Draft Indian Standard

CMVR Type Approval for Hybrid Electric Vehicles

ICS 43.120

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भारतीय मानक प्रारूप

हाइब्रिड इलेक्ट्रिक वाहनों के लिए CMVR प्रकार की स्वीकृति

Draft Indian Standard

CMVR Type Approval for Hybrid Electric Vehicles

Electric and Hybrid Vehicles Sectional Committee, TED 27

FOREWORD

(Formal Clause to be added later)

This standard is based on AIS 102 (Part- 1) - CMVR Type Approval for Hybrid Electric Vehicles. The purpose of this standard is to provide an appropriate frame-work for type approval for four wheelers whose gross vehicle mass does not exceed 3500 kg. The tailpipe emission compliance of these categories of vehicles is certified by an engine dynamometer test procedure.

Worldwide hybrid electric vehicles are gaining popularity with authorities and users because they can deliver better on-road fuel efficiency (and thus reduced green-house gases) and reduced pollution as compared to similar combustion engine vehicles. The Indian automotive industry is also developing and/or producing hybrid electric vehicles to meet this demand. Consequently, a framework of type approval needs to be created under the CMVR Rules, 1989 to ensure that these vehicles comply with the appropriate safety and emission norms.

This standard is to be treated as an interim standard for the following reasons:

a) Hybrid Electric Vehicle technology worldwide is still in its infancy and growing continuously to achieve better performance and efficiencies. This standard would need to be upgraded progressively to incorporate this evolving technology.

b) Partly, because the technology is in its infancy, no worldwide comprehensive standards exist for legislative approval of hybrid electric vehicles in these vehicle categories. In order to encourage the early implementation of these Hybrid Electric Vehicles into wide-spread use, India has taken leadership in creating these regulations. This standard may need to take the benefit of the new elements in legislation that may be introduced in regulations worldwide as they evolve.

c) This regulation requires that the combustion engine of the hybrid electric vehicle comply as a stand-alone entity with the tailpipe emissions requirements based on the engine dynamometer test procedure given in document no. MoRTH/TAP/115-116. While this meets the minimum requirements of emissions, it fails to encourage technology innovations where more fuel efficient vehicles could be developed by having the complete power train holistically deliver further reduced levels of green-house gases and other pollutants.

d) Because of the infancy of the technology, both for part-1 and part-2, it has been decided to create a support framework for type approval and once both the technology and the approval procedures reach the required maturation, these approval requirements can be appropriately embedded into the CMVR Rules 1989

and the standards called therein.

While preparing this standard considerable assistance has been derived from the following ECE Regulations:

1. **ECE R 83** : Uniform provisions concerning the approval of vehicles with regard to the emission of pollutants according to engine fuel requirements

2. **ECE R 100 :** Uniform provisions concerning the approval of battery electric vehicles with regard to specific requirements for the construction and functional safety

3. **ECE R 101 :** Uniform provisions concerning the approval of passenger cars powered by an internal combustion engine only, or powered by a hybrid electric power train with regard to the measurement of the emission of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range, and of categories M1 and N1 vehicles powered by an electric power train only with regard to the measurement of electric energy consumption and electric range

The composition of the Committee responsible for the formulation of this standard is given in Annex- H (to be added later)

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1 SCOPE

This standard lays down the requirements specific to hybrid electric vehicles of M and N category of vehicles, who's GVW does not exceed 3500 kg and L category vehicles as defined in IS 14272: 2011.

2 REFERENCES

IS No.	*Title*
AIS-004 (Part 3)	Automotive Vehicles Requirements for Electromagnetic Compatibility
AIS-007 (Rev.5) : 2014	Information on Technical Specifications to besubmitted by the Vehicle Manufacturer
AIS-038 (Rev.1) : 2015	Battery Operated Vehicles – Requirements forConstruction and Functional Safety
AIS-039 (Rev.1) : 2015	Battery Operated Vehicles – Measurement ofElectrical Energy Consumption
AIS-041 (Rev.1) : 2015	Battery Operated Vehicles Measurement of Net Power and the Maximum 30 Minute Power and Speed
Draft AIS-049/ (Rev.1)/F/May2015	Battery Operated Vehicles - CMVR TypeApproval for Battery Operated Vehicles
IS 14272: 2011	Automotive Vehicles – Types – Terminology
IS 2	Rules for Rounding off Numerical Values
IS 14664:1999	Automotive Vehicles - Performance Requirements and Testing Procedure for Braking System of Two and Three Wheeled Motor Vehicles
IS 11852: 2001 (Parts 1 to 9)	Automotive Vehicles - Brakes and Braking Systems

MoRTH/CMVR/ TAP-115/116	Document on Test Methods, Testing Equipment and Related Procedure for Testing Type Approval and Conformity of Production (COP) of Vehicles for Emission as per CMV Rules 115, 116 and 126

Central Motor Vehicle Rules 1989

3 DEFINITIONS

For the purpose of this standard the following definitions shall apply

3.1 For a Hybrid Electric Vehicle (HEV), the, "power train" comprises a combination of two different drive train types:

a) an internal combustion engine, and
b) one (or several) electric drive train(s)

3.2 OVC range: the total distance covered during complete combined cycles run until the energy imparted by external charging of the battery(or other electric energy storage device) is depleted, as measured according to the procedure described in ANNEX D."

3.3 "Where necessary, the definitions given in of Draft AIS-049 (Rev.1)/F/May2015 shall apply".

4 APPLICABILITY OF THE RULES PRESCRIBED IN CENTRAL MOTOR VEHICLES RULES, 1989 (CMVR)

4.1 The changes needed in Rule 2 of CMVR to take into account the requirement specific to hybrid vehicles are given in Annex A

4.2 All the other rules of CMVR, prescribed for category of the vehicle it belongs to and the fuel used are applicable.

5 APPLICABILITY OF STANDARDS NOTIFIED UNDER RULE 124 OF CMVR

5.1 Fuel Consumption: (Sl. No. 31 of S.O. 1365(E) dated 13th December 2004)

The changes in the test procedure MoRTH/CMVR/TAP-115/116 for measuring the fuel consumption are given in Annex B.

5.2 All other standards notified under Rule 124 of CMVR as applicable for category of the vehicle it belongs to and the fuel used, shall be complied with

6 UNAFFECTED PROVISIONS

If a base model is type approved, the test carried out for parameters, subject to the CEA of the such provisions, which are not affected by conversion to HEV's (covered in this standard) shall not be carried out and approvals shall be automatically extended for the HEV's.

7 EMISSION TEST PROCEDURE

7.1 The changes in the emission test procedure MoRTH/CMVR/TAP-115/116 for verifying compliance to Rule 115 of CMVR for verification of emission standards are given in Annex B.

7.2 When tested as per this procedure, the vehicle shall comply with the emission norms prescribed for category of the vehicle it belongs to and the fuel used.

8 BRAKE PERFORMANCE

The changes needed in the test procedure (IS 14664:1999 and IS 11852: 2001, Parts 1 to 9) for evaluating the prescribed performance requirements of braking systems, to take into account regenerative braking system of HEV's, are given in Annex C.

9 ENGINE AND MOTOR POWER TEST

9.1 Engine Power Test

Engine power shall be tested as per applicable current practices for CI and SI engines.

9.2 Motor Power Test

Electric drive train(s) shall be tested as per procedure given below:

9.2.1 These requirements apply for measuring the maximum net power and the maximum 30 minute power of electric drive trains used for propelling pure electric/ hybrid road vehicles.

9.2.2 *Test Conditions*

9.2.2.1 The drive train shall have been run-in according to the manufacturer's recommendations.

9.2.2.2 If the power measurement can be carried out only on a drive train with the gear-box or a reducer mounted, the efficiency shall be taken into account.

9.2.2.3 *Auxiliaries*

9.2.2.3.1 Auxiliaries to be Fitted

During the test, the auxiliaries necessary for the drive train operation in the intended application (as listed in Table 1 below) shall be installed in the same position as in the vehicle.

9.2.2.3.2 Auxiliaries to be Removed

The auxiliaries necessary for the proper operation of the vehicle, and which may be mounted on the motor shall be removed when performing the test. The following non-exhaustive list is given as an example:

Air compressor for brakes;

Power steering compressor; Suspension
system compressor; Air conditioner system,
etc.

Where accessories cannot be removed, the power they absorb in the unloaded condition may be determined and added to the measured power.

Table – 1

Auxiliaries to be fitted for the Test to Determine Net Power andthe Maximum 30 Minute Power of Electric Drive Trains

("Standard-production equipment" means equipment provided by the manufacturerfor a particular application)

No.	Auxiliaries	Fitted for Net Power andMax 30 Minute Power Test
1	DC voltage source	Voltage drop during test less than 5%
2	Speed vehicle variator and control	Yes: Standard-production equipment

3	Liquid Cooling :Motor bonnet Bonnet outlet Radiator (1) (2) Fan Fan cowl Pump Thermostat (3)	No Yes: Standard-productionequipment
	AIR COOLING Air filterCowl Blower Temperature adjustment system	Yes: Standard-productionequipment
4	Electric equipment	Yes : Standard-production equipment
5	Bench test auxiliary fan	Yes, if necessary

(1) The radiator, the fan, the fan cowl, the water pump and the thermostat shall be located on the test bench in the same relative position as on the vehicle. The cooling-liquid circulation shall be activated by the drive train water pump only.

