



BSI Standards Publication

**Light motorized vehicles for the transportation
of persons and goods and related facilities
and not subject to type-approval for on-
road use - Personal light electric vehicles
(PLEV) - Requirements and test methods**

National foreword

This British Standard is the UK implementation of EN 17128:2020.

BSI, as a member of CEN, is obliged to publish EN 17128:2020 as a British Standard. However, attention is drawn to the fact that during the development of this European Standard, the UK committee voted against its approval.

The UK committee voted against EN 17128:2020 because of concerns that it does not seek to improve safety. In particular, the committee is concerned that certain criteria introduced into the standard are unsuitable and do not cover many state-of-the-art systems available in the marketplace. The committee recommended changes to those clauses it considered to be inconsistent with the rest of the standard.

Specifically, the UK committee is of the following opinions regarding Subclause 10.1:

- In addition to the standards mentioned in paragraph 3, battery charging systems are also recommended to be in accordance with:
 - BS EN IEC 61558-1:2019 *Safety of transformers, reactors, power supply units and combinations thereof - Part 1: General requirements and tests* (and all BS EN 61558 Part 2 standards that cover battery charging)

or

- BS EN IEC 62368-1:2020+A11:2020 *Audio/video, information and communication technology equipment – Part 1: Safety requirements.*
- As the BS EN 50272 series has been withdrawn and superseded by the BS EN IEC 62485 series, the text at the start of paragraph 3 should read 'Battery charging systems shall be in accordance with EN IEC 62485 series'.
- In addition to the standards mentioned in paragraph 6, voltage between charging contacts is also recommended to conform to BS EN 61558-1:2005+A1:2009 and BS EN 62368-1:2014+A11:2017 according to the application and/or environment of the charging systems.
- The reference in paragraph 6 to BS EN 61140:2016 *Protection against electric shock – Common aspects for installation and equipment* is unnecessary because protection against electric shock is adequately covered by the other standards referenced in the subclause.

Furthermore, it is the UK committee's opinion that there are deficiencies in Subclause 10.1 regarding information about the power supply used to charge batteries in Personal light electric vehicles (PLEV). As additional points of clarification, the UK committee advises users that:

- PLEV covered by this standard are normally powered by lithium-ion batteries, which are normally charged from a power supply, not a battery charger.
- BS EN 60335-2-29:2004+A11:2018 *Household and similar electrical appliances – Safety – Part 2-29: Particular requirements for battery chargers* provides information on safety requirements for battery chargers, which is important for users to note as some PLEV may contain secondary cells other than lithium-ion.

- The safety requirements for protecting a battery from overcharging are achieved by the battery pack electronics, not the charger.

The UK committee also advises users that:

- It is illegal to use PLEV on UK public roads, footpaths, pavements or cycle tracks, unless users are licenced to do so.
- The requirements of BS EN 17128:2020 do not replace any legal road requirements in the UK regarding the use of PLEV.

The UK participation in its preparation was entrusted to Technical Committee AGE/6/2, Single track two wheeled motor vehicles/All-Terrain Vehicles (ATVs - Quads).

A list of organizations represented on this committee can be obtained on request to its committee manager.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020
Published by BSI Standards Limited 2020

ISBN 978 0 539 15928 8

ICS 43.120

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 October 2020.

Amendments/corrigenda issued since publication

Date	Text affected
30 November 2020	Inclusion of missing images in Annex E

English Version

Light motorized vehicles for the transportation of persons
and goods and related facilities and not subject to type-
approval for on-road use - Personal light electric vehicles
(PLEV) - Requirements and test methods

Véhicules légers motorisés pour le transport de
personnes et de marchandises, non homologables pour
l'utilisation sur la route, ainsi que les installations
d'utilisation - Véhicules électriques personnels légers
(PLEV) - Exigences de sécurité et méthodes d'essai

Nicht-typzugelassene leicht motorisierte Fahrzeuge für
den Transport von Personen und Gütern und damit
verbundene Einrichtungen - Persönliche leichte
Elektrofahrzeuge (PLEV) - Sicherheitstechnische
Anforderungen und Prüfverfahren

This European Standard was approved by CEN on 17 August 2020.

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European foreword

This document (EN 17128:2020) has been prepared by Technical Committee CEN/TC 354 “Light motorized vehicles for the transportation of persons and goods and related facilities and not subject to type-approval for on-road use”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2021, and conflicting national standards shall be withdrawn at the latest by April 2021.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This document has been developed in response to an increased demand throughout Europe for light electrically powered vehicles of a type which are excluded from the scope of Regulation (EU) No 168/2013.

This has created the possibility to initiate a European standardization work for personal light electric vehicles. Such standardization will help manufacturers to ensure that safe products are put into the European market, will give to testing institutes common guidelines to assess the products, will initiate confidence to users and also be useful to convince member states to apply harmonized rules for the use of these vehicles with the aim decrease uncertainty due to different national regulation.

