p_f and T_f for the hot soak test used for the calculation in paragraph 5. This completes the evaporative emission test procedure.
4.4.	**Alternative test procedures**
4.4.1.	At the request of the manufacturer to the satisfaction of the test agency, alternative methods may be used to demonstrate compliance with the requirements of this Appendix. In such cases, the manufacturer shall satisfy the test agency that the results from the alternative test can be correlated with those resulting from the procedure described in this Appendix. This correlation shall be documented and added to the information folder.
5.	**Calculation of results**
5.1.	The evaporative emission tests described in point 4 allow the hydrocarbon emissions from the tank breathing and hot soak phases to be calculated. Evaporative losses from each of these phases is calculated using the initial and final hydrocarbon concentrations, temperatures and pressures in the enclosure, together with the net enclosure volume.
	The formula below is used: Equation Ap1-3: $$m_{HC} = k \cdot V \cdot 10^{-4} \cdot \left(\frac{C_{HC_f} \cdot p_f}{T_f} - \frac{C_{HC_i} \cdot p_i}{T_i} \right)$$ where: m_{HC} = mass of hydrocarbon emitted over the test phase (grams); C_{HC} = hydrocarbon concentration measured in the enclosure (ppm (volume) C_1 equivalent); V = net enclosure volume in cubic metres corrected for the volume of the vehicle. If the volume of the vehicle is not determined, a volume of 0.25 m^3 shall be subtracted; T = ambient chamber temperature, K; p = barometric pressure in kPa; H/C = hydrogen to carbon ratio; k = 1.2 (12 + H/C); where:

		i is the initial reading;
		f is the final reading;
		H/C is taken to be 2.33 for tank breathing losses;
		H/C is taken to be 2.20 for hot soak losses.
5.2.		**Overall results of test**
		The overall evaporative hydrocarbon mass emission for the vehicle is taken to be:
		Equation Ap1-4: $$m_{total} = m_{TH} + m_{HS}$$ where: m_{total} = overall evaporative mass emissions of the vehicle (grams); m_{TH} = evaporative hydrocarbon mass emission for the tank heat build (grams); m_{HS} = evaporative hydrocarbon mass emission for the hot soak (grams).
6.		**Test limit values**
		When tested according to this Appendix, overall evaporative total hydrocarbon mass emission for the vehicle (m_{total}) shall not exceed the limit values as specified in the notification.

Appendix 2 to Chapter 3W- IV
Ageing test procedures for evaporative emission control devices

1.	Test methods for ageing of evaporative emission control devices The SHED test shall be conducted with aged evaporative emission control devices fitted. The ageing tests for those devices shall be conducted according to the procedures in this Appendix.
2.	Carbon canister ageing
	A carbon canister representative of the propulsion family as set out in Chapter 3W-XI shall be selected as test canister. Canister aging shall be conducted at the choice of manufacturer by the carbon canister aging procedure A or B.
	  Figure Ap A2-1 **Carbon canister gas flow diagram and ports**
2.1.	**Canister ageing test procedure A** In the case of a multiple carbon canister system, each carbon canister shall undergo the procedure separately. The number of test cycles of carbon canister loading and discharging shall correspond to the number set out in Table Ap 2a-1.
	Table Ap 2a-1 **Vehicle classification and the required number of loading and discharging of the carbon canister for rapid ageing.** | Vehicle classification	Number of cycles
vmax $\leqq$ 50 km/h	90
50km/h < vmax < 130 km/h	170
vmax $\geqq$ 130 km/h	300	
	The dwell time and subsequent purging of fuel vapour shall be run to age the test carbon canister at an ambient temperature of 24 °C ± 2 °C as follows:

2.1.1.	**Canister loading part of the test cycle**
2.1.1.1.	Loading of the carbon canister shall start within one minute of completing the purge portion of the test cycle.
2.1.1.2.	The (clean air) vent port of the carbon canister shall be open and the purge port shall be capped. A mix by volume of 50 percent air and 50 percent commercially available petrol or reference fuel shall enter through the tank port of the test carbon canister at a flow rate of 40 grams/hour. The petrol vapour shall be generated at a petrol temperature of 40 ± 2 °C.
2.1.1.3	The test carbon canister shall be loaded each time to 2000 mg or more breakthrough detected by:
2.1.1.3.1.	FID analyzer reading (using a mini-SHED or similar) or 5000 ppm instantaneous reading on the FID occurring at the (clean air) vent port; or
2.1.1.3.2.	Gravimetrical test method using the difference in mass of the test carbon canister charged to 2000 mg or more breakthrough and the purged carbon canister. In this case the test equipment shall be capable of measuring the mass with a minimum accuracy in the range between 0 and +100 mg.
2.1.2.	**Dwell time**
	A five minute dwell period between carbon canister loading and purging as part of the test cycle shall be applied.
2.1.3	Canister purging part of the test cycle
2.1.3.1.	The test carbon canister shall be purged through the purge port and the tank port shall be capped.
2.1.3.2.	Four hundred carbon canister bed volumes shall be purged at a rate of 24 l/min into the vent port.
2.2	**Canister ageing test procedure B**
2.2.1.	A test cycle will include loading the HC storing components with gasoline vapours up to 80 percent by weight of its maximum storing capacity followed by 10 minutes waiting with the system intake port sealed. Then purge shall start using a flow rate of 28.3 ± 5.5 l/min at 20 °C ± 5°C for 7.5 minutes
2.2.2.	The method to be used to load the storing components consists of heating a container filled with a pre-measured quantity of petrol up to 80 °C. At 80 °C approximately one third of the petrol will evaporate. The evaporated petrol shall be equivalent to 80 percent (by weight) of the HC storing capacity of the HC storing components. The petrol vapours are allowed to enter through the intake of the storing components.
2.2.3.	The number of test cycles of carbon canister loading and purging shall correspond to the number set out in Table Ap 2a-1.

Appendix 2 to Chapter 3W- IV
B) Alternate Ageing test procedures for evaporative emission control devices

1	Alternatively, for a canister ageing test specified in A) of this Appendix, following procedure may be used. In the case of a multiple canister system each canister must undergo the procedure separately
1.1	The canister is removed from the vehicle. Special care must be taken during this step to avoid damage to components and the integrity of the fuel system.
1.2	The weight of the canister must be checked.
1.3	The canister is connected to a fuel tank, possibly an external one, filled with reference fuel, to 40% volume of the fuel tank(s).
1.4	The fuel temperature in the fuel tank must be between 283 K (10 °C) and 287 K (14 °C)
1.5	The (external) fuel tank is heated from 288 K to 318 K (15 °C to 45 °C) (1 °C increase every 9 minutes)
1.6	If the canister reaches breakthrough before the temperature reaches 318 K (45 °C), the heat source must be turned off. Then the canister is weighed. If the canister did not reach breakthrough during the heating to 318 K (45 °C), the procedure from 1.3 of this appendix must be repeated until breakthrough occurs.
1.7	Breakthrough may be checked as is described in 2.4 and 2.5 of this Chapter, or with the use of another sampling and analytical arrangement capable of detecting the emission of hydrocarbons from the canister at breakthrough.
1.8	The canister must be purged with 25 ± 5 liters per minute with the emission laboratory air until 300 bed volume exchanges are reached
1.9	The weight of the canister must be checked.
1.10	The steps of the procedure in 1.4 and 1.9 must be repeated nine times. The test may be terminated prior to that, after not less than three ageing cycles, if the weight of the canister after the last cycles has stabilized.
1.11	The evaporative emission canister is reconnected and the vehicle restored to its normal operating condition.
2	One of the methods specified in 2.4 and 2.5 must be used to precondition the evaporative canister. For vehicles with multiple canisters, each canister must be preconditioned separately
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.
2.2	Breakthrough may be verified using the evaporative emission enclosure as described in 2.4 and 2.5 respectively. Alternatively, breakthrough may be determined using an auxiliary evaporative canister connected downstream of the vehicle's canister. The auxiliary canister must be well purged with dry air prior to loading

2.3	The measuring chamber must be purged for several minutes immediately before the test until a stable background is obtained. The chamber air mixing fan(s) must be switched on at this time. The hydrocarbon analyzer must be zeroed and spanned immediately before the test.
2.4	Canister Loading with Repeated Heat Builds to Breakthrough
2.4.1	The fuel tank(s) of the vehicle(s) is (are) emptied using the fuel tank drain(s). This must be done so as not to abnormally purge or abnormally load the evaporative control devices fitted to the vehicle. Removal of the fuel cap is normally sufficient to achieve this.
2.4.2	The fuel tank(s) is (are) refilled with test fuel at a temperature of between 283 K to 287 K (10 to 14 °C) to 40% ± 2 % of the tank's normal volumetric capacity. The fuel cap(s) of the vehicle must be fitted at this point.
2.4.3	Within one hour of being refueled the vehicle must be placed, with the engine shut off, in the evaporative emission enclosure. The fuel tank temperature sensor is connected to the temperature recording system. A heat source must be properly positioned with respect to the fuel tank(s) and connected to the temperature controller. The heat source is specified in 3.4 of this chapter In the case of vehicles fitted with more than one fuel tank, all the tanks must be heated in the same way as described below. The temperatures of the tanks must be identical to within ± 1.5 °K
2.4.4	The fuel may be artificially heated to the starting diurnal temperature of 293 K (20 °C) ± 1 K.
2.4.5	When the fuel temperature reaches at least 292 K (19 °C), the following steps must be taken immediately; the purge blower must be turned off; enclosure doors closed and sealed; and measurement initiated of the hydrocarbon level in the enclosure.
2.4.6	When the fuel temperature of the fuel tank reaches 293 K (20 °C) a linear heat build of 15 K (15 °C) begins. The fuel must be heated in such a way that the temperature of the fuel during the heating conforms to the function below to within ± 1.5 °K. The elapsed time of the heat build and temperature rise is recorded. $T_r = T_0 + 0.2333 \times t$ Where: T_r = required temperature (K); T_0 = initial temperature (K); T = time from start of the tank heat build in minutes.
2.4.7	As soon as breakthrough occurs or when the fuel temperature reaches 308 °K (35 °C), whichever occurs first, the heat source is turned off, the enclosure doors unsealed and opened, the vehicle fuel tank cap(s) removed. If breakthrough has not occurred by the time the fuel temperature reaches 308 °K (35 °C), the heat source is removed from the vehicle, the vehicle removed from the evaporative emission enclosure and the entire procedure outlined in 2.4 of this appendix repeated until breakthrough occurs.

Appendix 2 to Chapter 3W- IV
B) Alternate Ageing test procedures for evaporative emission control devices

2.5	**Butane Loading to Breakthrough**
2.5.1	If the enclosure is used for the determination of the breakthrough (see 2.2 of this appendix) the vehicle must be placed, with the engine shut off, in the evaporative emission enclosure.
2.5.2	The evaporative emission canister must be prepared for the canister loading operation. The canister must not be removed from the vehicle, unless access to it in its normal location is so restricted that loading can only reasonably be accomplished by removing the canister from the vehicle. Special care must be taken during this step to avoid damage to the components and the integrity of the fuel system
2.5.3	The canister is loaded with a mixture composed of 50% butane and 50% nitrogen by volume at a rate of 40 grams butane per hour.
2.5.4	As soon as the canister reaches breakthrough, the vapor source must be shut off,
2.5.5	The evaporative emission canister must then be reconnected and the vehicle restored to its normal operating condition

Appendix 3 to Chapter 3W- IV
Calibration of equipment for evaporative emission testing

1.	**Calibration frequency and methods**
1.1.	All equipment shall be calibrated before its initial use and then as often as necessary, and in any case in the month before approval testing. The calibration methods to be used are described in this Appendix.
2.	**Calibration of the enclosure**
2.1.	**Initial determination of enclosure internal volume**
2.1.1.	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.
2.1.2.	The net internal volume is determined by subtracting 0.25 m^3 from the internal volume of the chamber. Alternatively, the actual volume of the test vehicle may be subtracted.
2.1.3.	The chamber shall be checked as in point 2.3. If the propane mass does not tally to within $\pm$ 2 % with the injected mass, corrective action is required.
2.2.	**Determination of chamber background emissions**
	This operation determines that the chamber contains no materials that emit significant amounts of hydrocarbons. The check shall be carried out when the enclosure is brought into service, after any operations in it which may affect background emissions and at least once per year.
2.2.1.	Calibrate the analyzer (if required). The hydrocarbon analyzer shall be set to zero and spanned immediately before the test.
2.2.2.	Purge the enclosure until a stable hydrocarbon reading is obtained. The mixing fan is turned on, if not already on.
2.2.3.	Seal the chamber and measure the background hydrocarbon concentration, temperature and barometric pressure. These are the initial readings C_{HCi}. p_i and T_i used in the enclosure background calculation.
2.2.4.	The enclosure is allowed to stand undisturbed with the mixing fan on for 4 hours.
2.2.5.	The hydrocarbon analyzer shall be set to zero and spanned immediately before the end of the test.
2.2.6.	At the end of this time, use the same analyzer to measure the hydrocarbon concentration in the chamber. The temperature and the barometric pressure are also measured. These are the final readings C_{HCf}, p_f and T_f.
2.2.7.	Calculate the change in mass of hydrocarbons in the enclosure over the time of the test in accordance with the equation in point 2.4. The background emission of the enclosure shall not exceed 400 mg.

2.3.	**Calibration and hydrocarbon retention test of the chamber**
	The calibration and hydrocarbon retention test in the chamber provides a check on the calculated volume in point 2.1.1 and also measures any leak rate.
2.3.1.	Purge the enclosure until a stable hydrocarbon concentration is reached. Turn on the mixing fan, if it is not already on. The hydrocarbon analyzer shall be calibrated (if necessary) then set to zero and spanned immediately before the test.
2.3.2.	Seal the enclosure and measure the background concentration, temperature and barometric pressure. These are the initial readings C_{HCi}. p_i and T_i used in the enclosure calibration.
2.3.3.	Inject approximately 4 grams of propane into the enclosure. The mass of propane shall be measured to an accuracy of $\pm$ 2% of the measured value.
2.3.4.	Allow the contents of the chamber to mix for five minutes. The hydrocarbon analyzer shall be set to zero and spanned immediately before the following test. Measure the hydrocarbon concentration, temperature and barometric pressure. These are the final readings C_{HCf}, p_f and T_f for the calibration of the enclosure.
2.3.5.	Using the readings taken in accordance with points 2.3.2 and 2.3.4 and the formula in point 2.4, calculate the mass of propane in the enclosure. This shall be within $\pm$ 2% of the mass of propane measured in accordance with point 2.3.3. $\pm$ 2%
2.3.6.	Allow the contents of the chamber to mix for a minimum of 4 hours. Then measure and record the final hydrocarbon concentration, temperature and barometric pressure. The hydrocarbon analyzer shall be set to zero and spanned immediately before the end of the test.
2.3.7.	Using the formula in 2.4, calculate the hydrocarbon mass from the readings taken in points 2.3.6 and 2.3.2. The mass may not differ by more than 4% from the hydrocarbon mass calculated in accordance with point 2.3.5.
2.4.	**Calculations**
	The calculation of net hydrocarbon mass change within the enclosure is used to determine the chamber's hydrocarbon background and leak rate. Initial and final readings of hydrocarbon concentration, temperature and barometric pressure are used in the following formula to calculate the mass change: Equation Ap3-1: $$m_{HC} = kV \cdot 10^{-4} \cdot \left(\frac{C_{HC_f} \cdot p_f}{T_f} - \frac{C_{HC_i} \cdot p_i}{T_i} \right)$$ where:

	m_{HC} = mass of hydrocarbon in grams;
	C_{HC} = hydrocarbon concentration in the enclosure (ppm carbon (NB: ppm carbon = ppm propane x 3));
	V = enclosure volume in cubic metres as measured in accordance with point 2.1.1 above;
	T = ambient temperature in the enclosure, K;
	p = barometric pressure in kPa;
	k = 17.6;
	where:
	i is the initial reading;
	f is the final reading.
3.	**Checking of FID hydrocarbon analyzer**
3.1.	**Detector response optimization**
	The FID analyzer shall be adjusted as specified by the instrument manufacturer. Propane in air shall be used to optimize the response on the most common operating range.
3.2.	**Calibration of the HC analyzer**
	The analyzer shall be calibrated using propane in air and purified synthetic air. A calibration curve shall be established as described in points 4.1 to 4.5 below.
3.3.	**Oxygen interference check and recommended limits**
	The response factor (R_f) for a particular hydrocarbon species is the ratio of the FID C_1 reading to the gas cylinder concentration, expressed as ppm C_1.
	The concentration of the test gas shall be such as to give a response of approximately 80% of full scale deflection, for the operating range. The concentration shall be known to an accuracy of ± 2% in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder shall be preconditioned for 24 hours at between 293.2 K (20 °C) and 303.2 K (30 °C).
	Response factors shall be determined when introducing an analyzer into service and thereafter at major service intervals. The reference gas to be used is propane balanced with purified air which shall be taken to give a response factor of 1.00.
	The test gas to be used for oxygen interference and the recommended response factor range are given below:
	Propane and nitrogen $0.95 \leq R_f \leq 1.05$.

4.	**Calibration of the hydrocarbon analyzer**
	Each of the normally used operating ranges are calibrated by the following procedure:
4.1.	Establish the calibration curve by at least five calibration points spaced as evenly as possible over the operating range. The nominal concentration of the calibration gas with the highest concentrations shall be at least 80 % of the full scale.
4.2.	Calculate the calibration curve by the method of least squares. If the resulting polynomial degree is greater than 3, then the number of calibration points shall be at least the number of the polynomial degree plus 2.
4.3.	The calibration curve shall not differ by more than 2 % from the nominal value of each calibration gas.
4.4.	Using the coefficients of the polynomial derived from point 4.2, a table of indicated reading against true concentration shall be drawn up in steps of no greater than 1% of full scale. This is to be carried out for each analyser range calibrated. The table shall also contain: a) date of calibration; b) span and zero potentiometer readings (where applicable), 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.
4.5.	Alternative technology (e.g. computer, electronically controlled range switch) may be used if it can be shown to the satisfaction of the test agency that it can ensure equivalent accuracy.

Appendix 4 to Chapter 3W- IV
CONFORMITY OF PRODUCTION FOR VEHICLES WITH EVAPORATIVE EMISSION CONTROL SYSTEM

1	**Conformity of Production (COP)**
1.1	For routine end of production-line testing, the holder of the approval may demonstrate compliance by sampling vehicles which shall meet the following requirements. Alternatively, the full test procedure described in this Chapter shall be carried out. At the request of the manufacturer, an alternative test procedure may be used, if the procedure has been presented to and has been accepted during the type approval procedure by the test agency.
1.2	**Test for leakage:**
1.2.1	Vents to the atmosphere from the evaporative emission control system shall be isolated.
1.2.2	A pressure of 370 ± 10 mm of H_2O shall be applied to the fuel system.
1.2.3	The pressure shall be allowed to stabilize prior to isolating the fuel system from the pressure source.
1.2.4	Following isolation of the fuel system, the pressure shall not drop by more than 50 mm of H_2O in five minutes.
1.3	**Tests for Venting:**
1.3.1	Vents to the atmosphere from the emission control shall be isolated.
1.3.2	A pressure of 370 ± 10 mm of H_2O shall be applied to the fuel system.
1.3.3	The pressure shall be allowed to stabilize prior to isolating the fuel system from the present source.
1.3.4	The venting outlets from the emission control systems to the atmosphere shall be reinstated to the production condition.
1.3.5	The pressure of the fuel system shall drop to below 100 mm of H_2O within two minutes
1.4	**Purge Test:**
1.4.1	Equipment capable of detecting an airflow rate of 0.25 litres in one minutes 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.
1.4.2	The manufacturer may use a flow meter of his own choice, if acceptable to the test agency.
1.4.3	The vehicle shall be operated in such a manner that any design features of the purge system that could restrict purge operation is detected and the circumstances noted.
1.4.4	Whilst the engine is operating within the bounds note in 8.4.3 the air flow shall be determined by either.

CONFORMITY OF PRODUCTION FOR VEHICLES WITH EVAPORATIVE EMISSION CONTROL SYSTEM

1.4.4.1	The device being switched in a pressure drop from atmosphere to a level indicating that a volume of 0.25 litres of air has flowed into the evaporative emission control system within one minute; or
1.4.4.2	An alternative flow measuring device with a detectable reading of no less than 0.25 litre per minute.
1.5	If the requirements of 1.2, 1.3 and 1.4 are not met or cannot be verified, the SHED test as per Appendix 1 of this Chapter shall be carried out to establish compliance to COP. In case of COP test failure, manufacturer shall ensure that all necessary steps are taken to re-establish conformity of production as rapidly as possible by conducting a test(s) as per Appendix 1 of this Chapter and inform to test agency.

Chapter 3W- V
Type V tests – Durability of pollution control devices.

0	**Introduction**
0.1	This Chapter describes the procedures for type V testing to verify the durability of pollution-control devices of L5 category vehicles in accordance with notification .
0.2	The type V test procedure includes mileage accumulation procedures to age the test vehicles in a defined and repeatable way. It also includes the frequency of applied type I emission verification test procedures conducted before, during and after the mileage accumulation of the test vehicles.
1	**General requirements**
1.1	The powertrain of test vehicles and pollution-control device type fitted on the test vehicles shall be documented and listed by the manufacturer. The list shall include at a minimum such items as the specifications of the propulsion type and its powertrain, where applicable, the exhaust oxygen sensor(s), catalytic converter(s) type, particulate filter(s) or other pollution-control devices, intake and exhaust systems and any peripheral device(s) that may have an impact on the environmental performance of the approved vehicle. This documentation shall be added to the test report.
1.2	After environmental performance type approval, the manufacturer shall provide evidence of the possible impacts on type V test results of any modification, to the emission reduction system specification, the pollution-control device type specifications or other peripheral device(s) interacting with the pollution-control devices, in production of the vehicle type. The manufacturer shall provide the test agency with this documentation and evidence upon request in order to prove that the durability performance of the vehicle type with regard to environmental performance will not be negatively affected by any change in vehicle production, retrospective changes in the vehicle specification, changes in the specifications of any pollution-control device type, or changes in peripheral devices fitted on the approved vehicle type.
2	**Specific requirements**
2.1	**Test vehicle requirements**
2.1.1	The test vehicles used for type V durability testing and in particular the pollution-control and peripheral devices, that are relevant for the emission reduction system, shall be representative of the vehicle type produced in series and placed on the market, with regard to environmental performance.
2.1.2	The test vehicles shall be in good mechanical condition at the start of mileage accumulation and it shall not have run more than 100 km after it was first started at the end of the production line. The propulsion and pollution-control devices shall not have been used since its manufacture, with the exception of quality control tests and running of the first 100 km.
2.1.3	Regardless of the durability test procedure selected by the manufacturer, all pollution-control devices and systems, both including hardware, powertrain software and powertrain calibration, fitted on the test vehicles shall be installed and operating for the entire mileage accumulation period.

