**AIS-123 (Part 2)**

AUTOMOTIVE INDUSTRY STANDARD

# CMVR Type Approval of Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category having GVW > 3500 kg

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AUTOMOTIVE INDUSTRY STANDARDS COMMITTEE

UNDER
CENTRAL MOTOR VEHICLE RULES – TECHNICAL STANDING COMMITTEE

SET-UP BY
MINISTRY OF ROAD TRANSPORT & HIGHWAYS
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GOVERNMENT OF INDIA

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

| Sr. No. | Corrigenda | Amendment | Revision | Date | Remark | Misc. |
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**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 of preparation of 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). After approval, The Automotive Research Association of India, (ARAI), Pune, being the secretariat of the AIS Committee, has published this standard. For better dissemination of this information, ARAI may publish this standard on their website.

This standard prescribes the CMVR Type Approval requirements for hybrid electric system intended for retro-fitment on vehicles of M and N category having GVW > 3500 kg.

Considerable assistance has been taken from the following UN regulations:

| | | |
|---|---|---|
| 1. | UN R 100 : | Uniform provisions concerning the approval of REESS electric vehicles with regard to specific requirements for the construction and functional safety. |
| 2. | UN 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 AISC panel and the Automotive Industry Standards Committee (AISC) responsible for preparation of this standard are given in Annexure I and Annexure J respectively.

**CMVR Type Approval of Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category having GVW > 3500 kg**

# CMVR Type Approval of Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category having GVW > 3500 kg

## 1.0 SCOPE

This standard lays down the requirements specific to Hybrid Electric System (HES) intended for retro-fitment on vehicles of M and N Category having GVW > 3500 kg, which

i) comply to BS-II or subsequent emission norms;
ii) have not been retrofitted earlier (e.g. CNG / LPG / Electric kits etc.);
iii) are not provided with permits for carrying dangerous or hazardous goods, as defined in CMVR;

## 2.0 REFERENCES

| | | |
|---|---|---|
| 2.1 | AIS-049( Rev1) | Electric power train vehicles - CMVR type approval for REESS operated vehicles |
| 2.2 | IS:11825-1986 | Method of weighment of automotive vehicles |
| 2.3 | AIS-071 (Part1 and Part 2):2009 | Automotive Vehicles - Identification of Controls Tell-Tales and Indicators |
| 2.4 | AIS-003-1999 | Automotive vehicles - Starting gradeability method of measurement and requirements |
| 2.5 | AIS-041(Rev 1):2015 | Electric power train vehicles-Measurement of net power and the maximum 30 minute power and speed |
| 2.6 | IS:11852: 2001 | Automotive vehicles - Brakes and braking systems |
| 2.7 | AIS-038(Rev 1):2015 | Electric power train vehicles – Requirements for construction and functional safety |
| 2.8 | AIS-039(Rev1):2015 | Electric power train vehicles – Measurement of electrical energy consumption |
| 2.9 | IS:3028-1998 | Automotive vehicles – Noise emitted by moving vehicles- Method of measurement |
| 2.10 | IS:3141-2007 | Starter Motors for Internal Combustion Engines Used for Automotive and other Applications – Specification |
| 2.11 | IS 9000 (Part 7) (Sec 1) | IEC 60068-2-27 : 1987 Basic Environmental Testing Procedures for Electronic and Electrical Items Part 7 Impact Test Section 1 Shock (Test Ea) |
| 2.12 | IS:8925-1978 | Specification for Alternators for Automobiles |

| | | |
|---|---|---|
| 2.13 | AIS-004 (Part 3):2009 | Automotive vehicles – Requirements for electromagnetic compatibility |
| 2.14 | AIS-008 (Rev. 1) | Installation Requirements of Lighting and Light-Signaling Devices for Motor Vehicle having more than Three Wheels, Trailer and Semi-Trailer excluding Agricultural Tractor and Special Purpose Vehicle |
| 2.15 | AIS-102 (Part 1) and Part 2 | CMVR Type Approval for Hybrid Electric Vehicles |
| 2.16 | AIS-048:2009 | Battery Operated Vehicles - Safety Requirements of Traction Batteries |
| 2.17 | ISO:6722-2006 | Road vehicles – 60v and 600v single core cables – Dimensions, test method and requirements. |
| 2.18 | JASO D 616:2011 | Automotive parts – Test method and general performance requirements for wiring harness connectors. |
| 2.19 | TAP 115/116 | Emission testing procedures |
| 2.20 | IS 2-1960 | Rules for rounding off numerical values |
| 2.21 | IS 14785 – 2000 | Automotive Vehicles - Determination of Road-load Constants by Coast Down Test Method |

## 3.0 DEFINITION

For the purpose of this Standard the following definitions shall apply:

3.1 **Hybrid Electric System (HES)** means aggregate of components added by manufacturer/ supplier to the base vehicle for hybrid electric operation without modification/change of fuel type of base vehicle power train and base vehicle configuration.

**Note:** Permissible modifications/alterations in base vehicle for Hybrid Electric System (HES) retro-fitment shall be such that, normal operation of base vehicle is possible even with Hybrid Electric System (HES) only in OFF/disabled/inactive condition.

3.2 **Off Vehicle Charging (OVC) range** means the total distance covered during complete combined cycles run until the energy imparted by external charging of the Rechargeable Energy Storage System (REESS) or other electric REESS device is depleted, as measured according to the procedure described in Appendix-2 of Annexure A.

3.3 **Drive System** is a means of connecting the Electric Powertrain i.e. Motor to the engine or wheels.

3.4 **Electric Motor** means an electromechanical device that converts electrical energy into mechanical energy.

3.5 **Motor Controller** means for starting and stopping the motor, selecting forward or reverse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and faults.

3.6 **REESS** means a single mechanical assembly comprising of REESS modules and retaining frames or trays. A vehicle may have one or several REESS

3.7 **Charger** it is a means for charging REESS from external power supply.

3.8 **Charging Socket** means all the parts used to connect the vehicle to an external electric power supply (alternative or direct current supply).

3.9 **Wiring Harness - Power and Control –** Wiring harness is an assembly of cable or wires which transmit electric signals or electrical power.

3.10 **SOC Indicator** means REESS state of Charge Indicator.

3.11 **Hybrid ECU** means Electronic Control Unit to manage the Hybrid Electric system's operation.

3.12 **BMS** means REESS Management System is an electronic Control Unit to manage the REESS operation and ensure safety.

3.13 Where necessary, the definitions given in Annexure E of AIS-049 (Rev. 1) shall apply.

## 4.0 VEHICLE WEIGHMENT

4.1 Vehicle weighment with retrofitted Hybrid Electric System (HES) shall be done as per IS 11825-1986. Permissible increase in vehicle unladen weight (ULW) due to Hybrid Electric System (HES) shall be as follows:

| Vehicle Category | Permissible increase in ULW (%) | Remarks |
|---|---|---|
| M2 (GVW > 3500 kg) | 17 | -- |
| M3 | 17 | -- |
| N2/N3 | Equal to weight of Hybrid Electric System (HES) | Increase in FAW shall not be more than 10% and all axle loads shall be within laden limits prescribed in APPENDIX XII of CMV Rules 1989. |

## 5.0 COAST DOWN TEST

5.1 Coast down test shall be done as per IS 14785 – 2000 to find out vehicle road load coefficients for fuel consumption test.

## 6.0 VISUAL INDICATION

6.1 Hybrid Electric System (HES) manufacturer/supplier shall provide minimum following indications:

- Rechargeable Energy Storage System State of Charge (REESS SOC)
- Motor temperature
- Hybrid Electric System (HES) fault

These indications shall be as per the guidelines of AIS-071 (Part 1 and Part 2).

## 7.0 GRADEABILITY TEST

7.1 The vehicle retro-fitted with Hybrid Electric System (HES) shall meet requirement of gradeability when tested as per AIS-003-1999.

## 8.0 FUEL CONSUMPTION TEST

8.1 Fuel consumption test shall be performed on vehicle retrofitted with Hybrid Electric System (HES) as per Annexure A, on road load simulation chassis dynamometer using applicable driving cycle specified below. The fuel consumption measurement shall be performed using meter having accuracy of ±1% of the reading or better, in two modes, as follows:

a) Hybrid Electric System (HES) in Off mode or disabled or inactive (As per A-6.0 of Annexure A) (baseline test).

b) Hybrid Electric System (HES) in On mode or enabled or active (As per A-1.0 of Annexure A).

Reference mass for chassis dynamometer setting shall be as per AIS-049 (Rev. 1) and Driving cycle shall be as per clause 5.1 of AIS-039 (Rev. 1):2015.

Results of fuel consumption test (in L/100 km) for above two modes shall be reported.

Fuel consumption of vehicle retro-fitted with Hybrid Electric System (HES) (mode b) shall be lower than that of base vehicle with Hybrid Electric System (HES) in off mode or disabled or inactive (mode a).

## 9.0 BRAKE PERFORMANCE

9.1 The vehicle retrofitted with Hybrid Electric System (HES) shall meet the requirements of brake performance test as per IS 11852-2001 (Part 1 to Part 9) and Annexure B of this standard.

## 10.0 TRACTION MOTOR TEST

Following tests shall be carried out on traction motor.

10.1 Motor Power Test**:** Test shall be carried out as per AIS-041(Rev. 1):2015

10.2 Environmental validation tests for traction motor:

Manufacturer/supplier of Hybrid Electric System (HES) should provide the test reports of the following tests conducted on traction motor

| | | |
|---|---|---|
| a) | Thermal Shock test | Test shall be carried out as per IS:3141:2007 |
| b) | Media resistance test | Test shall be carried out as per IS:3141:2007 |
| c) | Impact test | Test shall be carried out as per IS:9000 Part 7/Sec1:2006 |
| d) | Dust Test | Test shall be carried out as per IS: 3141:2007 |
| e) | Water immerse test | Test shall be carried out as per IS: 8925:1978. |

## 11.0 EMC TEST

11.1 Hybrid Electric System (HES) kit electronic components shall meet the requirement of EMC test as per AIS-004 (Part 3):2009.

At the request of Hybrid Electric System (HES) kit manufacturer/supplier EMC test may be performed on vehicle retrofitted with Hybrid Electric System (HES), instead of performing EMC test on individual Hybrid Electric System (HES) kit components.

REESS charger shall be excluded from the test as it is utilized when vehicle is in off condition.