This document will not deal with topics like comfort of the user, quality of the product or ergonomic issues unless there is an impact on the safety of the user.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

- machine manufacturers (small, medium and large enterprises);
- health and safety bodies (regulators, accident prevention organizations, market surveillance etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

- machine users/employers (small, medium and large enterprises);
- machine users/employees (e.g. trade unions, organizations for people with special needs);
- service providers, e.g. for maintenance (small, medium and large enterprises);
- consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

The machinery concerned and the extent to which hazards, hazardous situations or hazardous events are covered are indicated in the Scope of this document.

When requirements of this type-C standard are different from those which are stated in type-A or type-B standards, the requirements of this type-C standard take precedence over the requirements of the other standards for machines that have been designed and built according to the requirements of this type-C standard.

1 Scope

This document applies to personal light electric vehicles totally or partially electrically powered from self-contained power sources with or without self-balancing system, with exception of vehicles intended for hire from unattended station.

This document applies to personal light electric vehicles with or without self-balancing system totally or partially electrically powered from self-contained power sources having battery voltages up to 100 VDC, with or without an integrated battery charger with up to a 240 VAC input. This document specifies safety requirements, test methods, marking and information relating to personal light electric vehicles to reduce the risk of injuries to both third parties and the user during intended use, i.e. when used as intended and under conditions of misuse that are reasonably foreseeable by the manufacturer.

This document does not apply to:

- vehicles that are considered as toys;
- vehicles without self-balancing system with a seat;
- vehicles intended for competition;
- electrically powered assisted cycles (EPAC);
- vehicles and/or devices intend for use for medical care;
- electric vehicles having a maximum design speed above 25 Km/h;
- vehicles having a rated voltage of more than 100 VDC or 240 VAC;
- vehicles without an on-board driving operator.

NOTE 1 EN ISO 13482 gives the requirements for vehicles without on-board driving operator.

NOTE 2 See D.2.

NOTE 3 The local regulation could limit the use of the vehicle to a speed lower than 25 km/h.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 3744:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane (ISO 3744:2010)*

EN 22248:1992, *Packaging — Complete, filled transport packages — Vertical impact test by dropping (ISO 2248:1985)*

EN IEC 55012:—¹, *Vehicles, boats and internal combustion engines — Radio disturbance characteristics — Limits and methods of measurement for the protection of off-board receivers (CISPR 12)*

¹ Under preparation. Stage at the time of publication: FprEN IEC 55012:2018.

EN 55025:2017, *Vehicles, boats and internal combustion engines — Radio disturbance characteristics — Limits and methods of measurement for the protection of on-board receivers (CISPR 25)*

EN 60068-2-64:2008, *Environmental testing — Part 2-64: Tests — Test Fh: Vibration, broadband random and guidance (IEC 60068-2-64)*

EN 60068-2-75:2014, *Environmental testing — Part 2-75: Tests — Test Eh: Hammer tests (IEC 60068-2-75)*

EN 60335-1:2012, *Household and similar electrical appliances — Safety — Part 1: General requirements (IEC 60335-1:2010)*

EN 60335-2-29:2004, *Household and similar electrical appliances — Safety — Part 2-29: Particular requirements for battery chargers (IEC 60335-2-29)*

HD 60364-5-52:2011, *Low-voltage electrical installations — Part 5-52: Selection and erection of electrical equipment — Wiring systems*

EN 60384-14:2013, *Fixed capacitors for use in electronic equipment — Part 14: Sectional specification — Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

EN 61000-4-2:2009, *Electromagnetic compatibility (EMC) — Part 4-2: Testing and measurement techniques — Electrostatic discharge immunity test (IEC 61000-4-2)*

EN IEC 61000-6-1:2019, *Electromagnetic compatibility (EMC) — Part 6-1: Generic standards — Immunity for residential, commercial and light-industrial environments (IEC 61000-6-1)*

EN 61000-6-3:2007, *Electromagnetic compatibility (EMC) — Part 6-3: Generic standards — Emission standard for residential, commercial and light-industrial environments (IEC 61000-6-3)*

EN 61140:2016, *Protection against electric shock — Common aspects for installation and equipment*

EN 61558-1:2005, *Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests*

EN 61558-2-16:2009, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V — Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units*

EN 61851:2001 (all parts), *Electric vehicle conductive charging system (IEC 61851)*

EN 60204-1:2018, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1)*

EN 62133 (all parts), *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications (IEC 62133)*

ISO 6742-1:2015, *Cycles — Lighting and retro-reflective devices — Part 1: Lighting and light signalling devices*

ISO 6742-2:2015, *Cycles — Lighting and retro-reflective devices — Part 2: Retro-reflective devices*

ISO 14878:2015, *Cycles — Audible warning devices — Technical specification and test methods*

EN IEC 62485 (all parts), *Safety requirements for secondary batteries and battery installations (IEC 62485)*

ISO 11451-1, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

ISO 11452-1:2015, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 1: General principles and terminology*

ISO 11452-2:2019, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Absorber-lined shielded enclosure*

ISO 11452-3:2016, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 3: Transverse electromagnetic (TEM) cell*

ISO 11452-4:2020, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 4: Harness excitation methods*

ISO 11452-5:2002, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 5: Stripline*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

public space

place that is accessible to the public whether it is in the public domain or privately owned

Note 1 to entry: Examples are roads, cycle tracks, sidewalks, public squares, parks, stations, airports...