2.1.4	The pollution-control devices on the test vehicles shall be permanently marked under surveillance of the test agency before the start of mileage accumulation and be listed together with the vehicle identification number, powertrain software and powertrain calibration sets. The manufacturer shall make that list available at the request of the test agency.
2.1.5	Maintenance, adjustments and the use of the controls of the test vehicles shall be as recommended by the manufacturer in the appropriate repair and maintenance information. Same shall be also be included in the user's manual.
2.1.6	The durability test shall be conducted with commercially available fuel meeting with the requirements for the commercial fuel specified in notification . If the test vehicles is/are equipped with a two-stroke engine, lubricating oil shall be used in the proportion and of the grade recommended by the manufacturer in the user manual. The actual quality and quantity used shall be reported.
2.1.7	The cooling system of test vehicle shall enable the vehicle to operate at temperatures similar to those obtained during normal road use conditions (oil, coolant, exhaust system, etc.).
2.1.8	If the durability test is completed on a test track or road, the reference mass of the test vehicle shall be at least equal to that used for type I emission tests conducted on a chassis dynamometer.
2.1.9	If approved by the test agency and to their satisfaction, the type V test procedure may be carried out using a test vehicle of which the body style, gear box (automatic or manual) and wheel or tyre size differ from those of the vehicle type for which the environmental performance type-approval is sought.
2.2	In the type V test procedure, mileage shall be accumulated by driving the test vehicles either on a test track, or on the road or on a chassis dynamometer. The test track or test road shall be selected at the discretion of the manufacturer. The mileage accumulated in the type I emission verification tests may be added to the total accumulated mileage
2.2.1	**Chassis dynamometer used for mileage accumulation**
2.2.1.1	Chassis dynamometers used to accumulate test type V durability mileage shall enable the durability mileage accumulation cycle in Appendix 1 of this chapter, as applicable, to be carried out.
2.2.1.2	In particular, the dynamometer shall be equipped with systems simulating the same inertia and resistance to progress as those used in the type I emission laboratory test in Chapter 3W-II. Emission analysis equipment is not required for mileage accumulation. The same inertia and flywheel settings and calibration procedures shall be used for the chassis dynamometer referred to in Chapter 3W-II used to accumulate mileage with the test vehicles.
2.2.1.3	The test vehicles may be moved to a different bench in order to conduct type I emission verification tests.
2.3	The type I emission verification tests before, during and after durability mileage accumulation shall be conducted according to the test procedures for emissions after cold start set out in Chapter 3W-II. All type I emission verification test results shall be listed and made available to the test agency upon request. The

	results of type I emission verification tests at the start and the finish of durability mileage accumulation shall be included in the test report. At least the first and last type I emission verification tests shall be conducted or witnessed by the test agency and reported to them. The test report shall confirm and state whether the test agency conducted or witnessed the type I emission verification testing.
2.4	The difference between the actual mileage accumulation at each emission test interval and the planned mileage accumulation shall not exceed 200 km.
2.5	During the emission test (Type-I), if the test is affected by abnormal behavior of the vehicle, test shall be discarded. In any other case, the test result shall be deemed effective. The results which are discarded and the reasons thereof shall be recorded in the test report.
2.6	If D.F. is less than 1, it shall be deemed as 1.
2.7	D.F. for each applicable pollutant shall be calculated separately.
3	**Test type V, durability test procedure specifications** The durability test may be carried out at the choice of the manufacturer in the following ways prescribed in 3.1 and 3.2 :
3.1	**Actual durability testing with full mileage accumulation :** In the durability test procedure with full mileage accumulation to age the test vehicles, the test vehicles shall physically accumulate the full distance set out in the notification and shall be tested in accordance with the defined procedure. The emission test results up to and including the full distance set out in notification shall be lower than the tailpipe emission limits set out in notification. Full mileage accumulation shall mean full completion of the assigned test distance laid down in notification by repeating the driving cycle laid down in Appendix 1 of this chapter.
3.1.1	The emission limits in the applicable type I emission laboratory test cycle, as set out in notification, of the aged test vehicles shall not exceed when starting mileage accumulation, during the accumulation phase and after full mileage accumulation has been finalized.
3.1.2	Multiple type I emission tests shall be conducted during the full mileage accumulation phase with a frequency and amount at the choice of the manufacturer as per type I test procedures and to the satisfaction of the test agency. The type I emission test results shall provide sufficient statistical relevance to identify the deterioration trend, which shall be representative of the vehicle type with regard to environmental performance as placed on the market (see Figure 5-1).

Chapter 3W- V
Type V tests – Durability of pollution control devices.

	Figure 5-1 **Test type V – durability test procedure with full mileage accumulation**
3.2	**Actual durability testing with partial mileage accumulation :** In the durability test procedure with partial mileage accumulation, the test vehicles shall physically accumulate a minimum of 50 % of the full distance set out in BS VI emission norms and shall be tested in accordance with the defined procedure. The test results shall be extrapolated up to the full distance set out in BS VI emission norms. Both the test results and the extrapolated results shall be lower than the tailpipe emission limits set out in BS VI emission norms. Partial mileage accumulation shall involve completion of a minimum of 50 % of the test distance specified in BS VI emission norms and compliance with the stop criteria in clause 3.2.3.
3.2.1	The manufacturer shall provide evidence that the emission limits in the applicable type I emission laboratory test cycle, as set out in BS VI emission norms, of the tested aged vehicles are not exceeded at the start of mileage accumulation, during the accumulation phase and after the partial accumulation.
3.2.2	Multiple type I emission tests shall be conducted during the partial mileage accumulation phase, with the frequency and number chosen by the manufacturer as per type I test procedures. The type I emission test results shall provide sufficient statistical relevance to identify the deterioration trend, which shall be representative of the vehicle type with regard to the environmental performance placed on the market (see Figure 5-2).

	Figure 5-2
	Test type V – accelerated durability test procedure with partial mileage accumulation
	New vehicle(s) from (proto-type) production line Start Type V test: conduct Type I emission tests, degreened vehicle Multiple Type I emission tests, partially aged vehicle Finish type V test: conduct Type I emission tests, partially aged vehicle Maximum allowed mileage prior to start mileage accumulation: 100 km Partial mileage accumulation, minimum 50 % of assigned distance: 1) For all 3 Wheelers
3.2.3	Stop criteria for the durability test procedure with partial mileage accumulation Partial mileage accumulation may stop if the following criteria are met:
3.2.3.1	if a minimum of 50 % of the applicable test distance laid down in BS VI emission norms has been accumulated; and
3.2.3.2	if all the type I emission verification test results are below the emission limits laid down in BS VI emission norms at all times during the partial mileage accumulation phase; or
3.2.3.3	if the manufacturer cannot prove that the stop criteria in clauses 3.2.3.1 and 3.2.3.2 are met, the mileage accumulation shall continue to the point where those criteria are met or to the fully accumulated mileage set out clause 3.1.
3.2.4	Data processing and reporting for the durability test procedure with partial mileage accumulation
3.2.4.1	The manufacturer shall use the arithmetic mean of the type I emission test results at each test interval, with a minimum of two emission tests per test interval. All arithmetic means of type I emissions test results shall be plotted per CO, HC+NOx, NOx, and if applicable PM, emission constituent, against accumulation distance rounded to the nearest kilometer.
3.2.4.2	The best fit linear line (trend line: $y = ax + b$) shall be fitted and drawn through all these data points based on the method of least squares. This best-fit straight trend line shall be extrapolated over the full durability mileage laid down in notification. At the request of the manufacturer, the trend line may start as of 20 % of the durability mileage laid down in notification, in order to take into account possible run-in effects of the pollution-control devices.

3.2.4.3	A minimum of four calculated arithmetic mean data points shall be used to draw each trend line, with the first at, or before, 20 % of the durability mileage laid down in BS VI emission norms and the last one at the end of mileage accumulation; at least two other data points shall be equally spaced between the first and final type I test measurement distances.
3.2.4.3.1	If the planned emission (Type I) test is coinciding with a scheduled maintenance kilometer, the manufacturer shall have following options: Option-1, the emission type I test shall be conducted before or after the maintenance at the choice of manufacturer. Option 2: the emission type I test shall be conducted before and after the maintenance. Arithmetic mean of the results before maintenance and after maintenance shall be calculated separately. These two arithmetic mean values shall be used determining the best fit line.
3.2.4.4	The applicable emission limits set out in notification shall be plotted in the graphs per emission constituent . The plotted trend line shall not exceed these applicable emission limits at any mileage data point. The graph per HC+NOx, CO, NOx and if applicable PM, emission constituent plotted against accumulation distance shall be added to the test report. The list with all the type I emission test results used to establish the best-fit straight trend line shall be made available to the test agency upon request.
	Theoretical example of the type I results of a pollutant is plotted and the best-fit straight trend line is drawn.
	  Fig A5-3.1 **illustrates full mileage accumulation test.**

	Fig A5-3.2 **illustrates partial mileage accumulation test.**
3.2.4.5	Trend line parameters a, x and b of the best-fit straight lines and the calculated pollutant value at the end of mileage according to the vehicle category shall be stated in the test report. The graph for all emission constituents shall be plotted in the test report. In the test report it shall also be stated which measurements were taken or witnessed by the test agency and which by the manufacturer.
3.2.4.6	**Calculation of Full D.F** : The D.F for HC, CO, NOx+HC, NOx and If applicable PM shall be calculated from the best fit line derived from clause 3.2. D.F is the ratio of mass emission values for each above pollutants calculated from the best fit line at full mileage and that at 1000 km mileage as given in following equation. $D.F_{(full)} = \dfrac{Mi2}{Mi1}$ Where M_{i2} = mass emission of the pollutants in g/km at full mileage. M_{i1} = mass emission of the pollutants in g/km at 1000 km mileage.
3.2.4.7	D.F Extrapolated In case the test is done for partial mileage accumulation, the M_{i2} will be calculated from the extrapolated line at full mileage. $D.F_{(extrapolated)} = \dfrac{Mi2}{Mi1}$ Where M_{i2} = mass emission of the pollutants in g/km at extrapolated full mileage. M_{i1} = mass emission of the pollutants in g/km at 1000 km mileage.

3.2.4.8	D.F Extended
	Partial accumulation of mileage: D.F(partial) shall be calculated as per following equation:
	$$D.F_{(extended)} = \frac{Mi2}{Mi3}$$
	Where
	M_{i2} = mass emission of the pollutants in g/km at full mileage.
	M_{i3} = mass emission of the pollutants in g/km at partial mileage. To be revised with table.
3.4	**Durability mileage accumulation cycle**
	Durability mileage accumulation test cycle specified in Appendix 1 of the chapter shall be conducted to age the test vehicles until the assigned test distance laid down notification is fully completed according to the full mileage accumulation test procedure set out in clause 3.1 or partially completed according to the partial mileage accumulation test procedure in clause 3.2
3.5	Test type V durability verification testing using 'golden' pollution-control devices
3.5.1	The pollution-control devices may be removed from the test vehicles after:
3.5.1.1	full mileage accumulation according to the test procedure in clause 3.1 is completed, or
3.5.1.2	partial mileage accumulation according to the test procedure in clause 3.2 is completed.
3.5.2	At the choice of the manufacturer later on in vehicle development, 'golden' pollution-control devices may repeatedly be used for durability performance verification and approval demonstration testing on the same vehicle type with regard to the environmental performance by fitting them on a representative parent vehicles representing the propulsion family set out in Chapter 3W-XI.
3.5.3	The 'golden' pollution-control devices shall be permanently marked and the marking number, the associated type I test results and the specifications shall be made available to the test agency upon request.
3.5.4	In addition, the manufacturer shall mark and store new, non-aged pollution-control devices with the same specifications as those of the 'golden' pollution-control devices and, in the event of a request under point 3.5.5, make these available also to the test agency, as a reference base.
3.5.5	The test agency shall be given access at any time during or after the environmental performance type-approval process both to the 'golden' pollution-control devices and 'new, non-aged' pollution- control devices. The test agency may request and witness a verification test by the manufacturer or may have the 'new, non-aged' and 'golden' pollution-control devices tested by an independent test laboratory in a non-destructive way.

3.6	**Maintenance of vehicle during mileage accumulation:**
3.6.1	A scheduled engine tune up shall be conducted in a manner consistent with owner's manual / service instructions and specifications provided by the manufacturer for use by customer service personnel. Typical servicing items are listed below: a) Contact Breaker points & setting b) Ignition timing and setting c) Idle speed and Idle air/fuel mixture setting d) Tappet clearance e) Engine bolt tightening f) Spark plugs (Clean, gap setting, replace) g) Change of engine and transmission oil, change of elements for oil, air and fuel filters h) De-carbonization of engine including silencer in case of two stroke engines. i) Adjustment of chains (transmission, valve train) j) Adjustment of control cables, clutch etc. k) The catalytic converter may be serviced only once during the mileage accumulation, if the failure of the catalytic converter system activates an audible and/ or visual signal which alerts the vehicle operator to the need for catalytic converter system maintenance or if the need for the periodic maintenance of the catalytic converter system is overly signaled to the vehicle operator by appropriate means, e.g., An indicator light or significantly reduced drivability performance. The catalytic converter may be serviced as recommended by the vehicle manufacturer. l) Fuel injectors (Clean) m) O2 sensor n) EGR o) Catalytic Converter p) MIL
3.6.2	**Other maintenance:** Certain engine components may require maintenance/replacement, which, by its nature cannot be scheduled for periodic interval, but which the manufacturer believes will be necessary, shall be permitted. For example, piston and cylinder replacement caused by piston seizure, excessive wear, which results in the vehicle being inoperative.

3.6.2.1	Any unscheduled engine, emission control system, or fuel system adjustment, repair, removal, disassembly, cleaning or replacement on vehicle shall be performed only in case of significantly reduced driving performance, subject to the following:
	
	a) part failure or system malfunction or the repairs of such failure or malfunction does not render the vehicle unrepresentative of vehicles in use, and
	b) does not require direct access to the combustion chamber except for:
	   a. spark plug, fuel injection component, or
	   b. removal or replacement of the removable pre-chamber, or
	   c. decarbonizing

3.6.2.2	Equipment, instruments or tools shall not be used to identify the malfunctioning, mal-adjustment or defective engine components unless the same or equivalent equipment, instrument or tools will be available at the dealerships and other service outlets and are used in conjunction with scheduled maintenance on such components.
3.6.2.3	Emission measurements shall not be used as a means of determining the need for an unscheduled maintenance.
3.6.2.4	Repairs/replacement to vehicle components of test vehicle, other than engine, emission control system or fuel system, shall be performed only as a result of part failure, vehicle system malfunction
3.6.2.5	In case MIL comes on during the mileage accumulation the fault shall be identified, repaired and reported to the test agency, with relevant documentation data with necessary corrective actions taken.
3.6.3	Records of maintenance activities: All the maintenance work carried out shall be recorded in the test report.

Appendix 1 to Chapter 3W- V
Mileage accumulation Test cycle

1.0	**Mileage accumulation:**
1.1	Mileage accumulation may be done on road/ test track or on chassis dynamometer, at the option of the vehicle manufacturer
1.2	If the mileage accumulation is carried out on roads, the traffic on the selected road shall be such that the lap speeds can be maintained. The details of routes followed and the trends of the traffic pattern shall be recorded
1.3	If the mileage accumulation is done on a chassis dynamometer, the chassis dynamometer shall comply with the requirements given in Appendix 3 of Chapter 3W-II. Suitable robotic controls may be used when the mileage accumulation is being carried out on a chassis dynamometer
1.4	Mileage accumulation shall be exclusive of the running in period
1.5	Speeds for mileage accumulation:
1.6	Mileage accumulation shall be done in laps of 6 km. A trip consisting of eleven laps is counted as one test cycle. The following test cycles shall be followed for three wheelers: **Table Ap1-1**

Table Ap1-1

Test Cycle for all 3W	Lap speed, km/hr										
	1	2	3	4	5	6	7	8	9	10	11
	35	30	35	35	30	30	30	40	30	40	40

1.6.1	The breakdown of time vs. speed for each lap is given in Table Ap1-1. The time versus speed is pictorially shown in Figures 1,2 and 3 for laps 1 to 9, 10 and 11 respectively
1.6.2	If the lap speed is not achievable because of the speed capability of the vehicle, the vehicle shall be driven at 90% of the actual maximum speed of the vehicle. In such cases, the actual lap speed followed shall be reported

Pictorial representation of Laps 1 to 9

Figure Ap1-1

Figure Ap1-2

Pictorial representation of Lap 10
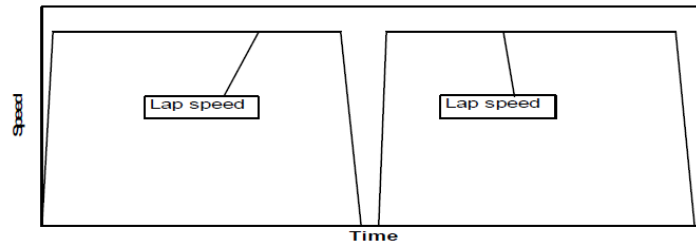
Figure Ap1-3

Pictorial representation of Lap 11

2.0	**Gear shifting**
	During lap 1 to 10 gear shifting shall be as recommended by the manufacturer. In acceleration phase of lap 11, gearshift shall be done at the maximum safe speed of engine recommended by the manufacturer. The gear shifting pattern actually followed shall be reported for a test cycle

Table Ap1-2

Mode-wise break up for Laps 1 to 9 of Test cycle classification A

Mode	Driving Mode Lap speed--->	Time for each mode (second) 30	35	40
1	Acceleration: Idle - Lap speed	13	15	18
2	Steady state cruise	68	68	52
3	Deceleration: Lap speed - 15km/h	10	11	10
4	Acceleration: 15km/h - Lap speed	10	11	10
5	Steady state cruise	45	45	37
6	Deceleration: Lap speed - idle	10	11	10
7	Idle	15	15	15
8	Acceleration: Idle - Lap speed	13	15	18
9	Steady state cruise	100	100	85
10	Deceleration: Lap speed - 15km/h	10	11	10
11	Acceleration: 15km/h - Lap speed	10	11	10
12	Steady state cruise	100	100	85
13	Deceleration: Lap speed - 15km/h	10	11	10
14	Acceleration: 15km/h - Lap speed	10	11	10
15	Steady state cruise	52	33	29
16	Deceleration: Lap speed - idle	10	11	10
17	Idle	15	15	15
18	Acceleration: Idle - Lap speed	13	15	18
19	Steady state cruise	63	63	52
20	Deceleration: Lap speed - 15km/h	10	11	10
21	Acceleration: 15km/h - Lap speed	10	11	10
22	Steady state cruise	52	11	30
23	Deceleration: Lap speed - idle	10	11	10
24	Idle	15	15	15
25	Acceleration: Idle - Lap speed	13	15	18
26	Steady state cruise	52	52	30
27	Deceleration: Lap speed - 15km/h	10	11	10
28	Acceleration: 15km/h - Lap speed	10	11	10
29	Steady state cruise	59	50	44
30	Deceleration: Lap speed - idle	10	11	10

Mode-wise break up for Lap 10 & 11 of Test cycle classification A

Mode	Driving Mode Lap speed--->	Time for each mode (second) For Lap 10 40	For Lap 11 40
1	Acceleration: Idle - Lap speed	18	10
2	Steady state cruise	515	260
3	Deceleration: Lap speed - idle	18	18
4	Idle	Not applicable	15
5	Acceleration: Idle - Lap speed		10
6	Steady state cruise		260
7	Deceleration: Lap speed - idle		18

Chapter 3W- VI
TEST PROCEDURE FOR ON BOARD DIAGNOSTICS – I (OBD-I)

1.	**INTRODUCTION**
	This chapter applies to the Type Approval procedure for on-board diagnostic I (OBD I) system L5 category.
2.	**DEFINITIONS : Refer overall Requirements.**
3.	**APPLICATION FOR TYPE APPROVAL**
3.1	The application for type approval of a vehicle model with regard to OBD I of the vehicles shall be submitted by the vehicle manufacturer along with duly filled OBD I specification sheet (refer Appendix 1 of this chapter for format) for components monitored by EMS/ECU/Computer & OBD I flow chart application table (refer Appendix 2 of this chapter for format).
3.2	A vehicle representative of the vehicle model to be type approved shall be submitted to the test agency responsible for conducting tests for compliance to the requirements referred in Para 5 of this chapter.
4.	**TYPE APPROVAL**
	For the purpose of type approval, manufacturer can choose one of the below mentioned options (4.1 or 4.2)
4.1	The vehicle submitted for type approval shall be tested for maximum four discontinuity demonstration tests selected by the test agency out of the OBD I parameters as declared by the vehicle manufacturer, subject to condition mentioned in clause 4.3.
4.2	Alternatively, the vehicle can be tested for all OBD I parameters for discontinuity demonstration tests, subject to condition mentioned in clause 4.3.
4.3	If discontinuity demonstration test is conducted on any vehicle model for a particular OBD parameter, demonstration test for such OBD parameter need not be conducted once again in the new vehicle model of same vehicle family submitted for type approval. In this case the vehicle manufacturer has to fill the vehicle model in which the demonstration test was carried out and date of testing (in DEMO column of Appendix 2 of this chapter)
4.4	If the submitted vehicle meets the requirements of Para 5 below when tested as per the procedure described in Para 6 below for circuit discontinuity of parameters in 5.1, approval of that vehicle model shall be granted.
5.	**REQUIREMENTS**
5.1	Vehicle submitted for type approval shall contain the OBD monitoring system. Please refer-GSR 889(E) dated 16 Sep 2016 for OBD – I monitoring system.
5.2	The vehicle manufacturer shall submit a test vehicle along with necessary equipments, which can simulate the discontinuity of OBD I parameters as declared by the manufacturer for testing.

| 5.3	**Activation of malfunction indicator (MI).**
5.3.4	Distance traveled since MIL is 'ON' shall be recorded.
5.3.5	The OBD system shall incorporate a malfunction indicator readily perceivable to the vehicle operator. The MI must not be used for any other purpose except to indicate emergency start-up or limp-home routines to the driver. The MI shall be visible in all reasonable lighting conditions. When activated, it shall display a symbol in conformity with ISO 2575:2010. A vehicle shall not be equipped with more than one general purpose MI for emission-related problems. Separate specific purpose telltales (e.g. brake system, fasten seat belt, oil pressure, etc.) are permitted. The use of red color for an MI is prohibited.
5.3.6	The MI shall activate when the vehicle's ignition is in the "key-on" position before engine starting or cranking and de-activate before engine starting after few seconds (or 'on' till engine is started) if no malfunction has previously been detected. For vehicles not equipped with a battery, the MI shall illuminate immediately after engine starting and shall subsequently be deactivated after 5 seconds, if no malfunction has previously been detected.
5.3.7	For meeting the requirements of 5.1, the manufacturer shall take appropriate steps to demonstrate that the OBD system will indicate a fault when discontinuity occurs.
5.4	The OBD system shall be capable of recording the fault code(s) indicating the status of the emission control system.
5.4.1	The distance traveled by the vehicle while the MI is activated must be available at any instant through the serial port on the standard link connector. By means of derogation for vehicles equipped with a mechanically operating odometer that does not allow input to the electronic control unit, 'distance travelled' may be replaced with 'engine operation time' and shall be made available at any moment through the serial port on the standardised diagnostic connector (standardise link connector)
6.	**TEST PROCEDURE**
6.1	The test Vehicle shall be mounted on the chassis dynamometer along with necessary equipments of test agency for carrying out test (OBD Scan tool and related accessories need to be provided by manufacturer).
6.2	Initial check
6.2.1	Switch "ON" the ignition and check for MIL "ON". MIL shall be "ON" for few seconds and then may turn "OFF" (in case of vehicle models with such design of MIL operation) or may continue to glow.
6.2.2	Start the engine and check for MIL "OFF".
6.2.3	Switch "OFF" the engine and ignition key to "OFF" position.