## 12.0 VERTICAL ORIENTATION OF DIPPED BEAM – HEAD LAMP

12.1 Hybrid Electric System (HES) manufacturer / supplier shall carry out head lamp leveling adjustment on retrofitted vehicle to comply with the requirement of AIS-008 (Rev.1): 2010.

## 13.0 REQUIREMENTS FOR CONSTRUCTIONAL AND FUNCTIONAL SAFETY

13.1 The vehicle retrofitted with Hybrid Electric System (HES) shall meet the requirements for constructional and functional safety as per para. 4.2 of AIS-102 (Part 2).

## 14.0 REQUIREMENTS FOR RECHARGEABLE ENERGY STORAGE SYSTEM (REESS)

14.1 REESS of the Hybrid Electric System (HES) shall meet the requirements of AIS-048:2009.

## 15.0 WIRING HARNESS / CABLES / CONNECTORS

15.1 Manufacturer/supplier of Hybrid Electric System (HES) should comply with the following standards and guidelines for control, power harness and all connectors used in harness.

OR

Manufacturer/supplier of Hybrid Electric System (HES) should provide the test reports of the following tests conducted on control, power harness and all connectors used in harness as given in 15.2 and 15.3.

15.2 The cables used in the harness shall comply with following tests as mentioned in ISO 6722-2006.

| | | |
|---|---|---|
| a) | Electrical characteristics-Withstand Voltage | Test shall be carried out as per para. 6.2 of ISO 6722-2006 |
| b) | Low temperature characteristics | Test shall be carried out as per para. 8 of ISO 6722-2006 |
| c) | Heat ageing – Thermal Overload | Test shall be carried out as per para. 10.3 of ISO 6722-2006 |
| d) | Resistance to chemicals fluid compatibility | Test shall be carried out as per para. 11.2.2 and 11.2.3 of ISO 6722-2006 |
| e) | Resistance to flame propagation | Test shall be carried out as per para. 12 of ISO 6722-2006. |

15.3 **General guidelines for performance and reliability of single pole and multi pole connectors for wiring harness.**

It is desirable to use counter mating connector to pig tail any existing connector. The mating connector shall meet the following requirements. JASO D 616:2011 or equivalent standard can be referred.

a) Water ingress protection when water is splashed during driving or the vehicle is washed
b) Sufficient tensile strength of crimped connections.
c) Connector housing lock strength and terminal retention
d) Connection resistance shall be < 10 mOhms
e) Leakage current shall not exceed 1 mA for non-water proof connector and 50 µA for water proof connector.
f) Insulation resistance shall be > 100 mOhms.

## 16.0 ADDITIONAL REQUIRMENTS

16.1 The vehicle retrofitted with Hybrid Electric System (HES) shall continue to comply with the requirements for external projection as per IS 13942:1994.

16.2 Bus (M3 category) complying with requirements of Bus Body Code as per AIS-052(Rev.1) shall continue, to comply with the said requirements after Hybrid Electric System (HES) kit retro-fitment.

16.3 Vehicle equipped with Speed Limiting Device (SLD) or Speed Limiting Function (SLF), if retrofitted with Hybrid Electric System (HES), shall continue to comply with the requirements of clause 5.7 of AIS-018: 2001 as amended from time to time.

16.4 If the increase in weight on steered axle of the vehicle retrofitted with Hybrid Electric System (HES) is greater than 10%, the vehicle shall be retested for checking compliance with the requirements of steering effort as per IS 11948: 2010

16.5 The vehicle intended for retro-fitment of Hybrid Electric System (HES) shall have valid certificate of fitness as per CMV Rule 62.

16.6 The vehicles with modifications in configuration/components/sub systems due to Hybrid Electric System (HES) retro-fitment shall continue to comply with CMVR requirements applicable to base vehicle and its components and sub system. Additional test(s) to be carried out to establish this compliance shall be decided by the test agency.

## 17.0 TECHNICAL SPECIFICATION

17.1 Technical specification for Hybrid Electric System (HES) and vehicles retrofitted with Hybrid Electric System (HES) shall be provided as per Annexure E and F respectively.

## 18.0 CODE OF PRACTICE

18.1 Hybrid Electric System (HES) manufacture and supplier and authorized retrofitter shall comply with Code of Practice as per Annexure G. Documentary evidence shall be provided at the time of Type Approval along with technical specification.

## 19.0 CHANGE IN THE TECHNICAL SPECIFICATIONS ALREADY TYPE APPROVED

19.1 Every modification pertaining to the information declared in accordance with para. 17 shall be intimated by the Hybrid Electric System (HES) manufacturer/supplier to the testing agency.

19.2 If the changes are in parameters not related to the provisions of this standard, no further action need be taken.

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

a) the model with the changed specifications still complies with provisions of this standard; or,
b) any further verification / testing is required to establish compliance.

For considering whether any further verification / testing is required or not, guidelines given in Annexure H shall be used. For other cases, the guide lines given in the individual standard shall be applicable.

19.3 In case of para. 19.2(b), verification for only those parameters which are affected by the modifications needs to be carried out.

19.4 In case of fulfillment of criterion of para. 19.2 (a) or after results of further verification as per para. of 19.2(b) are successful, the approval of compliance shall be extended for the changes carried out.

## 20.0 TYPE APPROVAL CERTIFICATE AND ITS VALIDITY

20.1 Testing agency shall issue Type Approval to the Hybrid Electric System (HES) based on the tests carried out on the vehicle retrofitted with Hybrid Electric System (HES) submitted for Type Approval.

Based on the request by the Hybrid Electric System (HES) manufacturer/supplier to the testing agency, Type Approval can be extended to the Hybrid Electric System (HES) for retro-fitment on vehicle irrespective of its make and model provided,

a) GVW of vehicle is within a range of 15% of the retrofitted vehicle tested for Type Approval as per this standard.
b) Hybrid Electric System (HES) kit components have same specifications as that of Type approved configuration.

For the extension of Type Approval of Hybrid Electric System (HES) for retro-fitment on other vehicle models, test agency shall carry out following tests on each model.

| | |
|---|---|
| i | Requirements for construction and functional safety as per clause 13.0 |
| ii | Vehicle Weighment as per clause 4.0 |
| iii | Fuel Consumption Test as per clause 8.0 |
| iv | Brake test, if applicable, based on the guidelines of criteria for extension of approval as per IS 11852-2001 (Part 1 to Part 9) (clause 9.0) |
| v | Steering effort test, if applicable, based on the guidelines of criteria for extension of approval as per IS 11948: 2010 |

Type Approval (TA) of Hybrid Electric System (HES) shall be extended for retro-fitment on vehicle models complying with the requirements specified in (i) to (v) above.

20.2 Validity of TA certificate of Hybrid Electric System (HES) shall be 3 years from the date of its original issue and needs to be revalidated thereafter. During revalidation of Hybrid Electric System (HES) type approved , vehicle installed with Hybrid Electric System (HES) shall be subjected to fuel consumption test as per clause no 8.0 and any other test applicable because of amendment/ revision of standard(s) referred in this standard.

Additionally test agency shall physically verify layout of Hybrid Electric System (HES) on the vehicle submitted for re-validation with the layout submitted during initial type approval.

20.3 Type approval of Hybrid Electric System (HES) as per this standard shall permit retro-fitment of vehicles which are manufactured after the year of manufacture of the prototype retrofitted vehicle on which such kit has been tested and type approved.

## ANNEXURE A
(See 8.1)

## TEST PROCEDURE FOR MEASUREMENT OF FUEL CONSUMPTION OF VEHICLES OF M AND N CATEGORY HAVING GVW > 3500 kg RETROFITTED WITH HYBRID ELECTRIC SYSTEM(HES)

**A-1.0 Fuel consumption test with Hybrid Electric System (HES) in ON mode or enabled or active**

**Categories of Vehicles Retrofitted with Hybrid Electric System (HES) are mentioned 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"<br>[2/] also known as "not externally chargeable" | | | | |

**A-2.0 Vehicles Retrofitted with Hybrid Electric System (HES) (Externally Chargeable) 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 (REESS).

(b) **Condition B**: test shall be carried out with an electrical energy/power storage device (REESS) 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 (REESS) during different stages of the test is given in Appendix 1 of this Annexure**.**

A-2.1. **Condition A**

A-2.1.1. Discharge of REESS

The procedure shall start with the discharge of the electrical energy/power storage device as described in para. 2.1.1.1 below.

A-2.1.1.1 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.)

a) At a steady speed of 50 km/h until the fuel consuming engine 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 just does not start up for a defined time/distance (to be specified between testing agency and Hybrid Electric System (HES) manufacturer/supplier).

c) Or with Hybrid Electric System (HES) manufacturer/supplier's recommendation.

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

A-2.1.2 **Charging of REESS**

The electrical energy/power storage device shall be charged using normal overnight charge procedure(see para. C-4.1.2.1).

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

(b) With an external charger recommended by the Hybrid Electric System (HES) manufacturing/supplier, using the charging pattern prescribed for normal charging.

(c) 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 Hybrid Electric System (HES) manufacturer/supplier shall declare that during the test, a special charge procedure has not occurred.

(d) For details of end of charge, see para C-4.1.3.

A-2.1.3 **Conditioning of vehicle**

Conditioning of vehicle shall be done with Hybrid Electric System (HES) kit OFF condition.

A-2.1.3.1 Vehicle with compression ignition engine

For conditioning compression-ignition engined vehicles, 24 cycles of Delhi Driving Cycle or 3 cycles of Part 2 of MIDC as applicable shall be used in combination with the applicable gear shift.

A-2.1.3.2 Vehicle with positive ignition engine

Vehicles fitted with positive-ignition engines shall be preconditioned with 21 cycles of Delhi Driving Cycle or one part one and two part two of MIDC as applicable, in combination with the applicable gear shifting.

A-2.1.4 **Fuel consumption test**

A-2.1.4.1 In case of special gear shifting strategy according to the Hybrid Electric System (HES) manufacturer/supplier'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.

A-2.1.4.2 The vehicle shall be started up by the means provided for normal use to the driver. The first cycle starts on the initiation of the vehicle start-up procedure.

A-2.1.4.3 The test procedures defined in either para. A-2.1.4.3.1 or A-2.1.4.3.2 may be used.

