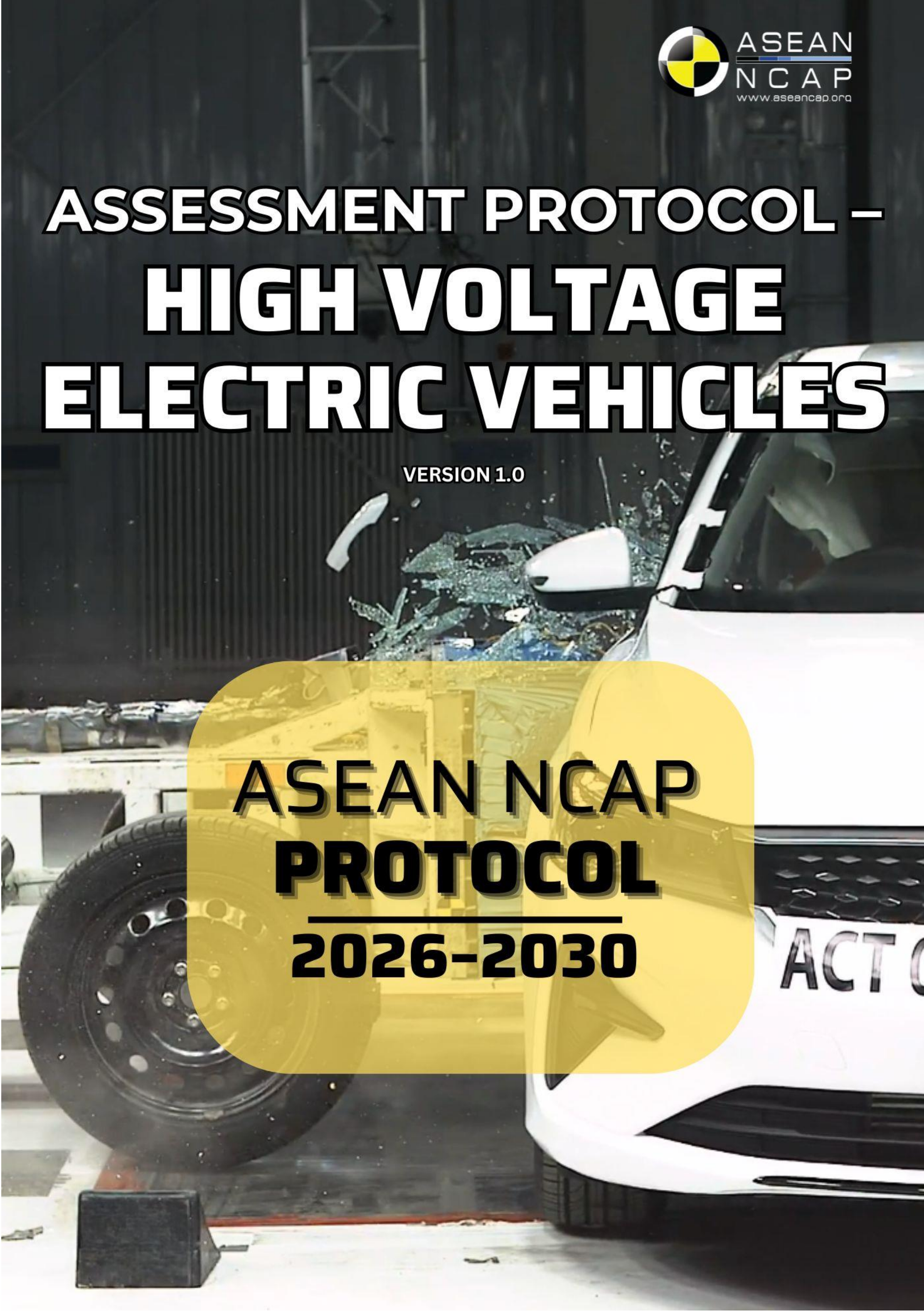

ASEAN NCAP
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ASSESSMENT PROTOCOL – HIGH VOLTAGE ELECTRIC VEHICLES

VERSION 1.0

ASEAN NCAP PROTOCOL

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Preface

This document contains the Assessment Protocol and Assessment Procedure for High Voltage Electric Vehicles (HVEVs), providing extensive testing and assessment of safety standards about electrical isolation, high-voltage system safety, and emergency protocols.

During test preparation, vehicle manufacturers are encouraged to collaborate with the laboratory and ensure satisfaction with the setup for testing. Any desired alterations should be communicated to the laboratory staff for implementation, with manufacturers prohibited from modifying parameters that could influence the test, such as dummy positioning, vehicle settings, or the laboratory environment.

Additional considerations may be required for HVEVs. Manufacturers should ensure that their vehicles are prepared according to specific safety standards for electric vehicles during testing. This may include measures related to high-voltage systems, battery safety, electrical isolation, and emergency procedures in case of electric system malfunctions.

In case of disagreements between the laboratory and manufacturer regarding test setup or procedures for HVEVs, it is essential to inform the ASEAN NCAP secretariat promptly for resolution. If there are suspicions of manufacturer interference or non-compliance with safety standards related to HVEVs, appropriate warnings should be given, and repeat incidents may lead to the manufacturer's representatives being asked to leave the test site. Persistent issues could result in the manufacturer and individuals involved being barred from attending future ASEAN NCAP tests.