6.3	**Circuit Discontinuity check**
6.3.1	Vehicle soaking for 6 hours, if necessary for certain OBD parameters as specified by vehicle manufacturer.
6.3.2	Open or disconnect the circuit for the OBD parameter to be checked for circuit discontinuity.
6.3.3	Switch "ON" the ignition. Check for MIL "ON".
6.3.4	Start the engine and check for MIL "ON".
6.3.4.1	If the OBD I parameter requires engine to be driven for MIL activation, vehicle shall be driven as per driving cycle (Indian Driving Cycle); including key `ON` `OFF` cycles, vehicle can be considered meeting circuit discontinuity when the MIL activates within maximum of 10 (as cold start T=0 sec) driving cycles.
6.3.4.2	If the OBD I parameter does not require vehicle to be driven for MIL activation, vehicle can be considered meeting circuit discontinuity for the tested OBD parameter.
6.3.4.3	The DTC code shall be retrieved by the OBD Scan tool or any other method as mutually agreed between test agency and vehicle manufacturer.
6.3.5	Procedure from 6.3.1 to 6.3.4 shall be repeated for other OBD parameters to be checked for circuit discontinuity.
6.4	The requirement of distance traveled or engine operating time since MIL "ON" shall be checked along with one of the circuit discontinuity tests for OBD parameters as specified by vehicle manufacturer by running the vehicle on chassis dynamometer or on road as per driving cycle preferred by the vehicle manufacturer.
6.5	The process flow is shown in the figure 1 of this chapter.
7.	**Modifications of the vehicle model**
7.1	Every modification in the essential characteristics of the vehicle model shall be intimated by the vehicle manufacturer to the test agency which type approved the vehicle model. The test agency may either,
7.2	Consider that the vehicle with the modifications made may still comply with the requirement, or require a further test to ensure further compliance.
7.3	In case of 7.2 above, the testing agency shall extend the type approval covering the modified specification or the vehicle model shall be subjected to necessary tests as per the guidelines for extension of approval (clause 8). In case, the vehicle complies with the requirements, the test agency shall extend the type approval.
8.	**Guidelines for Extension of Approval of the vehicle for OBD I.**
8.1	Approval granted to a vehicle type with respect to the OBD system may be extended to different vehicle types belonging to the same vehicle-OBD family as described in Appendix 3 of this chapter. The engine emission control system must be identical to that of the vehicle already approved and comply with the description of the OBD engine family given in Appendix 3 of this chapter, regardless of the following vehicle

	characteristics:
	- engine accessories,
	- tyres,
	- equivalent inertia,
	- cooling system,
	- overall gear ratio,
	- transmission type,
	- type of bodywork.
8.2	In a vehicle model, which is previously approved for OBD parameter, if there is any change in OBD parameter, then the discontinuity testing for the changed OBD parameter only needs to be conducted as mutually agreed between the test agency and vehicle manufacturer if manufacturer can prove that changed OBD parameter don't have any interaction with other OBD parameters.

Figure 1: OBD-1 TEST PROCEDURE FLOW CHART
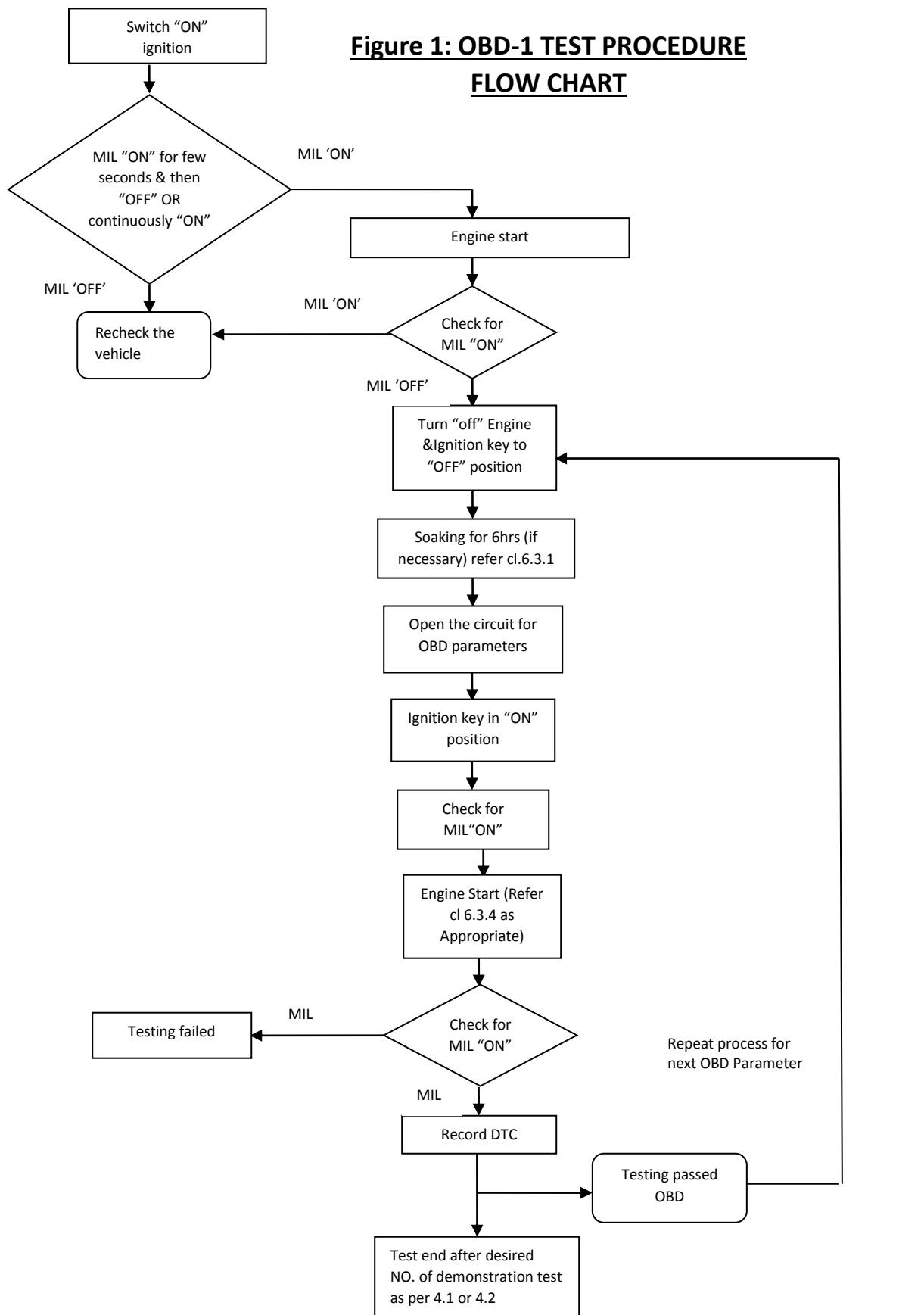
Appendix 1 to Chapter 3W-VI
OBD Specification table format – OBD

OBD specification table format					
Component/ System	Fault Code	Monitor Strategy Description	Malfuction Criteria	Secondary Parameters	MIL Illuminations

Appendix 2 to Chapter 3W-VI				
OBD Flow Chart Application Table Format				
FUNCTION	**DEMO**	**DTC**	**TYPE**	**CONFIGURATION**
DEMO: The monitoring sysytem simulated for the pupose of the type-approval is marked with the tested vehicle and date.				

Appendix 3 to Chapter 3W-VI
ESSENTIAL CHARACTERISTICS OF THE VEHICLE FAMILY OBD-I

1.	**PARAMETERS DEFINING THE OBD FAMILY**
	The OBD family may be defined by basic design parameters, which must be common to vehicles within the family. In some cases there may be interaction of parameters. These effects must also be taken into consideration to ensure that only vehicles with similar exhaust emission characteristics are included within an OBD family.
2.	To this end, those vehicle types whose parameters described below are identical are considered to belong to the same engine-emission control/OBD system combination. Engine: - combustion process (i.e. positive-ignition, compression-ignition, two stroke,four-stroke), - method of engine fuelling (i.e. carburetor or fuel injection). - fuel type (i.e petrol, diesel, NG, LPG, bi-fuel petrol/NG, bi-fuel petrol/LPG Emission control system): - type of catalytic converter (i.e. oxidation, three-way, heated catalyst, other), - type of particulate trap, - secondary air injection (i.e. with or without), - exhaust gas recirculation (i.e. with or without) OBD parts and functioning: - the methods of OBD functional monitoring, malfunction detection and malfunction indication to the vehicle driver.

Chapter 3W-VII
TEST PROCEDURE FOR ON BOARD DIAGNOSTICS-II (OBD-II)

1	**INTRODUCTION**
	This Chapter applies to the functional aspects of on-board diagnostic (OBD - II) System for the emission control of L5.
2	**DEFINITIONS : refer overall requirements.**
3	**REQUIREMENTS AND TESTS**
3.1	All vehicles shall be equipped with an OBD system so designed, constructed and installed in a vehicle as to enable it to identify types of deterioration or Malfunction over the entire life of the vehicle. In achieving this objective the test agency shall accept that vehicles which have traveled distances in excess of the Type V durability distance, referred to in Para 3.3.1, may show some deterioration in OBD system performance such that the emission limits given in the applicable Gazette Notification under CMVR may be exceeded before the OBD system signals a failure to the driver of the vehicle
3.1.1	Access to the OBD system required for the inspection, diagnosis, servicing or repair of the vehicle shall be unrestricted and standardised. All emission-related fault codes must be consistent with Para 6.5.3.4 of Apendix 4 to this Chapter.
3.2	The OBD system must be so designed, constructed and installed in a vehicle as to enable it to comply with the requirements of this Chapter during conditions of normal use.
3.2.1	**Temporary disablement of the OBD system**
3.2.1.1	A manufacturer may disable the OBD system if its ability to monitor is affected by low fuel levels. Disablement shall not occur when the fuel tank level is above 20 % of the nominal capacity of the fuel tank.
3.2.1.2	A manufacturer may disable the OBD system at ambient engine starting temperatures below 266 degrees K (-7 degrees C) or at elevations over 2,500 m above sea level provided the manufacturer submits data and/or an engineering evaluation which adequately demonstrate that monitoring would be unreliable when such conditions exist. A manufacturer may also request disablement of the OBD system at other ambient engine starting temperatures if he demonstrates to the test agency with data and/or an engineering evaluation that misdiagnosis would occur under such conditions.
3.2.1.3	For vehicles designed to accommodate the installation of power take-off units, disablement of affected monitoring systems is permitted provided disablement occurs only when the power take-off unit is active.
3.2.2.	Engine misfire - vehicles equipped with positive-ignition engines
3.2.2.1	Manufacturers may adopt higher misfire percentage malfunction criteria than those declared to the authority, under specific engine speed and load conditions where it can be demonstrated to the authority that the detection of lower levels of misfire would be unreliable.

3.2.2.2	When a manufacturer can demonstrate to the authority that the detection of higher levels of misfire percentages is still not feasible, or that misfire cannot be distinguished from other effects (e.g. rough roads, transmission shifts, after engine starting; etc.) the misfire monitoring system may be disabled when such conditions exist.
3.3.	**Description of tests**
3.3.1	The OBD II tests are carried out on the vehicle used for the Type V durability test, given in Chapter **3W –V**, and using the test procedure in Appendix I to this Chapter. OBD II tests are carried out at the conclusion of the Type V durability testing. When no Type V durability testing is carried out, or at the request of the manufacturer, a suitably aged and representative vehicle may be used for these OBD II demonstration tests.
3.3.2	The OBD system must indicate the failure of an emission-related component or system when that failure results in emissions exceeding the threshold limits given in the applicable Gazette Notification under CMVR.
3.3.3	Monitoring requirements for vehicles equipped with positive-ignition engines In satisfying the requirements of Para 3.3.2 the OBD system must, at a minimum, monitor for
3.3.3.1	Reduction in the efficiency of the catalytic converter with respect to the emissions of HC only. Manufactures may monitor the front catalyst alone or in combination with the next catalyst(s) downstream. Each monitored catalyst or catalyst combination shall be considered malfunctioning when the emissions exceed the threshold given in the applicable Gazette Notification under CMVR.
3.3.3.2	The presence of engine misfire in the engine operating region bounded by the following lines: (a) a maximum speed of 4,500 min-1 or 1,000 min-1 greater than the highest speed occurring during a Type I test cycle, whichever is the lower; (b) the positive torque line (i.e. engine load with the transmission in neutral); (c) a line joining the following engine operating points: the positive torque line at 3,000 min-1 and a point on the maximum speed line defined in (a) above with the engine's manifold vacuum at 13.33 kPa lower than that at the positive torque line.
3.3.3.3	Oxygen sensor deterioration
3.3.3.4	If active on the selected fuel, other emission control system components or systems, or emission-related power train components or systems which are connected to a computer, the failure of which may result in tailpipe emissions exceeding the limits given in the applicable Gazette Notification under CMVR.
3.3.3.5	Unless otherwise monitored, any other emission-related power train component connected to a computer, including any relevant sensors to enable monitoring functions to be carried out, must be monitored for circuit continuity.

3.3.3.6	the electronic evaporative emission purge control must, at a minimum, be monitored for circuit continuity.
3.3.4.	Monitoring requirements for vehicles equipped with compression-ignition engines In satisfying the requirements of Para 3.3.2 the OBD system must monitor:
3.3.4.1	Where fitted, reduction in the efficiency of the catalytic converter;
3.3.4.2	Where fitted, the functionality and integrity of the particulate trap;
3.3.4.3	The fuel-injection system electronic fuel quantity and timing actuator(s) is/are monitored for circuit continuity and total functional failure;
3.3.4.4	Other emission control system components or systems, or emission-related power train components or systems, which are connected to a computer, the failure of which may result in tailpipe emissions exceeding the limits given in the applicable Gazette Notification under CMVR. Examples of such systems or components are those for monitoring and control of air mass-flow, air volumetric flow (and temperature), boost pressure and inlet manifold pressure (and relevant sensors to enable these functions to be carried out).
3.3.4.5	Unless otherwise monitored, any other emission-related powertrain component connected to a computer must be monitored for circuit continuity.
3.3.5	Manufacturers may demonstrate to the approval authority that certain components or systems need not be monitored if, in the event of their total failure or removal, emissions do not exceed the emission limits given in the official applicable Gazette Notification under CMVR.

3.4	A sequence of diagnostic checks for OBD II must be initiated at each engine start and completed at least once provided that the correct test conditions are met. The test conditions must be selected in such a way that they all occur under normal driving as represented by the Type I test.
3.5	**Activation of malfunction indicator (MI)**
3.5.1	The OBD system must incorporate a malfunction indicator readily perceivable to the vehicle operator. The MI must not be used for any other purpose except to indicate emergency start-up or limp-home routines to the driver. The MI must be visible in all reasonable lighting conditions. When activated, it must display a symbol in conformity with ISO 2575[1]. A vehicle must not be equipped with more than one general purpose MI for emission-related problems. Separate specific purpose telltales (e.g. brake system, fasten seat belt, oil pressure, etc.) are permitted. The use of red for an MI is prohibited. [1] International Standard ISO 2575-1982 (E), entitled 'Road vehicles – Symbols for controls indicators and tell tales', Symbol Number 4.36.
3.5.2.	For strategies requiring more than two preconditioning cycles for MI activation, the manufacturer must provide data and/or an engineering evaluation, which adequately demonstrates that the monitoring system is equally effective and timely in detecting component deterioration. Strategies requiring on average more than 10 driving

	cycles for MI activation are not accepted. The MI must also activate whenever the engine control enters a permanent emission default mode of operation if the emission limits given in the applicable Gazette Notification under CMVR are exceeded or if the OBD system is unable to fulfill the basic monitoring requirements specified in Para 3.3.3 or Para 3.3.4 of this Chapter. The MI must operate in a distinct warning mode, e.g. a flashing light, under any period during which engine misfire occurs at a level likely to cause catalyst damage, as specified by the manufacturer. The MI shall activate when the vehicle's ignition is in the "key-on" position before engine starting or cranking and de-activate before engine starting after few seconds (or 'on' till engine is started) if no malfunction has previously been detected.
3.6.	The OBD system must record fault code(s) indicating the status of the emission control system. Separate status codes must be used to identify correctly functioning emission control systems and those emission control systems, which need further vehicle operation to be fully evaluated.
	If the MI is activated due to deterioration or malfunction or permanent emission default modes of operation, a fault code must be stored that identifies the type of malfunction. A fault code must also be stored in the cases referred to in Para 3.3.3.5 and Para 3.3.4.5 of this Chapter.
3.6.1.	The distance traveled by the vehicle while the MI is activated must be available at any instant through the serial port on the standard link connector.
3.6.2.	In the case of vehicles equipped with positive-ignition engines, misfiring cylinders need not be uniquely identified if a distinct single or multiple cylinder misfire fault code is stored.
3.7.	**Extinguishing the MI**
3.7.1.	If misfire at levels likely to cause catalyst damage (as specified by the manufacturer) is not present any more, or if the engine is operated after changes to speed and load conditions where the level of misfire will not cause catalyst damage, the MI may be switched back to the previous state of activation during the first driving cycle on which the misfire level was detected and may be switched to the normal activated mode on subsequent driving cycles. If the MI is switched back to the previous state of activation, the corresponding fault codes and stored freeze-frame conditions may be erased.
3.7.2	For all other malfunctions, the MI may be de-activated after three subsequent sequential driving cycles during which the monitoring system responsible for activating the MI ceases to detect the malfunction and if no other malfunction has been identified that would independently activate the MI.
3.8.	**Erasing a fault code**
3.8.1.	The OBD system may erase a fault code and the distance traveled and freezeframe information if the same fault is not re-registered in at least 40 engine warmup cycles.

3.9.	**Bi-fuelled gas vehicles**
	In general, for bi-fuelled gas vehicles for each of the fuel types (petrol and NG/LPG) all the OBD requirements as for a mono-fuelled vehicle are applicable. To this end one of the following two options in paragraphs 3.9.1. or 3.9.2. or any combination there of shall be used.
3.9.1.	**One OBD system for both fuel types.**
3.9.1.1.	The following procedures shall be executed for each diagnostic in a single OBD system for operation on petrol and on NG/LPG, either independent of the fuel currently in use or fuel type specific:
	(a) activation of malfunction indicator (MI) (see paragraph 3.5. of this appendix),
	(b) fault code storage (see paragraph 3.6. of this Chapter),
	(c) extinguishing the MI (see paragraph 3.7. of this Chapter),
	(d) erasing a fault code (see paragraph 3.8. of this Chapter).
	For components or systems to be monitored, either separate diagnostics for each fuel type can be used or a common diagnostic.
3.9.1.2.	The OBD system can reside in either one or more computers. Notwithstanding this requirement, the status code (described in Para 3.6 of this Chapter) shall indicate fully evaluated control systems for both fuel types (petrol and gas) when the control systems are fully evaluated for one of the fuel types
3.9.2.	**Two separate OBD systems, one for each fuel type.**
3.9.2.1.	The following procedures shall be executed independently of each other when the vehicle is operated on petrol or on NG/LPG:
	(a) activation of malfunction indicator (MI) (see paragraph 3.5. of this chapter),
	(b) fault code storage (see paragraph 3.6. of this chapter),
	(c) extinguishing the MI (see paragraph 3.7. of chapter),
	(d) erasing a fault code (see paragraph 3.8. of this chapter).
3.9.2.2	The separate OBD systems can reside in either one or more computers.
3.9.3.	Specific requirements regarding the transmission of diagnostic signals from bifuelled gas vehicles.
3.9.3.1.	On a request from a diagnostic scan tool, the diagnostic signals shall be transmitted on one or more source addresses. The use of source addresses is described in ISO DIS 15031-5 "Road vehicles - communication between vehicles and external test equipment for emissions-related diagnostics - Part 5: Emissions-related diagnostic services", dated 1 November 2001.