A-2.1.4.3.1 The vehicle shall be driven using applicable driving cycle (Three cycles of Part 1 of MIDC or 15 Cycles of Delhi Driving Cycle).
Fuel consumption meter measurement shall begin before or at the initiation of the vehicle start up procedure and end on conclusion of the final idling period of the respective driving cycle.

A-2.1.4.3.2 The vehicle shall be driven using applicable driving cycle ( Part 1 of MIDC or Delhi Driving Cycle).

Fuel consumption meter measurement shall begin before or at the initiation of the vehicle start up procedure and continue over a number of repeat test cycles of MIDC or Delhi Driving Cycle as applicable. It shall end on conclusion of the final idling period during which the REESS reached the minimum state of charge according to the criterion defined below.

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

The REESS minimum state of charge is considered to have been reached in cycle N if the electricity balance measured during cycle N+1 is not more than 3 per cent discharge, expressed as a percentage of the nominal capacity of the REESS (in Ah) in its maximum state of charge, as declared by the Hybrid Electric System (HES) manufacturer/supplier.

At the Hybrid Electric System (HES) manufacturer/supplier request additional test cycles may be run and their results included in the calculations in para below, provided that the electricity balance for each additional test cycle shows less discharge of the REESS than over the previous cycle.

A-2.1.4.3.3 The test result for Condition A shall be recorded ($c_1$ [l]).

In the case of testing according to para. A-2.1.4.3.1., $c_1$ is simply the results of single cycle run. In the case of testing according to para. A-2.1.4.3.2., $c_1$ is the sums of the results of the N cycles run.

$$c_1 = \sum_{1}^{N} c\ i$$

A-2.1.4.3.4 Within 30 minutes after the conclusion of the last cycle, the electrical energy/power storage device shall be charged according to para. C-4.1.2 and C-4.1.3.

The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy $e_1$ [Wh] delivered from the mains.

The electric energy consumption for condition A is $e_1$ [Wh].

A-2.2 **Condition B**

A-2.2.1 Discharge of REESS shall be carried out as per para. A-2.1.1

A-2.2.2 Conditioning of vehicle shall be carried out at the Hybrid Electric System (HES) kit manufacturer/supplier's request as per para. A-2.1.3

**Test Procedure**

A-2.2.3 The vehicle shall be started up by the means provided for normal use to the driver. The first cycle starts on the initiation of the vehicle start-up procedure.

A-2.2.4 The vehicle shall be driven using applicable driving cycle (3 cycles of Part 1 of MIDC or 15 Cycles of Delhi Driving Cycle).

Fuel consumption meter measurement shall begin before or at the initiation of the vehicle start up procedure and end on conclusion of the final idling period of the respective driving cycle.

A-2.2.5 The test result for Condition B shall be recorded ($c_2$ [l]).

A-2.2.6 Within 30 minutes after the conclusion of the cycle, the electrical energy/power storage device shall be charged according to para. C-4.1.2 and C-4.1.3.

The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy $e_2$ [Wh] delivered from the mains.

A-2.2.7 The electrical energy/power storage device of the vehicle shall be discharged in accordance with para. A-2.1.1**.**

A-2.2.8 Within 30 minutes after discharge, the electrical energy/power storage device shall be charged according to para. C-4.1.2 and C-4.1.3.

The energy measurement equipment, placed between the mains socket and the vehicle charger, measures the charge energy $e_3$ [Wh] delivered from the mains.

A-2.2.9 The electric energy consumption $e_4$ [Wh] for condition B is:

$$e_4 = e_2 - e_3$$

A-2.3 **Test results**

The values of fuel consumption shall be

$C_1 = 100 \times c_1 / D_{test1}$ (l/100 km) and

$C_2 = 100 \times c_2 / D_{test2}$ (l/100 km)

where $D_{test1}$ and $D_{test2}$ are the total actual driven distances in the test performed under conditions A and B respectively.

The weighted value of fuel consumption shall be calculated as below.

A-2.3.1 In the case of testing according to para. A-2.1.4.3.1. The final result of fuel consumption shall be

$$C = ( D_e \times C_1 + D_{av} \times C_2 ) / ( D_e + D_{av} )$$

Where

$C$ = fuel consumption in l/100km

$C_1$ = fuel consumption of the vehicle in l/100km with a fully charged electrical energy/power storage device,

$C_2$ = average fuel consumption of the vehicle in l/100km with an electrical energy/power storage device in minimum state of charge (maximum discharge of capacity)

$D_e$ = Vehicle electric range, according to the procedure described in Annexure C., where Hybrid Electric System (HES) manufacturer/ supplier must provide the means for performing the measurement with the vehicle running in pure electric operating state.

$D_{av}$ = 25 km (average distance between two REESS recharges)

A-2.3.2 In the case of testing according to para. A-2.1.4.3.2. The final result of fuel consumption shall be

$$C = (D_{ovc} \cdot C_1 + D_{av} \cdot C_2)/(D_{ovc} + D_{av})$$

Where:

$C$ = fuel consumption in l/100km

$C_1$ = fuel consumption of the vehicle in l/100km with a fully charged electrical energy/power storage device

$C_2$ = fuel consumption of the vehicle in l/100km 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 Annexure C.

$D_{av}$ = 25 km (average distance between two REESS recharges).

A-2.3.3 **Electric Energy Consumption**

The values of electrical energy consumption shall be

A-2.3.4 $E_1 = e_1/D_{test1}$ [Wh/km] for condition A, and
$E_4 = e_4/D_{test2}$ [Wh/km] for condition B

A-2.3.4.1 where $D_{test1}$ and $D_{test2}$ are the actual driven distances in the tests performed under conditions A and B respectively.

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

A-2.3.4.2.1 In the case of testing according to para. A-2.1.4.3.1

$$E = ((D_e \times E_1) + (D_{av} \times E_4)) / (D_e + D_{av})$$

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).

$D_e$ = Vehicle electric range, according to the procedure described in Annexure C., where Hybrid Electric System (HES) manufacturer/ supplier must provide the means for performing the measurement with the vehicle running in pure electric operating state.

$D_{av}$ = 25 km (assumed average distance between two REESS recharges)

A-2.3.4.2.2 In the case of testing according to para. A-2.1.4.3.2.

$$E = (D_{ovc} \cdot E_1 + D_{av} \cdot E_4) / (D_{ovc} + D_{av})$$

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 Annexure C.

$D_{av}$ = 25 km (assumed average distance between two REESS recharges).

**A-3.0 Vehicles Retrofitted with Hybrid Electric System (HES) (Externally Chargeable) with an Operating Mode Switch.**

Two tests shall be performed under the following conditions

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

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

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

| Hybrid-modes / REESS State of charge | - Pure electric<br>- Hybrid Switch in position | - Pure fuel consuming<br>- Hybrid Switch in position | - Pure electric<br>- Pure fuel consuming<br>- Hybrid Switch in position | - Hybrid mode n [1/]<br>- Hybrid mode m [1/]<br>Switch in position |
|---|---|---|---|---|
| Condition A Fully charged | Hybrid | Hybrid | Hybrid | Most electric hybrid mode [2/] |
| Condition B Min. state of charge | Hybrid | Fuel consuming | 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 Annexure B, to be established based on information/test reports provided by the Hybrid Electric System (HES) manufacturer/supplier 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 Annexure B, to be established based on information/test reports provided by the Hybrid Electric System (HES) manufacturer/supplier and in agreement with the testing agency. |

3.2 **Discharge of REESS:**

The procedure shall start with discharge of electrical energy/power storage device (REESS) of the vehicle as described below.

A-3.2.1 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 speed of the vehicle in pure electric mode.

A-3.2.2 Stopping the discharge occurs when any of the following conditions happens, earliest :

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

A-3.2.3 In case of Hybrid Electric System (HES) retro-fitted vehicle, is not equipped with "pure electric" mode, the discharge procedure shall be as per para. A-2.1.1.

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

A-3.3.1 However, if the pure electric range of the vehicle measured in accordance with Annexure-C is higher than 3 cycles of Part 1 of MIDC or 15 Cycles of Delhi Driving Cycle, on the request of the Hybrid Electric System (HES) manufacturer/supplier, the Fuel consumption test for Condition A may not be carried out.

In such cases, the value of $C_1$ shall be taken as zero for calculation of final results (Refer para. A-2.3.1 and A-2.3.2).

A-3.3.2 Final test results shall be obtained using procedure given in para. A-2.3.

**A-4.0 Vehicles Retrofitted With Hybrid Electric System (HES) (Not Externally Chargeable) without an Operating Mode Switch**

A-4.1 Preconditioning shall be carried out as per para. A-2.1.3

A-4.2 For fuel consumption measurement, vehicle shall be run for 3 cycles of Part 1 of MIDC or 15 Cycles of Delhi Driving Cycle as applicable, in combination with the applicable gear shifting, taking into account requirements given in para. A-2.1.4.1 in case of special gear shifting strategy.

A-4.3 Special requirements for measurement and correction of the test results for fuel consumption are given in Annexure D.

**A-5.0 Vehicles Retrofitted with Hybrid Electric System (HES) (Not Externally Chargeable) with an Operating Mode Switch**

A-5.1 These vehicles shall be tested in hybrid mode. If several hybrid modes are available, the test shall be carried out in the most fuel consuming mode.

A-5.2 Preconditioning of vehicle shall be as per para. A-2.1.3

A-5.3 For fuel consumption measurement, vehicle shall be run for 3 cycles of Part 1 of MIDC or 15 Cycles of Delhi Driving Cycle as applicable, in combination with the applicable gear shifting, taking into account requirements given in para. A-2.1.4.1 in case of special gear shifting strategy.

A-5.4 Special requirements for measurement and correction of the test results for fuel consumption are given in Annexure D.

**A-6.0 Fuel consumption test with Hybrid Electric System (HES) in OFF mode or disabled or inactive**

A-6.1 Preconditioning of vehicle shall be as per para. A-2.1.3.

A-6.2 **Fuel consumption test**

A-6.2.1 For fuel consumption measurement, vehicle shall be run for 3 cycles of Part 1 of MIDC or 15 Cycles of Delhi Driving Cycle as applicable, in combination with the applicable gear shifting, taking into account requirements given in para. A-2.1.4.1 in case of special gear shifting strategy.

A-6.2.2 The vehicle shall be started up by the means provided for normal use to the driver. The first cycle starts on the initiation of the vehicle start-up procedure.

A-6.2.3 Fuel consumption meter measurement shall begin 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.