DISCLAIMER: ASEAN NCAP has taken all reasonable care to ensure that the information published in this protocol is accurate and reflects the technical decisions taken by the organization. In the unlikely event that this protocol contains a typographical error or any other inaccuracy, ASEAN NCAP reserves the right to make corrections and determine the assessment and subsequent result of the affected requirement(s).

In addition to the settings specified in this protocol, the following information will be required from the manufacturer of the car being tested to facilitate the vehicle preparation. A vehicle handbook should be provided to the test laboratory before the assessment.

ASSESSMENT PROTOCOL – HIGH VOLTAGE ELECTRIC VEHICLES

Table of Contents

NEW CAR ASSESSMENT PROGRAM FOR SOUTHEAST ASIAN COUNTRIES (ASEAN NCAP)

TEST PROCEDURE TO PREVENT ELECTRIC SHOCK PROTECTION AFTER COLLISION FOR ELECTRIC VEHICLES

1 INTRODUCTION

Electric vehicles have become a trend in the ASEAN market. There are many new energy vehicles have been introduced to the market. Hence, they require additional precaution procedures in vehicle preparation to ensure safety for all persons involved before, during, and after the crash. It requires OEM to provide information about the vehicle to the laboratory. It also covers checks the test laboratory needs to perform on the vehicle before, during, and after the test.

2 DEFINITIONS OF TERMS

The terms in this testing procedure are defined as follows:

2.1 "Power system": Electric circuits including those described in 2.1.1 to 2.1.6:

2.1.1 Traction motor, its accessory wire harness, connectors, etc.

2.1.2 Rechargeable energy storage system (REESS)

2.1.3 Electrical energy conversion system

2.1.4 Electronic converter (meaning devices capable of controlling or converting electric power, such as electronic control of the traction motor and DC/DC converters)
2.1.5 Auxiliaries related to running (heaters, defrosters, power steering systems, etc.)
2.1.6 Coupling system for the charging system

2.2 "High Voltage": The classification of an electric component or circuit, if its working voltage is direct current (DC) of > 60 V and ≤ 1,500 V or alternating current (AC) of 30 V and ≤ 1,000 V root mean square (RMS).

2.3 "Working Voltage": The highest value of the voltage root mean square (RMS) of an electric circuit, specified by the manufacturer, which may occur between any conductive parts in open circuit conditions or under normal operating conditions. If the electric circuit is divided by galvanic isolation, the working voltage is defined for each divided circuit, respectively.

2.4 "Rechargeable Energy Storage System (REESS)": The rechargeable energy storage system that provides electrical energy to the electric motor for propulsion.

2.5 "Coupling System for the Charging System": The electric circuit is mainly used for charging the rechargeable energy storage system (REESS) from an external electrical power supply and is divided from the power system by galvanic isolation except when connected with an external power supply with a contactor or isolation transformer that opens or closes the electric circuit that includes the items indicated in 2.5.1 to 2.5.3 below:

2.5.1 Vehicle inlet (meaning part of the vehicle connected to the external power supply)
2.5.2 Wire harness, connectors, etc. between the vehicle inlet and the power system
2.5.3 Electric circuits galvanically connected to the electric circuits prescribed in paragraphs 3.5.1 and 3.5.2

2.6 "External Power Supply": Alternating or direct current electric power supply outside the vehicle.

2.7 "Cabin": The space for occupant accommodation, bounded by the roof, floor, side walls, doors, outside glazing, front bulkhead, and rear bulkhead, or rear gate as well as the electrical protection barriers and enclosures provided for protecting the occupants from direct contact with the live parts of the power system.

2.8 "Direct Contact": The contact of persons with the live parts of the power system.

2.9 "Live Parts": Conductive part(s) intended to be electrically energized in normal use.

2.10 "Indirect Contact": The contact of persons with exposed conductive parts.

2.11 "Protection Degree IPXXB": What is defined in Attachment 1, "Protection from Direct Contact with Live Parts of Power System."

2.12 "Exposed Conductive Part": Among the conductive parts which normally are not electrically energized but may become so under isolation failure conditions ("potential conductive parts"), are those which can be easily touched without using tools. In such a case, whether the part can be easily touched or not is judged based on whether the part has a structure of protection degree IPXXB.

2.13 "Isolation Resistance": Isolation between the live parts of the power system and exposed conductive parts that can be touched and isolation between the live parts of the power system and electrical chassis.

2.14 "Residual Voltage": The voltage between (Vb) the positive side (V2) and the negative side (V1) of a high-voltage bus prescribed in Attachment 3 (on a vehicle with an automatic disconnect, the electric circuit on the side of the traction motor) and the electrical chassis; and the voltage between the 3 positive side (V2) and the negative side (V1) of a high-voltage bus (on a vehicle with an automatic disconnect, the electric circuit on the side of the traction motor), measured between 5 and 60 seconds after a collision.

2.15 "Residual Energy": The energy present in the high-voltage parts of the power system measured between 5 and 60 seconds after a collision.

2.16 "Electrical Circuit": An assembly of connected live parts of the power system which is designed to be electrically energized in normal operation.

2.17 "High-Voltage Bus": The electric circuit, including the coupling system for charging the REESS, that operates on a high voltage.