3.9.3.2.	Identification of fuel specific information can be realized:
	(a) by use of source addresses and/or
	(b) by use of a fuel select switch and/or
	(c) by use of fuel specific fault codes.
	The following procedures shall be executed for each diagnostic in a single OBD system for operation on petrol and on NG/LPG, either independent of the fuel currently in use or fuel type specific:
	(a) activation of malfunction indicator (MI) (see paragraph 3.5. of this chapter),
	(b) fault code storage (see paragraph 3.6. of this chapter),
	(c) extinguishing the MI (see paragraph 3.7. of this chapter),
	(d) erasing a fault code (see paragraph 3.8. of this chapter).
	For components or systems to be monitored, either separate diagnostics for each fuel type can be used or a common diagnostic.
3.9.4.	Regarding the status code (as described in paragraph 3.6. of this chapter), one of the following two options has to be used:
	(a) the status code is fuel specific, i.e. use of two status codes, one for each fuel type;
	(b) the status code shall indicate fully evaluated control systems for both fuel types (petrol and NG/LPG) when the control systems are fully evaluated for one of the fuel types. If none of the diagnostics reporting readiness is fuel type specific, then only one status code has to be supported.
4.	**Requirements relating to the type-approval of on-board diagnostic systems**
4.1.	A manufacturer may request to the authority that an OBD system be accepted for type-approval even though the system contains one or more deficiencies such that the specific requirements of this Chapter are not fully met.
4.2.	In considering the request, the authority shall determine whether compliance with the requirements of this Chapter is infeasible or unreasonable. The authority shall take into consideration data from the manufacturer that details such factors as, but not limited to, technical feasibility, lead time and production cycles including phase-in or phase-out of engines or vehicle designs and programmed upgrades of computers, the extent to which the resultant OBD system will be effective in complying with the requirements of this chapter and that the manufacturer has demonstrated an acceptable level of effort toward compliance with the requirements of this chapter
4.2.1.	The authority will not accept any deficiency request that includes the complete lack of a required diagnostic monitor.
4.2.2.	The authority will not accept any deficiency request that does not respect the OBD threshold limits in the applicable Gazette Notification under CMVR

4.3.	In determining the identified order of deficiencies, deficiencies relating to Para 3.3.3.1, 3.3.3.2 and 3.3.3.3 of this Chapter for positive-ignition engines and Para 3.3.4.1, 3.3.4.2 and 3.3.4.3 of this Chapter for compression-ignition engines shall be identified first.
4.4.	Prior to or at the time of type-approval, no deficiency shall be granted in respect of the requirements of Para 6.5, except Para 6.5.3.4 of Appendix 1 to this Chapter.
4.5.	**Deficiency period**
4.5.1.	A deficiency may be carried-over for a period of two years after the date of type approval of the vehicle type unless it can be adequately demonstrated that substantial vehicle hardware modifications and additional lead-time beyond two years would be necessary to correct the deficiency. In such a case, the deficiency may be carried-over for a period not exceeding three years.
4.5.2.	A manufacturer may request that the type-approval authority grant a deficiency retrospectively when such a deficiency is discovered after the original type approval. In this case, the deficiency may be carried-over for a period of two years after the date of notification to the type-approval authority unless it can be adequately demonstrated that substantial vehicle hardware modifications and additional lead-time beyond two years would be necessary to correct the deficiency. In such a case, the deficiency may be carried-over for a period not exceeding three years.
5.	**ACCESS TO OBD INFORMATION**
5.1.	Upon request, the type-approval agency shall make Chapter to the type approval certificate containing the relevant information on the OBD system available to any interested components, diagnostic tools or test equipment manufacturer on a non-discriminatory basis.
5.2.	Information can only be requested for replacement or service components that are subject to type-approval, or for components that form part of a system that is subject to type approval.
5.3	The request for information must identify the exact specification of the vehicle model for which the information is required. It must confirm that the information is required for the development of replacement or retrofit parts or components or diagnostic tools or test equipment.
6	**Modifications of the vehicle model**
6.1	Every modification in the essential characteristics of the vehicle model shall be intimated by the vehicle manufacturer to the test agency which type approved the vehicle model. The test agency may either,
6.2	Consider that the vehicle with the modifications made may still comply with the requirement, or require a further test to ensure further compliance.
6.3	In case of 6.2 above, the testing agency shall extend the type approval covering the modified specification or the vehicle model shall be subjected to necessary tests as per the guidelines for extension of approval (clause 7). In case, the vehicle complies with the requirements, the test agency shall extend the type approval.

7.	**Guidelines for Extension of Approval of the vehicle for OBD.**

7.1	Approval granted to a vehicle type with respect to the OBD system may be extended to different vehicle types belonging to the same vehicle-OBD family as described in Appendix 1 of this chapter. The engine emission control system must be identical to that of the vehicle already approved and comply with the description of the OBD engine family given in Appendix 2 of this chapter, regardless of the following vehicle characteristics:
	
	  - engine accessories,
	
	  - tyres,
	
	  - equivalent inertia,
	
	  - cooling system,
	
	  - overall gear ratio,
	
	  - transmission type,
	
	  - type of bodywork.

7.2	In a vehicle model, which is previously approved for OBD parameter, if there is any change in OBD parameter, then the testing for the changed OBD parameter only needs to be conducted as mutually agreed between the test agency and vehicle manufacturer if manufacturer can prove that changed OBD parameter don't have any interaction with other OBD parameters.

Appendix 1 to Chapter 3W-VII
Functional Aspects of ON BOARD DIAGNOSTIC (OBD) SYSTEM

1	INTRODUCTION
	This Chapter describes the procedure of the test according to Para 5 of this Chapter. The procedure describes a method for checking the function of the onboard diagnostic (OBD) system installed on the vehicle by failure simulation of relevant systems in the engine management or emission control system. It also sets procedures for determining the durability of OBD systems. The manufacturer must make available the defective components and/or electrical devices which would be used to simulate failures. When measured over the Type I test cycle, such defective components or devices must not cause the vehicle emissions to exceed the limits given in the applicable Gazette Notification under CMVR by more than 20 %.
	When the vehicle is tested with the defective component or device fitted, the OBD system is approved if the MI is activated. The OBD system is also approved if the MI is activated below the OBD threshold limits given in the applicable Gazette Notification under CMVR.
2.	DESCRIPTION OF TEST
2.1.	The testing of OBD – II systems consists of the following phases:
	- simulation of malfunction of a component of the engine management or emission control system,
	- preconditioning of the vehicle with a simulated malfunction over preconditioning specified in Para 6.2.1 or Para 6.2.2.
	- driving the vehicle with a simulated malfunction over the Type I test cycle and measuring the emissions of the vehicle,
	- determining whether the OBD system reacts to the simulated malfunction and indicates malfunction in an appropriate manner to the vehicle driver.
2.2.	Alternatively, at the request of the manufacturer, malfunction of one or more components may be electronically simulated according to the requirements of Para 6.
2.3.	Manufacturers may request that monitoring take place outside the Type I test cycle if it can be demonstrated to the authority that monitoring during conditions encountered during the Type I test cycle would impose restrictive monitoring conditions when the vehicle is used in service.
3.	TEST VEHICLE AND FUEL
3.1.	Vehicle
	The test vehicle shall meet the requirements of 4.2of Chapter 3W-II.
3.2.	Fuel: refer reference Fuel
4.	TEST TEMPERATURE AND PRESSURE
4.1.	The test temperature and pressure must meet the requirements of the Type I test as described in para 4.2.2 of Chapter 3W-II.

5.	TEST EQUIPMENT
5.1.	**Chassis dynamometer**
	The chassis dynamometer must meet the requirements of Chapter 3W-II.
6.	**OBD – II TEST PROCEDURE**
6.1.	The operating cycle on the chassis dynamometer must meet the requirements of Chapter 3W-II..
6.2.	Vehicle preconditioning
6.2.1.	According to the engine type and after introduction of one of the failure modes given in Para 6.3, the vehicle must be preconditioned by driving cycle of Type I tests
6.2.2.	At the request of the manufacturer, alternative preconditioning methods may be used.
6.3.	Failure modes to be tested
6.3.1.	Positive-ignition engine vehicles:
6.3.1.1	Replacement of the catalyst with a deteriorated or defective catalyst or electronic simulation of such a failure.
6.3.1.2	Engine misfire conditions according to the conditions for misfire monitoring given in Para 3.3.3.2 of this chapter.
6.3.1.3	Replacement of the oxygen sensor with a deteriorated or defective oxygen sensor or electronic simulation of such a failure.
6.3.1.4	Electrical disconnection of any other emission-related component connected to a power-train management computer (if active on the selected fuel type).
6.3.1.5	Electrical disconnection of the electronic evaporative purge control device, (if equipped and if active on the selected fuel type) Fuel tank leakage, and fuel system. For this specific failure mode, the Type I test need not be performed.
6.3.2.	**Compression-ignition engine vehicles:**
6.3.2.1	Where fitted, replacement of the catalyst with a deteriorated or defective catalyst or electronic simulation of such a failure.
6.3.2.2	Where fitted, total removal of the particulate trap or, where sensors are an integral part of the trap, a defective trap assembly.
6.3.2.3	Electrical disconnection of any fuelling system electronic fuel quantity and timing actuator.
6.3.2.4	Electrical disconnection of any other emission-related component connected to a power train management computer.
6.3.2.5	In meeting the requirements of 6.3.2.3 and 6.3.2.4, and with the agreement between the test agency, the manufacturer must take appropriate steps to demonstrate that the OBD system will indicate a fault when disconnection occurs.

6.4.	**OBD system test**
6.4.1.	Vehicles fitted with positive-ignition engines:
6.4.1.1	After vehicle preconditioning according to 6.2, the test vehicle is driven over a Type I test .The MI must activate before the end of this test under any of the conditions given in 6.4.1.2 to 6.4.1.5. The test agencymay substitute those conditions by others in accordance with 6.4.1.6. However, the total number of failures simulated must not exceed 4 for the purpose of typeapproval. In the case of testing a bi-fuel gas vehicle, both fuel types shall be used within the maximum of four (4) simulated failures at the discretion of the test agency.
6.4.1.2	Replacement of a catalyst with a deteriorated or defective catalyst or electronic simulation of a deteriorated or defective catalyst that results in emissions exceeding the limit given in the applicable Gazette Notification under CMVR.
6.4.1.3	An induced misfire condition according to the conditions for misfire monitoring given in Para 3.3.3.2 of this chapter that results in emissions exceeding any of the limits given in the applicable Gazette Notification under CMVR.
6.4.1.4	Replacement of an oxygen sensor with a deteriorated or defective oxygen sensor or electronic simulation of a deteriorated or defective oxygen sensor that results in emissions exceeding any of the limits given in the applicable Gazette Notification under CMVR.
6.4.1.5	Electrical disconnection of the electronic evaporative purge control device (if equipped and if active on the selected fuel type).
6.4.1.6	Electrical disconnection of any other emission-related power train component connected to a computer that results in emissions exceeding any of the limits given in the applicable Gazette Notification under CMVR (if active on the selected fuel type).
6.4.2	**Vehicles fitted with compression-ignition engines:**
6.4.2.1	After vehicle preconditioning according to 6.2, the test vehicle is driven over a Type I test .The MI must activate before the end of this test under any of the conditions given in 6.4.2.2 to 6.4.2.5. The test agencymay substitute those conditions by others in accordance with 6.4.2.5. However, the total number of failures simulated must not exceed four for the purposes of type approval.
6.4.2.2	Where fitted, replacement of a catalyst with a deteriorated or defective catalyst or electronic simulation of a deteriorated or defective catalyst that results in emissions exceeding limits given in the applicable Gazette Notification under CMVR.
6.4.2.3	Where fitted, total removal of the particulate trap or replacement of the particulate trap with a defective particulate trap meeting the conditions of 6.3.2.2 that results in emissions exceeding the limits given in the applicable Gazette Notification under CMVR.
6.4.2.4	With reference to 6.3.2.5, disconnection of any fuelling system electronic fuel quantity and timing actuator that results in emissions exceeding any of the limits given in the applicable Gazette Notification under CMVR.
6.4.2.5	With reference to 6.3.2.5, disconnection of any other emission-related power train component connected to a computer that results in emissions exceeding any of the limits given in the applicable Gazette Notification under CMVR.

6.5.	Diagnostic signals
6.5.1.1	Upon determination of the first malfunction of any component or system, 'freezeframe' engine conditions present at the time must be stored in computer memory. Should a subsequent fuel system or misfire malfunction occur, any previously stored freeze-frame conditions must be replaced by the fuel system or misfire conditions (whichever occurs first). Stored engine conditions must include, but are not limited to calculated load value, engine speed, fuel trim value(s) (if available), fuel pressure (if available), vehicle speed (if available), coolant, temperature, intake manifold pressure (if available), closed - or open – loop operation (if available) and the fault code which caused the data to be stored. The manufacturer must choose the most appropriate set of conditions facilitating effective repairs for freeze-frame storage. Only one frame of data is required. Manufacturers may choose to store additional frames provided that at least the required frame can be read by a generic scan tool meeting the specifications of 6.5.3.2 and 6.5.3.3. If the fault code causing the conditions to be stored is erased in accordance with Para 3.7 of this Chapter, the stored engine conditions may also be erased.
6.5.1.2	If available, the following signals in addition to the required freeze-frame information must be made available on demand through the serial port on the standardized data link connector, if the information is available to the on-board computer or can be determined using information available to the on-board computer: diagnostic trouble codes, engine coolant temperature, fuel control system status (closed-loop, open-loop, other), fuel trim, ignition timing advance, intake air temperature, manifold air pressure, air flow rate, engine speed, throttle position sensor output value, secondary air status (upstream, downstream or atmosphere), calculated load value, vehicle speed and fuel pressure. The signals must be provided in standard units based on the specifications given in 6.5.3. Actual signals must be clearly identified separately from default value or limp-home signals.
6.5.1.3	For all emission control systems for which specific on-board evaluation tests are conducted (catalyst, oxygen sensor, etc.), except misfire detection, fuel system monitoring and comprehensive component monitoring, the results of the most recent test performed by the vehicle and the limits to which the system is compared must be made available through the serial data port on the standardized data link connector according to the specifications given in 6.5.3. For the monitored components and systems excepted above, a pass/fail indication for the most recent test results must be available through the data link connector.
6.5.1.4	The OBD requirements to which the vehicle is certified (i.e. this Chapter or the alternative requirements specified in para 2 of Chapter 3W-II) and the major emission control systems monitored by the OBD system consistent with 6.5.3.3 must be available through the serial data port on the standardized data link connector according to the specifications given in 6.5.3.
6.5.1.5	Vehicles entering into service, the software calibration identification number shall be made available through the serial port on the standardised data link connector. The software calibration identification number shall be provided in a standardised format.

6.5.2.	The emission control diagnostic system is not required to evaluate components during malfunction if such evaluation would result in a risk to safety or component failure.
6.5.3.	The emission control diagnostic system must provide for standardised and unrestricted access and conform with the following ISO standards and/or SAE specification.
6.5.3.1	One of the following standards with the restrictions as described must be used as the on-board to off-board communications link: ISO 9141 - 2: 1994 (amended 1996) "Road Vehicles - Diagnostic Systems – Part 2: CARB requirements for interchange of digital information"; SAE J1850: March 1998 "Class B Data Communication Network Interface". Emission-related messages must use the cyclic redundancy check and the threebyte header and not use interbyte separation or checksums; ISO 14230 - Part 4 "Road Vehicles - Keyword protocol 2000 for diagnostic systems - Part 4: Requirements for emissions-related systems"; ISO DIS 15765-4 "Road vehicles - Diagnostics on Controller Area Network (CAN) - Part 4: Requirements for emissions-related systems", dated 1 November 2001.
6.5.3.2	Test equipment and diagnostic tools needed to communicate with OBD systems must meet or exceed the functional specification given in ISO DIS 15031-4 "Road vehicles Communication between vehicle and external test equipment for emissions-related diagnostics - Part 4: External test equipment", dated 1 November 2001.
6.5.3.3	Basic diagnostic data, (as specified in 6.5.1) and bi-directional control information must be provided using the format and units described in ISO DIS 15031-5 "Road vehicles - Communication between vehicle and external test equipment for emissions-related diagnostics - Part 5: Emissions-related diagnostic services", dated 1 November 2001, and must be available using a diagnostic tool meeting the requirements of ISO DIS 15031-4. The vehicle manufacturer shall provide to a national standardisation body the details of any emission-related diagnostic data, e.g. PID's, OBD monitor Id's, Test Id's not specified in ISO DIS 15031-5 but related to this standred.
6.5.3.4	When a fault is registered, the manufacturer must identify the fault using an appropriate fault code consistent with those given in Section 6.3. of ISO DIS 15031-6 "Road vehicles - Communication between vehicle and external test equipment for emissions-related diagnostics - Part 6: Diagnostic trouble code definitions", relating to "emission related system diagnostic trouble codes". If such identification is not possible, the manufacturer may use diagnostic trouble codes according to Sections 5.3 and 5.6 of ISO DIS 15031-6. The fault codes must be fully accessible by standardised diagnostic equipment complying with the provisions of section 6.5.3.2. The vehicle manufacturer shall provide to a national standardisation body the details of any emission-related diagnostic data, e.g. PID's, OBD monitor Id's, Test Id's not specified in ISO DIS 15031-5 but related to this standred.

6.5.3.5	The connection interface between the vehicle and the diagnostic tester must be standardized and must meet all the requirements of ISO DIS 15031-3 "Road vehicles – Communication between vehicle and external test equipment for emissions-related diagnostics - Part 3: Diagnostic connector and related electrical circuits: specification and use", dated 1 November 2001. The installation position must be subject to agreement of the approval authority such that it is readily accessible by service personnel but protected from accidental damage during normal conditions of use.
6.5.3.6	The manufacturer shall also make accessible, where appropriate on payment, the technical information required for the repair or maintenance of motor vehicles unless that information is covered by an intellectual property right or constitutes essential, secret know how which is identified in an appropriate form; in such case, the necessary technical information shall not be withheld improperly. Entitled to such information is any person engaged in commercially servicing or repairing, road side rescuing, inspecting or testing of vehicles or in the manufacturing or selling replacement or retro-fit components, diagnostic tools and test equipment.

Appendix 2 to Chapter 3W-VII
ESSENSIAL CHARACTERISTICS OF THE VEHICLE FAMILY-OBD II

1.	**PARAMETERS DEFINING THE OBD FAMILY**
	The OBD family may be defined by basic design parameters, which must be common to vehicles within the family. In some cases there may be interaction of parameters. These effects must also be taken into consideration to ensure that only vehicles with similar exhaust emission characteristics are included within an OBD family.
2.	To this end, those vehicle types whose parameters described below are identical are considered to belong to the same engine-emission control/OBD system combination. Engine:
	- combustion process (i.e. positive-ignition, compression-ignition, two stroke, four-stroke),
	- method of engine fuelling (i.e. carburetor or fuel injection).
	- fuel type (i.e petrol, diesel, NG, LPG, bi-fuel petrol/NG, bi-fuel petrol/LPG
	Emission control system:
	- type of catalytic converter (i.e. oxidation, three-way, heated catalyst, other),
	- type of particulate trap,
	- secondary air injection (i.e. with or without),
	- exhaust gas recirculation (i.e. with or without)
	OBD parts and functioning:
	- the methods of OBD functional monitoring, malfunction detection and malfunction indication to the vehicle driver

1	**Introduction**
1.1	In order to alleviate the test burden on manufacturers when demonstrating the environmental performance of vehicles these may be grouped as a vehicle propulsion family. One or more parent vehicles shall be selected from this group of vehicles by the manufacturer to the satisfaction of the test agency that shall be used to demonstrate environmental performance test types I – V and VIII.
1.2	An L5 category vehicle may continue to be regarded as belonging to the same vehicle propulsion family provided that the vehicle variant, version, propulsion, pollution-control system listed in Table 11-1 are identical or remain within the prescribed and declared tolerances.
1.3.	Vehicle and propulsion family attribution with regard to environmental tests
	For the environmental test types I - V and VIII, a representative parent vehicle shall be selected within the boundaries set by the classification criteria laid down in point 3.
	Note: To represent all the combinations more than one parent vehicle can be used.
2.	**For Definitions refer clause 3 of overall requirements**
3.	**Classification criteria**
3.1	Legend: - a) Wherever "X" is mentioned in the columns for tests, means that the parameter mentioned in classification criteria falls in the same family and hence test is not required for extension of approval or addition of variant / version within the same type. b) Wherever "-" is mentioned in the columns for tests, means that the parameter mentioned in classification criteria is not applicable for that test and hence test need not be carried out for extension of approval or addition of variant / version within the same type.