A-6.2.4 The measured fuel consumption multiplied by 100 and divided by actual driving distance in the test , is the result expressed in l/100 km for vehicle with Hybrid Electric System (HES) kit in OFF mode or disabled or inactive

## ANNEXURE A

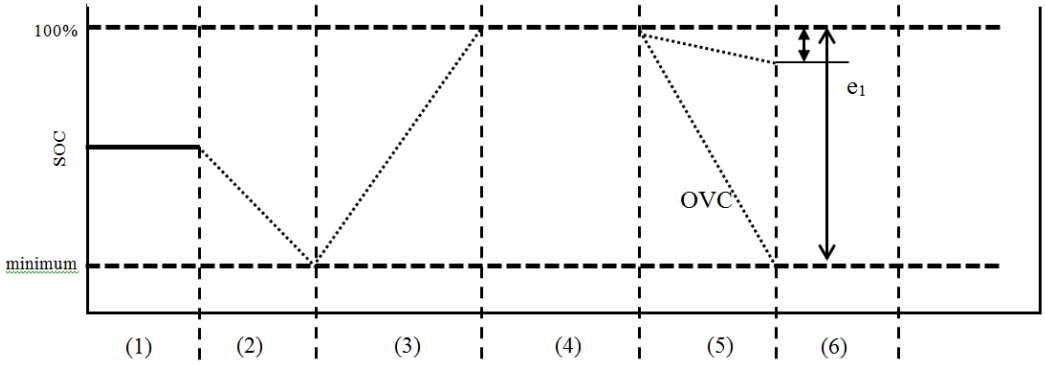
## APPENDIX 1

(See A-2.0(c))

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

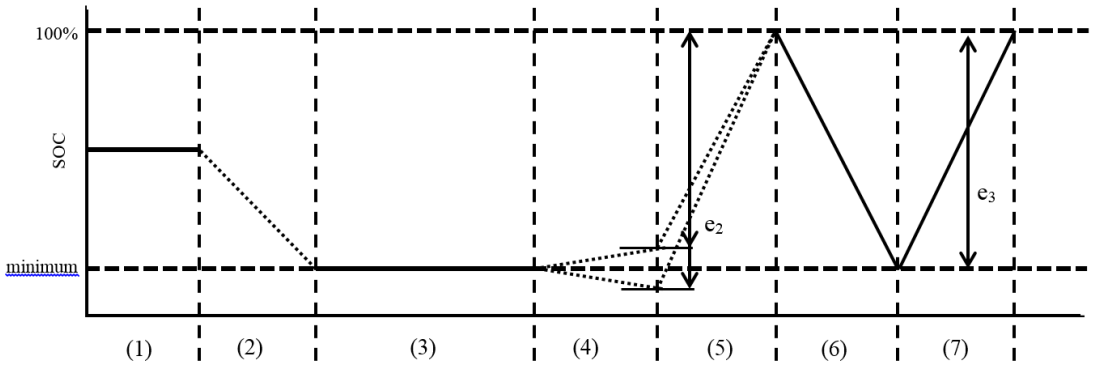
The SOC profiles for OVC-HEV's tested under Conditions A and B are

**Condition A**




| | |
|---|---|
| (1) | Initial state of charge of the electrical energy/power storage device |
| (2) | Discharge according to para. A-2.1.1 or A-3.2 of Annexure-A |
| (3) | Charging according to para A-2.1.2 of Annexure-A |
| (4) | Vehicle conditioning according to para. A-2.1.3 of Annexure-A |
| (5) | Test according to para. A-2.1.4 of Annexure-A |
| (6) | charging (A-2.1.4.3.4) |

**Condition B:**




| | |
|---|---|
| (1) | Initial state of charge |
| (2) | Discharge according to para. A-2.2.1 of Annexure-A |
| (3) | Vehicle conditioning according to para. A-2.2.2 of Annexure-A |
| (4) | Test according to para. A-2.2.3 of Annexure-A |
| (5) | Charging according to para. A-2.2.4.1 |
| (6) | Discharging according to para. A-2.2.4.2. |
| (7) | Charging according to para. A-2.2.4.3. |

## ANNEXURE A

## APPENDIX-2

(See A- 2.1.4.3.2)

## METHOD FOR MEASURING THE ELECTRICITY BALANCE OF THE REESS OF OVC AND NOVC HEVS

### 1.0 Introduction

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 Not Off 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 REESS has been reached during the test procedure defined in para. A-2.0. and A-3.0. of Annexure A; and

(b) To correct the measured fuel consumption for the change in REESS energy content occurring during the test, using the method defined in para. A-5.0 of Annexure A.

1.2 The method described in this Annexure shall be used by the Hybrid Electric System (HES) manufacturer/supplier for the measurements that are performed to determine the correction factors K fuel, as defined in para. A-4.3 , and A-5.4 of this Annexure A.

The Testing Agency shall check whether these measurements have been performed in accordance with the procedure described in this Annexure A and Annexure D.

1.3 The method described in this annexure shall be used by the Testing Agency for the measurement of the electricity balance Q, as defined in para. A-2.1.4.3.2 of this Annexure A and Annexure D.

### 2.0 Measurement Equipment and Instrumentation

2.1 During the tests as described in para. A-2.0, A-3.0, A-4.0, and A-5.0. of this Annexure A, the REESS 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 connecting to 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. Hybrid Electric System (HES) manufacturer/supplier 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 REESS. In order to easily measure REESS current using external measuring equipment, vehicle Hybrid Electric System (HES) manufacturer/suppliers should preferably

integrate appropriate, safe and accessible connection points in the vehicle. If

that is not feasible, the vehicle Hybrid Electric System (HES) manufacturer/supplier is obliged to support the Testing Agency by providing the means to connect a current transducer to the wires connected to the REESS in the above described manner.

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.

2.2 A list of the instrumentation (Hybrid Electric System (HES) manufacturer/supplier model no., serial no.) used by the Hybrid Electric System (HES) manufacturer/supplier for determining

(a) When the minimum state of charge of the REESS has been reached during the test procedure defined in para. A-2.0. and A-3.0. of Annexure A; and

(b) The correction factors K fuel (as defined in para. A-4.3. and A-5.4. of Annexure A and the last calibration dates of the instruments (where applicable) should be provided to the Testing agency.

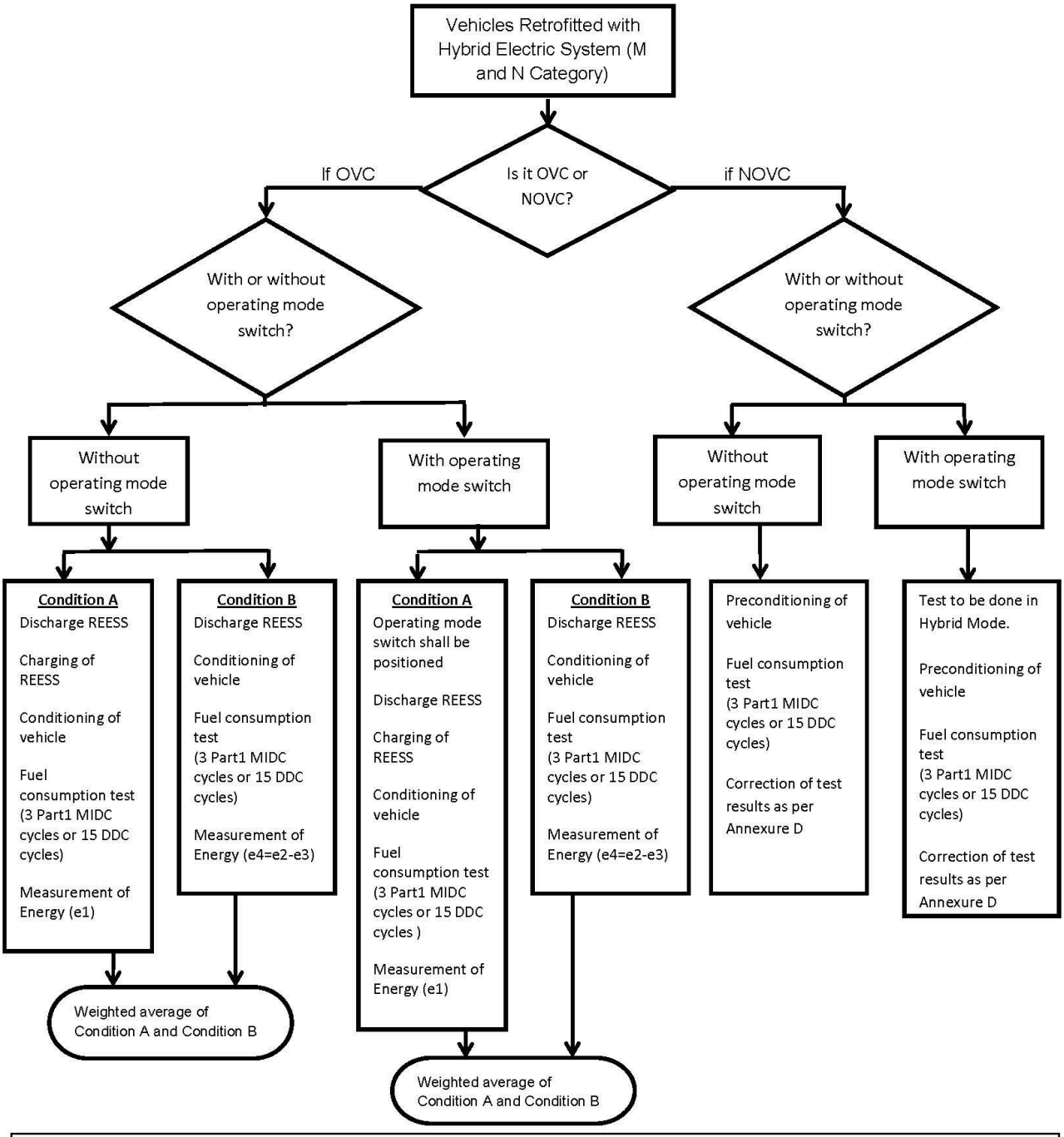
**3. 0 Measurement procedure**

3.1 Measurement of the REESS current shall start at the same time as the test starts and shall end immediately after the vehicle has driven the complete driving cycle.