2.18 "Electrical Circuit on the REESS Side": The part of the power system electric circuits, disconnected by the automatic disconnect, which includes the coupling system for charging the REESS.

2.19 "Electrical Circuit on the side of the Traction Motor": The part of the power system electric circuits disconnected by the automatic disconnect which includes the traction motor.

2.20 "Automatic Disconnect": A device that, when sensing an impact from a collision, separates the REESS side circuits from the traction motor side circuits.

2.21 "Electrical Chassis": A set made of conductive parts electrically linked together, whose electrical potential is taken as a reference.

2.22 "Electrical Energy Convergence System": A system (e.g. fuel cell) that generates and provides electrical energy for electrical propulsion.

2.23 "Electrical Protection Barrier": The part protecting direct contact, from any direction, with the high-voltage live parts.

2.24 "Enclosure": The part enclosing the internal units and providing protection against contact from any direction.

2.25 "Open Type Traction Battery": A type of battery requiring liquid and generating hydrogen gas released to the atmosphere.

3 OEM PRE-TEST INFORMATION / TEST PREPARATION

To achieve the safe and timely testing of vehicles the following items and information should be provided (at the latest upon vehicle delivery to the lab) by the OEM completing the HV vehicle questionnaire (Appendix 1) covering the following:

- The location of the service plug (if applicable).
- Diagram/drawing/photos and guidelines to show the location of the HV connection*.
- The minimum State of Charge (SoC) of the Rechargeable Electrical Energy Storage System (REESS) to any state that allows the normal operation of the powertrain.
- Instructions on how to put the vehicle in the correct state to be tested (restraint system deploys as normal as it would on the road, ADL, eCall, etc functioning “as normal”).
- Pre & Post test: Instructions on how to move the vehicle in order not to damage the HV system (for Pre) and not to create additional risk (for Post).

**If possible, break-out leads from HV and relevant adaptors to DAU may be fitted by OEM personnel at the test lab during the vehicle crash preparation phase (ideally one week in advance from the crash test date).*

4 TEST CONDITIONS

4.1 TEST VEHICLE CONDITIONS

4.1.1 RECHARGEABLE ENERGY STORAGE SYSTEM (REESS)

The rechargeable energy storage system (REESS) shall be charged to its normal state of operation prescribed by the manufacturer, etc. Furthermore, if the REESS is an open-type traction battery that is open to the atmosphere and needs water refilling, it shall be filled with electrolytes to the prescribed maximum amount.

4.1.2 ELECTRONIC CONVERTER

The vehicle shall be subjected to a collision test with the electronic converter turned off, the working principle of the electronic converter having been clearly presented. To do so, other than turning the electronic converter off, necessary modifications may be added such as modification of software programs.

4.1.3 AUTOMATIC DISCONNECT

The automatic disconnect shall operate normally upon collision; provided, however, that, in conducting the test, if ASEAN NCAP finds that the operating conditions of the automatic disconnect prescribed by the manufacturer are not satisfied, the test may be conducted with the electric circuit on the REESS side disconnected from the electric circuit on the side of the traction motor.

4.2 PRELIMINARY PREPARATIONS

4.2.1 INDICATOR LAMP CONFIRMING THE OPERATION OF THE AUTOMATIC DISCONNECT

A lamp allowing the state of operation of the automatic disconnect to be confirmed from outside the vehicle shall be provided at a conspicuous location on the side rear part of the vehicle to be tested; provided, however, that this shall not apply when the state of operation of the automatic disconnect can be confirmed easily with an operation indicator lamp provided inside the compartment.

4.2.2 REQUIREMENTS FOR PROTECTION FROM ELECTRIC SHOCK

Before conducting the test, the testing service shall make the preparations prescribed in paragraph 4.2.2.1; provided, however, that when offered by the manufacturer, the preparations prescribed in paragraphs 4.2.2.2 to 4.2.2.4 shall be made.

4.2.2.1 Preparing for Measuring Indirect Contact

4.2.2.1.1 Points for measuring the resistance between conductive parts (except for the coupling system for the charging system) and the electrical chassis shall be determined. Necessary modifications may be made as appropriate so that resistance can be measured easily after the test.

4.2.2.1.2 The value of resistance shall be measured between the measurement points determined above and recorded in Appendix 2.

4.2.2.2 Preparing for Measuring Isolation Resistance

4.2.2.2.1 The points for measuring the isolation resistance between the live part of the power system (except for the coupling system for the charging system) and exposed conductive parts that might come into contact with the test probe, and between the live part of the power system and the electrical chassis, shall be determined. Modifications may be made as appropriate so that resistance can be measured easily after the test.

4.2.2.2.2 The value of isolation resistance shall be measured between the measurement points 5 determined above and recorded in Appendix 2.

4.2.2.2.3 Stabilizing the Isolation Resistance
When the values measured above are found to be unstable due to the operation of the isolation resistance drop alarm, etc., modifications necessary for measurement may be made as needed by turning off or removing such devices. When removing such a device, it shall be demonstrated with drawings, etc. that such removal does not affect the isolation resistance between the live part of the power system and the electrical chassis.

4.2.2.3 Measuring the Residual Voltage

4.2.2.3.1 The points for measuring the voltage in the high-voltage bus shall be determined.

4.2.2.3.2 After consulting the manufacturer and ASEAN NCAP, a device shall be installed that allows the voltage in the high-voltage bus to be measured at any time and the results shall be recorded as necessary.