3.2

private space

place that is not accessible to the public

Note 1 to entry: Enclosed or fenced area.

3.3

driving power

electric power enabling the vehicle to move

3.4

personal light electric vehicle

PLEV

wheeled vehicle partially or totally motorized used for the transportation of one person in a public and/or private space

Note 1 to entry: For the purpose of this standard the word “vehicle(s)” is used.

3.5

self-balancing vehicle

inherently instable vehicle that dynamically stabilizes in at least one direction (pitch) itself using a control system

Note 1 to entry: PLEV can be stable without the action of the user or a control system can provide a self-balancing function.

Note 2 to entry: Self-balancing PLEV oscillates slightly in order to maintain its balance.

Note 3 to entry: User controls its direction and speed by shifting his centre of gravity, without using any traditional device such as handle, steering, brake pedal, etc.

Note 4 to entry: Self-balancing vehicle controlled using inverted pendulum model is already in the market.

3.6

intended use

supposed use according to the manufacturer's specification, instructions and other information including communication

3.7**fully-assembled vehicle**

vehicle fitted with all of the equipment required for its intended use

3.8**direct braking system**

system actuated directly by the user (for example, a brake handle or a brake pedal)

3.9**indirect braking system**

system actuated without voluntary action by the user (for example, braking activated by a gyroscopic system or through the detection of obstacles/anomalies)

3.10**parking device**

device to maintain the vehicle in a stationary position

3.11**braking device**

device to reduce the speed of the vehicle

3.12**locking mechanism**

assembly of components consisting of one or more *locking device(s)* and *one or more operating device(s)*

3.13**locking device**

mechanical component that maintains part(s) of the vehicle erected in the position of use or storage (e.g. latch(es), hooks, over centre lock...) which could be deactivated or activated by action(s) on the *operating device*

3.14**operating device**

part of the *locking mechanism(s)* designed to be activated by the user through one or several positive action(s)

3.15**folding or unfolding system**

mechanism enabling the vehicle to be folded or unfolded in order to change from the configuration of use (unfolded) to the configuration of storage (folded) and vice versa

3.16**no-load current**

current for which there is no torque on the driving wheel

3.17**electromagnetic compatibility**

ability of a vehicle or one of its electrical/electronic systems to function satisfactorily in its electromagnetic environment without producing intolerable electromagnetic disturbance to anything in that environment

3.18

electromagnetic disturbance

electromagnetic phenomenon which may degrade the performance of a vehicle or one of its electronic/electrical systems

EXAMPLE An electromagnetic disturbance is for example an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

[SOURCE: EN 15194:2017, 3.10]

3.19

electromagnetic environment

all electromagnetic phenomena existing in a given point

3.20

reference limit

nominal level to which both the component type-approval of the vehicle and conformity of production limit value refer

3.21

electrical/electronic subassembly

ESA

electrical and/or electronic device or assembly of such units intended, together with all electrical connections and the associated wiring, to form an integral part of a vehicle and perform several specialized functions

3.22

rated voltage

voltage declared by the manufacturer of the vehicle

3.23

continuous rated power

continuous (or constant) output power specified by the manufacturer at which the motor reaches its thermal equilibrium under given ambient conditions

Note 1 to entry: Thermal equilibrium: the temperature variation of the motor's parts does not exceed 2K per hour.

3.24

integrated charger

charger forming an integral part of the vehicle and the dismantling of which requires the use of tools

3.25

suspension frame

frame incorporating controlled, vertical flexibility to reduce the transmission of road-shocks to the user

[SOURCE: EN ISO 4210-1:2014, 2.47 modified: "user" instead of "rider"]

3.26

braking distance

distance travelled by a vehicle between the commencement of braking and the point at which it comes to rest

[SOURCE: EN ISO 4210-1:2014, 2.10 modified: "vehicle" instead of "bicycle"]

3.27**commencement of braking**

point on the test track or test machine at which the brake-actuating mechanism, operated directly by the user's hand or foot or by a test device, starts to move from its rest position

[SOURCE: EN ISO 4210-1:2014, 2.10 modified: “mechanism” instead of “device”, “user” instead of “rider”, Note 1 deleted]

3.28**braking force**

tangential rearward force between the tyre and the ground or the tyre and the drum or belt of the test machine

3.29**visible crack**

crack which results from a test where that crack is visible to the naked eye

3.30**fracture**

unintentional separation into two or more parts

3.31**wheel**

assembly or combination of hub, spokes or disc, and rim, but excluding the tyre

3.32**brake**

parts of the braking system where the forces opposing the movement of the vehicle are developed