3.2 Separate values of Q shall be logged for each Delhi Driving Cycle.

Flow chart for Fuel Consumption Test of vehicles retrofitted with Hybrid electric system
(M and N Category having GVW > 3500 kg)

**HES system in ON mode or enabled or active (Clause A-1.0 to A-5.0)**




*Note: The flowchart is for illustration only. In case of any conflict, text as per Annexure A will be considered as final

## ANNEXURE B

(See 9.0)

## ADDITIONAL REQUIREMENTS FOR REGENERATIVE BRAKING SYSTEM

### B-1.0 Definitions

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

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

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

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

### B-2.0 Vehicles Fitted with Electric Regenerative Braking System of Category A

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

B-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.

### B-3.0 Vehicles Fitted with Electric Regenerative Braking System of Category B

B-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

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

B-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.

**B-4.0** If so desired by the Hybrid Electric System (HES) manufacturer/supplier 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.

**B-5.0 General**

B-5.1 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.

## ANNEXURE C

(See A -2.3.1)

## METHOD OF MEASURING THE ELECTRIC AND OVC RANGE OF VEHICLES RETROFITTED WITH HYBRID ELECTRIC SYSTEM

**C-1.0** The test method described hereafter permits to measure the electric range and OVC range, expressed in km, of externally chargeable retrofitted HEV's (OVC-HEV) as defined in para. A-1.

**C-2.0 Parameters, Units and Accuracy of Measurements**

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

**Table C1**

**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 |

**C-3.0 Test Conditions**

C-3.1 **Condition of the vehicle**

C-3.1.1 The vehicle tyres shall be inflated to the pressure specified by the vehicle Hybrid Electric System (HES) manufacturer/supplier when the tyres are at the ambient temperature.

C-3.1.2 The viscosity of the oils for the mechanical moving parts shall conform to the specifications of the vehicle Hybrid Electric System (HES) manufacturer/supplier.

C-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.

C-3.1.4 All REESS systems available for other than traction purposes (electric, hydraulic, pneumatic, etc.) shall be charged up to their maximum level specified by the Hybrid Electric System (HES) manufacturer/supplier.

C-3.1.5 If the batteries are operated above the ambient temperature, the operator shall follow the procedure recommended by the vehicle Hybrid Electric System (HES) manufacturer/supplier in order to keep the temperature of the REESS in the normal operating range.

The Hybrid Electric System (HES) manufacturer/supplier's representative shall be in a position to attest that the thermal management system of the REESS is neither disabled nor reduced.

C-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 Hybrid Electric System (HES) manufacturer/supplier.

C-3.2 **Climatic conditions**

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

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

C-3.2.3 The test may be carried out at temperatures different from those specified above, with mutual agreement between Hybrid Electric System (HES) manufacturer/supplier and testing agency

**C-4.0 Operation Modes**

The test method includes the following steps:

(a) Initial charge of the REESS.
(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).

C-4.1 **Initial Charge of the REESS**

Charging the REESS consists of the following procedures**:**

**Note:** "Initial charge of the REESS" applies to the first charge of the REESS, 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 REESS" and the following may be done in accordance with the "normal overnight charge" procedure.

C-4.1.1 **Discharge of the REESS**

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

C-4.1.1.2.1 The procedure shall start with the discharge of the electrical energy/power storage device of the vehicle is as per para. A-2.1.1.

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

C-4.1.1.3.1 If there is not a pure electric position, the Hybrid Electric System (HES) manufacturer/supplier 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 para. A-3.2.

C-4.1.1.3.2 If the vehicle is not equipped with pure electric operating state, the procedure for discharge of the electrical energy/power storage device of the vehicle is as per para. A-2.1.1.

C-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.

C-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 Hybrid Electric System (HES) manufacturer/supplier using the charging pattern prescribed for normal charging;

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

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 Hybrid Electric System (HES) manufacturer/supplier shall declare that during the test, a special charge procedure has not occurred.

C-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,

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

C-4.2 **Application of the cycle and measurement of the range**

C-4.2.1 The applicable test sequence as per the applicable driving cycles (Part 1 of MIDC or Delhi Driving Cycle) is applied on a chassis dynamometer until the end of the test criteria is reached. Gear shifting pattern shall be as prescribed in para. A-2.1.4.1.

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

To determine the electric range (De) of OVC retrofitted HEV equipped with an operating mode switch the same operating mode position, in accordance with paragraph A-3.1 of Annexure A of this standard, shall be used as for the determination of fuel consumption.

C-4.2.2.1 The end of the test criteria is reached if any one of the following conditions is achieved.

C-4.2.2.1.1 When the vehicle is not able to meet the target curve up to 50 km/h,

C-4.2.2.1.2 or when an indication from the standard on-board instrumentation is given to the driver to stop the vehicle or when the battery has reached its minimum state of charge.

C-4.2.2.2 Then the vehicle shall be slowed down to 5 km/h by releasing the accelerator pedal, without touching the brake pedal and then stopped by braking.

C-4.2.2.3 At a speed over 50 km/h when the vehicle does not reach the required acceleration or speed of the test cycle, the accelerator pedal shall remain fully depressed until the reference curve has been reached again.

C-4.2.2.4 During this procedure, the electricity balance ($QES_i$) of the high voltage battery (expressed in Ampere hours), measured continuously using the procedure specified in Appendix 2 to the Annexure A 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 4.2.2.5 of this Annexure.

This procedure shall be followed until the end of the test as defined in paragraph 4.2.2.1.1 of this Annexure.

C-4.2.2.5 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 engine started 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 ($\Delta Qrb_i$); and
(c) The electricity balance when the fuel consuming engine starts ($QES_i$) defined previously should be corrected by $\Delta Qrb_i$ (hence new $QSA_i = QES_i + \Delta Qrb_i$);

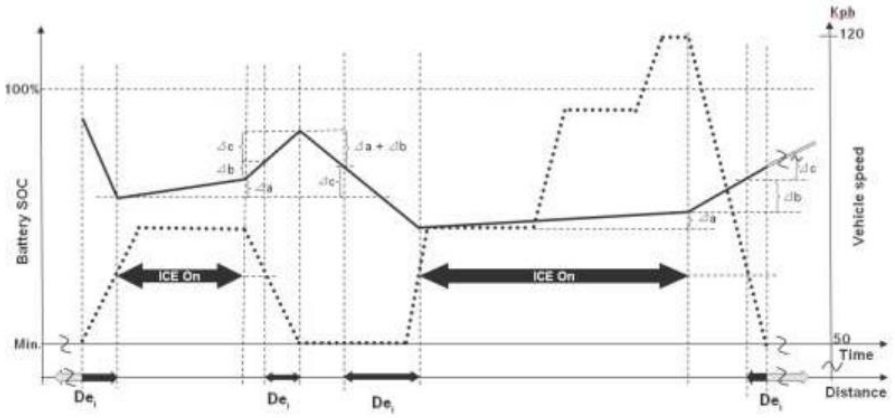
$VES_i$ = Vehicle speed at the moment when the ICE starts;

$QES_i$ = Energy of the battery at the moment when the ICE starts;

$\Delta Qrb_i$ = The increase in electricity balance during deceleration phases, when the vehicle speed is less than the vehicle speed at which the ICE started previously;

$QSA_i$ = Energy of the battery at the moment of the further accumulation of De.

Example:




⊿a = Charged by ICE

⊿b = Charged by regeneration (vehicle acceleration by ICE)

C-4.2.2. $\Delta c$ = Charged by regeneration ($\Delta Qrb_i$,vehicle acceleration with energy from battery)

$De = \Sigma De_i$

$De_i$ = Distances where the propulsive energy was not produced by ICE

——— Battery SOC

..... Vehicle Speed

C-4.2.2.6 To respect human needs, up to three interruptions are permitted between test sequences, of no more than 15 minutes in total.

C-4.2.2.7 At the end, the electric range is the sum of all cycle portions $D_{ei}$ in km. It shall be rounded to the nearest whole number.

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

C-4.2.3.1 To measure the OVC range, the end of the test criteria is reached when the battery has reached its minimum state of charge according to the criteria defined in Annexure A, paragraph A-2.1.4.3.2 Driving is continued until the final idling period in applicable driving cycle.

C-4.2.3.2 To respect human needs, up to three interruptions are permitted between test sequences, of no more than 15 minutes in total.

C-4.2.3.3 At the end, the total distance driven in km, rounded to the nearest whole number, is the OVC range of the hybrid electric vehicle.

## ANNEXURE D

(See A-4.3, A-5.4)

## SPECIAL REQUIREMENTS FOR MEASUREMENT AND CORRECTION OF THE TEST RESULTS FOR MEASUREMENT OF FUEL CONSUMPTION IN RESEPECT OF NOT EXTERNALLY CHARGEABLE (NOVC) RETROFITTED HEV.

### D-1 Test Results

D-1.1 The test results (fuel consumption C [l/100 km] ) of the test are corrected in function of the energy balance $\Delta E_{batt}$ of the vehicle's REESS. The corrected values ($C_0$ [l/100 km]) should correspond to a zero energy balance ($\Delta E_{batt} = 0$), and are calculated using a correction coefficient determined by the Hybrid Electric System (HES) manufacturer/supplier as defined below. In case of other storage systems than an electric REESS, $\Delta E_{batt}$ is representing $\Delta E_{storage}$, the energy balance of the electric REESS device.

D-1.2 The electricity balance Q [Ah], measured using the procedure specified in Appendix 2 of Annexure A is used as a measure of the difference in the vehicle REESS's energy content at the end of the cycle compared to the beginning of the cycle.

D-1.3 Under the conditions below, it is allowed to take the uncorrected measured values C as the test result:

a) in case the Hybrid Electric System (HES) manufacturer/supplier can prove that there is no relation between the energy balance and fuel consumption,

b) in case that $\Delta E_{batt}$ always corresponds to a REESS charging,

c) in case that $\Delta E_{batt}$ always corresponds to a REESS discharging and $\Delta E_{batt}$ is within 1 per cent of the energy content of the consumed fuel (consumed fuel meaning the total fuel consumption over one cycle).

The change in REESS energy content $\Delta E_{batt}$ can be calculated from the measured electricity balance Q as follows:

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

Where $E_{TEbatt}$ [MJ] is the total energy storage capacity of the REESS and $V_{batt}$ [V] is the nominal battery voltage.