4.2.2.4 Measuring the Residual Energy

4.2.2.4.1 The points for measuring the residual energy inside the high-voltage parts of the power system in the high-voltage bus shall be determined.

4.2.2.4.2 After consulting the manufacturer and ASEAN NCAP, a device shall be installed that allows the voltage in the high-voltage bus to be measured at any time and the results shall be recorded as necessary.

4.2.3 ELECTRICAL PROTECTION BARRIERS AND ENCLOSURES

An appropriate paint shall be applied to the electrical protection barriers and enclosures to allow checking for the leakage of electrolytes from the rechargeable energy storage system (REESS) after a collision as necessary.

4.2.4 ELECTROLYTE AND OTHER AGGREGATES

Aggregates other than electrolytes (substitute liquids for oil, fuel, etc.) shall be colored so that they can be distinguished or separated from electrolytes as necessary.

5 RECORDING, MEASUREMENT ITEMS, AND MEASUREMENT RANGE

5.1 ACTIVATION OF AUTOMATIC DISCONNECT

After the collision test, whether the automatic disconnect was activated or not shall be checked and the result shall be recorded.

5.2 REQUIREMENTS FOR PROTECTION FROM ELECTRIC SHOCK

5.2.1 REQUIREMENTS REGARDING DIRECT CONTACT

After the collision test, it shall be checked whether the test probe came in direct contact with the live parts (except for the coupling system for the charging system) of the power system (except for the coupling system for the charging system) according to Attachment 1" Protection from Direct Contact with Live Parts of Power System, and the results shall be recorded; provided, however, that this shall not apply when protection from electric shock is checked as prescribed in paragraphs 5.2.4 and 5.2.5.

5.2.2 REQUIREMENTS REGARDING INDIRECT CONTACT

After the collision test, measurements shall be made of resistance between the conductive parts determined before the test and the electrical chassis, except for the coupling system for the charging system, and it shall be checked where the conductive parts are located (whether there are inside or outside the cabin) as well as whether they are exposed conductive parts or not, and the results shall be recorded.

5.2.3 REQUIREMENTS REGARDING ISOLATION RESISTANCE

If necessary from Paragraph 5.2.2, after the collision test, the isolation resistance between the live parts of the power system (except for the coupling system for the charging system) determined before the test and the exposed conductive parts that came into contact with the test probe, and between the live parts of the power system (except for the coupling system for the charging system) and the electrical chassis, except for the coupling system for the charging system, shall be measured according to Attachment 2: Measurement of Isolation Resistance, and the results shall be recorded.

5.2.4 REQUIREMENTS REGARDING RESIDUAL VOLTAGE

If necessary, from Paragraph 5.2.2, the maximum voltage shall be measured at a point in time between 5 seconds and 60 seconds after the collision and recorded. However, this excludes cases where protection from electric shock is confirmed as per Paragraph 5.2.1.

5.2.5 REQUIREMENTS REGARDING RESIDUAL ENERGY

If necessary, from Paragraph 5.2.2, the maximum energy shall be measured and recorded at a point in time between 5 seconds and 60 seconds after the collision. However, this excludes cases where protection from electric shock is confirmed as per Paragraph 5.2.1.

5.3 REQUIREMENTS REGARDING ELECTROLYTE LEAKAGE FROM THE RECHARGEABLE ENERGY STORAGE SYSTEM (REESS)

The state of electrolyte leakage from the rechargeable energy storage system (REESS) shall be checked and recorded. Furthermore, if the system is an open-type traction battery, this fact shall be recorded.

5.4 REQUIREMENTS REGARDING FIXATION OF THE RECHARGEABLE ENERGY STORAGE SYSTEM (REESS)

The state of fixation of the rechargeable energy storage system (REESS) shall be checked and recorded.

5.5 PHOTOGRAPHED DATA

Immediately after the test, characteristic parts of the rechargeable energy storage system (REESS) that are associated with its safety (e.g. fixation of the system) and their state shall be observed and recorded (photographs taken).

6 TREATMENTS OF MEASURED VALUES, ETC.

(1) The measured values of the exposed amount of electrolyte shall be rounded off to one decimal place in units of L.
(2) The resistance between the exposed conductive parts and the electrical chassis shall be rounded Off to four decimal places in units of Ω.

(3) The working voltage shall be rounded off to one decimal place in units of V.
(4) The isolation resistance for 1 V of working voltage shall be rounded off to three significant figures.
(5) The residual voltage shall be rounded off to one decimal place in units of V.
(6) The residual energy shall be rounded off to two decimal places in the module.

ASSESSMENT OF PREVENT ELECTRIC SHOCK PROTECTION AFTER COLLISION FOR ELECTRIC VEHICLES

(1) Assessment Procedure

(i) Electrical Shock Protection Performance

- Direct contact: Protection against live parts of power systems shall meet IP code IPXXB.
- Indirect contact: The value of resistance to the electric chassis connected to exposed conductive parts and the electrical chassis that is accessible shall be less than 0.1 Ω with a current of 0.2 A or higher.
- Insulation resistance: The operating voltage of an AC circuit and a circuit that includes an AC circuit shall be 500 Ω / V or higher.
- The operating voltage shall be 100 Ω / V or higher when satisfying the requirements of IP code IPXXB and when the voltage of AC parts is 30V or less.
- The operating voltage of a DC circuit shall be 100 Ω / V or higher.
- Residual voltage: Residual voltage of high-voltage parts as of 5 to 60 seconds after a collision shall be AC 30 V or less or DC 60 V or less.
- Residual energy: Energy of the high voltage parts of power systems as of 5 to 60 seconds after a collision shall be 2.0 J or less.