3.33**brake system**

combination of parts consisting of the control, transmission, and brake, whose function it is to progressively reduce the speed of a moving vehicle, bring it to a halt, and keep it stationary when halted, the electric motor can be a part of the system

3.34**service brake system**

brake system which is used for slowing the vehicle when in motion

3.35**Technical Permissible Maximum Mass****TPMM**

sum of the mass of the vehicle in running order and the maximum payload (user, cargo, etc.) as indicated by the manufacturer

3.36**mass in running order**

unladen mass to which the mass of the following components are added

- all standard (removable) batteries as used for normal operation and indicated in the owner's manual,
- additional equipment installed in or fitted to the vehicle by the manufacturer in addition to that needed for normal operation (tool kit, luggage carrier, windscreen, protective equipment, etc.)

3.37

partially electrically powered vehicle

vehicle that needs to be pushed forward by human power to start, to accelerate and/or keep running in addition to the electric power

3.38

all wheel integrated braking system

brake system where the brakes on all wheels are operated by the actuation of a single control

3.39

acceleration controlled braking system

brake system to decelerate the PLEV by means of combination of wheel acceleration and deceleration, which detect and control the attitude of the whole PLEV system including the user

Note 1 to entry: For vehicles class 3 and 4, the abovementioned brakes are controlled brakes for stop category 1 or 2.

Note 2 to entry: Stop categories are specified in EN 60204-1:2018, 9.2.2.

3.40

deck

platform supporting the mass of the user standing during use

3.41

footrest

surface provided to support the feet during a seating intended use

3.42

pedestrian mode

speed limit of the vehicle up to 6 km/h

3.43

overspeed

over than 10 % of the maximum designed speed

3.44

overheat

temperature defined by the manufacturer as a threshold beyond which the operating functions are impaired

3.45

insufficient battery power

below the minimum level defined by the manufacturer

3.46

normal operation

functional part of the PLEV, with a fully charged battery is operated in such a way to simulate the riding position and is operated

Note 1 to entry: The appliance is loaded with a minimum mass of 100 kg or the maximum load specified in the instructions, whichever is higher. The motors are loaded to 66 % of their locked rotor current by adjusting the load on its rotational axis in the forward direction.

4 Classes of vehicles

Various personal light electric vehicles (vehicles) exist covering as many different uses offered to different users based on their age, mass, size and driving experience.

The main classes of vehicle are defined below combined with the main design choices that characterize them.

Table 1 — Classes of vehicle (Design elements)

Classes	With self-balanced system	Maximum design speed (km/h)	Seating position
Class 1	No	Up to 6 km/h	No
Class 2	No	Up to 25 km/h	No
Class 3	Yes	Up to 6 km/h	with or without
Class 4	Yes	Up to 25 km/h	with or without

NOTE Examples of vehicles are given in Annex E.

5 General safety requirements and protective measures

Vehicle shall comply with the specific requirements of all clauses of this standard.

NOTE Annex A shows the list of hazards considered this document.

For vehicles which are not sold fully assembled, there shall be a maximum of three separate parts requiring assembly (e.g. steering device, wheels and batteries), the necessary tools and detailed assembly instructions shall be provided which specify by a text and diagrams the operations to be carried out as well as the clamping force.

6 Electrical components

6.1 General mechanical strength

The ESA including the battery shall have adequate mechanical strength and be constructed to withstand such rough handling that may be expected in intended use and foreseeable misuse.

Compliance is checked by:

- Applying impacts to the enclosures of ESA mounted on the vehicles by means of the spring hammer as specified in EN 60068-2-75:2014. The ESA is rigidly supported and three impacts are applied to every point of the enclosure that is likely to be weak with an impact energy of $(0,7 \pm 0,05)$ J.
- Detachable ESA are submitted to free fall on a rigid surface as specified in EN 22248:1992 at a height of 0,90 m in three different positions. The positions shall be one surface, one edge and one corner of the enclosure that are likely to be the most onerous position.

After the test the ESA shall show no damage that could lead to emission of dangerous substances (gas or liquid) ignition, fire or overheating. A temperature rise test shall be performed, in accordance with 6.3.2.2, During the test, the temperature rises are monitored continuously and shall not exceed the values shown in EN 60335-1:2012, Table 3 and after the test the ESA shall show no damage or malfunction that could impair the safe use of the vehicles.

Batteries and other electric conductive power supply systems shall be assessed and tested in accordance with EN 62133-1:2017 and EN 62133-2:2017 or other relevant standards.

NOTE Transportation regulations can give additional requirements for general design of the battery and battery pack.

6.2 Electrical power on/off control

An electrical power on/off control shall be fitted to on and power-off the driving power. It shall be apparent, easy to reach and unmistakable. This electrical power on/off control shall be activated voluntarily by the user to enable the driving power.