Cooling of the liquid may be produced either by the drive train radiator, or by an external circuit, provided that the pressure loss of this circuit and the pressure at the pump inlet remain substantially the same as those of the drive train cooling system. The radiator shutter, if any, shall be in the open position.

Where the fan, radiator and fan cows can not conveniently be fitted for the bench test, the power absorbed by the fan when separately mounted in its correct position in relation to the radiator and cows (if used), shall be determined at the speed corresponding to the motor speeds used for measurement of the motor power either by calculation from standard characteristics or by practical tests. This power, corrected to the standard atmospheric conditions should be deducted from the correct power.

(2) Where a disconnectable or progressive fan or blower is incorporated, the test should be carried out with the disconnected fan (or blower) disconnected or at maximum slip condition.

(3) The thermostat may be fixed in the fully open position.

9.2.2.4 *Setting conditions*

The setting conditions shall conform to the manufacturer's specifications for the production motor and be used without further alteration for the particular application.

9.2.2.5 *Data to be recorded*

9.2.2.5.1 The test for determining the net power shall be carried out with the accelerator control set at the maximum position.

9.2.2.5.2 The motor must have been run-in in accordance with the recommendations of the applicant for the approval.

9.2.2.5.3 Torque and speed data shall be recorded simultaneously.

9.2.2.5.4 If needed, the cooling liquid temperature recorded at the motor outlet must be maintained at ±5K of the thermostat temperature setting specified by the manufacturer.

For air cooling drive trains, the temperature at a point indicated by the manufacturer shall be kept within ±0/-20K of the maximum value specified by the manufacturer.

9.2.2.5.5 The temperature of the lubricating oil measured in the oil sump or at the outlet from the oil temperature exchanger (if any) shall be maintained within the limits prescribed by the manufacturer.

9.2.2.5.6 An auxiliary regulating system may be used, if necessary, to maintain the temperature within the limits specified in Paragraphs **9.2.5.4**. and **9.2.5.5**

9.2.3 *Accuracy of Measurements*

9.2.3.1 Torque : ±1% of measured torque.

The torque measuring system shall be calibrated to take friction losses into account. The accuracy in the lower half of the measuring range of the dynamometer bench may be ±2% of measured torque.

9.2.3.2 Motor Speed : 0.5% of measured speed.

9.2.3.3 Motor Inlet Air Temperature : ± 2K."

9.2.4 *Test Procedure*

Motor shall be tested as per test procedure specified in AIS-041: 2003.

10 MEASUREMENT OF PASS BY NOISE LEVEL

Noise test shall be as per current CMVR rules. In the case of series HEV's, the approach speed for noise testing shall be as given in **clause 3.2** of Draft AIS 049/Rev.1/F/May 2015

11 EMC test shall be done as per AIS-004 (Part 3) for L-category of Hybrid Electric Vehicle.

11.1 For M and N category vehicles with BS IV and above, EMC test shall be done as per AIS-004 (Part 3).

For other M and N Category vehicles, EMI test shall be done as per AIS-004 (Part 1).

Measurement of Electromagnetic Radiations as per AIS-004(Part 1) or (Part 3)

Hybrid Electric Vehicle shall be tested as per procedure laid down in AIS-004 (Part 1) or (Part 3) standard as applicable, over the specifiedfrequency range with both the combustion engine and electric drive running.

If the above condition is not possible, two separate tests shall be conducted as follows:

11.1.1 *Electric Motor Drive Mode*

Test shall be conducted as per AIS-004(Part 1) or (Part 3) as applicable over specified frequency range from 30 MHz to 1000 MHz, provided that a continuous power source may be supplied to the Rechargeable Energy Storage System (REESS) to keep the vehicle running without starting the combustion engine. Manufacturer may facilitate this through service mode.

11.1.2 *Engine Mode*

The test shall be conducted as per AIS-004(Part 1) or (Part 3), as applicable for engine type. Manufacturer may recommend energy storage level of REESS, such that combustion engine does not chargethe REESS during the test

Radiated Immunity test shall be done as per AIS 004 (Part 3) standard for Hybrid Electric vehicle as specified in **clause No. 11.0** above.

12 ADDITIONAL REQUIREMENTS

The HEV's shall comply with the following provisions ofAIS-038(Rev.1)

12.1	Clause 3.1.	Protection against electric shock.
12.2	Clause 3.2	Rechargeable Energy Storage System (REESS)

12.3	Clause 3.3	Functional safety However provisions of clause no.3.3.2 of AIS-038: (Rev. 1) ("active driving possible mode") does not apply, under conditions where an internal combustion engine provides directly or indirectly the vehicle´s propulsion power. Requirements of clause 3.3.14 shall be applicable only if an "on board charger" is provided.
12.4	Clause 3.4	Creepage Distance Measurement for Open Type of Traction Batteries"

13 TECHNICAL SPECIFICATIONS

The information to be submitted by the manufacturer for type approval shall contain the information given in the version of AIS 007 (Rev. 5) as applicable to that category of vehicle.

The additional information needed for HEV's are given in Annex G.

14 CHANGES IN THE TECHNICAL SPECIFICATIONS ALREADY TYPE APPROVED

14.1 Every modification pertaining to the information declared in accordance with paragraph 12 shall be intimated by the manufacturer to the testing agency.

14.2 If the changes are in parameters not related to the provisions, no further action need be taken.

If the changes are in parameters related to the provisions, the testing agency shall then consider, whether,

a) the model with the changed specifications still complies with provisions; or,

b) any further verification is required to establish compliance.

"For considering whether any further verification is required or not, guidelines given in Draft AIS-049 (Rev.1)/F/May 2015shall be used for the electrical requirements. For other cases, the guide lines given in the individual standard shall be applicable."

14.3 In case of 13.2 b), verification for only those parameters which are affected by the modifications needs to be carried out.

14.4 In case of fulfillment of criterion of para 13.2 a) or after results of further verification as per para of 13.2 b) are successful, the approval of compliance shall be extended for the changes carried

out.

14.5 Tests such as Evaporative emission, crankcase emission, idling emission, full load smoke (for diesel engine vehicles) etc. need not be carried out, if the related technical specification is same as those of a model already type approved.

15 CONFORMITY OF PRODUCTION REQUIREMENTS

15.1 Vehicle approved under this standard shall be so manufactured as to conform to the type approved as per this AIS.

15.2 Verification of COP by the testing agencies for the emission requirements shall be as per the procedure laid down in CMVR and MORTH/CMVR/TAP-115/116.

15.3 Verification of COP for the other provisions shall be applicable as per Whole Vehicle COP procedure, as and when laid down by the Ministry of Road Transport and Highways.

16 VALIDITY OF ANNEXES

It is expected that in due course of time the details given in Annexes A to G would be incorporated in CMVR and other related documents referred in this AIS. Once, such an incorporation takes place, the details given in these annexes would be automatically defunct.

17 TRANSITORY PROVISIONS

17.1 Testing agency may issue a provisional certificate of compliance to CMVR for HEV's, based on compliance to this standard, before this standard is adopted by CMVR TSC and/or notified in CMVR.

Such provisional certificates shall indicate the following:

"This certificate is issued based on compliance to AIS-102 (Part 1), which is not yet notified in CMVR. This certificate is valid for a period of 6 months from date of notification of this standard and needs to be revalidated thereafter."

ANNEX A

(*See* 4.1)

THE CHANGES NEEDED IN CMVR 1989

A-1 RULE 2 DEFINITIONS

After the existing sub-rule (v) of Rule 2, insert the following as sub-rule (w)

"(w) Hybrid Electric Vehicle (HEV)" means a vehicle that, for the purpose of mechanical propulsion, draws energy from both of the following on-vehicle sources of stored energy/power:

- a consumable fuel and
- an electrical energy/power storage device (e.g.: battery, capacitor, flywheel / generator etc.)"

ANNEX B
(*See* 5.1 and 7.1)

THE CHANGES NEEDED IN MORTH/CMVR/TAP-115/116FOR EMISSION TESTS AND MEASUREMENT OF FUEL CONSUMPTION FOR HYBRID ELECTRIC VEHICLES

B-1 CATEGORIES OF HYBRID ELECTRIC VEHICLES

HEV's are categorized as below.

Vehicle charging	**Off Vehicle Charging (OVC)** [1/]		**Not Off Vehicle Charging (NOVC)** [2/]	
Operating mode switch	without	with	without	with
[1/] also known as "externally chargeable" [2/] also known as "not externally chargeable"				

B-2 TYPE I TEST METHOD FOR EXTERNALLY CHARGEABLE (OVC HEV) WITHOUT AN OPERATING MODE SWITCH

Two tests shall be performed under the following conditions

(a) Condition A: test shall be carried out with a fully charged electrical energy / power storage device.

(b) Condition B: test shall be carried out with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity).

(c) The profile of the state of charge (SOC) of the electrical energy/power storage device during different stages of the Type I test for condition A and B are given in ANNEX E-Appendix 1."