(ii) REESS Electrolyte Leakage Performance

- The electrolyte shall not leak into the passenger compartment.
- When there is electrolyte leakage to the outside of the passenger compartment, the amount of leakage in 30 minutes from the collision shall be 7% or less of the total electrolyte amount. However, for open-type traction batteries, the amount shall be 7% or less of the total electrolyte amount or 5 L or less.

(iii) REESS Anchorage Performance

- For the REESS inside the passenger compartment, it shall be anchored in a prescribed position.
- For the REESS outside the passenger compartment, it shall not penetrate into the passenger compartment.

(iv) Checking the Operation of Automatic Shutoff Device

- During a collision, the automatic shutoff device shall be activated, and the high voltage circuit shut off.

(2) Assessment Results

When the vehicle meets the requirements for electric shock protection performance, REESS electrolyte leakage performance, REESS anchorage performance, and operational check of the automatic shutoff device, a compliance label is given (Figure 1).

Figure 1

ATTACHMENT 1: PROTECTION FROM DIRECT CONTACT WITH LIVE PARTS OF POWER SYSTEM.

1. Overview

Protection degree IPXXB regarding direct contact with the live parts of the power system (excluding the coupling system for the charging system) is as defined in this Attachment. Further, this Attachment applies to power systems in which the working voltage is not more than 1000 V for AC and 1500 V for DC. Furthermore, for the purpose of this Attachment, besides the live parts of the power system prescribed in paragraph 2.7 of the main text, the parts prescribed in paragraphs 1.1 and 1.2 below are also regarded as live parts of the power system and judged as such.

1.1 The live parts of the power system that are coated with varnish or paint alone; provided, however, that this shall not apply to those that use varnish or paint for isolation.

1.2 The live parts of the power system that are protected by oxidization or similar treatment.

2. Testing Conditions

In principle, the test vehicle shall be in the state it was in immediately after the collision test.

2.1 Test Probe, etc.

2.1.1 The test probe to be used to check the protection degree is as prescribed in Table 1.

2.1.2 When checking the contact of the test probe with high-voltage live parts inside the electrical barriers, enclosures, etc. by a signal indication circuit method, a low-voltage power supply (of not less than 40 V and not more than 50 V) in series with a suitable lamp shall be connected between the test probe and high-voltage live parts.

2.1.3 Additionally, when a signal indication circuit method is used, the parts prescribed in paragraphs 1.1 and 1.2 above shall be covered with a conductive metallic film before the collision test and the metallic film shall be electrically connected to normal high-voltage live parts.

3. Test Method

3.1 Press the test probe against an opening of the electrical barriers, enclosures, etc. (meaning any gaps or openings in the electrical barriers, enclosures, etc. that are already present or that might be made when the test probe is pressed against them with the prescribed force) with the force prescribed in the "Test Force" column in Table 1.

3.2 If possible, the movable parts inside the enclosure should be moved slowly.

3.3 If the test probe partially or fully penetrates the opening, the probe shall be placed in every position that can be touched to check whether it can be touched or not (whether the lamp lights if the signal indicator lamp method is used; the same shall apply hereinafter in this Attachment). In such cases, starting from the straight position, both joints of the test finger shall be rotated progressively through an angle of 90 degrees concerning the axis of the adjoining section of the finger and placed in every possible position to check whether it can touch them.

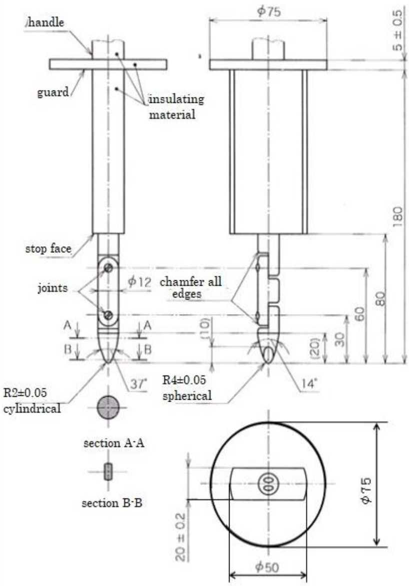
4. Criteria

4.1 The test probe shall not be able to contact high-voltage live parts.

4.2 The stop face of the test probe shall not be able to fully penetrate the electrical protection barriers or enclosures through any opening.

4.3 When checking for contact by the signal indicator circuit method, the lamp shall not light.

Table 1: Test Probe

	Test Probe	Test Force
When testing in relation to protection degree IPXXB	 Materials: Metal, except where otherwise specified. Linear dimensions in millimeters. Tolerances on dimensions without specific tolerance: On angles: +0' / -10' On linear dimensions: when <25mm: +0mm / -0.05mm when >25mm: ±0.2mm Both joints shall permit movement in the same plane and the same direction through an angle of 90 degrees with a 0 to +10 degrees tolerance.	10N±10%

ATTACHMENT 2: MEASUREMENT OF ISOLATION RESISTANCE

Isolation resistance is measured by choosing either the method prescribed in paragraph 1 or paragraph 2 below as appropriate depending on the state of electric charge or isolation resistance of the live parts to be measured.