Chapter 3W-VIII
Vehicle Propulsion family with regard to environmental performance demonstration tests

Table 11-1

Classification criteria propulsion family with regard to test types I, II, V and VIII

#	Classification criteria description (Vehicle continues to be regarded as belonging to the same family if the vehicle variant, version, propulsion, pollution-control system and OBD parameters are identical or remain within the prescribed limits.)	Test type I	Test type II	Test type V	Test type VIII
1.					
1.1	Category(L5M / L5N)	X	-	X	X
1.3.	the inertia of a vehicle variant(s) or version(s) within two inertia categories above or below the nominal inertia category;	X	-	X	X
1.4.	overall gear ratios (± 8 %); (see note below)	X	-	X	X
2.					
2.1.	Number of engines	X	X	X	X
2.2.	Reserved.				
2.3.	number of cylinders of the combustion engine;	X	X	X	X
2.4.	engine capacity (± 2 %) of the combustion engine;	X	X	X	-
	To include provision for combined weight and coast down coefficient changes from existing TAP				
2.4.1	maximum 30 % (*i.e.* the difference in the maximum CC between the lowest value and the highest value does not exceed 30% of the lowest value)	-	-	-	*X*
2.5.	number and control (variable cam phasing or lift) of combustion engine valves;	X	X	X	X
2.6.	Type of fuel (Note:Example change of petrol/diesel/LPG/CNG and monofuel / bifuel / flex fuel H_2NG / multifuel calls for retest)	X	X	X	X
2.7.	fuel system (Note:Example change of carburettor / scavenging port / port fuel injection /direct fuel injection / common rail / pump-injector / other calls for retest)	X	X	X	X

2.8.	fuel storage (Only for vehicles equipped with storage for gaseous fuel)	-	-	-	X
2.9.	type of cooling system of combustion engine;	X	X	X	X
2.10.	combustion cycle (Note: Example change of PI / CI / two-stroke / four-stroke / other calls for retest);	X	X	X	X
2.11.	intake air system (Note: Example change of naturally aspirated / charged (turbocharger / super-charger) / intercooler / boost control) and air induction control (mechanical throttle / electronic throttle control / no throttle calls for retest);	X	X	X	X
3.					
3.1.	propulsion exhaust (not) equipped with catalytic	X	X	X	-
3.2.					
3.2.1.	number and elements of catalytic converters;	X	X	X	-
3.2.2.	size of catalytic converters (volume of monolith(s) ±15 %);	X	X	X	-
3.2.3.	operation principle of catalytic activity (oxidising, three-way, heated, SCR, other.);	X	X	X	-
3.2.4.	precious metal load (identical or higher);	X	X	X	-
3.2.5	precious metal ratio (±15 %);	X	X	X	-
3.2.6.	substrate (structure and material);	X	X	X	-
3.2.7	cell density;	X	X	X	-
3.2.8.	type of casing for the catalytic converter(s);	X	X	X	-
3.3.					
3.3.1.	PF types;	X	X	X	-
3.3.2.	number and elements of PF;	X	X	X	-
3.3.3.	size of PF (volume of filter element ± 10 %);	X	X	X	-
3.3.4.	operation principle of PF (partial / wall-flow / other);	X	X	X	-
3.3.5.	active surface of PF;	X	X	X	-
3.4.					
3.4.1.	periodically regenerating system type;	X	X	X	-
3.4.2.	operation principle of periodically regenerating system;	X	X	X	-
3.5.					
3.5.1.	SCR system type;	X	X	X	-
3.5.2.	operation principle of periodically regenerating system;	X	X	X	-

3.6.					
3.6.1.	lean NO_X trap / absorber type;	X	X	X	-
3.6.2.	operation principle of lean NO_X trap / absorber;	X	X	X	-

3.7.					
3.7.1.	cold-start or starting aid device type;	X	X	X	-
3.7.2.	operation principle of cold start or starting aid device(s);	X	X	X	X
3.7.3.	Activation time of cold-start or starting aid device(s) and /or duty cycle (only limited time activated after cold start / continuous operation);	X	X	X	X
3.8.					
3.8.1.	O_2 sensor types;	X	X	X	X
3.8.2.	operation principle of O_2 sensor (binary / wide range /	X	X	X	X
3.8.3.	O_2 sensor interaction with closed-loop fueling system (stochiometry / lean or rich operation);	X	X	X	X
3.9.					
3.9.1.	EGR system types;	X	X	X	-
3.9.2.	operation principle of EGR system (internal / external);	X	X	X	-
3.9.3.	maximum EGR rate (± 5 %);	X	X	X	-

Note: 1. For each of the transmission ratios used in the Type I Test, it shall be necessary to determine the proportion E = (V2 - V1)/V1, where V1 and V2 are respectively the speed at 1000 rev/min of the engine of the vehicle model type approved and the speed of the vehicle model for which extension of the approval is requested. If for each gear ratio E < ± 8%, the extension shall be granted without repeating the Type I Tests.

3.2. Test types III and IV

Table 8-1

Classification criteria propulsion family with regard to test types III

1.	Vehicle	
2.	System	
2.1.	propulsion (not) equipped with crankcase ventilation system;	X
2.1.1.	crankcase ventilation system type;	X
2.1.2.	operation principle of crank case ventilation system (breather / vacuum / overpressure);	X

Chapter 3W-VIII
Vehicle Propulsion family with regard to environmental performance demonstration tests

Table 8-2

Classification criteria propulsion family with regard to test types IV

No.	Classification criteria description	Test type IV
1.	**Vehicle**	
1.1.	Category;	-
2.	**System[1]**	
2.1.	Propulsion (not) equipped with evaporative emission control system	X
2.1.1.	Evaporative emission control system type;	X
2.1.2.	Operation principle of evaporative emission control system (active / passive / mechanically or electronically controlled);	X
2.1.3.	Identical basic principle of fuel/air metering (e.g. carburetor / single point injection / multi point injection / engine speed density through MAP/ mass airflow);	X
2.1.4.	Identical material of the fuel tank; Note: material of all metallic fuel tanks are considered to be identical.	X
2.1.5	Liquid fuel hoses are identical and the surface area is lower;	X
2.1.6.	The fuel storage capacity declared by the manufacturer is within a range of +10 /- 50 % of the nominal fuel tank volume	X
2.1.7.	The fuel storage relief valve pressure setting is identical or higher;	X
2.1.8.	Identical method of storage of the fuel vapour (i.e. trap form, storage medium, air cleaner (if used for evaporative emission control) etc.);	X
2.1.9.	Identical or higher volume of the carbon canister the canister or with HC absorbent material or other equivalent	X
2.1.10.	Identical method of purging of the stored vapour (e.g. air flow, purge volume over the driving cycle);	X
2.1.11.	Identical method of sealing and venting of the fuel metering system;	X

Chapter 3W-IX
Type VII requirements: CO$_2$ emissions, fuel consumption, electric energy consumption and electric range

1.	**Introduction**
1.1.	This Chapter sets out requirements with regard to energy efficiency of L5-category vehicles, in particular with respect to the measurement of CO$_2$ emissions, fuel or energy consumption as well as the electric range of a vehicle.
1.2.	The requirements laid down in this chapter apply to the following tests of L5-category vehicles equipped with associated power train configurations:
	(a)) the measurement of the emission of carbon dioxide (CO$_2$) and fuel consumption, the measurement of electric energy consumption and the electric range of L5-category vehicles powered by a combustion engine only or by a hybrid electric powertrain.
	(b) the measurement of electric energy consumption and electric range of L5-category vehicles powered by an electric power train only.
2.	**Specification and tests**
2.1.	General The components liable to affect CO$_2$ emissions and fuel consumption or the electric energy consumption shall be so designed, constructed and assembled as to enable the vehicle, in normal use, despite the vibrations to which it may be subjected, to comply with the provisions of this Chapter .
2.2.	Description of tests for vehicles powered by a combustion engine only
2.2.1.	The emissions of CO$_2$ and fuel consumption shall be measured according to the test procedure described in Appendix 1. Vehicles which do not attain the acceleration and maximum speed values required in the test cycle shall be operated with the accelerator control fully depressed until they reach the required operating curve again. Deviations from the test cycle shall be recorded in the test report.
2.2.2	For CO$_2$ emissions, the test results shall be expressed in grams per kilometer (g/km) rounded to the nearest whole number.
2.2.3.	Fuel consumption values shall be expressed in litres per 100 km in the case of petrol, LPG, ethanol (E85) and diesel or in kg and m^3 per 100 km in the case of hydrogen, NG/biomethane and H$_2$NG. The values shall be calculated according to point 1.4.3. of Chapter 2W-II by the carbon balance method, using the measured emissions of CO$_2$ and the other carbon-related emissions (CO and HC). The results shall be rounded to one decimal.
2.2.4.	The appropriate reference fuels as set out in Appendix 2 to Chapter 2W-II shall be used for testing.
	For LPG, NG/biomethane, H$_2$NG, the reference fuel used shall be that chosen by the manufacturer for the measurement of the propulsion unit performance.
	For the purpose of the calculation referred in point 2.2.3., the fuel consumption shall be expressed in appropriate units and the following fuel characteristics

Chapter 3W-IX
Type VII requirements: CO₂ emissions, fuel consumption, electric energy
consumption and electric range

	shall be used:
	(a) density: measured on the test fuel according to ISO 3675:1998 or an equivalent method. For petrol and diesel fuel, the density measured at 288.2 K (15 °C) and 101.3 kPa shall be used; for LPG, natural gas, H₂NG and hydrogen, a reference density shall be used, as follows:
	0.538 kg/litre for LPG; 0.654 kg/m₃ for NG (1) / biogas; Equation 7-1: $$\frac{1{,}256 \cdot A + 136}{0{,}654 \cdot A}$$ for H₂NG (with A being the quantity of NG/biomethane in the H₂NG mixture, expressed in percent by volume for H₂NG); 0.084 kg/m₃ for hydrogen
	(b) hydrogen-carbon ratio: fixed values will be used, as follows: C_1 : 1.89 O 0.016 for E5 petrol; C_1 : 1,86 O 0,005 for diesel; C_1 : 2525 for LPG (liquefied petroleum gas); C_1 : 4 for NG (natural gas) and biomethane; C_1 : 2,74 O 0,385 for ethanol (E85).
2.3.	Description of tests for vehicles powered by an electric powertrain only
2.3.1.	The test agency in charge of the tests shall conduct the measurement of the electric energy consumption according to the method and test cycle described in Appendix 6 to Chapter 2W- II.
2.3.2.	The test agency in charge of the tests shall measure the electric range of the vehicle according to the method described in Appendix 3.3 of this chapter.
2.3.2.1.	The electric range measured by this method shall be the only one referred to in promotional material
2.3.2.2.	Category L1e vehicles designed to pedal referred to in Article 2(94) shall be exempted from the electric range test.
2.3.3.	Electric energy consumption shall be expressed in Watt hours per kilometer (Wh/km) and the range in kilometers, both rounded to the nearest whole number.
	(1) Mean value of G20 and G25 reference fuels at 288.2 K (15 °C).

2.4.	Description of tests for vehicles powered by a hybrid electric powertrain
2.4.1.	The test agency in charge of the tests shall measure the CO_2 emissions and the electric energy consumption according to the test procedure described in Appendix 3.
2.4.2.	The test results for CO_2 emissions shall be expressed in grams per kilometre (g/km) rounded to the nearest whole number.
2.4.3.	The fuel consumption, expressed in litres per 100 km (in the case of petrol, LPG, ethanol (E85) and diesel) or in kg and m^3 per 100 km (in the case of NG/biomethane, H 2 NG and hydrogen), shall be calculated according to point 1.4.3. of Chapter 2W-II by the carbon balance method using the CO_2 emissions measured and the other carbon- related emissions (CO and HC). The results shall be rounded to the first decimal place
2.4.4.	For the purpose of the calculation referred to in point 2.4.3., the prescriptions and reference values of point 2.2.4. shall apply.
2.4.5.	If applicable, electric energy consumption shall be expressed in Watt hours per kilometer (Wh/km), rounded to the nearest whole number.
2.4.6.	The test agency in charge of the tests shall measure the electric range of the vehicle according to the method described in Appendix 3.3. The result shall be expressed in kilometer, rounded to the nearest whole number.
	The electric range measured by this method shall be the only one referred to in promotional material and used for the calculations in Appendix 3
2.5.	Interpretation of test results
2.5.1.	The CO_2 value or the value of electric energy consumption adopted as the type-approval value shall be that declared by the manufacturer if this is not exceeded by more than 4 percent by the value measured by the Test Agency. The measured value may be lower without any limitations
	In the case of vehicles powered by a combustion engine only which are equipped with periodically regenerating systems as defined in Article 2(16), the results are multiplied by the factor Ki obtained from Appendix 10 to Chapter 2W-II before being compared with the declared value.
2.5.2.	If the measured value of CO_2 emissions or electric energy consumption exceeds the manufacturer's declared CO_2 emissions or electric energy consumption value by more than 4 percent, another test shall be run on the same vehicle.
	Where the average of the two test results does not exceed the manufacturer's declared value by more than 4 percent, the value declared by the manufacturer shall be taken as the type-approval value.
2.5.3.	If, in the event of another test being run, the average still exceeds the declared value by more than 4 percent, a final test shall be run on the same vehicle. The average of the three test results shall be taken as the type- approval value.

Chapter 3W-IX
Type VII requirements: CO₂ emissions, fuel consumption, electric energy consumption and electric range

3.	**Modification and extension of approval of the approved type**
3.1.	For all approved types, the test agency that approved the type shall be notified of any modification of it. The test agency may then either:
3.1.1.	consider that the modifications made are unlikely to have an appreciable adverse effect on the CO_2 emissions and fuel or electric energy consumption values and that the original environmental performance approval will be valid for the modified vehicle type with regard to the environmental performance, or
3.1.2.	require a further test report from the test agency responsible for conducting the tests in accordance with point 4.
3.2.	Confirmation or extension of approval, specifying the alterations, shall be communicated as per AIS 017.
4.	**Conditions of extension of vehicle environmental performance type-approval**
4.1.	Vehicles powered by an internal combustion engine only, except those equipped with a periodically regenerating emission-control system
	A type-approval may be extended to vehicles produced by the same manufacturer that are of the same type or of a type that differs with regard to the following characteristics in Appendix 1, provided the emissions measured by the test agencydo not exceed the type-approved value by more than 4 percent:
4.1.1.	reference mass;
4.1.2.	maximum authorized mass.;
4.1.3.	type of bodywork;
4.1.4.	overall gear ratios;
4.1.5.	engine equipment and accessories;
4.1.6.	engine revolutions per kilometer in highest gear with an accuracy of +/− 5 %.
4.2.	Vehicles powered by an internal combustion engine only and equipped with a periodically regenerating emission- control system.
	The type-approval may be extended to vehicles produced by the same manufacturer that are of the same type or of a type that differs with regard to the characteristics in Appendix 1, as referred to in points 4.1.1. to 4.1.6., without exceeding the propulsion family characteristics of chapter 2W-IX, provided the CO_2 emissions measured by the test agencydo not exceed the type-approved value by more than 4 percent, where the same K i factor is applicable.

	The type-approval may also be extended to vehicles of the same type, but with a different Ki factor, provided the corrected CO$_2$ value measured by the test agencydoes not exceed the type-approved value by more than 4 percent
4.3.	Vehicles powered by an electric powertrain only Extensions may be granted after agreement with the test agency
4.4.	Vehicles powered by a hybrid electric powertrain The type-approval may be extended to vehicles of the same type or of a type that differs with regard to the following characteristics in Appendix 3 provided the CO$_2$ emissions and the electric energy consumption measured by the test agency do not exceed the type-approved value by more than 4 percent
4.4.1.	reference mass;
4.4.2.	maximum authorized mass;
4.4.3.	type of bodywork
4.4.4.	type and number of propulsion batteries. Where multiple batteries are fitted, e.g. to extend the range extrapolation of the measurement, the base configuration, taking into account the capacities and the way in which the batteries are connected (in parallel, not in series), shall be deemed sufficient
4.5.	Where any other characteristic is changed, extensions may be granted after agreement with the test agency .
5.	**Special provisions**
	Vehicles produced in the future with new energy-efficient technologies may be subject to complementary test programmes, to be specified at a later stage. Such testing will enable manufacturers to demonstrate the advantages of the technologies.

Appendix 1 to Chapter 3W-IX
Method of measuring carbon dioxide emissions and fuel consumption of vehicles
powered by a combustion engine only

1.	**Specification of the test**
1.1.	The carbon dioxide (CO_2) emissions and fuel consumption of vehicles powered by a combustion engine only shall be determined according to the procedure for the type I test in chapter 2W-II in force at the time of the approval of the vehicle.
1.2.	In addition to the CO_2 emission and fuel consumption results for the entire type I test, CO_2 emissions and fuel consumption shall also be determined separately for parts 1, 2 and 3, if applicable, by using the applicable type I test procedure in force at the time of the approval of the vehicle
1.3.	In addition to the conditions in chapter 2W-II in force at the time of the approval of the vehicle, the following conditions shall apply:
1.3.1.	Only the equipment necessary for the operation of the vehicle during the test shall be in use. If there is a manually controlled device for the engine intake air temperature, it shall be in the position prescribed by the manufacturer for the ambient temperature at which the test is performed. In general, the auxiliary devices required for the normal operation of the vehicle shall be in use.
1.3.2.	If the radiator fan is temperature-controlled, it shall be in normal operating condition. The passenger compartment heating system, if present, shall be switched off, as shall any air-conditioning system, but the compressor for such systems shall be functioning normally
1.3.3.	If a super-charger is fitted, it shall be in normal operating condition for the test conditions.
1.3.4.	All lubricants shall be those recommended by the manufacturer of the vehicle and shall be specified in the test report.
1.3.5.	The widest tyre shall be chosen, except where there are more than three tyre sizes, in which case the second widest shall be chosen. The pressures shall be indicated in the test report.
1.4.	Calculation of CO 2 and fuel consumption values
1.4.1.	The mass emission of CO 2, expressed in g/km, shall be calculated from the measurements taken in accordance with the provisions of point 6 of Chapter 2W- II
1.4.1.1.	For this calculation, the density of CO 2 shall be assumed to be Q CO 2 = 1,964 g/litre
1.4.2.	The fuel consumption values shall be calculated from the hydrocarbon, carbon monoxide and carbon dioxide emission measurements taken in accordance with the provisions of point 6 of chapter 2W-II in force at the time of the approval of the vehicle.
1.4.3.	Fuel consumption (FC), expressed in litres per 100 km (in the case of petrol, LPG, ethanol (E85) and diesel) or in kg per 100 km (in the case of an alternative fuel vehicle propelled with NG/biomethane, H 2 NG or hydrogen) is calculated using the following formulae:

Appendix 1 to Chapter 3W-IX
Method of measuring carbon dioxide emissions and fuel consumption of vehicles
powered by a combustion engine only

1.4.3.1.	for vehicles with a positive ignition engine fuelled with petrol (E5): Equation Ap1-1: FC = (0,118/D) · ((0,848 · HC) + (0,429 · CO) + (0,273 · CO 2));
1.4.3.2.	for vehicles with a positive ignition engine fuelled with LPG: Equation Ap1-2: FC norm = (0,1212/0,538) · ((0,825 · HC) + (0,429 · CO) + (0,273 · CO 2))
	If the composition of the fuel used for the test differs from that assumed for the calculation of normalised consumption, a correction factor (cf) may be applied at the manufacturer's request, as follows Equation Ap1-3: FC norm = (0,1212/0,538) · (cf) · ((0,825 · HC) + (0,429 · CO) + (0,273 · CO 2)).
	The correction factor is determined as follows: Equation Ap1-4: cf = 0,825 + 0,0693 · n actual ;. where: n actual = the actual H/C ratio of the fuel used;
1.4.3.3.	for vehicles with a positive ignition engine fuelled with NG/biomethane: Equation Ap1-5: FC norm = (0,1336/0,654) · ((0,749 · HC) + (0,429 · CO) + (0,273 · CO 2)) in m 3 ;
	1.4.3.4. for vehicles with a positive ignition engine fuelled by H 2 NG: Equation Ap1-6: $$FC = \frac{910,4 \cdot A + 13\,600}{44\,655 \cdot A^2 + 667,08 \cdot A} \left(\frac{7\,848 \cdot A}{9\,104 \cdot A^2 + 136} \cdot HC + 0,429 \cdot CO + 0,273 \cdot CO_2 \right) \text{ in } m^3;$$
1.4.3.5.	for vehicles fuelled with gaseous hydrogen: Equation Ap1-7: $$FC = 0,024 \cdot \frac{V}{d} \cdot \left[\frac{1}{Z_2} \cdot \frac{p_2}{T_2} - \frac{1}{Z_1} \cdot \frac{p_1}{T_1} \right]$$
	For vehicles fuelled with gaseous or liquid hydrogen, the manufacturer may alternatively, with the prior agreement of the test agency , choose either the formula

Appendix 1 to Chapter 3W-IX
Method of measuring carbon dioxide emissions and fuel consumption of vehicles
powered by a combustion engine only

	Equation Ap1-8: $FC = 0,1 \cdot (0,1119 \cdot H_2O + H_2$
	or a method in accordance with standard protocols such as SAE J2572.
1.4.3.6.	for vehicles with a compression ignition engine fuelled with diesel (B5): Equation Ap1-9: $FC = (0,116/D) \cdot ((0,861 \cdot HC) + (0,429 \cdot CO) + (0,273 \cdot CO_2));$
1.4.3.7.	for vehicles with a positive ignition engine fuelled with ethanol (E85): Equation Ap1-10: $FC = (0,1742/D) \cdot ((0,574 \cdot HC) + (0,429 \cdot CO) + (0,273 \cdot CO_2)).$
1.4.4.	In these formulae: FC = the fuel consumption in litres per 100 km in the case of petrol, ethanol, LPG, diesel or biodiesel, in m 3 per 100 km in the case of natural gas and H_2 NG or in kg per 100 km in the case of hydrogen
	HC = the measured emission of hydrocarbons in mg/km CO = the measured emission of carbon monoxide in mg/km CO_2 = the measured emission of carbon dioxide in g/km H_2O = the measured emission of water (H_2O) in g/km
	H_2 = the measured emission of hydrogen (H_2) in g/km A = the quantity of NG/biomethane in the H_2 NG mixture, expressed in percent by volume A = the quantity of NG/biomethane in the H_2 NG mixture, expressed in percent by volume D = the density of the test fuel In the case of gaseous fuels, D is the density at 15 °C and at 101,3 kPa ambient pressure: d = theoretical distance covered by a vehicle tested under the type I test in km p_1 = pressure in gaseous fuel tank before the operating cycle in Pa p_2 = pressure in gaseous fuel tank after the operating cycle in Pa T_1 = temperature in gaseous fuel tank before the operating cycle in K T_2 = temperature in gaseous fuel tank after the operating cycle in K Z_1 = compressibility factor of the gaseous fuel at p_1 and T_1