B-2.1 Condition A

B-2.1.1 *Discharge of Battery*

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.):

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

(b) or, if a vehicle cannot reach a steady speed of 50 km/h without starting up the fuel consuming engine or for other reasons, the speed shall be reduced until the vehicle can run at a lower steady speed where the fuel consuming engine does not start up for a defined time/distance (to be specified between testing agency and manufacturer).

(c) or with manufacturer's recommendation.

The fuel consuming engine shall be stopped within 10 seconds of it being automatically started.

B-2.1.2 *Conditioning of Vehicle*

B-2.1.2.1 *M and N Category fitted with Compression Ignition Engine*

Vehicle shall be driven according to paragraph B-2.1.4.2. for three consecutive Part II cycles of the modified Indian driving cycle defined in Table II of Annex IV B of CMVR 1989.

B-2.1.2.2 *M and N Category fitted with Positive Ignition Engine*

Vehicle shall be driven according to paragraph B-2.1.4.2. for one Part One and two Part Two driving cycles of the modified Indian driving cycle defined in Table I and Table II of Annex IV B respectively of CMVR 1989.

B-2.1.2.3 Driving Cycle for L category vehicle shall be as given below

(a) With design maximum speed not greater than 50 km/h: IDC defined in Annexure II of CMVR 1989

(b) With design maximum speed greater than 50km/h:

(i) For compliance with BSIII norms: IDC as defined in Annexure II of CMVR 1989 or applicable parts of WMTC as defined in TAP document MORTH/CMVR/TAP-115/116, as per manufacturer's option.

(ii) For compliance with BSIV norms: Applicable parts of WMTC as defined in applicable TAP document MORTH/CMVR/TAP-115/116"

B-2.1.3 *Soak*

B-2.1.3.1 After this preconditioning, and before testing, the vehicle shall be soaked as prescribed for IC engine vehicles as per MORTH/CMVR/TAP-115/116 and the electrical energy/power storage device is fully charged as a result of the charging prescribed in paragraph B-2.1.3.2.

B-2.1.3.2 During soak, the electrical energy/power storage device shall be charged:

(a) with the on board charger if fitted, or

(b) with an external charger recommended by the manufacturer, using the normal overnight charging procedure (*see* **D-4.1.2**.)

This procedure excludes all types of special charges that could be automatically or manually initiated like, for instance, the equalization charges or the servicing charges. The manufacturer shall declare that during the test, a special charge procedure has not occurred

(c) For details of end of charge, (*see* **D-4.1.3**.)

B-2.1.4 *Mass Emission Test*

B-2.1.4.1 Mass emission test shall be carried out, as prescribed for corresponding IC engined vehicle

B-2.1.4.2 However, in case of special gear shifting strategy according to the manufacturer's instructions, as incorporated in the drivers' handbook of production vehicles and indicated by a technical gear shift instrument (for drivers information) shall be followed. For these vehicles the gear shifting points prescribed in MORTH/CMVR/TAP-

115/116 are not applied.

B-2.1.4.3 *Test Procedure*

The test procedures defined in either paragraph **B-2.1.4.4.1**or **B-2.1.4.4.2** may be used.

B-2.1.4.3.1 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 respective driving cycle (end of sampling(ES)).

B-2.1.4.3.2 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:

In case of M or N category vehicle, the first extra-urban (Part Two) cycle

In case of L category, the end of an IDC or part of WMTC during which the battery reached the minimum state of charge according to the criterion defined below (end of sampling (ES)).

The electricity balance Q [Ah] is measured over each combined cycle, using the procedure specified in Appendix 2 to Annexure E, and used to determine when the battery minimum state of charge has been reached.

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 3 per cent 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 paragraphs below, provided that the electricity balance for each additional test cycle shows less discharge of the battery than over the previous cycle.

In between each of the cycles a hot soak period of up to ten minutes is allowed. The powertrain shall be switched offduring this period.

B-2.1.4.3.3 The test results on the combined cycle (CO_2 and fuel consumption) for Condition A shall be recorded (respectively m1 [g] and c1 [l]). In the case of testing according to paragraph B-2.1.4.4.1., m1 and c1 are simply the results of the single combined cycle run. In the case of testing according to paragraph B-2.1.4.4.2., m1 and c1 are the sums of the results of the N combined cycles run.

$$m1 = \sum_{1}^{N} mi$$

$$c1 = \sum_{1}^{N} ci$$

In the case of testing according to paragraph **B-2.1.4.4.1**.,for CO, HC and NOx, m1 and c1 are simply the results of the single combined cycle run multiplied by the appropriate deterioration and Ki factors, shall be less than the limits.

In the case of testing according to paragraph **B-2.1.4.4.2**. for CO, HC and NOx, test result of each combined cycle run multiplied by the appropriate deterioration and Ki factors, shall be less than the limits. And m1 and c1 are the sums of the results of the N combined cycles run calculated by above formula.

B-2.1.4.3.4 Within the 30 minutes after the conclusion of the cycle, ofthe v1 test, the electrical energy/power storage device shall becharged according to clause **D-4.1.2** and **D-4.1.3**.

The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy e1 [Wh] delivered from the mains.

The electric energy consumption for condition A is e1 [Wh]."

B-2.1.4.4 Number of tests to be carried and averaging shall be as prescribed in MORTH/CMVR/TAP-115/116 for IC engined vehicles.

B-2.2 Condition B

B-2.2.1 conditioning of vehicle: shall be as per paragraph **B-2.1.2**

B-2.2.2 Discharge of battery shall be as per paragraph **B-2.1.1**

B-2.2.3 After this discharge of the battery and before testing, the vehicle shall be soaked as prescribed for IC engined vehicles as per MORTH/CMVR/TAP-115/116.

B-2.2.4 Mass emission test shall be as per B-2.1.4"The test results on the combined cycle (CO2 and fuel consumption) for Condition B shall be recorded (respectively m2 (g) and c2 (l)).

B-2.2.5 *Measurement of Energy*

B-2.2.5.1 Within the 30 minutes after the conclusion of the cycle, of the v1 test, the electrical energy/power storage device shall be charged according to paragraph **D-4.1.2** and **D-4.1.3**.

The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy e2 [Wh] delivered from the mains.

B-2.2.5.2 The electrical energy/power storage device of the vehicle shall be discharged in accordance with paragraph **B-2.1.1**.

B-2.2.5.3 Within the 30 minutes after discharge, the electrical energy/power storage device shall be charged according to paragraph **D-4.1.2** and **D-4.1.3.**

The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy e3 [Wh] delivered from the mains.

B-2.2.5.4 The electric energy consumption e4 [Wh] for condition B is: e4 = e2-e3

B-2.3 Final Test Results

"The values of pollutants and CO2 shall be M1i = m1/Dtest1 and M2i = m2/Dtest2 (g/km) with Dtest1 and Dtest2 the total actual driven distances in the tests performed under conditions A (paragraph 2.1 of this ANNEX) and B (paragraph 2.2 of this ANNEX) respectively, and m1 and m2 determined in paragraphs **B-2.1.4.4.3** and **B-2.2.4** of this ANNEX respectively."

B-2.3.1 In the case of testing according to paragraph B-2.1.4.4.1,

Mi = (De x M1i + Dav x M2i) / (De + Dav)		
where		
Mi	=	mass emission of the pollutant i in grams perkilometer
M1i =		average mass emission of the pollutant i in grams per kilometer with a fully charged electrical energy/powerstorage device, determined as per paragraph B-2.1.4
M2i =		average mass emission of the pollutant i in gramsper kilometer with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity) determined as per paragraph B-2.2.4
De =		Vehicle electric range, according to the procedure described in ANNEX D, where the manufacturer must provide the means for performing the measurementwith the vehicle running in pure electric operating state.

Dav =	25 km (average recharges)"	distance	between	two	battery

B-2.3.2 In the case of testing according to paragraph **B-2.1.4.4.2**, the final results of pollutants for deciding on compliance and for CO_2 shall be:

$$\underline{((D_{ovc}M1_i)+(D_{av}M2_i))}$$

$$M = \frac{}{D_{ovc}+D_{av}}$$

M	=	mass emission of the pollutant i in grams per kilometer
M1i	=	average mass emission of the pollutant i in grams per kilometerwith a fully charged electrical energy/power storage device, determined as per paragraph B-2.1.4
M2i	=	average mass emission of the pollutant i in grams per kilometer withan electrical energy/power storage device in minimum state of charge (maximum discharge of capacity) determined as perparagraph B-2.2.4
Dovc	=	OVC range according to the procedure described in ANNEX D.
Dav	=	25 km (average distance between two battery recharges).”

Where :

B-2.3.3 Reported fuel consumption shall be calculated by carbon balance method, as per procedure prescribed in MORTH/CMVR/TAP- 115/116, except that the values of HC, CO and CO_2 for calculation of fuel consumption shall be based on figures arrived at, as per paragraph **B-2.1.4.4.3** and **B-2.2.4** of this annex respectively.

The values of fuel consumption for Condition A test and Condition B Test shall be

C1 = Calculated value of Fuel Consumption in l/km by carbon balance method using HC, CO and CO_2 values arrived as per paragraph **B-2.1.4.4.3** for Condition A Test (paragraph 2.1 of this annex).

C2 = Calculated value of Fuel Consumption in l/km by carbon balance method using HC, CO and CO_2 values arrived as per paragraph **B-2.2.4** for Condition B Test (paragraph 2.2 of this annex).