The electrical power on/off system shall be designed such that, in the event of a malfunction, the vehicle shall still be able to stop or be able to be stopped with a smooth deceleration (as defined in 15.4.2.5 Electric failure braking compensation).

The electrical power on/off system shall be located in a position easily reachable by the user with appropriate symbol given in Annex F.

On self-balancing vehicles or vehicles with electric brake, the power -off control shall not disconnect the power while driving: the power -off control shall only work without user on the vehicle.

NOTE The electrical power on/off system is a mechanical solution (key-lock, button, etc.) or an electrical solution (user detection, turn off timer, etc.).

6.3 Electrical cables and connections

6.3.1 General

All electrical connectors shall be selected to prevent the corrosion..

6.3.2 Cable and plugs

6.3.2.1 Requirements

After the test according to 6.3.2.2, there shall be no deterioration of the insulation on either assembly.

The cable cross sections shall be selected in accordance with EN 61558-1:2005, EN 61558-2-16:2009, EN 60335-1:2012, EN 60335-2-29:2004, Table 11 or a temperature rise test shall be performed, in accordance with 6.3.2.2 the temperature of the cables and plugs in use shall be at least 5 °C lower than the maximum specified by the manufacturer.

NOTE 1 Cable used only for communication line is excluded.

NOTE 2 the rated current (accordance with EN 61558-1:2005, EN 61558-2-16:2009, EN 60335-1:2012, EN 60335-2-29:2004 Table 11) measured when the vehicle is supplied at rated voltage and operated under normal operation.

6.3.2.2 Test method

At an ambient room temperature (20 ± 5) °C, discharge the fully charged vehicle battery to the discharging limit for the vehicle, and the vehicle is supplied at rated voltage and operated under normal operation:

— measure the cable and plug temperature rises.

6.3.3 Wiring

Wiring shall be checked according to the following sequence at an ambient room temperature (20 ± 5) °C.

- a) Wireway shall be smooth and free from sharp edges.
- b) Wires shall be protected so that they do not come into contact with burrs, cooling fins or similar sharp edges that may cause damage to their insulation.
- c) Holes in metal through which insulated wires pass shall have smooth well-rounded surfaces or be provided with bushings.
- d) Wires shall be effectively prevented from coming into contact with moving parts.

Compliance with a), b), c) and d) shall be checked by physical inspection.

- e) Separate parts of the vehicles that can move in normal use or during user maintenance relative to each other, shall not cause undue stress to electrical connections and internal conductors, including those providing earthing continuity.
- f) If an open coil spring is used to protect wire, it shall be correctly installed and insulated. Flexible metallic tubes shall not cause damage to the insulation of the conductors contained within them.

Compliance with e) f) shall be checked by inspection and by the following test method:

- 1) If flexing occurs in normal use, the product is placed in its normal operational position and is supplied at rated voltage under normal operation.
- 2) The movable part is moved from an extreme position to the opposite extreme position, so that the conductor undergoes maximum flexion.
- 3) For conductors that are flexed in normal use, flex movable part for 10 000 cycles at a test frequency of 0,5 Hz.
- 4) For conductors that are flexed during user maintenance, flex the movable part for 100 cycles at the same frequency.

6.3.4 Wiring harness

When a wiring harness is installed, it shall be positioned to avoid any damage related to contact with moving parts or sharp edges. All connections shall withstand a tensile force of 10 N in any direction.

6.3.5 Power cables and conduits

Conduit entries, cable entries and knockouts shall be constructed or located so that the introduction of the conduit or cable does not reduce the protection measures adopted by the manufacturer.

Compliance is checked by inspection.

NOTE Guidance for power cables size selection is given in HD 60364-5-52:2011, 5.22.1.2, 523.1523.3 and Table A 52-10.

The insulation of internal wiring shall withstand the electrical stress likely to occur in intended use. The wiring and its connections shall withstand an electrical strength test with the following characteristics.

The test voltage expressed in volts shall be equal to $(500 + 2 \times U_r)$ where U_r is the rated voltage. The test voltage is applied for 2 min between live parts and other metal parts only.

6.3.6 External and internal electrical connections

Electrical connection shall comply with HD 60364-5-52:2011, 526.1 and tested in accordance with HD 60364-5-52:2011, 526.2.

6.4 Moisture resistance

The enclosure of electrical components of a fully assembled vehicles shall comply with and be tested in accordance with IPX4 tested in accordance with EN 60335-1:2012, 15.1.

6.5 Resistance to vibration for electric functions

6.5.1 Requirements

This requirements applies to all PLEV classes 1 to 4.

The vehicle shall withstand a vibration test representing the foreseeable use on roads and public areas.

When tested according to the method described in 6.5.2, all electric functions shall be fully maintained. Verification shall be by function test after the vibration test.

6.5.2 Test method

A random vibration test in accordance with EN 60068-2-64:2008 shall be performed.