The range of electric circuits to be measured shall be clarified by submitting circuit drawings, etc. to NASVA and the testing service in advance.

Additionally, modifications necessary for measuring the isolation resistance may be made as appropriate such as removing the cover, extracting measuring lines, and modifying software programs. When conducting the measurements, care shall be taken regarding the risk of short-circuiting and electric shock because the method involves directly handling high-voltage circuits.

1 Measuring by Applying Direct Current from Outside

1.1 Measuring Tools

To measure the isolation resistance, an isolation resistance tester that can apply a direct current higher than the working voltage of high-voltage circuits shall be used.

1.2 Measuring Method

1.2.1 Connect an isolation resistance tester between the live parts and the electrical chassis or exposed conductive parts and apply a direct current higher than the working voltage of the high-voltage circuits; provided, however, that if parts may be damaged by overvoltage during measurement because the external direct current is combined with the voltage of the rechargeable energy storage system (REESS) or the isolation resistance tester cannot apply an appropriate voltage due to its properties, etc., measurements may be taken at a voltage lower than the working voltage or by removing relevant parts.

1.2.2 If the measurement of the live parts of electric circuits to be measured shows that the requirement for isolation resistance is satisfied even taking the rechargeable energy storage system (REESS) into account or if the live parts to be measured are not charged, such measured values are regarded as values of isolation resistance. If the live parts to be measured are charged and the measured values do not satisfy the requirement for isolation resistance or the values of isolation resistance when the voltage of the REESS is taken into account do not satisfy the required isolation resistance, isolation resistance shall be measured by the method prescribed in paragraph 2.

2 Measurement Using Internal Power Supply for Direct Current

The isolation resistance between live parts (high-voltage bus) and the electrical chassis can be demonstrated either by measurement or by a combination of measurement and calculation.

2.1 When demonstrating isolation resistance by measurement, do the following:

2.1.1 Measure and record voltage (V_b) between the negative side and the positive side of the high-voltage bus. (See Fig.1 in Attachment 3.)

2.1.2 Measure and record voltage (V_1) between the negative side of the high-voltage bus and the electrical chassis. (See Fig. 1 in Attachment 3.)

2.1.3 Measure and record voltage (V_2) between the positive side of the high-voltage bus and the electrical chassis. (See Fig. 1 in Attachment 3.)

2.1.4 If V_1 is greater than or equal to V_2

2.1.4.1 Insert a standard known resistance (R_o) between the negative side of the high-voltage bus and the electrical chassis. With R_o installed, measure the voltage (V_1') between the negative side of the high-voltage bus and the vehicle electrical chassis (see Fig. 1). Calculate the isolation resistance (R_i) using the formula:

$$R_i = R_o \times (V_b/V_1' - V_b/V_1) \text{ or } R_i = R_o \times V_b \times (1/V_1' - 1/V_1)$$

2.1.4.2 Divide the result R_i, which is the electrical isolation resistance value in units of Ω, by the working voltage of the high-voltage bus in units of volt (V).

$$Ri\ (\Omega / V) = Ri\ (\Omega) \,/\, \text{Working Voltage}(V)$$

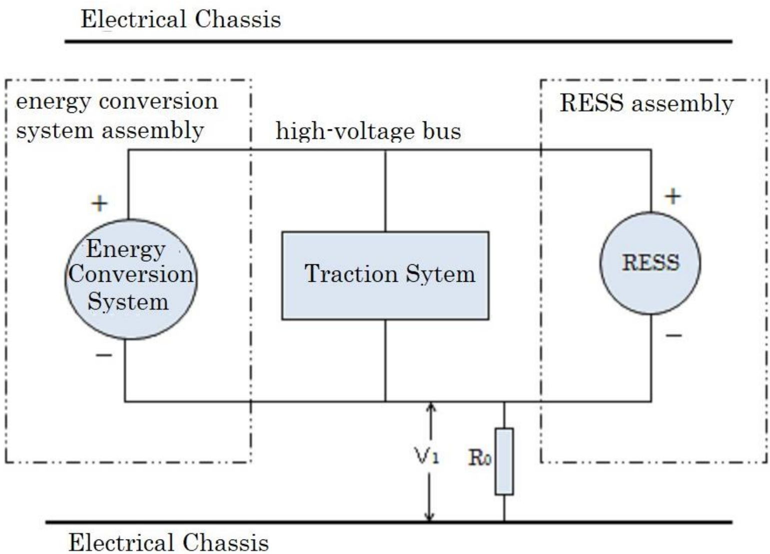


Figure 1: (Measurement of V_1')

2.1.5 If V2 is greater than V1

2.1.5.1 Insert a standard known resistance (R_o) between the positive side of the high-voltage bus and the electrical chassis. With Ro installed, measure the voltage (V_2') between the positive side of the high-voltage bus and the vehicle's electrical chassis (see Fig. 2).
Calculate the isolation resistance (R_i) using the formula:

$$R_i = R_o \times (V_b/V_2' – V_b/V_2) \text{ or } R_i = R_o \times V_b \times (1/V_2' – 1/V_2)$$