**D-2 Fuel consumption correction coefficient ($K_{fuel}$) defined by the Hybrid Electric System (HES) manufacturer/supplier**

D-2.1 The fuel consumption correction coefficient ($K_{fuel}$) shall be determined from a set of n measurements performed by the Hybrid Electric System (HES) manufacturer/supplier. This set should contain at least one measurement with $Q_i < 0$ and at least one with $Q_j > 0$.

D-2.2 If the latter condition cannot be realized on the driving cycle 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 $\Delta E_{batt} = 0$.

The fuel consumption correction coefficient ($K_{fuel}$) is defined as

$$k_{fuel} = \frac{n.\Sigma Q_i C_i - \Sigma Q_i \cdot \Sigma C_i}{n\Sigma Q_i^2 - (\Sigma Q_i)^2} \quad \text{(1/100 Km /Ah)}$$

Where

$C_i$ **:** fuel consumption measured during i-th Hybrid Electric System (HES) manufacturer/ supplier's test (l/100 km)

$Q_i$ **:** electricity balance measured during i-th Hybrid Electric System (HES) manufacturer/supplier'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.

**D-3.0 Fuel Consumption at Zero Energy Balance ($C_0$)**

D-3.1 The fuel consumption $C_0$ at $\Delta E_{batt} = 0$ is determined by the following equation

$C_0 = C - K_{fuel} * Q$ (l/100 km)

Where

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

Q **:** electricity balance measured during test (Ah)

**ANNEXURE E**
(See 18.1)

## TECHNICAL SPECIFICATION OF HYBRID ELECTRIC SYSTEM

| | |
|---|---|
| **1.** | **Details of Hybrid Electric System Manufacturer / Supplier** |
| a. | Name of the Hybrid Electric System (HES) Manufacturer / Hybrid Electric System (HES) Supplier: |
| b. | Address: |
| c. | Telephone No. and Fax No.: |
| d. | Contact person: |
| **2.** | **System Identification** |
| a. | Identification No.: |
| b. | Variants, if any: |
| **3.** | **Electric Motor** |
| a. | Name and address of manufacturer: |
| b. | Model name/Identification No.: |
| c. | Type: (e.g. Asynchronous AC Induction, Synchronous Permanent Magnet AC, BLDC, SRM etc.) |
| d. | No. of Phases: |
| e. | Maximum Power (kw @ xxxx rpm): |
| f. | Maximum torque (Nm @ xxxx rpm): |
| g. | Maximum Thirty Minutes Power, kW: |
| h. | Maximum Thirty Minutes speed km/h: |
| i. | Cooling System (Liquid /Air / Naturally air cooled): |
| j. | International Protection (IP)-Code: |
| k. | No. of Electric Motors Used: |

| | | |
|---|---|---|
| Test Agency: | Manufacturer: | Document No. (indicating revision status) |
| Signature: | Signature: | |
| Name: | Name: | |
| Designation: | Designation: | |
| Date: | Date: | Sheet no……..of…….. |

| | | |
|---|---|---|
| **4** | **Motor Controller Unit** | |
| a. | Name and address of manufacturer: | |
| b. | Model name/Identification No: | |
| c. | Type: | |
| d. | Control Principle: (e.g vectorial / open loop / closed / other) | |
| e. | Cooling System (Liquid /Air / Naturally air cooled): | |
| f. | International Protection (IP)-Code: | |
| g. | No. of Motor Controller Units Used: | |
| **5.** | **REESS** | |
| a. | Name and address of manufacturer: | |
| b. | Identification No.: | |
| c. | Type: (e.g Lead Acid/ Li-Ion etc.) | |
| d. | Voltage: | |
| e. | Capacity (kWh): | |
| f. | End of discharge voltage value: | |
| g. | No. of batteries used: | |
| h. | Weight of REESS: | |
| **6.** | **Charger (Applicable only for Externally Chargeable HEV's)** | |
| a. | Name and address of the manufacturer: | |
| b. | Model name/Identification No: | |
| c. | Type: | |
| d. | Rating: | |
| e. | Charger (on board / external): | |
| f. | Specifications of mains: | |
| | i | mains (single phase/ three phase): |
| | ii | Nominal Voltage (V) and frequency (Hz) with tolerances: |
| g. | Recommended duration of a complete charge: | |

| Test Agency: | Manufacturer: | Document No. (indicating revision status) |
|---|---|---|
| Signature: | Signature: | |
| Name: | Name: | |
| Designation: | Designation: | |
| Date: | Date: | Sheet no……..of…….. |

| | | |
|---|---|---|
| h. | In case of on-board charger: | |
| | i | Continuous rating of charger socket (A): |
| | ii | Maximum initial in-rush current (A): |
| **7** | **Charging / interlocking Socket** | |
| a. | Name and address of the manufacturer: | |
| b. | Model name/Identification No.: | |
| c. | Type: | |
| d. | Rating: | |
| **8** | **Power Harness** | |
| a. | Name and address of manufacturer: | |
| b. | Model name/Identification No.: | |
| c. | Type : FLRY | |
| d. | Operating Temperature: | |
| e. | Insulation material used: | |
| f. | IEC protection class: | |
| g. | Conduits provided Yes / No: | |
| h. | Cable size ( DC side ) sqmm: | |
| i. | Cable size ( AC side ) sqmm: | |
| j. | Electrical circuit diagram and Layout: | |
| **9.** | **Control Harness** | |
| a. | Name and address of manufacturer: | |
| b. | Model name/Identification No.: | |
| c. | Type: FLRY | |
| d. | Operating Temperature: | |
| e. | Insulation material used: | |
| f. | IEC protection class: | |
| g. | Conduits provided Yes / No: | |
| h. | Cable size in sqmm: | |
| i. | Electrical circuit diagram and Layout: | |

| Test Agency: | Manufacturer: | Document No. (indicating revision status) |
|---|---|---|
| Signature: | Signature: | |
| Name: | Name: | |
| Designation: | Designation: | |
| Date: | Date: | Sheet no……..of…….. |

| | | |
|---|---|---|
| **10** | **REESS State of Charge (SOC) and Fault indicator / HMI** | |
| a. | Name and address of manufacturer: | |
| b. | Model name/Identification No: | |
| c. | Type: | |
| d. | Details of indication when state of charge of the REESS reaches a level when the manufacturer recommends re-charging | |
| | i | Indication format: |
| | ii | Relationship of state of charge indicator and the indication: |
| **11** | **Hybrid Controller Unit** | |
| a. | Name and address of manufacturer: | |
| b. | Model name/Identification No.: | |
| c. | Type: | |
| d. | No. of Hybrid Controller units used: | |
| **12** | **Any Additional component as a part of retro-fitment of Hybrid Electric System (HES)** | |
| | | |
| **13** | **REESS Management System (Popularly known as Battery Management System, BMS)** | |
| a. | Name and address of manufacturer: | |
| b. | Model name/Identification No.: | |
| c. | Type: | |
| **14** | **Brief Description of System Including Dimensional Layout for Hybrid Electric System components Installation in the vehicle.**<br>Typical layout shall indicate details of circuit brakers, MCBs used, location of charger, etc., and key Hybrid Electric System (HES) components<br>Description of System Operation: | |

| | | |
|---|---|---|
| Test Agency: | Manufacturer: | Document No. (indicating revision status) |
| Signature: | Signature: | |
| Name: | Name: | |
| Designation: | Designation: | |
| Date: | Date: | Sheet no……..of…….. |

| | |
|---|---|
| **15** | **Catalytic Converter (OE fitted)** |
| a. | Name and address of manufacturer: |
| b. | Model name/Identification No.: |
| c. | Type: |
| **16** | **Current Limiting Device (Fuse)** |
| a. | Name and address of manufacturer: |
| b. | Identification No.: |
| c. | Voltage/current rating: |
| d. | Type: |
| **17** | **Main Contactor / REESS Cut-off Switch** |
| a. | Name and address of manufacturer: |
| b. | Identification No.: |
| c. | Voltage/current rating: |
| d. | Type: |
| e. | No. of Switched Units Used: |

**ANNEXURE F**
(See 18.1)

**TECHNICAL SPECIFICATION OF VEHICLE RETROFITTED WITH HYBRID ELECTRIC SYSTEM**

| | |
|---|---|
| **1.0** | **General Description of Vehicle** |
| 1.1 | Vehicle Make / Model: |
| 1.2 | Vehicle Type: |
| 1.3 | Year and Month of Manufacture: |
| 1.4 | Engine No.: |
| 1.5 | Chassis No.: |
| 1.6 | Type of hybrid vehicle (Externally chargeable/Not externally chargeable): |
| 1.7 | Mode selection switch provided: Yes/No |
| 1.8 | If yes, the modes available: |
| **2.0** | **Engine** |
| 2.1 | Type: |
| 2.2 | Bore x Stroke, mm: |
| 2.3 | No. of Cylinders: |
| 2.4 | Displacement: |
| 2.5 | Compression Ratio: |
| 2.6 | Max Engine Output: |
| 2.7 | Max Torque: |
| 2.8 | Weight of Engine (Complete): |
| **3.0** | **Clutch** |
| 3.1 | Type: |
| 3.2 | Outside Diameter: |
| **4.0** | **Gear Box** |
| 4.1 | Model: |
| 4.2 | Type: |
| 4.3 | No. of Gears: |

| Test Agency: | Manufacturer: | Document No. (indicating revision status) |
|---|---|---|
| Signature: | Signature: | |
| Name: | Name: | |
| Designation: | Designation: | |
| Date: | Date: | Sheet no……..of…….. |

| | |
|---|---|
| 4.4 | Gear ratio: |
| | 1st |
| | 2nd |
| | 3rd |
| | 4th |
| | 5th |
| | 6th |
| | Reverse |
| 4.5 | Front Axle: |
| 4.6 | Rear Axle: |
| 4.7 | Ratio: |
| **5.0** | **Steering** |
| 5.1 | Steering Wheel Diameter: |
| 5.2 | Ratio: |
| **6.0** | **Frame** |
| 6.1 | Long member size,mm: |
| 6.2 | No. of cross members: |
| **7.0** | **Suspension** |
| 7.1 | Front: |
| 7.2 | Rear: |
| **8.0** | **Brake** |
| 8.1 | Service Brake: |
| 8.2 | Front: |
| 8.3 | Rear: |
| 8.4 | Parking Brake: |
| 8.5 | Wheels and Tyres: |
| **9.0** | **Electrical System** |
| 9.1 | System voltage: |
| 9.2 | REESS: |
| 9.3 | Alternator (Max. Output): |

| | |
|---|---|
| **10.0** | **Dimensions** |
| 10.1 | Wheel Base, mm: |
| 10.2 | Overall Width, mm: |
| 10.3 | Overall Length, mm: |
| 10.4 | Front Track, mm: |
| 10.5 | Rear Track, mm: |
| 10.6 | Min. Ground Clearance, mm: |
| 10.7 | Cargo Box Dimensions: |
| 10.8 | Load Body Platform Area: |
| **11.0** | **Weights** |
| 11.1 | Gross Vehicle Weight (GVW): |
| 11.2 | Unladen Weight (ULW with 90% fuel, Spare wheel and tools etc): |
| 11.3 | Front Axle weight (FAW): |
| 11.4 | Rear Axle weight (RAW): |
| 11.5 | Maximum Gradeability in 1st Gear: |
| **12.0** | **Other details** |
| 12.1 | Fuel capacity: |
| 12.2 | Seating capacity: |

| | | |
|---|---|---|
| Test Agency: | Manufacturer: | Document No. (indicating revision status) |
| Signature: | Signature: | |
| Name: | Name: | |
| Designation: | Designation: | |
| Date: | Date: | Sheet no……..of…….. |

## ANNEXURE G
(See 18.1)

## CODE OF PRACTICE FOR RETROFITMENT OF HYBRID ELECTRIC SYSTEM ON VEHICLES

### 1.0 General

This code of practice shall be called as "Code of Practice for retro-fitment of Hybrid Electric System (HES) on Vehicles".