Z_2 = compressibility factor of the gaseous fuel at p_2 and T_2

V = inner volume of the gaseous fuel tank in m 3

The compressibility factor shall be obtained from the following table:

Table Ap1-1

Compressibility factor Z_x of the gaseous fuel

T(k) \ p(bar)	5	100	200	300	400	500	600	700	800	900
33	0,8589	10,508	18,854	26,477	33,652	40,509	47,119	53,519	59,730	65,759
53	0,9651	0,9221	14,158	18,906	23,384	27,646	31,739	35,697	39,541	43,287
73	0,9888	0,9911	12,779	16,038	19,225	22,292	25,247	28,104	30,877	33,577
93	0,9970	10,422	12,334	14,696	17,107	19,472	21,771	24,003	26,172	28,286
113	10,004	10,659	12,131	13,951	15,860	17,764	19,633	21,458	23,239	24,978
133	10,019	10,757	11,990	13,471	15,039	16,623	18,190	19,730	21,238	22,714
153	10,026	10,788	11,868	13,123	14,453	15,804	17,150	18,479	19,785	21,067
173	10,029	10,785	11,757	12,851	14,006	15,183	16,361	17,528	18,679	19,811
193	10,030	10,765	11,653	12,628	13,651	14,693	15,739	16,779	17,807	18,820
213	10,028	10,705	11,468	12,276	13,111	13,962	14,817	15,669	16,515	17,352
233	10,035	10,712	11,475	12,282	13,118	13,968	14,823	15,675	16,521	17,358
248	10,034	10,687	11,413	12,173	12,956	13,752	14,552	15,350	16,143	16,929

T(k) \ p(bar)	5	100	200	300	400	500	600	700	800	900
263	10,033	10,663	11,355	12,073	12,811	13,559	14,311	15,062	15,808	16,548
278	10,032	10,640	11,300	11,982	12,679	13,385	14,094	14,803	15,508	16,207
293	10,031	10,617	11,249	11,897	12,558	13,227	13,899	14,570	15,237	15,900
308	10,030	10,595	11,201	11,819	12,448	13,083	13,721	14,358	14,992	15,623
323	10,029	10,574	11,156	11,747	12,347	12,952	13,559	14,165	14,769	15,370
338	10,028	10,554	11,113	11,680	12,253	12,830	13,410	13,988	14,565	15,138
353	10,027	10,535	11,073	11,617	12,166	12,718	13,272	13,826	14,377	14,926

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Method of measuring the electric energy consumption of a vehicle powered
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1	**Test sequence**
1.1	Electric energy consumption of pure electric vehicles shall be determined according to the procedure for the type I test in Chapter 2W- II in force at the time of the approval of the vehicle. For this purpose, a pure vehicle shall be classified according to its maximum attainable design vehicle speed.
	If the vehicle has several driving modes which may be selected by the driver, the operator shall select that which best matches the target curve.
2.	**Test method**
2.1.	Principle The following test method shall be used for measuring of the electric energy consumption, expressed in Wh/km:
2.2.	Table Ap2-1 **Parameters, units and accuracy of measurement** <table><tr><td>Parameter</td><td>Units</td><td>Accuracy</td><td>Resolution</td></tr><tr><td>Time</td><td>s</td><td>0.1 s</td><td>0.1 s</td></tr><tr><td>Distance</td><td>m</td><td>± 0.1 percent</td><td>1 m</td></tr><tr><td>Temperature</td><td>K</td><td>± 1 K</td><td>1 K</td></tr><tr><td>Speed</td><td>km/h</td><td>± 1 percent</td><td>0.2 km/h</td></tr><tr><td>Mass</td><td>kg</td><td>± 0.5 percent</td><td>1 kg</td></tr><tr><td>Energy</td><td>Wh</td><td>± 0.2 percent</td><td>Class 0.2 s according to IEC ([1]) 687</td></tr></table>
	([1]) International Electro technical Commission.
2.3.	Test vehicle
2.3.1.	Condition of the vehicle
2.3.1.1.	The vehicle tyres shall be inflated to the pressure specified by the vehicle manufacturer when the tyres are at ambient temperature.
2.3.1.2.	The viscosity of the oils for the mechanical moving parts shall conform to the vehicle manufacturer's specification.
2.3.1.3.	The lighting, signaling and auxiliary devices shall be off, except those required for the testing and usual day- time operation of the vehicle
2.3.1.4.	All energy storage systems for other than traction purposes (electric, hydraulic, pneumatic, etc.) shall be charged to their maximum level as specified by the manufacturer.

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2.3.1.5.	If the batteries are operated above the ambient temperature, the operator shall follow the procedure recommended by the vehicle manufacturer in order to keep the battery temperature in the normal operating range. The manufacturer shall be in a position to attest that the thermal management system of the battery is neither disabled nor reduced.
2.3.1.6.	The vehicle shall have travelled at least 300 km in the seven days before the test with the batteries installed for the test.
2.3.2.	Classification of the pure electric test vehicle in the type I test cycle.
	In order to measure its electric consumption in the type I test cycle, the test vehicle shall be classified according to the achievable maximum design vehicle speed thresholds only, as per the notification.
2.4.	Operation mode All the tests are conducted at a temperature of between 293.2 K and 303.2 K (20 °C and 30 °C). The test method includes the four following steps: (a) initial charge of the battery; (b) two runs of the applicable type I test cycle; (c) charging the battery; (d) Calculation of the electric energy consumption. If the vehicle moves between the steps, it shall be pushed to the next test area (without regenerative recharging)
2.4.1.	Initial charge of the battery Charging the battery consists of the following procedures
2.4.1.1.	Discharge of the battery The battery is discharged while the vehicle is driven (on the test track, on a chassis dynamometer, etc.) at a steady speed of 70 percent ± 5 percent of the maximum design vehicle speed Discharging shall stop: (a) when the vehicle is unable to run at 65 percent of the maximum thirty minutes speed, or (b) when the standard on-board instrumentation indicates that the vehicle should be stopped, or (c) after 100 km.

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Method of measuring the electric energy consumption of a vehicle powered by an electric powertrain only

	By means of derogation if the manufacturer can prove to the test agency to the satisfaction of the test agency that the vehicle is physically not capable of achieving the thirty minutes speed the maximum fifteen minute speed may be used instead.
2.4.1.2.	Application of a normal overnight charge The battery shall be charged according to the following procedure
2.4.1.2.1.	Normal overnight charge procedure The charge shall be carried out: (a) with the on-board charger if fitted (b) with an external charger recommended by the manufacturer, using the charging pattern prescribed for normal charging; (c) in an ambient temperature of between 293.2 K and 303.2 K (20 °C and 30 °C). This procedure excludes all types of special charges that could be automatically or manually initiated, e.g. equalization or servicing charges. The vehicle manufacturer shall declare that no special charge procedure has occurred during the test.
2.4.1.2.2	End-of-charge criteria The end-of-charge criteria shall correspond to a charging time of 12 hours except where the standard instrumentation indicates clearly that the battery is not yet fully charged, in which case
	Equation Ap2-1: the maximum time is $= \dfrac{3 . \text{claimed battery capacity (Wh)}}{\text{Mains power supply (W)}}$
2.4.1.2.3.	Fully charged battery Propulsion batteries shall be deemed as fully charged when they have been charged according to the overnight charge procedure until the end-of-charge criteria are fulfilled.
2.4.2.	Application of the type I test cycle and measurement of the distance The end of charging time t_0 (plug off) shall be reported. The chassis dynamometer shall be set according to the method in point 4.5.6. of Chapter 2W- II.
	Starting within four hours of t_0, the applicable type I test shall be run twice on a chassis dynamometer, following which the distance covered in km (D_{test}) is recorded. If the manufacturer can demonstrate to the test agency that twice the type I test distance can physically not be attained by the vehicle, the test cycle shall be conducted once and subsequently followed by a partial second test run. The second test run may stop if the minimum state of charge of the propulsion battery is reached as referred to in Appendix 3.1.

Method of measuring the electric energy consumption of a vehicle powered by an electric powertrain only

2.4.3.	Charge of the battery : The test vehicle shall be connected to the mains within 30 minutes of the second run of the applicable type I test cycle. The vehicle shall be charged according to the normal overnight charge procedure in point 2.4.1.2. The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the energy charge E delivered from the mains and its duration. Charging shall stop 24 hours after the end of the previous charging time (t_0).
	Note: In the event of a mains power cut, the 24 hour period may be extended in line with the duration of the cut. The validity of the charge shall be discussed between the test agency of the approval laboratory and the vehicle manufacturer to the satisfaction of the test agency .
2.4.4.	Electric energy consumption calculation Energy E in Wh and charging time measurements are to be recorded in the test report. The electric energy consumption c shall be determined using the formula *Equation Ap2-2:* $\quad C = \dfrac{E}{D_{test}}$ (expressed in Wh/km and rounded to the nearest whole number where D_{test} is the distance covered during the test (in km).

Appendix 3 to Chapter 3W-IX

Method of measuring the carbon dioxide emissions, fuel consumption, electric energy consumption and driving range of vehicles powered by a hybrid electric powertrain

1.	**Introduction**
1.1.	This Appendix lays down specific provisions on the type-approval of hybrid electric L-category vehicles (HEV) as regards measuring carbon dioxide emissions, fuel consumption, electric energy consumption and driving range.
1.2.	As a general principle for type VII tests, HEVs shall be tested according to the specified type I test cycles and requirements and in particular Appendix 6 to Chapter 2W- II, except where modified by this Appendix
1.3.	OVC (externally chargeable) HEVs shall be tested under Conditions A and B. The test results under Conditions A and B and the weighted average referred to in point 3 shall be given in the test report.
1.4.	Driving cycles and gear-shift points
1.4.1.	The driving cycle in Appendix 6 to Chapter 2W- II applicable at the time of approval of the vehicle shall be used, including the gear-shifting points in point 4.5.5. of Chapter 2W- II.
1.4.4.	For vehicle conditioning, a combination of the driving cycles in Appendix 6 to Chapter 2W- II applicable at the time of approval of the vehicle shall be used as laid down in this Appendix.
2	**Categories of hybrid electric vehicles (HEV)** Table Ap3-1 <table><tr><td>Vehicle charging</td><td colspan="2">Off-Vehicle Charging ([1]) (OVC)</td><td colspan="2">Not-off-vehicle Charging ([2]) (NOVC)</td></tr><tr><td>Operating mode switch</td><td>Without</td><td>With</td><td>Without</td><td>With</td></tr></table> ([1]) Also known as 'externally chargeable'. ([2]) Also known as 'not externally chargeable'.
3.	**OVC (externally chargeable) HEV without an operating mode switch**
3.1.	Two type I tests shall be performed under the following conditions
	(a) condition A: the test shall be carried out with a fully charged electrical energy/power storage device;
	(b) Condition B: the test shall be carried out with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity).

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	The profile of the state of charge (SOC) of the electrical energy/power storage device at different stages of the test is set out in Appendix 3.1
3.2.	Condition A
3.2.1.	The procedure shall start with the discharge of the electrical energy/power storage device in accordance with point 3.2.1.1.:
3.2.1.1.	Discharge of the electrical energy/power storage device The electrical energy/power storage device of the vehicle is discharged while driving (on the test track, on a chassis dynamometer, etc.) in any of the following conditions: — at a steady speed of 50 km/h until the fuel-consuming engine starts up, — if a vehicle cannot reach a steady speed of 50 km/h without the fuel-consuming engine starting up, the speed shall be reduced until it can run at a lower steady speed at which the fuel-consuming engine does not start up for a defined time or distance (to be determined by the test agency and the manufacturer to the satisfaction of the test agency), — in accordance with the manufacturer's recommendation. The fuel-consuming engine shall be stopped within ten seconds of being automatically started.
3.2.2.	Conditioning of the vehicle
3.2.2.1.	The test vehicle shall be preconditioned by conducting the applicable type I test cycle in combination with the applicable gear-shifting in point 4.5.5. of Chapter 2W- II.
3.2.2.2.	After this preconditioning and before testing, the vehicle shall be kept in a room in which the temperature remains relatively constant between 293.2 and 303.2 K (20 °C and 30 °C). This conditioning shall be carried out for at least six hours and continue until the temperatures of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room, and the electrical energy/power storage device is fully charged as a result of the charging in point 3.2.2
3.2.2.3.	During soak, the electrical energy/power storage device shall be charged in accordance with the normal overnight charging procedure described in point 3.2.
3.2.2.4.	Application of a normal overnight charge The electrical energy/power storage device shall be charged according to the following process.

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3.2.2.4.1.	Normal overnight charge procedure The charging shall be carried out as follows: (a) with the on-board charger, if fitted or (b) with an external charger recommended by the manufacturer using the charging pattern prescribed for normal charging; and (c) in an ambient temperature of between 20 °C and 30 °C. This procedure shall exclude all types of special charge that could be automatically or manually initiated, e.g. equalization or servicing charges. The manufacturer shall declare that no special charge procedure has occurred during the test.
3.2.2.4.2.	End-of-charge criteria
	The end-of-charge criteria shall correspond to a charging time of twelve hours, except where the standard instrumentation indicates clearly that the electrical energy/power storage device is not yet fully charged, in which case: Equation Ap3-1: $$\text{the maximum time is} = \frac{3.\text{claimed battery capacity (Wh)}}{\text{Mains power supply (W)}}$$
3.2.3.	Test procedure
3.2.3.1	The vehicle shall be started up by the means provided for normal use by the driver. The first cycle starts on the initiation of the vehicle start-up procedure.
3.2.3.2.	The test procedures defined in either point 3.2.3.2.1. or 3.2.3.2.2. may be used
3.2.3.2.1.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period in the applicable type I driving cycle (end of sampling (ES)).
3.2.3.2.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and continue over a number of repeat test cycles. It shall end on conclusion of the applicable type I driving cycle during which the battery reached the minimum state of charge in accordance with the following procedure (end of sampling (ES)):
3.2.3.2.2.1.	The electricity balance Q (Ah) is measured over each combined cycle, using the procedure in Appendix 3.2., and used to determine when the battery's minimum state of charge has been reached.
3.2.3.2.2.2.	The battery's minimum state of charge is considered to have been reached in combined cycle N if the electricity balance Q measured during combined cycle N + 1 is not more than a 3 percent discharge, expressed as a percentage of the

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	nominal capacity of the battery (in Ah) in its maximum state of charge, as declared by the manufacturer. At the manufacturer's request, additional test cycles may be run and their results included in the calculations in points 3.2.3.5. and 3.4., provided that the electricity balance for each additional test cycle shows less discharge of the battery than over the previous cycle.
3.2.3.2.2.3.	Between each pair of cycles, a hot soak period of up to ten minutes is allowed. The powertrain shall be switched off during this period.
3.2.3.3.	The vehicle shall be driven according to the applicable type I driving cycle and gear-shifting prescriptions in Chapter 2W- II.
3.2.3.4.	The tailpipe emissions of the vehicle shall be analyzed according to the provisions of Chapter 2W- II in force at the time of approval of the vehicle.
3.2.3.5.	The CO_2 emission and fuel consumption results from the test cycle(s) for Condition A shall be recorded (respectively m_1 (g) and c_1 (l)). Parameters m_1 and c_1 shall be the sums of the results of the N combined cycles run.
	Equation Ap3-2: $$m_1 = \sum_1^N m_i$$ *Equation Ap3-3:* $$c_1 = \sum_1^n c_i$$
3.2.4.	Within the 30 minutes after the conclusion of the cycle, the electrical energy / power storage device shall be charged according to point 3.2.2.4. The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy e_1 (Wh) delivered from the mains.
3.2.5.	The electric energy consumption for Condition A shall be e_1 (Wh).
3.3.	Condition B
3.3.1.	Conditioning of the vehicle
3.3.1.1.	The electrical energy/power storage device of the vehicle shall be discharged in accordance with point 3.2.1.1. At the manufacturer's request, a conditioning in accordance with point 3.2.2.1. may be carried out before electrical energy/power storage discharge.
3.3.1.2.	Before testing, the vehicle shall be kept in a room in which the temperature remains relatively constant between 293.2 K and 303.2 K (20 °C and 30 °C). This conditioning shall be carried out for at least six hours and continue until the temperatures of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room.

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3.3.2.	Test procedure
3.3.2.1.	The vehicle shall be started up by the means provided for normal use by the driver. The first cycle starts on the initiation of the vehicle start-up procedure.
3.3.2.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period in the applicable type I driving cycle (end of sampling (ES)).
3.3.2.3.	The vehicle shall be driven using the applicable type I driving cycle and gear-shifting prescriptions set out in Appendix 6 to Chapter 2W- II.
3.3.2.4.	The tailpipe emissions of the vehicle shall be analyzed according to the provisions of Chapter 2W- II.
3.3.2.5.	The test results for Condition B shall be recorded (m_2 (g) and c_2 (l) respectively
3.3.3.	Within 30 minutes of the end of the cycle, the electrical energy/power storage device shall be charged in accordance with point 3.2.2.4. The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the energy charge e_2 (Wh) delivered from the mains.
3.3.4.	The electrical energy/power storage device of the vehicle shall be discharged in accordance with point 3.2.1.1
3.3.5.	Within 30 minutes of the discharge, the electrical energy/power storage device shall be charged in accordance with point 3.2.2.4. The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the energy charge e_3 (Wh) delivered from the mains.
3.3.6.	The electric energy consumption e_4 (Wh) for Condition B is: Equation Ap3-4: $e_4 = e_2 - e_3$
3.4.	Test results
3.4.1.	The CO_2 values shall be: Equation Ap3-5: $M_1 = m_1 / D_{test1}$ and Equation Ap3-6: $M_2 = m_2 / D_{test2}$ (mg/km) where: D_{test1} and D_{test2} = the actual distances driven in the tests performed under Conditions A (point 3.2.) and B (point 3.3.) respectively, and m_1 and m_2 = test results determined in points 3.2.3.5. and 3.3.2.5. respectively.

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3.4.2.1.	For testing in accordance with point 3.2.3.2.1:
	The weighted CO_2 values shall be calculated as follows:
	Equation Ap3-7:
	$$M = (D_e \cdot M_1 + D_{av} \cdot M_2)/(D_e + D_{av})$$
	where:
	M = mass emission of CO_2 in grams per kilometer,
	M_1 = mass emission of CO_2 in grams per kilometer with a fully charged electrical energy/power storage device,
	M_2 = mass emission of CO_2 in grams per kilometer with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity),
	D_e = electric range of the vehicle determined according to the procedure described in Appendix 3.3., where the manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state,
	D_{av} = average distance between two battery recharges, D_{av} =:
	— 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ;
	— 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h;
	— 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
3.4.2.2.	For testing in accordance with point 3.2.3.2.2.:
	Equation Ap3-8:
	$$M = (D_{ovc} \cdot M_1 + D_{av} \cdot M_2)/(D_{ovc} + D_{av})$$
	where:
	M = mass emission of CO_2 in grams per kilometer,
	M_1 = mass emission of CO_2 in grams per kilometer with a fully charged electrical energy/power storage device,
	M_2 = mass emission of CO_2 in grams per kilometer with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity),
	D_{ovc} = OVC range according to the procedure described in Appendix 3.3.,

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	D_{av} = average distance between two battery recharges, D_{av} =: — 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ; — 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h; — 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h
3.4.3.	The fuel consumption values shall be: Equation Ap3-9: $$C_1 = 100 \, {}^{C_1}\!/_{D_{test1}}$$ Equation Ap3-10: $$C_2 = 100 \, {}^{C_2}\!/_{D_{test2}} \; \text{(l/100 km) for liquid fuels and (kg/100) km for gaseous fuel}$$ where: D_{test1} and D_{test2} = the actual distances driven in the tests performed under Conditions A (point 3.2.) and B (point 3.3.) respectively, and c 1 and c 2 = test results determined in points 3.2.3.8. and 3.3.2.5 respectively.
3.4.4.	The weighted fuel consumption values shall be calculated as follows:
3.4.4.1.	For testing in accordance with point 3.2.3.2.1.: Equation Ap3-11: $C = (D_e \cdot C_1 + D_{av} \cdot C_2)/(D_e + D_{av})$ where: C = fuel consumption in l/100 km, C_1 = fuel consumption in l/100 km with a fully charged electrical energy/power storage device, C_2 = fuel consumption in l/100 km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), D_e = electric range of the vehicle determined according to the procedure described in Appendix 3.3., where the manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state,

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	D_{av} = average distance between two battery recharges, D_{av} =:
	— 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ;
	— 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h;
	— 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm ^{3} and v max ≥ 130 km/h.
3.4.4.2.	For testing in accordance with point 3.2.3.2.2.:
	Equation Ap3-12:
	$C = (D_{ovc} \cdot C_1 + D_{av} \cdot C_2)/(D_{ovc} + D_{av})$
	where:
	C = fuel consumption in l/100 km,
	C_1 = fuel consumption in l/100 km with a fully charged electrical energy/power storage device,
	C_2 = fuel consumption in l/100 km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity),
	D_{ovc} = OVC range according to the procedure described in Appendix 3.3.
	D_{av} = average distance between two battery recharges, D_{av} =:
	— 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ;
	— 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h;
	— 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
3.4.5.	The electric energy consumption values shall be:
	Equation Ap3-13:
	$E_1 = e_1 /D_{test1}$ and
	Equation Ap3-14:
	$E_4 = e_4 /D_{test2}$ (Wh/km)
	with D_{test1} and D_{test2} the actual distances driven in the tests performed under Conditions A (point 3.2.) and B (point 3.3.) respectively, and e1 and e4 determined in points 3.2.5. and 3.3.6 respectively.