The weighted values of fuel consumption shall be calculated as below:

B-2.3.3.1 In the case of test procedure according to paragraph **B- 2.1.4.4.1**. of this annex:

$$C = (De \cdot C1 + Dav \cdot C2)/(De + Dav)$$

Where:

C =	fuel consumption in l/km.
C1 =	Calculated value of Fuel Consumption in l/km by carbon balance method using HC, CO and CO2 values arrived as per paragraph B-2.1.4.4.3 for Condition A Test (paragraph 2.1 of this annex) with a fully charged electrical energy /power storage device
C2 =	Calculated value of Fuel Consumption in l/km by carbon balance method using HC, CO and CO2 values arrived as per paragraph B-2.2.4 for Condition B Test (paragraph 2.2 of this annex) with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity).
De=	vehicle's electric range, according to the procedure described in ANNEX D, where the manufacturer must provide the means for performing the measurement with the vehicle running in pure electric operating state.
Dav=	25 km (assumed average distance between two battery recharges).

B-2.3.3.2 In the case of testing according to paragraph **B-2.1.4.4.2**. ofthis annex:

C = (Dovc·C1 + Dav·C2)/ (Dovc + Dav)

Where:

C =	Fuel consumption in l/km.
C1 =	Calculated value of Fuel Consumption in l/km by carbon balance method using HC, CO and CO2 values arrived as per paragraph B-2.1.4.4.3 for Condition A Test (paragraph 2.1 of this annex) with a fully charged electrical energy /power storage device.
C2 =	Calculated value of Fuel Consumption in l/km by carbon balance method using HC, CO and CO2 values arrived as per paragraph B-2.2.4 for Condition B Test (paragraph 2.2 of this annex) with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity).
Dovc=	OVC range according to the procedure Described in ANNEX D.
Dav =	25 km (assumed average distance between two battery Recharges).”

B-2.3.4 Electric Energy Consumption

B-2.3.4.1 The values of electric energy consumption shall be

E1 = e1/Dtest1 [Wh/km] for condition A, and

E4 = e4/Dtest2 [Wh/km] for condition B

With Dtest1 and Dtest2 are the actual driven distances in the tests performed under conditions A (**B-2.1.4**) and B (**B-2.2.4**) respectively, and e1 and e4 determined in paragraphs **B-2.1.4.4** and **B-2.2.5.4** respectively.

B-2.3.4.2 The weighted values of electric energy consumption shall be calculated as below:

E = (De * E1 + Dav * E4) / (De + Dav) Where:

E = electric consumption Wh/km

E1 = electric consumption Wh/km with a fully charged electrical energy/power storage device calculated as per **B-2.3.3.1**.

E4 = electric consumption Wh/km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity) **B-2.3.3.1**.

De = vehicle electric range, according to the procedure described in Annex D.

Dav = 25 km (assumed average distance between two battery recharges)

B-2.3.4.2.1: In the case of testing according to paragraph **B-2.1.4.4.1**,"

B-2.3.4.2.2: In the case of testing according to paragraph **B-2.1.4.4.2**:

$$E = \frac{(DovcE1 + DavE4)}{Dovc + Dav}$$

where:

E	**=**	**electric consumption Wh/km.**
E1	**=**	**electric consumption Wh/km with a fully charged electrical energy/power storage device calculated as per B-2.3.3.1.**
E4	**=**	**electric consumption Wh/km with an electrical energy/powerstorage device in minimum state of charge (maximum discharge of capacity). B-2.3.3.1**
Dovc	**=**	**OVC range according to the procedure described in ANNEX D.**
Dav	**=**	**25 km (assumed average distance between two battery recharges).”**

B-2.4 If the tests are carried out only for measurement of CO2, fuel consumption and electrical energy:

B-2.4.1 Only one test need be carried out and the conditions of paragraph **B-2.1.4.5** are not applicable.

B-2.4.2 The preconditioning as per paragraph **B-2.2.1** need to be carried out only on manufacturer's request.

If measurement of electric energy consumption is not part of the test, it is not necessary to carry out the measurement as per paragraphs **B-2.1.4.4** and **B-2.2.5**.

B-3 TYPE I TEST FOR EXTERNALLY CHARGEABLE (OVC HEV) WITH AN OPERATING MODE SWITCH

B-3.1 The operating mode switch shall be positioned according the table below

Hybrid-modes Battery State of charge	- Pure electric - Hybrid Switch in position	- Pure fuel consuming - Hybrid Switch in position	- Pure electric - Pure fuel consuming - Hybrid Switch in position	-Pure electric [4/] -Pure fuel consuming Switch in position	- Hybrid mode n [1/] - Hybrid mode m [1/] Switch in position
Condition A Fully charged	Hybrid	Hybrid	Hybrid	Pure Electric	Most electric hybrid mode [2/]
Condition B Min. state of charge	Hybrid	Fuel consuming	Fuel consuming	Pure fuel consuming	Most fuel consuming mode [3/]

1/ For instance: sport, economic, urban, extra urban position

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 of Annex B, to be established based on information/test reports provided by the manufacturer and in agreement with the testing 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 Annex B, to be established based on information/test reports provided by the manufacturer and in agreement with the testing agency.

4/ For Hybrid vehicles which operate either in pure electric or pure fuel consumption mode, pure electric range shall be more than full emission cycle for Type A test.

B-3.2 Two tests shall be performed one under Condition A and the other under Condition as defined in **B-2.0.** The test procedures for Condition A and Condition B shall be same as those given in B-2.1 and **B-2.2** respectively, except that the switching modes shall be as given in **B- 3.1**, **B-3.2.1** and **B-3.3**.

B-3.2.1 However, if the pure electric range of the vehicle measured in accordance with Annex-D is higher than one full emission test cycle, on the request of the manufacturer, the Type I test for condition A may not be carried out.

In such cases, the value of M1i shall be taken as zero for calculation of final results. (**B-2.3.1** and **B-2.3.2**).

In this case, engine preconditioning prescribed in paragraph **B-2.1.2** can be omitted at the request of manufacturer.

B-3.3 Discharge of Battery

B-3.3.1 In the case of OVC HEV's equipped with a pure electric mode, 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 per cent ± 5 per cent of the maximum thirty minutes speed of the vehicle (determined according to **clause 5.0** of AIS-041: (Rev. 1)).

Stopping the discharge occurs when any of the following conditions happens, earliest:

- when the vehicle is not able to run at 65 per cent of the maximum thirty minutes speed; or
- when an indication to stop the vehicle is given to the driver by the standard onboard instrumentation, or
- after covering the distance of 100 km.

B-3.3.2 In case of HEV's not equipped with "pure electric" mode, the discharge procedure shall be as per **B-2.1.1**.

B-3.4 Final test results shall be obtained using procedure given in **B-2.3**.

B-4 TYPE I TESTS FOR NOT EXTERNALLY CHARGEABLE (NOT OVC HEV) WITHOUT AN OPERATING MODE SWITCH

B-4.1 These vehicles shall be tested according to MORTH/CMVR/ TAP-115/116

B-4.2 In the case of M and N category vehicles, for preconditioning, at least two consecutive complete driving cycles (one Part One and one Part Two) are carried out without soak.

In the case of L category vehicles, preconditioning as per **B-2.1.2.3** are carried out without soak.

B-4.3 The vehicle shall be driven according to driving cycles prescribed, taking into account requirements given in paragraph **B-2.1.4.2** in case of special gear shifting strategy.

B-4.4 Special requirements for measurement and correction of the test results for CO2 and fuel consumption are given in Annex F.

B-5 TYPE I TESTS FOR NOT EXTERNALLY CHARGEABLE (NOT OVC HEV) WITH AN OPERATING MODE SWITCH

B-5.1 These vehicles shall be tested in Hybrid mode, according to MORTH/CMVR/TAP-115/116. If several hybrid modes are available, the test shall be carried out in the mode that is automatically set after turn on of the ignition key (normal mode). On the basis of information provided by the manufacturer, the testing agency will make sure that the limit values are met in all hybrid modes.

B-5.2 Preconditioning of vehicle shall be as per **B-4.2**.

B-5.3 The vehicle shall be driven according to driving cycles prescribed, taking into account requirements given in paragraph **B-2.1.4.2** in case of special gear shifting strategy.

B-5.4 Special requirements for measurement and correction of the test results for CO2 and fuel consumption are given in Annex F.

B-6 TYPE II TEST METHODS (IDLING EMISSIONS) FOR SI ENGINES

B-6.1 The vehicles shall be tested according to MoRTH/CMVR/TAP-115/116 with the fuel consuming engine running.

B-6.2 The manufacturer shall provide a "service mode" that makes execution of this test possible, however for HEV's using constant speed engine, type II test shall be done at constant speed of engine only."

B-6.3 If necessary, the special procedure provided for in paragraph **B-6.4** shall be used

B-6.4 It shall be possible to inspect the vehicle for roadworthiness test in order to determine its performance in relation to the data collected in accordance with the procedure prescribed in

MORTH/CMVR/ TAP-115/116. If this inspection requires a special procedure, this shall be detailed in the service manual (or equivalent media). This special procedure shall not require the use of special equipment other than that provided with the vehicle

B-7 TYPE III TEST METHOD: (CRANK CASE EMISSION)

B-7.1 In the case of M and N categories, the vehicles shall be tested according to conditions (1) and (2) of testing for crankcase emissions as mentioned in MoRTH/CMVR/TAP-115/116 with the fuel consuming engine running. The manufacturer shall provide a "service mode" that makes execution of this test possible.