2.1.5.2 Divide the result Ri, which is the electrical isolation resistance value in units of Ω, by the working voltage of the high-voltage bus in units of volt (V).

$$R_i\ (\Omega / V) = R_i\ (\Omega)\ /\ \text{Working Voltage(V)}$$

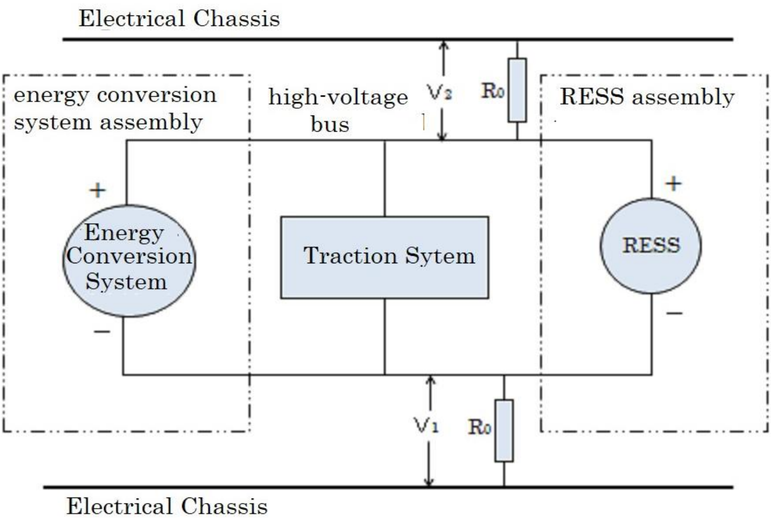


Figure 2: (Measurement of V_2’)

Note 1: Standard known resistance R_o (in units of Ω) is the value obtained by multiplying the minimum value of the required isolation resistance by the working voltage of the vehicle (in units of Ω /V) ±20%. Since this equation is valid for any R_o, R_o does not have to be strictly this value, but this range of R_o value provides a good resolution for voltage measurement.

ATTACHMENT 3: MEASUREMENT OF RESIDUAL VOLTAGE

After the collision test, measure the voltages of the high-voltage bus (V_b, V_1, V_2) (see Fig. 1). Voltage is measured at a point in time between 5 seconds and 60 seconds after the collision.

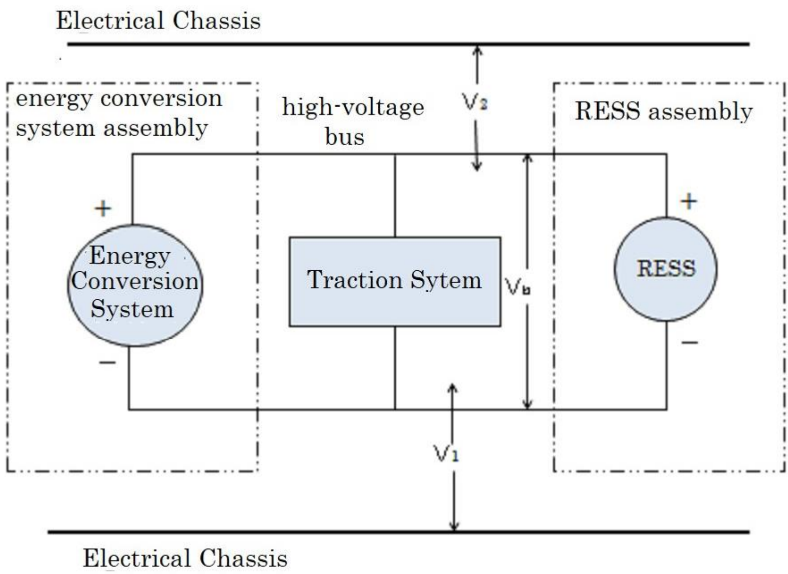


Figure 1: (Measurements of Vb, V1, and V2)

ATTACHMENT 4: MEASURING RESIDUAL ENERGY

Before conducting the collision test, connect switch S_1 and a known discharge resistance R_e with an appropriate capacitance in parallel (see Fig. 1).

Close the switch S_1 at a point in time between 5 seconds and 60 seconds after the collision and measure and record voltage V_b and current I_e. Integrate the product of the voltage V_b and current I_e over the time elapsed between the moment switch S_1 is closed (t_c) and the moment voltage V_b falls below the high-voltage threshold 60 V DC (t_h).

The result of this integration represents total energy (TE) expressed in units of Joule.

$$TE = \int_{tc}^{th} V_b \times \ I_e dt$$

When V_b is measured at a point in time between 5 seconds and 60 seconds after the collision and the capacitance of condenser X (C_x) is prescribed by the manufacturer, the total energy (TE) is calculated by the following formula:

$$TE = 0.5 \times C_x \times (V_b^2 - 3{,}600)$$

When V_1 and V_2 (see Fig. 1 in Attachment 3) are measured at a point in time between 5 seconds and 60 seconds after the collision and the capacitance of condenser Y (C_{y1}, C_{y2}) is prescribed by the manufacturer, the total energy (TE_{y1}, TE_{y2}) is calculated by the following formula:

$$TE_{y1} = 0.5 \times C_{y1} \times (V_1^2 - 3{,}600)$$
$$TE_{y2} = 0.5 \times C_{y2} \times (V_2^2 - 3{,}600)$$