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3.4.6.	The weighted electric energy consumption values shall be calculated as follows:
3.4.6.1	For testing in accordance with point 3.2.3.2.1.: Equation Ap3-15: $E = (D_e \cdot E_1 + D_{av} \cdot E_4)/(D_e + D_{av})$ where: E = electric consumption Wh/km, E1 = electric consumption Wh/km with a fully charged electrical energy/power storage device, E4= electric consumption Wh/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), De = electric range of the vehicle determined according to the procedure described in Appendix 3.3., where the manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state, Dav = average distance between two battery recharges, Dav =: — 4 km for an L-category vehicle with an engine capacity of < 150 cm3 ; — 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm3 and v max < 130 km/h; — 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm 3 and v max ≥ 130 km/h.
3.4.6.2.	For testing in accordance with point 3.2.3.2.2.: Equation Ap3-16: $E = (D_{ovc} \cdot E_1 + D_{av} \cdot E_4)/(D_{ovc} + D_{av})$ where: E = electric consumption Wh/km, E_1 = electric consumption Wh/km with a fully charged electrical energy/power storage device, E_4 = electric consumption Wh/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), D_{ovc} = OVC range according to the procedure described in Appendix 3.3. D_{av} = average distance between two battery recharges, D_{av} =:

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	— 4 km for an L-category vehicle with an engine capacity of < 150 cm 3 ;
	— 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm 3 and v max < 130 km/h;
	— 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm 3 and v max ≥ 130 km/h.
4.	**Externally chargeable (OVC HEV) with an operating mode switch**
4.1	Two tests shall be performed under the following conditions:
4.1.1.	Condition A: test carried out with a fully charged electrical energy/power storage device.
4.1.2.	Condition B: test carried out with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity).
4.1.3.	The operating mode switch shall be positioned in accordance with Table Ap12-2, point 3.2.1.3. of Appendix 12 of chapter 2W-II.
4.2.	Condition A
4.2.1	If the electric range of the vehicle, as measured in accordance with Appendix 3.3., is higher than one complete cycle, the type I test for electric energy measurement may be carried out in pure electric mode at the request of the manufacturer after agreement of the test agency and to the satisfaction of the test agency . In this case, the values of M1 and C1 in point 4.4. shall be taken as equal to 0.
4.2.2.	The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle as described in point 4.2.2.1.
4.2.2.1.	The electrical energy/power storage device of the vehicle is discharged while driving with the switch in pure electric position (on the test track, on a chassis dynamometer, etc.) at a steady speed of 70 percent ± 5 percent of the maximum design vehicle speed in pure electric mode, determined in accordance with the test procedure to measure the maximum design vehicle speed. Discharge shall stop in any of the following conditions: • when the vehicle is unable to run at 65 percent of the maximum thirty minutes speed, • when the standard on-board instrumentation indicates that the vehicle should be stopped, • after 100 km. If the vehicle is not equipped with a pure electric mode, the electrical energy/power storage device shall be discharged by driving the vehicle (on the

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	test track, on a chassis dynamometer, etc.) at any of the following conditions:
	— at a steady speed of 50 km/h until the fuel-consuming engine starts up,
	— if a vehicle cannot reach a steady speed of 50 km/h without the fuel-consuming engine starting up, the speed shall be reduced until it can run at a lower steady speed at which the fuel-consuming engine does not start up for a defined time or distance (to be determined by the test agencyand the manufacturer to the satisfaction of the test agency),
	— in accordance with the manufacturer's recommendation.
	The fuel-consuming engine shall be stopped within ten seconds of being automatically started. By means of derogation if the manufacturer can prove to the test agency to the satisfaction of the test agency that the vehicle is physically not capable of achieving the thirty minutes speed the maximum fifteen minute speed may be used instead.
4.2.3.	Conditioning of the vehicle
4.2.3.1.	The test vehicle shall be preconditioned by conducting the applicable type I test cycle in combination with the applicable gear-shifting prescriptions in point 4.5.5. of chapter 2W-II.
4.2.3.2.	After this preconditioning and before testing, the vehicle shall be kept in a room in which the temperature remains relatively constant between 293.2 K and 303.2 K (20 °C and 30 °C). This conditioning shall be carried out for at least six hours and continue until the temperatures of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room, and the electrical energy/power storage device is fully charged as a result of the charging prescribed in point 4.2.3.3.
4.2.3.3.	During soak, the electrical energy/power storage device shall be charged using the normal overnight charging procedure as defined in point 3.2.2.4.
4.2.4.	Test procedure
4.2.4.1.	The vehicle shall be started up by the means provided for normal use by the driver. The first cycle starts on the initiation of the vehicle start-up procedure.
4.2.4.2.	The test procedures defined in either point 4.2.4.2.1. or 4.2.4.2.2. may be used
4.2.4.2.1.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period in the applicable type I driving cycle (end of sampling (ES)).
4.2.4.2.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and continue over a number of repeat test cycles. It shall end on conclusion of the applicable type I driving cycle during which the battery reached the minimum state of charge in accordance with the following procedure (end of sampling (ES)):

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4.2.4.2.2.1	the electricity balance Q (Ah) is measured over each combined cycle, using the procedure in Appendix 3.2., and used to determine when the battery's minimum state of charge has been reached
4.2.4.2.2.2	. the battery's minimum state of charge is considered to have been reached in combined cycle N if the electricity balance measured during combined cycle N + 1 is not more than a 3 percent discharge, expressed as a percentage of the nominal capacity of the battery (in Ah) in its maximum state of charge, as declared by the manufacturer. At the manufacturer's request, additional test cycles may be run and their results included in the calculations in points 4.2.4.5. and 4.4., provided that the electricity balance for each additional test cycle shows less discharge of the [battery than over the previous cycle.
4.2.4.2.2.3.	between each pair of cycles, a hot soak period of up to ten minutes is allowed. The power train shall be switched off during this period.
4.2.4.3.	The vehicle shall be driven using the applicable driving cycle and gear-shifting prescriptions as defined in appendix 9 to chapter 2W-II.
4.2.4.4.	The exhaust gases shall be analyzed according to chapter 2W- II in force at the time of approval of the vehicle.
4.2.4.5.	The CO_2 emission and fuel consumption results on the test cycle for Condition A shall be recorded (m_1 (g) and c_1 (l) respectively). In the case of testing in accordance with point 4.2.4.2.1., m_1 and c_1 are the results of the single combined cycle run. In the case of testing in accordance with point 4.2.4.2.2., m_1 and c_1 are the sums of the results of the N combined cycles run: *Equation Ap3-17:* $$m_1 = \sum_1^N m_i$$ *Equation Ap3-18:* $$C_1 = \sum_1^N c_i$$
4.2.5.	Within 30 minutes of the end of the cycle, the electrical energy/power storage device shall be charged in accordance with point 3.2.2.4. The energy measurement equipment, placed between the mains socket and the vehicle charger, shall measure the energy charge e_1 (Wh) delivered from the mains.
4.2.6	The electric energy consumption for Condition A shall be e_1 (Wh).

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4.3.	Condition B
4.3.1.	Conditioning of the vehicle
4.3.1.1.	The electrical energy/power storage device of the vehicle shall be discharged in accordance with point 4.2.2.1. At the manufacturer's request, conditioning in accordance with point 4.2.3.1. may be carried out before electrical energy/power storage discharge.
4.3.1.2.	Before testing, the vehicle shall be kept in a room in which the temperature shall remain relatively constant between 293.2 K and 303.2 K (20 °C and 30 °C). This conditioning shall be carried out for at least six hours and continue until the temperatures of the engine oil and coolant, if any, are within ± 2 K of the temperature of the room.
4.3.2.	Test procedure
4.3.2.1.	The vehicle shall be started up by the means provided for normal use by the driver. The first cycle starts on the initiation of the vehicle start-up procedure.
4.3.2.2.	Sampling shall begin (BS) before or at the initiation of the vehicle start-up procedure and end on conclusion of the final idling period in the applicable type I driving cycle (end of sampling (ES)).
4.3.2.3.	The vehicle shall be driven using the applicable driving cycle and gear-shifting prescriptions as defined in chapter 2W-II.
4.3.2.4.	The exhaust gases shall be analyzed in accordance with the provisions of chapter 2W-II in force at the time of approval of the vehicle.
4.3.2.5.	The CO_2 emission and fuel consumption results on the test cycle(s) for Condition B shall be recorded (m_2 (g) and c_2 (l) respectively).
4.3.3.	Within 30 minutes of the end of the cycle, the electrical energy/power storage device shall be charged in accordance with point 3.2.2.4. The energy measurement equipment, placed between the mains socket and the vehicle charger, shall measure the energy charge e_2 (Wh) delivered from the mains.
4.3.4.	The electrical energy/power storage device of the vehicle shall be discharged in accordance with point 4.2.2.1.
4.3.5.	Within 30 minutes of the discharge, the electrical energy/power storage device shall be charged in accordance with point 3.2.2.4. The energy measurement equipment, placed between the mains socket and the vehicle charger, shall measure the energy charge e_3 (Wh) delivered from the mains.

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4.3.6.	The electric energy consumption e_4 (Wh) for Condition B shall be: Equation Ap3-19: $$e_4 = e_2 - e_3$$
4.4.	Test results
4.4.1.	The CO_2 values shall be: Equation Ap3-20: $M_1 = m_1 /D_{test1}$ (mg/km) and Equation Ap3-21: $M_2 = m_2 /D_{test2}$ (mg/km) where: D_{test1} and D_{test2} = the actual distances driven in the tests performed under Conditions A (point 4.2.) and B (point 4.3.) respectively, and m_1 and m_2 = test results determined in points 4.2.4.5. and 4.3.2.5. respectively
4.4.2.	The weighted CO_2 values shall be calculated as follows:
4.4.2.1.	For testing in accordance with point 4.2.4.2.1.: *Equation Ap3-22:* $M = (D_e \cdot M_1 + D_{av} \cdot M_2)/(D_e + D_{av})$ where: M = mass emission of CO_2 in grams per kilometer, M_1= mass emission of CO_2 in grams per kilometer with a fully charged electrical energy/power storage device, M_2= mass emission of CO_2 in grams per kilometer with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), D_e = electric range of the vehicle determined according to the procedure described in Appendix 3.3., where the manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state, D_{av} = average distance between two battery recharges, D_{av} =: — 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ; — 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v

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	max < 130 km/h; — 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
	4.4.2.2. For testing in accordance with point 4.2.4.2.2.: *Equation Ap3-23:* $M = (D_{ovc} \cdot M_1 + D_{av} \cdot M_2)/(D_{ovc} + D_{av})$ where: M = mass emission of CO_2 in grams per kilometer, M_1 = mass emission of CO_2 in grams per kilometer with a fully charged electrical energy/power storage device, M_2 = mass emission of CO_2 in grams per kilometer with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), D_{ovc} = OVC range according to the procedure described in Appendix 3.3. D_{av} = average distance between two battery recharges, Dav =: — 4 km for an L-category vehicle with an engine capacity of < 150 cm^3; — 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h; — 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
4.4.3.	The fuel consumption values shall be: Equation Ap3-24: $C_1 = 100 \cdot c_1 / D_{test1}$ and Equation Ap3-25: $C_2 = 100 \cdot c_2 / D_{test2}$ (l/100 km) where: D_{test1} and D_{test2} = the actual distances driven in the tests performed under Conditions A (point 4.2.) and B (point 4.3.) respectively. c_1 and c_2 = test results determined in points 4.2.4.5. and 4.3.2.5. respectively.
4.4.4.	The weighted fuel consumption values shall be calculated as follows:

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4.4.4.1.	For testing in accordance with point 4.2.4.2.1.:
	Equation Ap3-26:
	$C = (D_e \cdot C_1 + D_{av} \cdot C_2)/(D_e + D_{av})$
	where:
	C = fuel consumption in l/100 km,
	C_1 = fuel consumption in l/100 km with a fully charged electrical energy/power storage device,
	C_2 = fuel consumption in l/100 km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity),
	D_e = electric range of the vehicle determined according to the procedure described in Appendix 3.3., where the manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state,
	D_{av} = average distance between two battery recharges, D_{av} =:
	— 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ;
	— 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h;
	— 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
4.4.4.2.	For testing in accordance with point 4.2.4.2.2.:
	Equation Ap3-27:
	$C = (D_{ovc} \cdot C_1 + D_{av} \cdot C_2)/(D_{ovc} + D_{av})$
	where:
	C = fuel consumption in l/100 km,
	C_1 = fuel consumption in l/100 km with a fully charged electrical energy/power storage device,
	C_2 = fuel consumption in l/100 km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity),
	D_{ovc} = OVC range according to the procedure described in Appendix 3.3.,
	D_{av} = average distance between two battery recharges, D_{av} =:
	— 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ;
	— 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v

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	max < 130 km/h; — 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
4.4.5.	The electric energy consumption values shall be: Equation Ap3-28: $E_1 = E_1 = \dfrac{e_1}{D_{test1}} / D_{test1}$ and Equation Ap3-29: $E_4 = \dfrac{e_4}{D_{test2}}$ Wh/km) where: D_{test1} and D_{test2} = the actual distances driven in the tests performed under Conditions A (point 4.2.) and B (point 4.3.) respectively, and e_1 and e_4 = test results determined in points 4.2.6. and 4.3.6. respectively
4.4.6.	The weighted electric energy consumption values shall be calculated as follows:
4.4.6.1.	For testing in accordance with point 4.2.4.2.1.: *Equation Ap3-30:* E = (D$_e$ · E$_1$ + D$_{av}$ · E$_4$)/(D$_e$ + D$_{av}$) where: E = electric consumption Wh/km, E$_1$ = electric consumption Wh/km with a fully charged electrical energy/power storage device, E$_4$ = electric consumption Wh/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), D$_e$ = electric range of the vehicle determined according to the procedure described in Appendix 3.3., where the manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state, D$_{av}$ = average distance between two battery recharges, D$_{av}$ =: — 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ; — 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h; — 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
4.4.6.2.	For testing in accordance with point 4.2.4.2.2.:

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	Equation Ap3-31: $E = (D_{ovc} \cdot E_1 + D_{av} \cdot E_4)/(D_{ovc} + D_{av})$ where: E = electric consumption Wh/km, E_1 = electric consumption Wh/km with a fully charged electrical energy/ power storage device, E_4 = electric consumption Wh/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity), D_{ovc} = OVC range according to the procedure described in Appendix 3.3., D_{av} = average distance between two battery recharges, $D_{av} =$: — 4 km for an L-category vehicle with an engine capacity of < 150 cm^3 ; — 6 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max < 130 km/h; — 10 km for an L-category vehicle with an engine capacity of ≥ 150 cm^3 and v max ≥ 130 km/h.
5.	**Not externally chargeable hybrid electric vehicle (NOVC HEV) without an operating mode switch**
5.1.	The test vehicle shall be preconditioned by conducting the applicable type I test cycle in combination with the applicable gear-shifting prescriptions in point 4.5.5. of Chapter 2W- II.
5.1.1.	Carbon dioxide (CO_2) emissions and fuel consumption shall be determined separately for parts 1, 2 and 3, if applicable, of the applicable driving cycle in Appendix 6 to Chapter 2W- II.
5.2.	For preconditioning, at least two consecutive complete driving cycles shall be carried out without intermediate soak, using the applicable driving cycle and gear-shifting prescriptions set out in point 4.5.5. of Chapter 2W- II.
5.3.	Test results
5.3.1.	The test results (fuel consumption C (l/100 km for liquid fuels or kg/100 km for gaseous fuels) and CO_2 - emission M (g/km)) of this test shall be corrected in line with the energy balance ΔE_{batt} of the battery of the vehicle.
	The corrected values C_0 (l/100 km or kg/100 km) and M_0 (g/km) shall correspond to a zero energy balance ($\Delta E_{batt} = 0$) and shall be calculated using a correction coefficient determined by the manufacturer for storage systems other than electric batteries as follows: ΔE_{batt} shall represent ΔE storage , the energy balance of the electric energy storage device.
5.3.1.1.	The electricity balance Q (Ah), measured using the procedure in Appendix 3.2. to this Appendix, shall be used as a measure of the difference between the vehicle battery's energy content at the end of the cycle and that at the beginning of the cycle. The electricity balance is to be determined separately for the individual parts 1, 2 and 3, if applicable, of the type I test cycle in Chapter 2W- II.

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5.3.2.	the uncorrected measured values C and M may be taken as the test results under the following conditions: (a) the manufacturer can demonstrate to the satisfaction of the test agency that there is no relation between the energy balance and fuel consumption, (b) ΔE_{batt} always corresponds to a battery charging, (c) ΔE_{batt} always corresponds to a battery discharging and ΔE_{batt} is within 1 percent of the energy content of the consumed fuel (i.e. the total fuel consumption over one cycle). The change in battery energy content ΔE_{batt} shall be calculated from the measured electricity balance Q as follows: *Equation Ap3-32:* $\Delta E_{batt} = \Delta SOC(\%) \cdot E_{TEbatt} \equiv 0.0036 \cdot \lvert \Delta Ah \rvert \cdot V_{batt} = 0,0036 \cdot Q \cdot V_{batt}$ (MJ) where: E_{TEbatt} = the total energy storage capacity of the battery (MJ) and V_{batt} = the nominal battery voltage (V).
5.3.3.	Fuel consumption correction coefficient (K_{fuel}) defined by the manufacturer
5.3.3.1.	The fuel consumption correction coefficient (K_{fuel}) shall be determined from a set of n measurements, which shall contain at least one measurement with $Q_i < 0$ and at least one with $Q_j > 0$. If this second measurement cannot be taken on the applicable test type I driving cycle used in this test, the test agency shall judge the statistical significance of the extrapolation necessary to determine the fuel consumption value at $\Delta E_{batt} = 0$ to the satisfaction of the test agency
5.3.3.2.	The fuel consumption correction coefficient (K fuel) shall be defined as: *Equation Ap3-33:* $K_{fuel} = (n \sum Q_i C_i - \sum Q_i . \sum C_i)/(n. \sum Q_i{}^2 - (\sum Q_i)^2)$ (l/100 km/Ah) where: C_i = fuel consumption measured during i-th manufacturer's test (l/100 km or kg/100km), Q_i = electricity balance measured during i-th manufacturer's test (Ah), n = number of data. The fuel consumption correction coefficient shall be rounded to four significant figures (e.g. 0.xxxx or xx.xx). The test agency shall judge the statistical significance of the fuel consumption correction coefficient to the satisfaction of the test agency .

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5.3.3.3.	Separate fuel consumption correction coefficients shall be determined for the fuel consumption values measured over parts 1, 2 and 3, if applicable, of the type I test cycle in Chapter 2W- II.
5.3.4.	Fuel consumption at zero battery energy balance (C_0)
5.3.4.1.	Fuel consumption C_0 at $\Delta E_{batt} = 0$ is determined by the following equation: Equation Ap3-34: $C_0 = C - K_{fuel} \cdot Q$ (l/100 km or kg/100 km) where: C = fuel consumption measured during test (l/100 km for liquid fuels and kg/100 km for gaseous fuels), Q = electricity balance measured during test (Ah).
5.3.4.2.	Fuel consumption at zero battery energy balance shall be determined separately for the fuel consumption values measured over parts 1, 2 or 3, if applicable, of the type I test cycle in Chapter 2W- II
5.3.5.	CO_2 -emission correction coefficient (K_{CO_2}) defined by the manufacturer
5.3.5.1.	The CO_2 -emission correction coefficient (K_{CO_2}) shall be determined as follows from a set of n measurements, which shall contain at least one measurement with $Q_i < 0$ and at least one with $Q_j > 0$. If this second measurement cannot be taken on the driving cycle used in this test, the test agency shall judge the statistical significance of the extrapolation necessary to determine the CO_2 -emission value at $\Delta E_{batt} = 0$ to the satisfaction of the test agency .
5.3.5.2.	The CO_2 -emission correction coefficient (K_{CO_2}) is defined as: *Equation Ap3-35:* $K_{CO_2} = (n \sum Q_i M_i - \sum Q_i . \sum M_i)/(n. \sum Q_i^2 - (\sum Q_i)^2)$ (g/km/Ah) where: M_i = CO_2 -emission measured during i^{th} manufacturer's test (g/km), Q_i = electricity balance during i^{th} manufacturer's test (Ah), n = number of data. The CO_2 -emission correction coefficient shall be rounded to four significant figures (e.g. 0.xxxx or xx.xx). The test agency shall judge the statistical significance of the CO_2 -emission correction coefficient to the satisfaction of the test agency .