In the case of BS-IV compliant L category vehicles with design maximum speed greater than 50km/h, Crankcase ventilation system shall not permit the emission of any of the crankcase gases into the atmosphere."

B-8 TYPE IV TEST METHOD (EVAPORATIVE EMISSION)

B-8.1 In the case of petrol engined M, N and L (Speed above 50 kmph- BSIV) categories, the vehicles shall be tested according to MoRTH/CMVR/TAP-115/116"

B-8.2 Before starting the test procedure (MoRTH/CMVR/TAP-115/116), the vehicles shall be preconditioned as follows:

B-8.2.1 For Externally Chargeable (OVC HEV) Vehicles

B-8.2.1.1 For Externally Chargeable (OVC HEV) Vehicles without an Operating Mode Switch: The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle as per paragraph **B-2.1.1**

B-8.2.1.2 For Externally Chargeable (OVC HEV) Vehicles with an Operating Mode Switch with a "Pure Electric" mode: 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 as per **B-3.3.1**.

B-8.2.1.3 For Externally Chargeable (OVC HEV) Vehicles with Operating mode switch but without an Operating Mode for a "Pure Electric" mode: The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle as per paragraph **B-2.1.1**.

B-8.2.2 For Not Externally Chargeable (NOVC HEV) Vehicles

B-8.2.2.1 NOVC Vehicles without an Operating Mode Switch: The procedure shall start with a preconditioning of at least two consecutive complete driving cycles (one Part One and one Part Two) without soak.

B-8.2.2.2 NOVC Vehicles with an Operating Mode Switch: The procedure shall start with a

preconditioning of at least two consecutive complete driving cycles (one Part One and one Part Two) without soak, performed with the vehicle in "hybrid" mode. If several hybrid modes are available, the test shall be carried out in the mode which is automatically set after turn on of the ignition key (normal mode).

B-8.3 The preconditioning drive and the dynamometer test shall be carried out according to cycles and procedure given in MORTH/CMVR/ TAP-115/116.

B-8.3.1 In the case of externally chargeable (OVC) HEV: Under the same conditions, as specified by condition B of the Type I test (paragraphs **B-2.2** and **B-3.2**)

B-8.3.2 In the case of not externally chargeable (NOVC) HEV: Under the same conditions of Type I test as specified in **B-4.2** and **B-5.2**.

B-9 TYPE V TEST METHODS (DURABILITY)

In case the mileage accumulation for durability tests is opted by the vehicle manufacturer, vehicles shall be tested according to MoRTH/CMVR/TAP-115/116 with the following additional requirements.

B-9.1 For External Chargeable Vehicles (OVC)

B-9.1.1 It is allowed to charge the electrical energy/power storage device twice a day during mileage accumulation.

B-9.1.2 For External Chargeable vehicles (OVC) with an operating mode switch, mileage accumulation should be driven in the mode which is automatically set after turn on of the ignition key (normal mode). During the mileage accumulation a change into another hybrid mode is allowed if necessary in order to continue the mileage accumulation after agreement of the testing agency.

B-9.1.3 The measurements of emissions of pollutants shall be carried out under the same conditions as specified by condition B of the Type I test (paragraphs **B-2.2** and **B-3.2**).

B-9.2 For Not Externally Chargeable (NOVC HEV) Vehicles

For not externally chargeable (NOVC HEV) vehicles with an operating mode switch, mileage accumulation shall be driven in the mode which is automatically set after turn on of the ignition key (normal mode). The measurements of emissions of pollutants shall be carried out in the same conditions as in the Type I test. (Refer **B-5.0** and **B-4.0**).

ANNEX C
(*See* 8.0)
ADDITIONAL REQUIREMENTS FORREGENERATIVE BRAKING SYSTEM

C-1 DEFINITIONS

C-1.1 Electric Regenerative Braking System: A braking system, which during deceleration, provides for the conversion of vehicle kinetic energy into electrical energy.

C-1.2 Electric Regenerative Brake Control: A device which modulates the action of the electric regenerative braking system

C-1.3 Electric Regenerative Braking System of Category A: An electric regenerative braking system, which is not part of the service braking system.

C-1.4 Electric Regenerative Braking System of Category B: An electric regenerative braking system, which is part of the service braking system.

C-2 VEHICLES FITTED WITH ELECTRIC REGENERATIVE BRAKING SYSTEM OF CATEGORY A

C-2.1 The electric regenerative braking shall be only activated by accelerator control and/or the gear neutral position. In addition, for vehicles of categories M2, the electric regenerative braking control can be a separate switch or lever.

C-2.2 In the case of vehicles fitted with Category A type of regenerative braking system, any separate electric regenerative braking control which is provided, shall not be used during the Type P and Type F tests.

C-3 VEHICLES FITTED WITH ELECTRIC REGENERATIVE BRAKING SYSTEM OF CATEGORY B

C-3.1 It shall not be possible to disconnect partially or totally one part of the service braking system other than by an automatic device

C-3.2 The service braking system control shall also actuate the action of the electric regenerative braking system simultaneously.

C-3.3 The service braking system shall not be adversely affected by the disengagement of the motor(s) or gear ratio used, except during the short duration of operation of gear shifting.

C-3.4 In the case of L category, if the brake control (front or rear or combined) actuates the electric regenerative brake system the prescribed performance requirements shall be complied with the use of the electric regenerative system.

C-4 If so desired by the manufacturer the performance requirements may be verified without the use of the electric regenerative system by appropriately disconnecting the system. If, so this shall be recorded in the test report.

C-5 GENERAL

For vehicles powered completely or partially by an electric motor or motor(s), permanently connected to the wheels, all tests must be carried out with these motor(s) connected.

ANNEX D
(*See* B-3)

METHOD OF MEASURING THE ELECTRIC RANGE OF VEHICLES POWERED BY A HYBRID ELECTRIC POWERTRAIN AND THE OVC RANGE OF VEHICLES POWERED BY A HYBRID ELECTRIC POWERTRAIN

(*See* B-2.3.1, B-2.3.3 and B-3.2.1)

D-1 The test method described hereafter permits to measure the electric range and OVC range, expressed in km, of externally chargeable HEV's (OVC-HEV) as defined in paragraph B-1.

D-2 PARAMETERS, UNITS AND ACCURACY OF MEASUREMENTS

Parameters, units and accuracy of measurements shall be as given in Table D-1:

Table D1
(*see* D-2)
Parameters, Units and Accuracy of Measurements

Parameter	Unit	Accuracy	Resolution
Time	**s**	**± 0.1 s**	**0.1 s**
Distance	**m**	**± 0.1 per cent**	**1 m**
Temperature	**°C**	**± 1°C**	**1°C**
Speed	**km/h**	**± 1 per cent**	**0.2 km/h**
Mass	**kg**	**± 0.5 per cent**	**1 kg**
Electricity balance	**Ah**	**+/-0.5 per cent**	**0.3 per cent**

Where accuracy is specified in %, it is the % of the measured value.

D-3 TEST CONDITIONS

D-3.1 Condition of the Vehicle

D-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.

D-3.1.2 The viscosity of the oils for the mechanical moving parts shall conform to the specifications of the vehicle manufacturer.

D-3.1.3 The lighting and light-signalling and auxiliary devices shall be off, except those required for testing and usual daytime operation of the vehicle.

D-3.1.4 All energy storage systems available for other than traction purposes (electric, hydraulic, pneumatic, etc.) shall be charged up to their maximum level specified by the manufacturer.

D-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 temperature of the battery in the normal operating range.

The manufacturer's agent shall be in a position to attest that the thermal management system of the battery is neither disabled nor reduced.

D-3.1.6 The vehicle must have run at least 300 km during the seven days before the test with those batteries that are installed in the test vehicle. This condition can be waived on request of the vehicle manufacturer

D-3.2 Climatic Conditions

D-3.2.1 For testing performed outdoors, the ambient temperature shall be between 5 °C and 32 °C.

D-3.2.2 The indoors testing shall be performed at a temperature between 20 °C and 30 °C.

D-3.2.3 The test may be carried out at temperatures different from those specified above, at the request of manufacturer.

D-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. Between the steps, if the vehicle shall move, it is pushed to the following test area (without regenerative recharging).

D-4.1 Initial Charge of the Battery

Charging the battery consists of the following procedures:

Note: "Initial charge of the battery" applies to the first charge of the battery, at the reception of the vehicle. In case of several combined tests or measurements, carried out consecutively, the first charge carried out shall be an "initial charge of the battery" and the following may be done in accordance with the "normal overnight charge" procedure.

D-4.1.1 *Discharge of the Battery*

D-4.1.1.2 For externally chargeable hybrid electric vehicle (OVC HEV) without an operating mode switch:

D-4.1.1.2.1 The manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state.

D-4.1.1.2.2 The procedure for discharge of the electrical energy/power storage device of the vehicle is as per paragraph **B-2.1.1**.