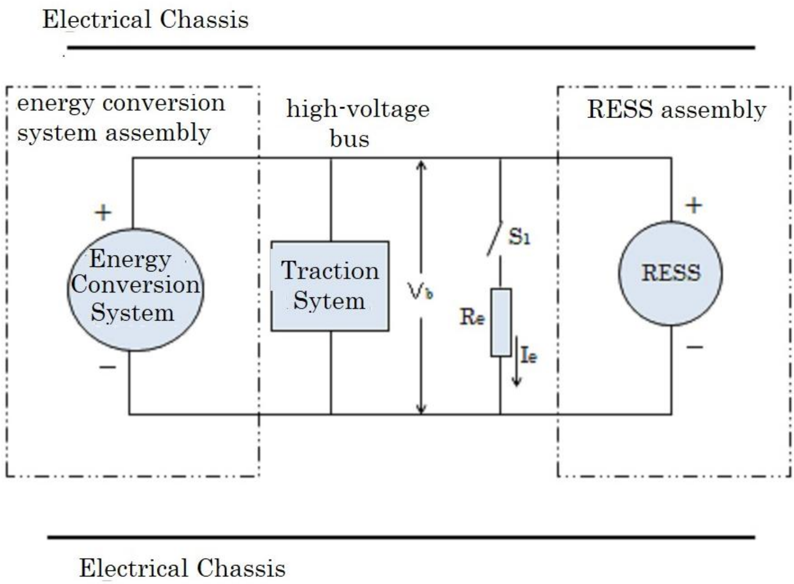


Figure 1: (Example: Measurement of high-voltage bus energy stored in condenser X)

APPENDIX 1: TEST VEHICLE DATA SHEET

[To be filled in by the vehicle manufacturer]

1. Principal Specifications

Vehicle name/model (type)		/ ( )
Engine Type	ICE	
	Electric	
REESS type and electrolyte capacity		
Presence or absence of automatic disconnect and condition of activation.		

2. Power Specifications

Relevant power system components		
Power system layout chart		
Power system components*1	Traction motor	
	REESS *2	
	Electric energy conversion system	
	Electrical converter	

	Auxiliaries for running	
	Coupling system for charging system	
	Other	

[*1] *Indicate respective locations (e.g., inside/outside the cabin) and attach drawings and photographs. Additionally, specify where to check for protection from electric shock.*
[*2] *Indicate where they are fixed and the method of fixation.*

3. Documents on the Installation of an Operation Indicator Lamp for Automatic Disconnect
(Indicate the principle of operation and method of installation of the indicator lamp (electric circuits, sketches, etc.)).

4. Documents on Testing Methods
(Indicate how you chose the method for checking electric shock preventive performance and how you conducted the test by the method selected.)

5. Document on Safety Precautions Taken
(Indicate precautions to be taken for the safety of work by the testing laboratory.)

APPENDIX 2: TEST RESULT RECORDING FORMS

[To be filled in by the testing laboratory]

Vehicle's name/model (type)		/ ( )
Chassis Number		
Engine Type	ICE	
	Electric	
REESS type and electrolyte capacity		
Presence or absence of automatic disconnect and condition of activation		

1. Activation of automatic disconnect

Activation of automatic disconnect	

2. Requirements for protection from electric shock

2.1 Requirements for protection from direct contact

Equipment Name	Inside or Outside the Vehicle	State of live parts	
		Before Test	After Test
	Inside / Outside	Pass / Fail	Pass / Fail
	Inside / Outside	Pass / Fail	Pass / Fail
	Inside / Outside	Pass / Fail	Pass / Fail

2.2 Requirements for protection from indirect contact

Equipment Name	Inside or Outside the Vehicle	Conductive parts: Exposed/ Nonexposed	Resistance Value (Measured)	
			Before Test	After Test
	Inside / Outside		Ω	Ω
	Inside / Outside		Ω	Ω
	Inside / Outside		Ω	Ω

2.3 Isolation Resistance

Equipment Name	Inside or Outside the Vehicle	AC/DC	Compliance with requirements for protection from direct contact	Isolation Resistance	
				Before Test	After Test
	Inside Outside	AC / DC	Pass / Fail	Ω/V	Ω/V
	Inside Outside	AC / DC	Pass / Fail	Ω/V	Ω/V
	Inside Outside	AC / DC	Pass / Fail	Ω/V	Ω/V

2.4 Residual Voltage Requirements

Equipment Name	AC/DC	Residual Voltage (Measured)
	AC/DC	V
	AC/DC	V

2.5 Residual Energy Requirements

Equipment Name	Total Energy (measured or calculated value)
	Joules
	Joules

3. Requirements Regarding Electrolyte Leakage from REESS

Electrolyte leakage inside cabin	Yes / No
Electrolyte leakage outside cabin	Yes / No (if yes, in ______ℓ)

4 .Requirements Regarding Fixation of REESS

REESS inside vehicle	State of fixation	Fixed / Movement observed
REESS outside vehicle	State of fixation	Fixed / Movement observed ( )

*If the REESS outside the compartment has been moved, indicate where it moved to.

5. Other (special notes)

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ASEAN NCAP **PROTOCOL**

2026–2030

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