### 2.0 Scope

This code of practice shall apply to the design, installation, operation, inspection and testing and maintenance of Hybrid Electric System (HES). In general the standard is directed towards vehicle installations.

### 3.0 Responsibility of Hybrid Electric System (HES) manufacturer / supplier

The responsibility of the type approval and ensuring that the Hybrid Electric System (HES) manufactured complies with the provisions of this standard shall be that of the Hybrid Electric System (HES) manufacturer /supplier.

3.1 Hybrid Electric System (HES) manufacturer/ supplier shall have third party ISO-9000 certification. The ISO 9000 certificate shall be submitted to the Test Agency at the time of type approval.

3.2 After obtaining type approval certification, Hybrid Electric System (HES) manufacturer / supplier shall authorize installer(s) to undertake Hybrid Electric System (HES) retro-fitment. The Hybrid Electric System (HES) manufacturer/supplier shall submit the information to Regional Transport Authorities as required.

3.3 The Hybrid Electric System (HES) manufacturer / Hybrid Electric System (HES) supplier shall maintain the record of the Vehicle Identification Numbers (VIN) and registration numbers of those vehicles on which the Hybrid Electric System (HES) has been installed. As part of this record, the Hybrid Electric System (HES) manufacturer/supplier shall identify the installation date and the Hybrid Electric System (HES) type approval certification number and shall identify the vehicle owners at the time of installation, including the owner's current addresses and phone numbers.

3.4 Name, address, and phone number of all the installer facilities which are authorised by the Hybrid Electric System (HES) manufacturer / supplier to install the approved Hybrid Electric System (HES) or sell the spare parts of Hybrid Electric System (HES) shall be published on Hybrid Electric System (HES) manufacturer/supplier website.

3.5 **Hybrid Electric System (HES) Layout:** The layout indicating the locations of key elements of the Hybrid Electric System (HES) shall be prepared by the Hybrid Electric System (HES) manufacturer / supplier and shall be submitted to the Testing Agency at the time of Type Approval. This will include the placement of each important element such as motor, controller, wiring harness routing, batteries, charging socket and other components which forms the integral part of the Hybrid Electric System (HES).

3.5.1 Test Agency shall verify the weight distribution due to Hybrid Electric System (HES) installation for any adverse impact on vehicle structure using best engineering practices.

If any part of Hybrid Electric System (HES) kit is fitted on roof top of buses (M3 category), Test Agency may consider carrying out Stability Test as per AIS-052 (Rev.1) to ascertain stability after Hybrid Electric System (HES) retro-fitment.

3.5.2 Serviceability and accessibility of the original vehicle shall not be adversely affected due to Hybrid Electric System (HES) mounting

3.6 **Owner's Manual for Hybrid Electric System (HES)**

The Owner's manual shall be prepared by the Hybrid Electric System (HES) manufacturer / supplier and shall clearly highlight the changes that would supersede the OEM vehicle Owner's manual. The Hybrid Electric System (HES) manufacturer / supplier shall ensure and instruct the Hybrid Electric System (HES) installers that the Hybrid Electric System (HES) owner's manual is provided with every Hybrid Electric System (HES) installed vehicle.

The Owner's manual shall cover the following minimum information:

3.6.1 Approved Hybrid Electric System (HES) layout diagram.

3.6.2 Description of the Hybrid Electric System (HES) including description of major components and their theory of operation.

3.6.3 REESS charging procedure.

3.6.4 **Warranty information of Hybrid Electric System (HES).** It should include the warranty information of Hybrid Electric System (HES) and its implications on the warranty provided by OEM (Base vehicle manufacturer). This notification must be signed by the purchaser prior to sale of the Hybrid Electric System (HES).

Responsibility of vehicle retrofitted with Hybrid Electric System is transferred from OEM to kit manufacturer / supplier, except in case of zero kilometer fitment.

3.6.5 Listing of necessary service intervals and a Check list for checks to be carried out during servicing.

3.6.6 FAQs and troubleshooting guide of Hybrid Electric System (HES).

The Hybrid Electric System (HES) manufacturer / supplier shall submit the complete owner's manual to the Test Agency along with the application of the Type Approval. In case the owner's manual is not available at the time of submitting the prototype vehicle, they shall be submitted by the Hybrid Electric System (HES) manufacturer /supplier as and when they are ready but not later than beginning of commercial production.

3.7 **Service Manual for Hybrid Electric System (HES)**

The Hybrid Electric System (HES) manufacturer/supplier shall make service manual available comprising of company's all service and warranty policies.

3.8 The Hybrid Electric System (HES) manufacturer/supplier shall impart training to installer on installation, maintenance and operation of Hybrid Electric System (HES) and issue the training certificate to installer after completion of training.

3.9 **Wiring harness, Cables and Connectors**

**Guidelines for Installation and Routing the Control and Power Harness through vehicle.**

3.9.1 Electric cables used in power and control wiring harness shall comply with the requirements of ISO 6722-2006 as per the para. 15 of this standard.

3.9.2 The electrical circuit shall be provided with current limiting and or short circuit protection device.

3.9.3 The layout of the wiring harnesses shall be such that they are secured tightly and shall be properly insulated or contained in a loom (Non-flammable corrugated tube) along its length to avoid any metal contact of body, damage by any means (e.g. sharp metallic edges) or sagging.

3.9.4 The Hybrid Electric System (HES) manufacturer/supplier has to select cables used for harness such a way that, there shall not be any EMI (Electro Magnetic Interference) causing malfunction of harness and other electrical systems of the vehicle.

3.9.5 **Guidelines for minimum Clearances between CNG and Electrical System in case of Hybrid Electric System (HES) retro-fitment on CNG vehicle.**

Minimum clearance shall be maintained between CNG pipes or devices handling CNG, High Voltage cables or High Voltage (HV) Equipment and Low Voltage (LV) Cables as given below.

| **Minimum Clearance between CNG/LV/HV Systems** | **mm** |
|---|---|
| CNG Pipes and HV Cables | 100 |
| CNG Equipment and HV Cables | 75 |
| CNG Pipes and HV Components | 75 |
| CNG Equipment and HV Components | 50 |

However in case the above clearances can’t be maintained because of space constraints special care should be taken to avoid :

1. Temperature rise of the cables by using proper thermal insulation;
2. Electric potential /shock hazard by providing proper insulation;
3. Abrasion by providing proper spacers and shielding.

3.9.6 **Guidelines for sharing the signal from existing sensors in a vehicle**

The Hybrid Electric System (HES) manufacturer/supplier shall follow the guidelines mentioned below for sharing the signal from existing sensors in a vehicle. This approach will ensure that the signals are not loaded and do not impact the functioning of the existing systems in the vehicle.

3.9.6.1 Guidelines for sharing sensors with pulse / frequency output or digital output

3.9.6.1.1 The input stage impedance should be such a way that it will not load the earlier stage. After loading the sensor signal by additional circuit, drop in the sensor voltage should not be more than 0.5 percent of sensor voltage before loading the circuit.

3.9.6.1.2 Logic zero voltage should not lift up due to sharing circuit.

3.9.6.1.3 The device should not allow reverse flow of current.

3.9.6.1.4 The input stage should not pick up any noise.

3.9.6.1.5 The input stage shall not introduce noise if it is kept open.

3.9.6.1.6 The additional circuit shall not have any adverse effect on the existing sensor circuit.

Examples of pulse / frequency output type sensors:

- Vehicle Speed Sensor (VSS)
- Pressure sensor
- Engine speed sensor

Examples of Digital output type sensors:

- Brake switch
- Clutch switch
- Air Condition ON-OFF switch
- Pressure switch
- Temperature switch

3.9.6.2 **Guidelines for sharing sensors with voltage / potentiometric / resistance type output.** The input stage of the signal sharing device shall have the following characteristics –

3.9.6.2.1 **Differential input:** This will provide high common mode rejection. It will not interfere with the electronics of the existing vehicle as it will not measure the signal with respect of signal ground.

3.9.6.2.2 **High Input impedance:** The input stage impedance should be such a way that it will not load the earlier stage. After loading the sensor signal by additional circuit, drop in the sensor voltage should not be more than 0.25 percent of sensor voltage before loading the circuit.

3.9.6.2.3 The device should not allow reverse flow of current.

3.9.6.2.4 The input stage should not pick up any noise.

3.9.6.2.5 The input stage shall not introduce noise if it is kept open.

3.9.6.2.6 The additional circuit shall not have any adverse effect on the existing sensor circuit.
Example of Voltage / Resistance type sensors:

- Throttle position sensor
- Pressure sensor
- Temperature sensor
- Air flow sensor

3.9.6.3 The motor controller and onboard charger shall be isolated from the vehicle battery during 'Ignition off' condition.

3.9.6.4 In case Hybrid Electric System (HES) is connected to the grounded chassis, it shall be equipped with Earth Leakage / Dark current protection at any time when vehicle is connected to the external / mains supply.