D-4.1.1.3 For externally chargeable hybrid electric vehicle (OVC HEV) with an operating mode switch.

D-4.1.1.3.1 If there is not a pure electric position, the manufacturer shall provide the means for performing the measurement with the vehicle running in pure electric operating state. The procedure for discharge of the electrical energy/power storage device of the vehicle is as per paragraph **B-3.3**.

D-4.1.1.3.2 If there is a pure electric position, the procedure for discharge of the electrical energy/power storage device of the vehicle is as per paragraph **B-3.3.1**.

D-4.1.2 *Application of a Normal Overnight Charge*

The electrical energy/power storage device shall be charged according to the normal overnight charge procedure given below.

D-4.1.2.1 *Normal Overnight Charge Procedure*

The charging is carried out:

(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;

(c) in an ambient temperature comprised between 20 ºC and 30 ºC.

Charging may be carried out at temperatures different from those specified above, at the request of manufacturer.

This procedure excludes all types of special charges that could be automatically or manually initiated like, for instance, the equalisation charges or the servicing charges. The manufacturer shall declare that during the test, a special charge procedure has not occurred.

D-4.1.3 *End of Charge Criteria*

The end of charge criteria corresponds to a charging time of 12 hours, except if a clear indication is given to the driver by the standard instrumentation that the electrical energy/power storage device is not yet fully charged.

In this case,

The maximum time is = $\frac{\text{3 x claimed battery capacity (Wh)}}{\text{Mains power supply (W)}}$

D-4.2 Application of the Cycle and Measurement of the Range

D-4.2.1 The applicable test sequence as per the driving cycle used for mass emission testing is applied on a chassis dynamometer until the end of the test criteria is reached. Gear shifting pattern shall be as prescribed in paragraph **B-2.1.4.2**.

D-4.2.2 *To determine the electric range of a hybrid electric vehicle*

To determine the electric range (De) of OVC HEVs equipped with an operating mode switch the same operating mode position, in accordance with Table **B-3.1** and paragraph **B-3.2.1** of ANNEX B to this Regulation, shall be used as for the determination of CO2 and fuel consumption.

D-4.2.2.1 The end of the test criteria is reached earliest or when the battery has reached its minimum state of charge.

D-4.2.2.1.1 When the vehicle is not able to meet the target curve up to 30 km/h,

D-4.2.2.1.2 or when an indication from the standard on-board instrumentation is given to the driver to stop the vehicle

D-4.2.2.1.3 Then the vehicle shall be slowed down to 5 km/h by releasing the accelerator pedal, without touching the brake pedal andthen stopped by braking.

D-4.2.2.1.4 At a speed over speeds specified in paragraph **D-4.2.2.1.1** when the vehicle does not reach the required acceleration or speed of the test cycle, the accelerator pedalshall remain fully depressed until the reference curve has been reached again.

During this procedure, the electricity balance (QES_i) of the high voltage battery (expressed in Ampere hours), measured continuously using the procedure specified inAppendix 2 to the

ANNEX E to this standard, the vehicle speed (VES_i) and De_i shall be recorded at the instant when the fuel consuming engine starts and the accumulation of De_i shall be stopped. Further accumulation of De_i shall not be permitted unless:

(a) The fuel consuming engine stopped running; and

(b) VES_i has returned to the same or any lower level of VES_i as recorded before the fuel consuming engine started; and

(c) QESi has returned to the same or any lower level of QES_i as recorded before the last fuel consuming engine start or, where applicable, to the same or any lower level of QSA_i as determined in accordance with paragraph **4.2.2.1.6** of this ANNEX.

This procedure shall be followed until the end of thetest as defined in paragraph **D-4.2.2.1** of this ANNEX.

D-4.2.2.1.5 To respect human needs, up to three interruptions are permitted between test sequences, of no more than 15 minutesin total.

D-4.2.2.1.6 During the first deceleration phase following each start of the fuel consuming engine, when the vehicle speed is less than the vehicle speed at which the fuel consuming enginestarted previously:

(a) The distance covered with engine off should be counted as De_i; and

(b) The increase in electricity balance during this period should be recorded (ΔQrb_i); and

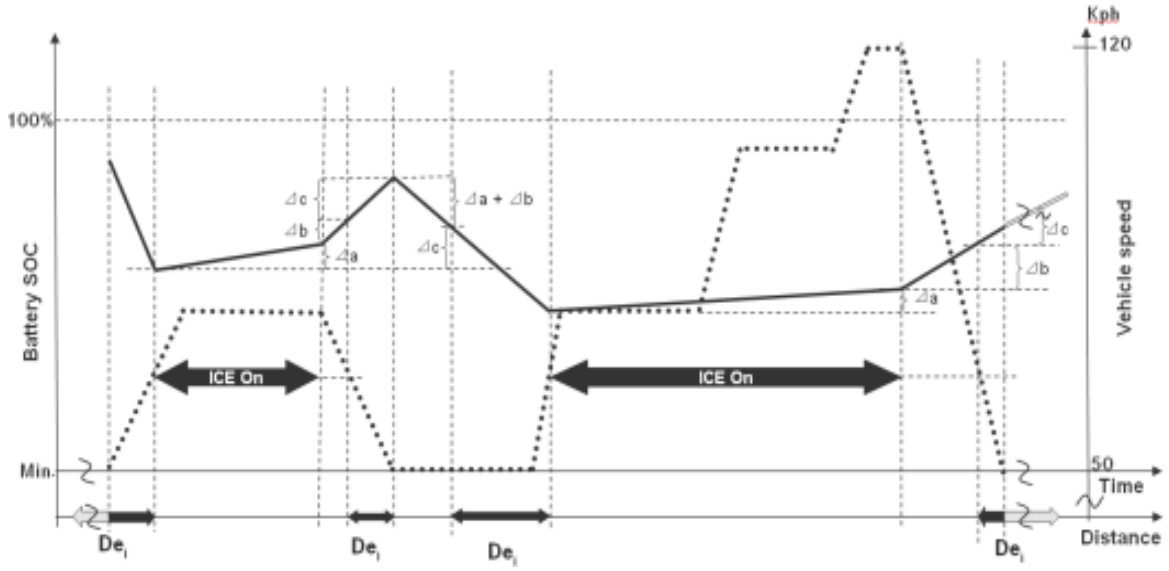
(c) The electricity balance when the fuel consuming engine starts (QES_i) defined previously should be corrected by ΔQrb_i (hence new $QSA_i = QES_i + \Delta Qrb_i$);

VES_i = moment when the ICE starts;

QES_i = hen the ICE starts;

ΔQrb_i = ing deceleration phases, when the vehicle speed is less than the vehicle speed at which the ICE started previously;

QSA_i = of the further accumulation of De



Δa	=	Charged by ICE
Δb	=	Charged by regeneration (vehicle acceleration by ICE)
De	=	ΣDe_i
De_i	=	Distances where the propulsive energy was not produced by ICE.

_____Battery SOC
---------Vehicle Speed

=

D-4.2.2.1.7 At the end, the electric range is the sum of all cycle portionsDei in km. It shall be rounded to the nearest whole number as per IS 2.

D-4.2.3 To determine the OVC range of a hybrid electric vehicle

D-4.2.3.1 To measure the OVC range the end of the test criteria isreached when the battery has reached its minimum stateof charge according to the criteria defined in ANNEX B, paragraph **B-2.1.4.4.2**. Driving is continued untilthe final idling period

In the case of M or N category vehicle, extra-urban cycle In the case of L category, the end of an IDC or part of WMTC"

D-4.2.3.2 To respect human needs, up to three interruptions are permitted between test sequences, of no more thanfifteen minutes in total.

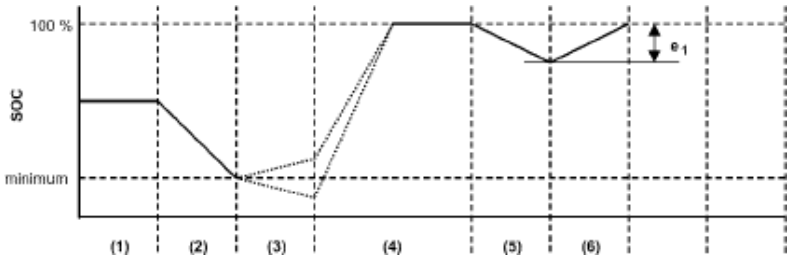
D-4.2.3.3 At the end, the total distance driven in km, rounded to thenearest whole number as per IS 2, is the OVC range of the hybrid electric vehicle.

ANNEX E-APPENDIX-1
(*See* B-2.0(c))

ELECTRICAL ENERGY/POWER STORAGE DEVICE STATE OF CHARGE (SOC) PROFILE FOR OVC-HEV'S.