Install the vehicle to the shaker table so the input vibratory motion is perpendicular to the plane of movement of the vehicle (excitation in vertical axis).

The vehicle shall be fixed at the wheel axles, if necessary, the wheels can be removed. If a fixation at the wheel axles is not possible, the vehicle can be clamped at the deck (footrest) or frame. Any test fixture used shall be as rigid and symmetrical as practicable. The mounting method(s) used shall be noted in the test report.

When necessary to determine resonant frequencies, accelerometers shall be attached to the vehicle to measure and record the equipment's vibration response in the axis of vibration to determine resonant frequencies and amplification factors. Locations selected may include frame structure, handlebar, footrest, batteries or other large components and modules.

The control accelerometer(s) shall be attached to the test fixture as near as practicable to the equipment mounting location. When more than one accelerometer is employed for test level control, the average of the accelerometer control signals of the acceleration power spectral densities (PSD) shall be used as the test level control.

Before the random vibration test, perform a 0,5 g-PK sinusoidal scan from 5 Hz to 500 Hz at a sweep rate not exceeding 1,0 octave/minute. Record plots of response accelerometers at selected position on the vehicle to determine resonant frequencies and amplification factors.

Apply the appropriate test level PSD of Table 3 for 15 h. During this random vibration period, also perform a PSD analysis of the vibration response measurements on the equipment.

Repeat the sinusoidal scan. Any changes in vibration resonant frequencies shall be recorded.

The vibration tests shall be performed under normal ambient environmental conditions with a temperature of $+23\text{ °C} \pm 5\text{ °C}$ (relative humidity $< 85\%$, normal atmospheric pressure).

The appropriate random vibration test curve shall be selected from Table 2 depending on the wheel size and design of the vehicle. The test curves are given in Table 3 and Figure 1.

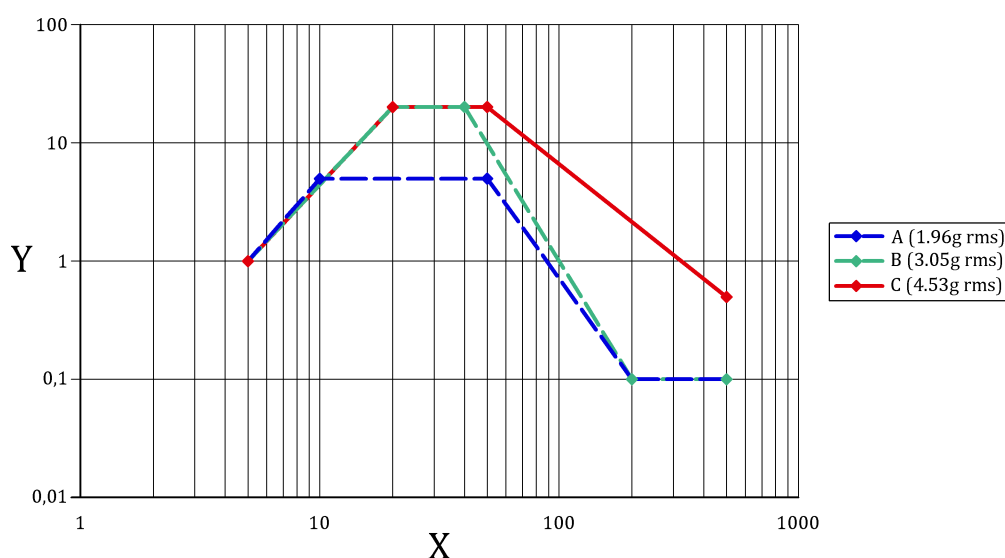
Table 2 — Categorization of vehicle for vibration tests

Design parameters				
Wheel size (outer diameter)	Suspension system			
	yes		no	
	Tire		Tire	
	Pneumatic	Solid rubber / elastomer	Pneumatic	Solid rubber / elastomer
< 10 inch (<254 mm)	A	B	B	C
≥ 10 inch (≥254 mm)	A	B	A	B

Table 3 — Test levels at test curve frequency break points

Acceleration Power Spectral Densities in (m/s ²) ² /Hz							
	5 Hz	10 Hz	20 Hz	40 Hz	50 Hz	200 Hz	500 Hz
A	1	5			5	0,1	0,1
B	1		20	20		0,1	0,1
C	1		20		20		0,5

Total rms: A: 19,2 m/s²; B: 29,4 m/s²; C: 44,4 m/s²

**Key**

X frequency (HZ)

Y acceleration Power Spectral Density (PSD) (m/s²)²/Hz

Figure 1 — Random Vibration Test Curves for vehicles

7 Driving power management

7.1 Driving power activation

7.1.1 Requirements

Driving power shall only be provided following at least two independent and dissimilar intentional actions by the user. In addition:

- a) For vehicles of class 1 or 2 with a partially electrically powered vehicle, the driving power shall not be delivered while moving forward at a speed of less than 3 km/h.