3.10 **Motor Controller**

The motor controller shall be designed to provide protection for Short circuit, over temperature, Input and Output Overloading. Controller should be so placed that the heat generated is adequately dissipated.

3.11 **Charging Socket and its Location (if provided)**

Vehicle starting system shall be disabled if the charging cable is plugged-in to the vehicle. In case of running engine if the charging cable is plugged-in to the vehicle, the engine shall be shut down.

To the extent possible, charging socket shall be located close to on board charger, if available. The location of charging socket should be away from the fuel tank. Preferably it should be on the opposite side of the fuel tank inlet. The socket body should be adequately earthed to prevent sparking and subsequent hazard of fire.

3.12 **REESS disconnect**

Vehicles should be equipped with an automatic disconnect for REESS to isolate the propulsion circuits in case of any fault in Hybrid Electric System (HES). The Hybrid Electric System (HES) manufacturer/supplier shall describe the automatic disconnect provided in the Owner's manual.

A manual service disconnect should also be present. This disconnect should be operable with the following capabilities:

3.12.1 Manual action to break the connection.

3.12.2 The disconnection does not create exposed conductors capable of becoming energized while exposed.

3.13 **REESS Charger**

The charger and the BMS shall provide protection for overcharge, over discharge, cell/pack voltage variation, Temperature variation etc. for safe operation of batteries.

3.14 **Compliance Plate**

Each Hybrid Electric System (HES) retrofitted vehicle shall be fitted with the compliance plate. It will be suitably located in an approachable location. Compliance plate shall provide the following information about the Hybrid Electric System (HES) and its installation.

- Date of Installation:
- Vehicle Reg. Number:
- Hybrid System Identification Number:
- Manufactured by:
- Installed by:
- System Weight:
- Axel Weights:

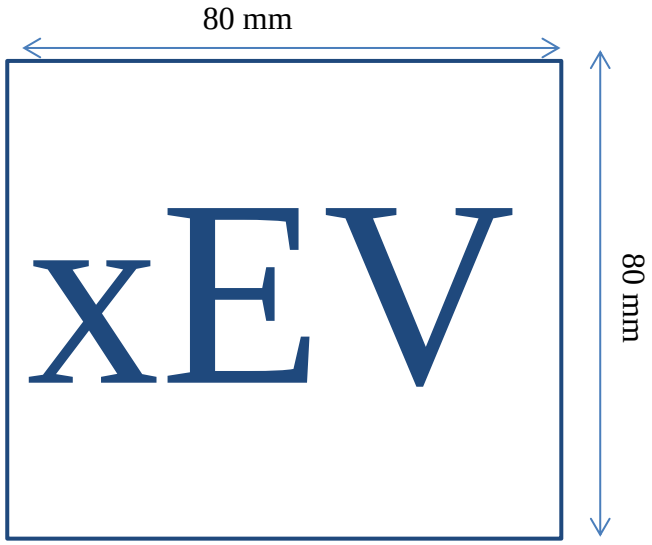
3.15 **Labels**

**Identification label in front and rear:** Label conforming to the specifications of this standard shall be affixed on left side of the front and rear safety glass so as to ensure visibility from the front and rear side of the vehicle.

Vehicles installed with Hybrid Electric System (HES) shall have identification label as follows:

3.15.1 The label shall be in position at all times, shall be in good condition, and the shape, colouring and lettering shall be easily identifiable.

3.15.2 Label shall be coloured ‘white’ and sized 80 mm x 80 mm square. Label shall have on them the text “xEV” in a central position not less than 20 mm high, coloured blue. The label shall have a blue border 1 mm wide, 5 mm inside the outer edge and running parallel to it. The 80 mm dimension is measured from the outer edge (Kindly refer the drawing given below).




3.16 **Safety Instructions**

Minimum one copy of safety instructions shall be displayed in passenger's compartment.

**4.0 Responsibility of the Hybrid Electric System (HES) installer**

4.1 **Criteria to Authorize Hybrid Electric System (HES) Installer**

Only the installer authorized by Hybrid Electric System (HES) manufacturer /supplier shall fit the Hybrid Electric System (HES) on vehicles. For this purpose, the Hybrid Electric System (HES) manufacturer/supplier shall issue a certificate of authorization to the installer concerned duly authorizing them to fit the Hybrid Electric System (HES) on behalf of Hybrid Electric System (HES) manufacturer/supplier. Only authorized installer shall be allowed to carry out the Hybrid Electric System (HES) fitments.

4.2 **Hybrid Electric System (HES) installer shall be equipped with the following tools and equipment**

Two post lift / ramp
- Electric hand drill machine and H.S.S. drill bits
- Set of 'D' ring and box spanners
- Set of screw driver (both flat and star)
- Set of Allen keys
- H.S.S. hand saw
- Crimping tool for electrical cable termination, if required
- Set letter and number punch
- Measurement tape
- Torque wrench
- Inspection light
- Vernier caliper
- Multimeter
- Silicon seal/sealant

- Alignment tool
- Belt tension measuring equipment
- Puller
- Fire - fighting equipment
- Dry chemical powder (DCP) type fire extinguisher – minimum two numbers of 5 kg each with ISI mark.
- $CO_2$ type fire extinguisher – minimum 1 number of 5 kg with ISI mark.
- Fire buckets – 2 buckets
- Testing equipment recommended by Kit Manufacturer

4.3 Installer shall have trained technicians having qualification as specified by Hybrid Electric System (HES) manufacturer/ supplier. Hybrid Electric System (HES) manufacturer/supplier shall impart extensive training to the technicians on Hybrid Electric System (HES) installation and certify the same.

4.4 Installer to display in the premises, authorization certificate issued by Hybrid Electric System (HES) manufacturer / supplier.

4.5 The record of retro-fitment of vehicles carried out by the Hybrid Electric System (HES) installer shall be maintained and made available to the transport authorities.

4.6 Hybrid Electric System (HES) installer shall carry out fitness and performance checks of the Hybrid Electric System (HES) retrofitted vehicle at least once in a year and maintain the records of the parameters audited and observations as per the norms established by Hybrid Electric System (HES) manufacturer /supplier.

4.7 Hybrid Electric System (HES) installer shall only use spare parts recommended by Hybrid Electric System (HES) manufacturer / supplier.

4.8 The Hybrid Electric System (HES) installer shall install Hybrid Electric System (HES) as per the guidelines and instructions provided by the Hybrid Electric System (HES) manufacturer / supplier. The installer shall also provide all documentation to the vehicle owner as instructed by Hybrid Electric System (HES) manufacturer / supplier as well as documentation required by law.

4.9 The Hybrid Electric System (HES) installer shall assess the fitness of the vehicle before taking up for Hybrid Electric System (HES) fitment, and explain the same to vehicle owner and seek written consent from vehicle owner.

## ANNEXURE H

(See 19.0)

## CRITERIA FOR EXTENSION APPROVAL

**1.0 Hybrid Electric System (HES) manufacturer and test agency shall mutually agree for test to be carried out in case of following changes**

(a.) Change in Make , Type, rating of Motor

(b.) Change in Make , Type, rating of Motor Drive/ECU

(c.) Change in Make, Type, rating of REESS

(d.) Change in cable harness

## ANNEXURE I

(See introduction)

## COMPOSITION OF AISC PANEL ON CMVR TYPE APPROVAL OF VEHICLES RETROFITTED WITH HYBRID ELECTRIC SYSTEM*

| | |
|---|---|
| **Convener** | |
| Shri. A.A. Deshpande | The Automotive Research Association of India (ARAI) |
| **Members** | |
| Shri M. M. Desai | The Automotive Research Association of India (ARAI) |
| Representative of | National Automotive Testing and R&D Infrastructure project (NATRiP) |
| Director | Vehicle Research and Development Establishment (VRDE) |
| Director | International Center for Automotive Technology (iCAT) |
| Director | Central Institute of Road Transport (CIRT) |
| Director | Indian institute of Petroleum (IIP) |
| Shri B Bhanot | Transport Engineering Division Council (TEDC) |
| Dr. A.K. Shukla | Indian Institute of Science |
| Shri. K.K. Gandhi / Shri Sourabh Rohila | Society of Indian Automobile manufacturers (SIAM) |
| Shri. S Ravishankar | Ashok Leyland Ltd. – Technical Center (SIAM) |
| Shri. Manik Narula/ Shri Dilrajsingh Bhullar | Maruti Suzuki India Ltd. (SIAM) |
| Shri Philip Jose / Shri Vikas Ratan | Tata Motors Ltd (SIAM) |
| Shri Nagendra H.V/ Shri Raju M | Toyota Kirloskar Motor Pvt. Ltd. (SIAM) |
| Shri Sanjay Deshpande / Shri Sanjay Tank | Mahindra & Mahindra Ltd. (SIAM) |
| Shri K. Umesh/ Shri V. M. Suresh | Mahindra Reva Electric Vehicles Pvt. Ltd. (SIAM) |
| Shri Rajendra Khile | General Motors Technical Center India Pvt. Ltd. (SIAM) |
| Shri Uday Harite | Automotive Components Manufacturers Association of India (ACMA) |

| | |
|---|---|
| Shri Sunil Gandhi/<br>Shri Tejas Kshatriya | KPIT Cummins Infosystems Ltd. |
| Shri P Chandrasekhar | HBL Power Systems Ltd. |
| Shri Ritwik Guha | Minda SAI Ltd. ( Corporate Office ) |
| Shri M. J. Purohit | AXIOM Energy Conversion Pvt. Ltd. |
| Shri D. A. Desai | Kirloskar Electric Co. Ltd. |
| Dr. Vijaymohanan K Pillai | Central Electrochemical Research Institute |
| Dr. S.K. Mittal | Exide Industries |
| Shri Vidyadhar Humnabadkar | Curtis Instruments India Pvt. Ltd. |

* At the time of approval of this Automotive Industry Standard (AIS)

**ANNEXURE J**
(See Introduction)
**COMMITTEE COMPOSITION** *
**Automotive Industry Standards Committee**

| **Chairman** | |
|---|---|
| Mrs. Rashmi Urdhwareshe | Director<br>The Automotive Research Association of India, Pune |
| **Members** | **Representing** |
| Representative from | Ministry of Road Transport and Highways,New Delhi |
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* At the time of approval of this Automotive Industry Standard (AIS)