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5.3.5.3.	Separate CO_2 -emission correction coefficients shall be determined for the fuel consumption values measured over parts 1, 2 and 3, if applicable, of the type driving cycle in Chapter 2W- II.
5.3.6.	CO_2 -emission at zero battery energy balance (M 0)
5.3.6.1.	The CO_2 -emission M_0 at $\Delta E_{batt} = 0$ is determined by the following equation: Equation Ap3-36: $$M0 = M - K_{CO_2} \cdot Q \ (g/km)$$ where: C = fuel consumption measured during test (l/100 km for liquid fuels and kg/100 km for gaseous fuels), Q = electricity balance measured during test (Ah).
5.3.6.2.	CO_2 emissions at zero battery energy balance shall be determined separately for the CO_2 emission values measured over part 1, 2 and 3, if applicable, of the type I test cycle set out in Appendix 6 to Chapter 2W- II
6.	**Not Externally Chargeable (not OVC HEV) with an operating mode switch**
6.1.	These vehicles shall be tested in hybrid mode in accordance with Appendix 1, using the applicable driving cycle and gear-shifting prescriptions in point 4.5.5. of Chapter 2W- II. If several hybrid modes are available, the test shall be carried out in the mode that is automatically set after the ignition key is turned on (normal mode).
6.1.1.	Carbon dioxide (CO_2) emissions and fuel consumption shall be determined separately for parts 1, 2 and 3 of the type I test cycle in Chapter 2W- II.
6.2.	For preconditioning, at least two consecutive complete driving cycles shall be carried out without intermediate soak, using the applicable type I test cycle and gear-shifting prescriptions in Chapter 2W- II.
6.3.	Test results
6.3.1.	The fuel consumption C (l/100 km) and CO_2 -emission M (g/km)) results of this test shall be corrected in line with the energy balance ΔE_{batt} of the battery of the vehicle The corrected values (C_0 (l/100 km for liquid fuels or kg/100 km for gaseous fuels) and M_0 (g/km)) shall correspond to a zero energy balance ($\Delta E_{batt} = 0$), and are to be calculated using a correction coefficient determined by the manufacturer as defined in 6.3.3 and 6.3.5. For storage systems other than electric batteries, ΔE_{batt} shall represent $\Delta E_{storage}$, the energy balance of the electric energy storage device

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6.3.1.1.	The electricity balance Q (Ah), measured using the procedure in Appendix 3.2., shall be used as a measure of the difference between the vehicle battery's energy content at the end of the cycle and that at the beginning of the cycle. The electricity balance is to be determined separately for parts 1, 2 and 3 of the applicable type I test cycle set out in Chapter 2W- II
6.3.2.	The uncorrected measured values C and M may be taken as the test results under the following conditions:
	(a) the manufacturer can prove that there is no relation between the energy balance and fuel consumption,
	(b) ΔE_{batt} always corresponds to a battery charging,
	(c) ΔE_{batt} always corresponds to a battery discharging and ΔE_{batt} is within 1 percent of the energy content of the consumed fuel (i.e. the total fuel consumption over one cycle).
	The change in battery energy content ΔE_{batt} can be calculated from the measured electricity balance Q as follows:
	Equation Ap3-37:
	$\Delta E_{batt} = \Delta SOC(\%) \cdot E_{TEbatt} \equiv 0.0036 \cdot \|\Delta Ah\| \cdot V_{batt} \equiv 0.0036 \cdot Q \cdot V_{batt}$ (MJ)
	where:
	E_{TEbatt} = the total energy storage capacity of the battery (MJ), and
	V_{batt} = the nominal battery voltage (V).
6.3.3.	Fuel consumption correction coefficient (K_{fuel}) defined by the manufacturer
6.3.3.1.	The fuel consumption correction coefficient (K_{fuel}) shall be determined from a set of n measurements, which shall contain at least one measurement with $Q_i < 0$ and at least one with $Q_j > 0$.
	If this second measurement cannot be taken on the driving cycle used in this test, the test agency shall judge the statistical significance of the extrapolation necessary to determine the fuel consumption value at $\Delta E_{batt} = 0$ to the satisfaction of the test agency.
6.3.3.2.	The fuel consumption correction coefficient (K fuel) shall be defined as:
	Equation Ap3-38:
	$K_{fuel} = (n \sum Q_i C_i - \sum Q_i . \sum C_i)/(n. \sum Q_i{}^2 - (\sum Q_i)^2)$ in (l/100 km/Ah)
	where:
	C_i = fuel consumption measured during i^{th} manufacturer's test (l/100 km for liquid fuels and kg/100 km for gaseous fuels)

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	Q_i = electricity balance measured during i-th manufacturer's test (Ah) n = number of data The fuel consumption correction coefficient shall be rounded to four significant figures (e.g. 0.xxxx or xx.xx). The statistical significance of the fuel consumption correction coefficient shall be judged by the test agency.
6.3.3.3.	Separate fuel consumption correction coefficients shall be determined for the fuel consumption values measured over parts 1, 2 and 3, if applicable, for the type I test cycle set out in Chapter 2W- II.
6.3.4.	Fuel consumption at zero battery energy balance (C 0)
6.3.4.1.	The fuel consumption C_0 at $\Delta E_{batt} = 0$ is determined by the following equation: Equation AP-39: $C_0 = C - K_{fuel} \cdot Q$ (in l/100 km for liquid fuels and kg/100 km for gaseous fuels) where: C = fuel consumption measured during test (in l/100 km or kg/100 km) Q = electricity balance measured during test (Ah)
6.3.4.2.	Fuel consumption at zero battery energy balance shall be determined separately for the fuel consumption values measured over parts 1, 2 and 3, if applicable, for the type I test cycle set out in Chapter 2W- II.
6.3.5.	CO_2 -emission correction coefficient (K_{CO_2}) defined by the manufacturer
6.3.5.1.	The CO_2 -emission correction coefficient (K_{CO_2}) shall be determined as follows from a set of n measurements. This set shall contain at least one measurement with Q i < 0 and one with Q j > 0. If this second measurement cannot be taken on the type I test cycle used in this test, the test agency shall judge the statistical significance of the extrapolation necessary to determine the CO_2 -emission value at ΔE batt = 0 to the satisfaction of the approval authori
6.3.5.2.	The CO_2-emission correction coefficient (K_{CO_2}) shall be defined as: *Equation AP-40:* $K_{CO_2} = (n \sum Q_i M_i - \sum Q_i . \sum M_i)/(n. \sum Q_i^2 - (\sum Q_i)^2)$ in (g/km/Ah) where: M_i = CO_2-emission measured during i-th manufacturer's test (g/km) Q_i = electricity balance during i-th manufacturer's test (Ah)

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	N = number of data The CO_2-emission correction coefficient shall be rounded to four significant figures (e.g. 0.xxxx or xx.xx). The statistical significance of the CO_2-emission correction coefficient shall be judged by the test agency.
6.3.5.3.	Separate CO_2-emission correction coefficients shall be determined for the fuel consumption values measured over parts 1, 2 and 3 of the applicable type I test cycle
6.3.6.	CO_2 emission at zero battery energy balance (M_0)
6.3.6.1.	The CO_2 emission M_0 at $\Delta E_{batt} = 0$ is determined by the following equation: Equation AP-41: $M_0 = M - K_{CO_2} \cdot Q$ in (g/km) where: C: fuel consumption measured during test (l/100 km) Q: electricity balance measured during test (Ah)
6.3.6.2	CO_2 emission at zero battery energy balance shall be determined separately for the CO_2 -emission values measured over parts 1, 2 and 3, if applicable, for the type I test cycle set out in Chapter 2W- II.

Appendix 3.1 to Chapter 3W-IX

Electrical energy/power storage device State Of Charge (SOC) profile for an Externally chargeable Hybrid Electric Vehicle (OVC HEV) in a type VII test

1.	**State of charge (SOC) profile for OVC HEV type VII test** The SOC profiles for OVC-HEVs tested under Conditions A and B of the test type VII shall be:
1.1.	Condition A:
	Figure Ap3.1-1 **Condition A of the type VII test** (1) initial state of charge of the electrical energy/power storage device; (2) discharge in accordance with point 3.2.1. or 4.2.2. of Appendix 3; (3) vehicle conditioning in accordance with point 3.2.2.or 4.2.3. of Appendix 3; (4) charge during soak in accordance with point 3.2.2.3. and 3.2.2.4. or 4.2.3.2. and 4.2.3.3. of Appendix 3; (5) test in accordance with point 3.2.3. or 4.2.4. of Appendix 3; (6) charging in accordance with point 3.2.4. or 4.2.5. of Appendix 3
1.2.	Condition B:
	Figure Ap3.1-2 **Condition B of the type VII test** (1) initial state of charge; (2) vehicle conditioning in accordance with point 3.3.1.1. or 4.3.1.1. (optional) of Appendix 3; (3) discharge in accordance with point 3.3.1.1. or 4.3.1.1. of Appendix 3; (4) soak in accordance with point 3.3.1.2. or 4.3.1.2. of Appendix 3; (5) test in accordance with point 3.3.2. or 4.3.2. of Appendix 3; (6) charging in accordance with point 3.3.3. or 4.3.3. of Appendix 3; (7) discharging in accordance with point 3.3.4. or 4.3.4. of Appendix 3; (8) charging in accordance with point 3.3.5. or 4.3.5. of Appendix 3;

The figures referenced above are:

Figure Ap3.1-1 — Condition A of the type VII test

Figure Ap3.1-2 — Condition B of the type VII test

Appendix 3.2 to Chapter 3W-IX

Method for measuring the electricity balance of the battery of OVC and NOVC HEV

1	**Introduction**
1.1	This Appendix sets out the method and required instrumentation for measuring the electricity balance of Off- vehicle Charging Hybrid Electric Vehicles (OVC HEV) and Not-Off-vehicle Charging Hybrid Electric Vehicles (NOVC HEV). Measurement of the electricity balance is necessary (a) to determine when the battery's minimum state of charge has been reached during the test procedure in points 3.3 and 4.3 of Appendix 3, and (b) to adjust the fuel consumption and CO_2 -emissions measurements in line with the change in battery energy content during the test, using the method in points 5.3.1.1. and 6.3.1.1. of Appendix 3.
1.2.	The method described in this Appendix shall be used by the manufacturer for taking the measurements to determine the correction factors K fuel and K_{CO_2}, as defined in points 5.3.3.2., 5.3.5.2., 6.3.3.2., and 6.3.5.2. of Appendix 3. The test agency shall check whether these measurements have been taken in accordance with the procedure described in this Appendix.
1.3.	The method described in this Appendix shall be used by the test agency for measuring the electricity balance Q, as defined in the relevant points of Appendix 3.
2.	**Measurement equipment and instrumentation**
2.1.	During the tests described in points 3 to 6 of Appendix 3, the battery current shall be measured using a current transducer of the clamp-on or the closed type. The current transducer (i.e. the current sensor without data acquisition equipment) shall have a minimum accuracy of 0.5 percent of the measured value or 0.1 percent of the maximum value of the scale. Original equipment manufacturer diagnostic testers are not to be used for the purpose of this test.
2.1.1.	The current transducer shall be fitted on one of the wires directly connected to the battery. To make it easier to measure the battery current with external equipment, the manufacturer shall integrate appropriate, safe and accessible connection points in the vehicle. If that is not feasible, the manufacturer is obliged to support the test agency by providing the means to connect a current transducer to the wires connected to the battery as described in point 2.1.
2.1.2.	The output of the current transducer shall be sampled with a minimum sample frequency of 5 Hz. The measured current shall be integrated over time, yielding the measured value of Q, expressed in Ampere hours (Ah).
2.1.3.	The temperature at the location of the sensor shall be measured and sampled with the same sample frequency as the current, so that this value can be used for possible compensation of the drift of current transducers and, if applicable, the voltage transducer used to convert the output of the current transducer

**Method for measuring the electricity balance of the battery of OVC and
NOVC HEV**

2.2.	The test agency shall be provided with a list of the instrumentation (manufacturer, model number, serial number) used by the manufacturer for determining the correction factors K fuel and K_{CO_2} out in Appendix 3 and the last calibration dates of the instruments, where applicable.
3.	**Measurement procedure**
3.1.	Measurement of the battery current shall start at the beginning of the test and end immediately after the vehicle has driven the complete driving cycle.
3.2.	Separate values of Q shall be logged over the parts (cold/warm or phase 1 and, if applicable, phases 2 and 3) of the type I test cycle set out in Chapter 2W- II.

Method of measuring the electric range of vehicles powered by an electric powertrain only or by a hybrid electric powertrain and the OVC range of vehicles powered by a hybrid electric powertrain

1.	**Measurement of the electric range**
	The following test method set out in point 4 shall be used to measure the electric range, expressed in km, of vehicles powered by an electric power train only or the electric range and OVC range of vehicles powered by a hybrid electric powertrain with off-vehicle charging (OVC HEV) as defined in Appendix 3.
2.	**Parameters, units and accuracy of measurements**
	Parameters, units and accuracy of measurements shall be as follows:

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Table Ap3.3.-1

Parameters, units and accuracy of measurements

Table Ap3.3.-1 Parameters, units and accuracy of measurements			
Parameter	Unit	Accuracy	Resolution
Time	s	± 0.1 s	0.1 s
Distance	m	± 0.1 percent	1 m
Temperature	K	± 1 K	1 K
Speed	km/h	± 1 percent	0.2 km/h
Mass	kg	± 0.5 percent	1 kg

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3.	**Test conditions**
3.1.	Condition of the vehicle
3.1.1.	The vehicle tyres shall be inflated to the pressure specified by the vehicle manufacturer when the tyres are at the ambient temperature.
3.1.2.	The viscosity of the oils for the mechanical moving parts shall conform to the vehicle manufacturer's specifications.
3.1.3.	The lighting and signalling and auxiliary devices shall be off, except those required for the testing and usual daytime operation of the vehicle.
3.1.4.	All energy storage systems for other than traction purposes (electric, hydraulic, pneumatic, etc.) shall be charged to their maximum level as specified by the manufacture
3.1.5.	If the batteries are operated above the ambient temperature, the operator shall follow the procedure recommended by the vehicle manufacturer in order to keep the battery temperature in the normal operating range. The manufacturer shall be in a position to attest that the thermal management system of the battery is neither disabled nor reduced.
3.1.6.	The vehicle shall have travelled at least 300 km in the seven days before the test with the batteries installed for the test.

Appendix 3.3 to Chapter 3W-IX

Method of measuring the electric range of vehicles powered by an electric powertrain only or by a hybrid electric powertrain and the OVC range of vehicles powered by a hybrid electric powertrain

3.2.	Climatic conditions For testing performed outdoors, the ambient temperature shall be between 278.2 K and 305.2 K (5 °C and 32 °C). The indoor testing shall be performed at a temperature of between 275.2 K and 303.2 K (2 °C and 30 °C).
4.	**Operation modes** The test method includes the following steps: (a) initial charge of the battery; (b) application of the cycle and measurement of the electric range. If the vehicle shall move between the steps, it shall be pushed to the next test area (without regenerative recharging).
4.1.	Initial charge of the battery Charging the battery consists of the following procedure:
4.1.1.	The 'initial charge' of the battery means the first charge of the battery, on reception of the vehicle. Where several combined tests or measurements are carried out consecutively, the first charge shall be an 'initial charge' and the subsequent charges may follow the 'normal overnight charge' procedure set out in 3.2.2.4. of Appendix 3.
4.1.2.	Discharge of the battery
4.1.2.1.	For pure electric vehicles:
4.1.2.1.1.	The procedure starts with the discharge of the battery of the vehicle while driving (on the test track, on a chassis dynamometer, etc.) at a steady speed of 70 percent ± 5 percent of the maximum design vehicle speed.
4.1.2.1.2.	Discharging shall stop under any of the following conditions: (a) when the vehicle is unable to run at 65 percent of the maximum thirty minutes speed; (b) when the standard on-board instrumentation indicates that the vehicle should be stopped; (c) after 100 km. By means of derogation if the manufacturer can prove to the test agency to the satisfaction of the test agency that the vehicle is physically not capable of achieving the thirty minutes speed the maximum fifteen minute speed may be used instead.
4.1.2.2.	For externally chargeable hybrid electric vehicles (OVC HEV) without an operating mode switch as defined in Appendix 3:

Appendix 3.3 to Chapter 3W-IX

Method of measuring the electric range of vehicles powered by an electric powertrain only or by a hybrid electric powertrain and the OVC range of vehicles powered by a hybrid electric powertrain

4.1.2.2.1.	The manufacturer shall provide the means for taking the measurement with the vehicle running in pure electric operating state.
4.1.2.2.2.	The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle while driving (on the test track, on a chassis dynamometer, etc.) in any of the following conditions: — at a steady speed of 50 km/h until the fuel-consuming engine of the HEV starts up; — if a vehicle cannot reach a steady speed of 50 km/h without the fuel-consuming engine starting up, the speed shall be reduced until it can run at a lower steady speed at which the fuel-consuming engine does not start up for a defined time or distance (to be determined by the test agency and the manufacturer) — in accordance with the manufacturer's recommendation. The fuel-consuming engine shall be stopped within ten seconds of being automatically started.
4.1.2.3.	For externally chargeable hybrid electric vehicles (OVC HEV) with an operating mode switch as defined in Appendix 3:
4.1.2.3.1.	If the mode switch does not have a pure electric position, the manufacturer shall provide the means for taking the measurement with the vehicle running in pure electric operating state.
4.1.2.3.2.	The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle while driving with the switch in pure electric position (on the test track, on a chassis dynamometer, etc.) at a steady speed of 70 percent ± 5 percent of the maximum design vehicle speed of the vehicle in pure electric mode.
4.1.2.3.3.	Discharging shall stop in any of the following conditions: — when the vehicle is unable to run at 65 percent of the maximum thirty minutes speed; — when the standard on-board instrumentation indicates that the vehicle should be stopped; — after 100 km. By means of derogation if the manufacturer can prove to the test agency to the satisfaction of the test agency that the vehicle is physically not capable of achieving the thirty minutes speed the maximum fifteen minute speed may be used instead.
4.1.2.3.4.	If the vehicle is not equipped with a pure electric operating state, the electrical energy/power storage device shall be discharged by driving the vehicle (on the test track, on a chassis dynamometer, etc.): — at a steady speed of 50 km/h until the fuel-consuming engine of the HEV starts up; or

Method of measuring the electric range of vehicles powered by an electric powertrain only or by a hybrid electric powertrain and the OVC range of vehicles powered by a hybrid electric powertrain

		— if a vehicle cannot reach a steady speed of 50 km/h without the fuel-consuming engine starting up, the speed shall be reduced until it can run at a lower steady speed at which the fuel-consuming engine does not start up for a defined time or distance (to be determined by the test agency and the manufacturer); or — in accordance with the manufacturer's recommendation. The fuel-consuming engine shall be stopped within ten seconds of being automatically started
4.1.3.		Normal overnight charge For a pure electric vehicle, the battery shall be charged according to the normal overnight charge procedure, as defined in point 2.4.1.2. of Appendix 2, for a period not exceeding twelve hours. For an OVC HEV, the battery shall be charged according to the normal overnight charge procedure as described in point 3.2.2.4. of Appendix 3.
4.2.		Application of the cycle and measurement of the range
4.2.1.		For pure electric vehicles:
4.2.1.1.		The test sequence set out in the Appendices shall be carried out on a chassis dynamometer adjusted as described in chapter 2W- II, until the test criteria are met.
4.2.1.2.		The test criteria shall be deemed as having been met when the vehicle is unable to meet the target curve up to 50 km/h, or when the standard on-board instrumentation indicates that the vehicle should be stopped. The vehicle shall then be slowed to 5 km/h without braking by releasing the accelerator pedal, and then stopped by braking.
4.2.1.3.		At speeds of over 50 km/h, when the vehicle does not reach the acceleration or speed required for the test cycle, the accelerator pedal shall remain fully depressed, or the accelerator handle shall be turned fully, until the reference curve has been reached again.
4.2.1.4.		Up to three interruptions, of no more than 15 minutes in total, are permitted between test sequences.
4.2.1.5.		The distance covered in km (D_e) is the electric range of the electric vehicle. It shall be rounded to the nearest whole number.
4.2.2.		For hybrid electric vehicles:
4.2.2.1.1.		The applicable type I test cycle and accompanying gearshift arrangements, as set out in point 4.5.5. of Chapter 2W- II shall be carried out on a chassis dynamometer adjusted as described in Chapter 2W- II, until the test criteria are m

Appendix 3.3 to Chapter 3W-IX

Method of measuring the electric range of vehicles powered by an electric powertrain only or by a hybrid electric powertrain and the OVC range of vehicles powered by a hybrid electric powertrain

4.2.2.1.2.	To measure the electric range, the test criteria shall be deemed as having been met when the vehicle is unable to meet the target curve up to 50 km/h, or when the standard on-board instrumentation indicates that the vehicle should be stopped, or when the battery has reached its minimum state of charge. The vehicle shall then be slowed to 5 km/h without braking by releasing the accelerator pedal, and then stopped by braking.
4.2.2.1.3.	At speeds of over 50 km/h, when the vehicle does not reach the acceleration or speed required for the test cycle, the accelerator pedal shall remain fully depressed until the reference curve has been reached again
4.2.2.1.4.	Up to three interruptions, of no more than 15 minutes in total, are permitted between test sequences
4.2.2.1.5.	The distance covered in km using the electrical motor only (D_e) is the electric range of the hybrid electric vehicle. It shall be rounded to the nearest whole number. Where the vehicle operates both in electric and in hybrid mode during the test, the periods of electric-only operation will be determined by measuring current to the injectors or ignition.
4.2.2.2.	Determining the OVC range of a hybrid electric vehicle
4.2.2.2.1.	The applicable type I test cycle and accompanying gearshift arrangements, as set out in point 4.4.5. of Chapter 2W- II, shall be carried out on a chassis dynamometer adjusted as described in Chapter 2W- II, until the test criteria are met.
4.2.2.2.2.	To measure the OVC range D_{OVC}, the test criteria shall be deemed as having been met when the battery has reached its minimum state of charge according to the criteria in points 3.2.3.2.2.2. or 4.2.4.2.2.2. of Appendix 3. Driving shall be continued until the final idling period in the type I test cycle has been completed.
4.2.2.2.3.	Up to three interruptions, of no more than fifteen minutes in total, are permitted between test sequences.
4.2.2.2.4.	The total distance driven in km, rounded to the nearest whole number, shall be the OVC range of the hybrid electric vehicle.
4.2.2.3.	At speeds of over 50 km/h, when the vehicle does not reach the acceleration or speed required for the test cycle, the accelerator pedal shall remain fully depressed, or the accelerator handle shall be turned fully, until the reference curve has been reached again.
4.2.2.4.	Up to three interruptions, of no more than 15 minutes in total, are permitted between test sequences
4.2.2.5.	The distance covered in km (D_{OVC}) is the electric range of the hybrid electric vehicle. It shall be rounded to the nearest whole number.