Verification shall be by the test of 7.1.2.

- b) For vehicles of class 1 or 2, it shall be possible for the user to power-off the driving power at any time during use in accordance with the driving power procedure described by the manufacturer in the instruction manual (see 7.3 and 19.4). For vehicles of class 3 or 4, the Driving power management shall not power-off motor power at any specified speed.

Verification shall be by inspection and function test.

- c) For vehicles of class 1 and 2, the cut-off of driving power shall take priority over the maintenance of power assistance (for example, if the user holds his accelerator grip while he is actuating the brake, the power assistance shall be cut off).

Verification shall be by the test of 7.1.2.

Compliance with the following requirements shall be checked by the test methods described in 7.1.2;

- d) Vehicles of class 3 or 4 shall act as follows:

- 1) Horizontal level foot rests (maintain constant speed),
- 2) Tilt back of foot rest shall result in a progressive controlled braking,
- 3) Foot rest tilt to the front shall result in a progressive controlled acceleration,
- 4) The vehicle shall be self-balancing in all operating states.

Verification shall be by inspection and function test.

- e) When the vehicle approaches the maximum speed of its class, the driving power shall be reduced in such a way that the maximum speed limit will not be exceeded. The driving power shall be managed smoothly and progressively.
- f) In the case where a class 1 or 2 vehicle is equipped with a mechanical brake system, the driving power shall be cut off at the commencement of braking (according to 15.4.2).
- g) In the case where the vehicle is equipped with an electric brake, the driving power management shall be such that braking starts immediately.
- h) For self-balancing vehicles, the driving power shall ensure that the vehicle speed cannot exceed the maximum speed of the vehicle's class.
- i) In case of overspeed during driving, the following shall apply to vehicles of class 3 or 4:

- 1) There shall be audible and if possible (in the particular vehicle) visual and other (physical) warnings to alert the user of a system issue.
 - 2) In all cases, the vehicle shall be slowed automatically and brought to a safe speed (lower than the maximum speed).
- j) In case of overheating of the driving power management during driving, the following shall apply for vehicles of class 3 or 4:
- 1) There shall be audible and if possible (in the particular vehicle) visual and other (physical) warnings to alert the user of a system issue.
 - 2) In all cases, the vehicle shall be slowed automatically and brought to a safe stop.
 - 3) It shall not be possible to drive the self-balancing vehicle until the vehicle's control system detects that the initiating problem has been corrected.
- k) In case of insufficient battery power, the following shall apply for vehicles of class 3 or 4:
- 1) There shall be audible and if possible (in the particular vehicle) visual and other (physical) warnings to alert the user of a system issue.
 - 2) In all cases, the vehicle shall be slowed automatically and brought to a safe stop.
 - 3) It shall not be possible to drive the self-balancing vehicle until the vehicle's control system detects that the initiating problem has been corrected.
- l) Acceleration Limitation
- 1) The acceleration of the vehicle shall be smooth without shocks and limited to 2 m/s^2 in order to avoid unstable riding conditions.

NOTE see D.3 and D.12.

7.1.2 Test method

7.1.2.1 Test conditions

- a) The test may be carried out on a test track, a test bench or on a roller.
- b) A test track shall comply with 8.1.2.2.
- c) The speedometer shall be accurate to $\pm 2 \%$.
- d) The ambient temperature shall be between $5 \text{ }^{\circ}\text{C}$ and $35 \text{ }^{\circ}\text{C}$.
- e) The maximum wind speed shall not exceed 3 m/s .
- f) The battery shall be fully charged in accordance with the manufacturer's instructions.
- g) The most onerous condition shall be applied (worst speed and gear ratio).
- h) With the vehicle operate under normal operation, but the motors are loaded to 33% their locked rotor current by adjusting the load on its rotational axis in the forward direction.

7.1.2.2 Test procedure

- a) For vehicles class 1 or 2, check that no driving power is delivered while moving forward at a speed of less than 3 km/h. Compliance shall be checked, in accordance with the technology used, either by:
 - 1) when attempting to drive the vehicle forward using the normal controls or procedures for speeds less than 3 km/h, measuring the no-load current or checking the torque delivered to the driving wheel
- b) For vehicles of class 1 or 2 check whether the power assistance is cut-off when the brake is applied. Compliance shall be checked, in accordance with the technology used, by:
 - 1) measuring the no-load current or checking the torque delivered to the driving wheel before and after actuating the direct or indirect braking system.
 - 2) reproducing the power assistance cut-off situation 30 times. The power assistance shall not continue after actuation of the braking system. Power assistance may resume immediately after releasing the braking device.
- c) At the end of the tests, the power assistance cut-off systems shall be made to fail (to simulate, for example, cable detachment or failure of a sensor). It shall no longer be possible to activate the power assistance by any means whatsoever.

NOTE These tests only check compliance with power cut-off requirements. For braking performance see 15.4.