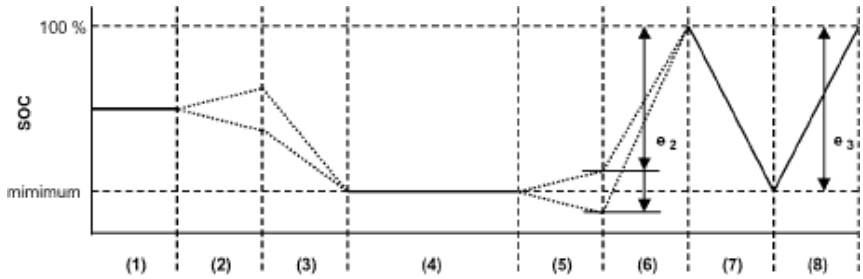
The SOC profiles for OVC-HEV's tested under conditions A and B are:

Condition A:



(1) initial state of charge of the electrical energy/power storage device
(2) discharge according to paragraph **B-2.1.1** or **B-3.3** of Annex-B
(3) vehicle conditioning according to paragraph **B-2.1.2** of Annex-B
(4) charge during soak according to paragraph **B-2.1.3.2** of Annex-B
(5) test according to paragraph **B-2.1.4** of Annex-B
(6) Charging (**B-2.1.4.4**)

Condition B:



(1) initial state of charge
(2) vehicle conditioning according to paragraph **B-2.2.1** of Annex-B
(3) discharge according to paragraph **B-2.2.2** of Annex-B
(4) soak according to paragraph **B-2.2.3** of Annex-B
(5) test according to paragraph **B-2.2.4** of Annex-B
(6) charging according to paragraph **B-2.2.5.1**
(7) discharging according to paragraph **B-2.2.5.2**.
(8) charging according to paragraph **B-2.2.5.3.**

ANNEX E- APPENDIX-2

METHOD FOR MEASURING THE ELECTRICITY BALANCE OFTHE BATTERY OF OVC AND NOVC HEVS

E-1 INTRODUCTION

E-1.1 The purpose of this appendix is to define the method and required instrumentation for measuring the electricity balance of Off Vehicle Charging Hybrid Electric Vehicles (OVC HEV and NotOff Vehicle Charging Hybrid Electric Vehicles (NOVC HEVs).
Measurement of the electricity balance is necessary

(a) To determine when the minimum state of charge of the battery has been reached during the test procedure defined in paragraphs **B-2** and **B-3** of ANNEX B; and

(b) To correct the measured fuel consumption and CO2-emissions for the change in battery energy content occurring during the test,using the method defined in paragraphs **B-5** and **B-6** of ANNEX B.

E-1.2 The method described in this annex shall be used by the manufacturer for the measurements that are performed to determinethe correction factors Kfuel and KCO2, as defined in paragraphs **B-4** and **B-5** of this ANNEX B.

The Testing Agency shall check whether these measurements have been performed in accordance with the procedure described in this ANNEX B and ANNEX F

E-1.3 The method described in this annex shall be used by the Testing Agency for the measurement of the electricity balance Q, as defined in paragraphs **B-2.1.4.4.2**, **B-4.0**, and **B-5** of thisANNEX B and ANNEX F

E-2 MEASUREMENT EQUIPMENT AND INSTRUMENTATION

E-2.1 During the tests as described in paragraphs **B-2**, **B-3** , **B-4**,and **B-5** of this ANNEX B, the battery current shall be measured using a current transducer of the clamp-on type or the closed type. The current transducer (i.e. the current sensor without data acquisition equipment) shall have a minimum accuracy of 0.5 per cent of the measured value (in A) or 0.1 per cent of the maximum value of the scale. Vehicle manufacturer diagnostic testers are notto be used for the purpose of this test.

E-2.1.1 The current transducer shall be fitted on one of the wires directly connected to the battery. In order to easily measure battery current using external measuring equipment, vehicle manufacturers should preferably integrate appropriate, safe and accessible connectionpoints in the vehicle. If that is not feasible, the vehicle manufacturer is obliged to support the Testing

Agency by providing the means to connect a current transducer to the wires connected to the battery in the above described manner.

E-2.1.2 The output of the current transducer shall be sampled with a minimum sample frequency of 5 Hz. The measured current shall beintegrated over time, yielding the measured value of Q, expressed in Ampere hours (Ah).

E-2.1.3 The temperature at the location of the sensor shall be measured andsampled with the same sample frequency as the current, so that thisvalue 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.

E-2.2 A list of the instrumentation (manufacturer, model no., serial no.) used by the manufacturer for determining:

(a) When the minimum state of charge of the battery has been reached during the test procedure defined in paragraphs **B-2** and **B-3** of ANNEX B; and

(b) The correction factors Kfuel and KCO_2 (as defined in paragraphs **B-4**., and **B-5**. of ANNEX B) and the last calibration dates of the instruments (where applicable) should be provided to the Technical Service.

E-3 MEASUREMENT PROCEDURE

E-3.1 Measurement of the battery current shall start at the same time as the test starts and shall end immediately after the vehicle has driventhe complete driving cycle.

E-3.2 Separate values of Q shall be logged over the Part One (urban driving) and Part Two (extra- urban driving) of the MIDC driving cycle."

ANNEX F

(*See* B-4.4 and B-5.4)

SPECIAL REQUIREMENTS FOR MEASUREMENT AND CORRECTION OF THE TEST RESULTS FOR CO2 AND FUEL CONSUMPTION FOR NOT EXTERNALLY CHARGEABLE (NOVC) HEV'S.

F-1 In the case of M and N category vehicles, emissions of carbon dioxide (CO2) and fuel consumption shall be determined separately for the Part One (urban driving) and the Part Two (extra-urban driving) of the specified driving cycle.

F-2 TEST RESULTS

F-2.1 The test results (fuel consumption C [l/100 km] and CO2-emission M [g/km]) of the test are corrected in function of the energy balance ΔEbatt of the vehicle's battery. The corrected values (C0 [l/100 km] and M0 [g/km]) should correspond to a zero energy balance (ΔEbatt = 0), and are calculated using a correction coefficient determined by the manufacturer as defined below. In case of other storage systems than an electric battery, ΔEbatt is representing ΔEbatt, the energy balance of the electric energy storage device.

F-2.2 The electricity balance Q [Ah], measured using the procedure specified in Appendix 2 of ANNEX E, is used as a measure of the difference in the vehicle battery's energy content at the end of the cycle compared to the beginning of the cycle. In the case of M and N category vehicles, the electricity balance is to be determined separately for the Part One cycle and the Part Two cycle."

F-2.3 Under the conditions below, it is allowed to take the uncorrected measured values C and M as the test results:

a) in case the manufacturer can prove that there is no relation between the energy balance and fuel consumption,

b) in case that ΔEbatt always corresponds to a battery charging,

c) in case that ΔEbatt always corresponds to a battery recharging and ΔEbatt is within 1 per cent of the energy content of the consumed fuel (consumed fuel meaning the total fuel consumption over one cycle):

Energy content of the consumed fuel can be calculated from the following equation:

Total Fuel Energy = NHVfuel *mfuel

Where,

NHVfuel = Net heating value of consumable fuel in J/kg
mfuel = Total mass of fuel consumed over one test cycle

The change in battery energy content ΔEbatt can be calculated from the measured electricity balance Q as follows:

$$\Delta E_{batt} = \Delta SOC(\%) \cdot E_{TEbatt} \cong 0.0036 \cdot |\Delta Ah| \cdot V_{batt} = 0.0036 \cdot Q \cdot V_{batt} \quad (MJ)$$

with ETEbatt [MJ] the total energy storage capacity of the battery and Vbatt [V] the nominal battery voltage.

F-3 FUEL CONSUMPTION CORRECTION COEFFICIENT (KFUEL) DEFINED BY THE MANUFACTURER

F-3.1 The fuel consumption correction coefficient (Kfuel) shall be determined from a set of n measurements performed by the manufacturer. This set should contain at least one measurement with Qi < 0 and at least one with Qj > 0.

F-3.2 If the latter condition cannot be realised on the driving cycle (Part One or Part Two of modified Indian Driving Cycle in the case of M and N category or IDC in the case of L category as applicable) used in this test, then it is up to the testing agency to judge the statistical significance of the extrapolation necessary to determine the fuel consumption value at ΔEbatt = 0

The fuel consumption correction coefficient (Kfuel) is defined as

$$K_{fuel} = (n \cdot \Sigma Q_i C_i - \Sigma Q_i \cdot \Sigma C_i) / (n \cdot \Sigma Q_i^2 - (\Sigma Q_i)^2) \qquad (l/100\ km/Ah)$$

Where :

Ci: fuel consumption measured during i-th manufacturer's test (l/100 km)

Qi: 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 is to be judged by the testing agency.

F-3.3 In the case of M and N category, separate fuel consumption correction coefficients shall be determined for the fuel consumption values measured over the Part One cycle and the Part Two cycle respectively

F-4 FUEL CONSUMPTION AT ZERO BATTERY ENERGY BALANCE (C0)

F-4.1 The fuel consumption C0 at ΔEbatt = 0 is determined by the following equation

C0 = C - Kfuel * Q (l/100 km)

where:

C: fuel consumption measured during test (l/100 km)

Q : electricity balance measured during test (Ah)

F-4.2 In the case of M and N category, fuel consumption at zero battery energy balance shall be determined separately for the fuel consumption values measured over the Part One cycle and the Part Two cycle respectively

F-5 CO2-EMISSION CORRECTION COEFFICIENT (KCO2) DEFINED BY THE MANUFACTURER

F-5.1 The CO2-emission correction coefficient (KCO2) shall be determined as follows from a set of n measurements performed by the manufacturer. This set should contain at least one measurement with Qi < 0 and at least one with Qj > 0. If the latter condition cannot be realised on the driving cycle (Part One or Part Two in the case of M and N category or IDC as applicable) used in this test, then it is up to the testing agency to judge the statistical significance of the extrapolation necessary to determine the CO2- emission value at ΔEbatt = 0.