- d) With the vehicle at standstill or if the electric power doesn't start at 0 km/h: bring the vehicle in a stable riding position at 6 km/h (± 2 km/h) and with the vehicle operate under normal operation, but the motors are loaded to 33 % of their locked rotor current by adjusting the load on its rotational axis in the forward direction.

Move the acceleration device to its maximum position and keep it in this position until the vehicle reaches 60 % of its maximum speed.

Measure the time from the start until the vehicle reaches 50 % of its maximum speed.

Calculate the acceleration.

7.2 Power failure of control system

For class 1 and class 2 vehicles, in the event of an electrical power failure the vehicle shall be able to brake normally or, shall come to a standstill with a deceleration between $(1,5 - 2) \text{ m/s}^2$.

For class 3 and class 4 vehicles, a fault condition in the power control system shall be indicated by a warning signal (visual, audible, vibrating...) on the handlebar, the vehicle itself or to the remote control (see Clause 17).

In a driving condition the loss of connection to the warning device, on the remote control, shall result in a speed reduction to 6 km/h or less for a Class 4 vehicle; the speed reduction shall happen in a safe manner without creating additional hazards with corresponding audio notification and tilt back of decks on self-balancing vehicles.

7.3 Unintended or unauthorized use of vehicle

Means shall be provided to prevent an unintended or unauthorized use of the vehicle, e.g. keys, locks, electronic control device.

NOTE see D.16.

8 Speed limitation

8.1 Pedestrian mode

8.1.1 General

Vehicles classes 2 and 4 shall be equipped with a pedestrian mode for limiting the speed to a maximum of 6 km/h

A distinctive and visible warning light shall be provided to indicate both to the user and others in the vicinity of the vehicle when pedestrian mode is in operation. It shall be active only when the pedestrian mode is activated.

Verification shall be in accordance with 8.1.2.

8.1.2 Test method

8.1.2.1 Test conditions

- a) The test may be carried out on a test track, a test bench or on a roller.
- b) The speed measuring apparatus and test conditions shall have the following characteristics:
 - 1) accuracy: $\pm 2 \%$;
 - 2) resolution: 0,1 km/h.
- c) The ambient temperature shall be between 5 °C and 35 °C.
- d) Maximum wind speed: 3 m/s.
- e) The battery shall be fully charged in accordance with the manufacturer's instructions.
- f) With the vehicle operate under normal operation, but the motors are loaded to 33 % of their locked rotor current by adjusting the load on its rotational axis in the forward direction.

8.1.2.2 Characteristic of the test track

The gradient of the track shall not exceed 0,5 %. If the gradient is less than 0,2 % carry out all runs in the same direction. If the gradient lies between 0,2 % and 0,5 % carry out alternate runs in opposite directions.

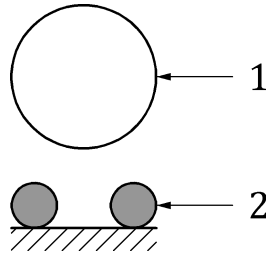
The surface shall be hard, of concrete or fine asphalt free from loose dirt or gravel. The minimum coefficient of friction between the dry surface and the vehicle tyre shall be 0,75.

8.1.2.3 Characteristic of the test bench

The test bench shall simulate normal road conditions.

8.1.2.4 Characteristic of the roller

The test roller shall support with bearing to decrease the resistance, load need to add to the roller to reach rated current (see Figure 2).



Key

- 1 Wheel
- 2 Roller (Ø 25 cm, add a load to the roller to reach rated current)

Figure 2 — Example of roller (side view of a wheel)

8.1.2.5 Test procedure

- a) Prepare the vehicle by running it for 5 min at 80 % of the speed corresponding to maximum power as declared by the manufacturer, then stop it.
- b) Actuate the mode for limiting the speed to 6 km/h (or less) and check whether the speed operating range of the power assistance is limited to 6 km/h (or a lower value).

NOTE The speed in pedestrian mode is set by the manufacturer according to local regulation.

8.2 Maximum speed with power assistance

8.2.1 Requirements

The maximum speed for which the electric motor gives assistance shall be in accordance with the maximum permitted speed for the class. It may differ by (± 10 %) of the maximum speed marked on the vehicle given in the instruction manual/sheet and determined according to the test method described in 8.2.2. The maximum speed in this mode shall not exceed 25 km/h.

8.2.2 Test method

8.2.2.1 Test conditions

The test shall be performed in accordance with 8.1.2.1, 8.1.2.2 and 8.1.2.3.

8.2.2.2 Test procedure

8.2.2.2.1 Test for vehicle with 100 % electric propulsion

If performed with a test bench:

- a) Put the vehicle on the bench and bring it to the maximum achievable speed and maintain the speed for 60 s at least;
- b) Measure the vehicle speed by measuring the speed of the test bench. If performed with a test track:
- c) Put the vehicle on the track and bring it to the maximum achievable speed and maintain the speed for 60 s at least;
- d) Measure the vehicle speed.