F-5.2 The CO2-emission correction coefficient (KCO2) is defined as:

$$K_{CO2} = (n \cdot \Sigma Q_i M_i - \Sigma Q_i \cdot \Sigma M_i) / (n \cdot \Sigma Q_i^2 - (\Sigma Q_i)^2) \qquad (g/km/Ah)$$

Where

Mi : CO2-emission measured during i-th manufacturer's test (g/km)

Qi: electricity balance during i-th manufacturer's test (Ah)

n : number of data

The CO2-emission correction coefficient shall be rounded to four significant figures (e.g. 0.xxxx or xx.xx). The statistical significance of the CO2-emission correction coefficient is to be judged by the testing agency.

F-5.3 In the case of M and N category, separate CO2-emission correction coefficients shall be determined for the CO2 emission values measured over the Part One cycle and the Part Two cycle respectively.

F-5.4 CO2-emission at zero battery energy balance (M0).

F-5.5 The CO2-emission M0 at □Ebatt = 0 is determined by the following equation:

M0 = M - KCO2 * Q (g/km)

Where:

C : CO2 emission measured during test (g/km)

Q : electricity balance measured during test (Ah)

F-5.6 In the case of M and N category, CO2 - emission at zero battery energy balance shall be determined separately for the CO2 - emission values measured over the Part One cycle and the Part Two cycle respectively

ANNEX G

(*See* 12.0)

THE ADDITIONAL INFORMATION NEEDED FOR HEV'S

1 GENERAL DESCRIPTION OF VEHICLE

1.1 Vehicle Model

1.2 Vehicle Type

1.3 Drawing and /or photographs of the vehicle

1.4 Type of hybrid vehicle (Externally chargeable/Not externally chargeable)

1.5 Mode selection switch provided: Yes/No

1.5.1 If yes the modes available

1.5.2 In the case of Externally Chargeable HEV's

1.5.2.1 The hybrid mode which can be proven to have the highest electricity consumption

1.5.2.2 The hybrid mode which can be proven to have the highest fuel consumption

1.5.3 In the case of Not Externally Chargeable HEV's, the mode which is automatically set after turn on of the ignition key (normal mode)

2 DESCRIPTION OF THE TRACTION BATTERY

2.1 Trade Name and Mark of the Battery

2.2 Kind of Electro – Chemical Couple

2.3 Nominal Voltage, V

2.4 Battery Maximum Thirty Minutes Power (Constant Power Discharge), kW

2.5 Battery Performance in 2 h Discharge (Constant Power or Constant Current)

2.5.1 Battery Energy , kWh

2.5.2 Battery Capacity , Ah in 2 h

2.6 End of Discharge Voltage Value, V

2.7 Provision of ventilation for battery Yes / No

2.7.1 Brief description of the ventilation system adopted in the vehicle. (Refer AIS-038(Rev.

1) **Clause 3.2.2**). Provide drawing if necessary.

2.7.2 Brief description of the ventilation system adopted in the battery compartment. (AIS-038(Rev. 1**) Clause 3.2.2**). Provide drawing if necessary

2.8 On-board Indication of battery state of charge (Applicable if there is a “pure electric mode”

2.8.1 Details of indication when state of charge of the battery reaches a level when the manufacturer recommends re-charging.

2.8.1.1 Indication format.

2.8.1.2 Relationship of state of charge indicator and the indication.

2.8.1.3 Make

2.8.1.4 Model

2.8.2 Indication of state of charge of battery reaches a level at which driving vehicle further may cause damage to batteries

2.8.2.1 Indication format.

2.8.2.2 Relationship of state of charge indicator and the indication.

2.9 Battery Mass, kg

2.10 Brief description of maintenance procedure, if any

3 DESCRIPTION OF THE DRIVE TRAIN

3.1 General

3.1.1 Make

3.1.2 Type

3.1.3 Use: Mono motor / multi motors (number)

3.1.4 Transmission Arrangement parallel / transaxial / others

3.1.5 Test Voltage, V

3.1.6 Motor Nominal Speed, Min -1

3.1.7 Motor Maximum Speed, Min –1 or by default reducer outlet shaft / gear box speed (specify gear engaged)

3.1.8 Maximum Power Speed, Min –1 and km/h

3.1.9 Maximum Power, kW

3.1.10 Maximum Thirty Minutes Power, kW

3.1.11 Maximum Thirty Minutes speed km/h

3.1.12 Range

3.1.13 Speed at the beginning of the range, Min –1

3.1.14 Speed at the end of the range, Min $^{-1}$

3.2 Traction Motor

3.2.1 Make

3.2.2 Working Principle

3.2.2.1 Direct current / alternating current / number of phases

3.2.2.2 Separate excitation / series / compound

3.2.2.3 Synchron / asynchron

3.2.2.4 Coiled rotor / with permanent magnets / with housing

3.2.2.5 Number of Poles of the Motor

3.2.3 Motor power curve (kW) with motor RPM (min-1) / vehicle speed in km/h

3.3 Power Controller

3.3.1 Make

3.3.2 Type

3.3.3 Control Principle: vectorial / open loop / closed / other (to be specified)

3.3.4 Maximum effective current supplied to the Motor, A

3.3.5 Voltage range use, V to V

3.4 Cooling System
Motor : liquid / air
controller : liquid / air

3.4.1 Liquid cooling equipment characteristics

3.4.1.1 Nature of the liquid,
circulating pumps, yes / no

3.4.1.2 Characteristics or make(s) and type(s) of the pump

3.4.1.3 Thermostat: setting

3.4.1.4 Radiator: drawing(s) or make(s) and type(s)

3.4.1.5 Relief valve: pressure setting

3.4.1.6 Fan: Characteristics or make(s) and type(s)

3.4.1.7 Fan: duct

3.4.2 Air-cooling equipment characteristics

3.4.2.1 Blower : Characteristics or make(s) and type(s)

3.4.2.2 Standard air ducting

3.4.2.3 Temperature regulating system yes / no

3.4.2.4 Brief description

3.4.2.5 Air filter : make(s)
type(s)

3.4.3 Maximum temperatures recommended by the manufacturer:

3.4.3.1 Motor Outlet: °C

3.4.3.2 Controller inlet : °C

3.4.3.3 At motor reference point(s) °C

3.4.3.4 At controller reference point(s) °C

3.5 Insulating Category :

3.5.1 International Protection (IP)-Code :

3.6 Lubrication System Principle Bearings : friction / ball

Lubricant: grease / oil
Seal : yes / no
Circulation: with / without

4.0 Charger (Applicable only for Externally Chargeable HEV's)

4.1 Charger: on board / external

4.1.1 Trademark, model, rating

4.2 Description of the normal profile of charging system :

4.3 Specifications of mains

4.3.1 Mains: single phase/ three phase :

4.3.2 Nominal Voltage (V) & frequency (Hz) with tolerances:

4.4 Reset period recommended between the end of the discharge and the start of the charge

4.5 Recommended duration of a complete charge

4.6 In case of on-board charger

4.6.1 Continuous rating of charger socket (A):

4.6.2 Time rating (h) of charger socket, if any:

4.6.3 Whether soft-start facility Yes / No:

4.6.4 Maximum initial in-rush current (A)

5.0 ELECTRICAL DETAILS OF VEHICLE FOR FUNCTIONAL SAFETY

5.1 Schematic diagram showing the electrical layout giving all major electrical items along with their physical location in the vehicle. It shall include batteries, power-train components, protection fuses, circuit breakers etc. (Reference in AIS-038(Rev. 1) Clause 3.2.1)

5.2 Specifications of circuit breakers/ fuses used for protection of batteries / power-train (Reference in AIS-038(Rev. 1) Clause 3.2.1)

5.2.1 IS / IEC specifications

5.2.2 Rating (A)

5.2.3 Opening time (ms)

5.3 Working voltage V (Reference in AIS-038 (Rev. 1) Clause 3.2.1)

5.4 Schematic highlighting physical location of live parts having working voltage greater than 60 V DC or 25 V AC (Reference in AIS-038(Rev. 1) Clause 3.2.1)

5.5 Electric cables / connectors / wiring harness (Reference in AIS-038(Rev. 1) Clause 3.1.1.3)

5.5.1 IEC protection class

5.5.2 Insulation material used

5.5.3 Conduits provided Yes / No

5.6 List of exposed conductive parts of on-board equipment. (Reference in AIS-038: (Rev. 1) Clause 3.1.1)

5.6.1 Any potential equalization resistance used to electrically connect these parts Yes/ No

5.6.2 If yes, give details

5.7 List of failures due to which the vehicle will come to standstill

5.8 List of conditions under which the performance of vehicle is limited and how.

5.9 Declaration regarding Design guidelines followed with respect to various requirements

6.0 Electrical energy consumption of Vehicle in W-h/km, as per clause 5.5.1 of AIS-039(Rev. 1)

7.0 Special gear shifting pattern if any

ANNEX H

(See Foreword)

COMMITTEE COMPOSITION -TED 27

(To be added later)