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Cycles — Safety requirements for bicycles —

Part 10: Safety requirements for electrically power assisted cycles (EPACs)

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 149, *Cycles*, Subcommittee SC 1, *Cycles and major sub-assemblies*.

A list of all parts in the ISO 4210 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document combines several countries' safety requirements for Electrically Power Assisted Cycles (EPACs). The commercialization of EPACs has accelerated in the global market, in response to global concerns about CO_2 reduction and energy saving. EPAC technologies for performance, electrical control, battery management and battery charging are currently developing rapidly in a competitive market. It is therefore necessary to standardize the safety of these technologies for EPACs.

This documentation will allow an easy and clear understanding of requirements for different types of EPAC.

This document includes safety requirements for the charging of EPACs. This includes off-board parts and EPAC battery chargers.

This document does not state the limit for the maximum permissible load of the EPAC. The manufacturer is advised to consider amongst other factors the maximum permissible load (luggage plus rider) as well as the intended use of the EPAC. Both have an influence on the mechanical requirements.

Cycles — Safety requirements for bicycles —

Part 10: Safety requirements for electrically power assisted cycles (EPACs)

1 Scope

This document specifies safety and performance requirements for the design, marking, assembly, and testing of two wheeled electrically power assisted cycles (hereafter EPACs), fully-assembled EPACs and subassemblies, and provides guidelines for information supplied by the manufacturers (i.e. instructions on the use and care of such EPACs).

This document applies to two wheeled EPACs that have a maximum saddle height of 635 mm or more and are intended for private and commercial use with exception of EPACs intended for hire from unattended stations.

This document is intended to cover all common significant hazards, hazardous situations and events listed in 5.3 of EPACs, when used as intended or under conditions of misuse that are reasonably foreseeable by the manufacturer.

This document specifies requirements and test methods for engine power management systems, electrical circuits including the charger for the assessment of the design and assembly of EPACs and sub-assemblies for systems having a Safety Extra Low Voltage (SELV) maximum voltage up to 60 V d.c. including tolerances.

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.

ISO 2409, *Paints and varnishes — Cross-cut test*

ISO 4210-1, *Cycles — Safety requirements for bicycles — Part 1: Terms and definitions*

ISO 4210-2:2015, *Cycles — Safety requirements for bicycles — Part 2: Requirements for city and trekking, young adult, mountain and racing bicycles*

ISO 4210-4:2014, *Cycles — Safety requirements for bicycles — Part 4: Braking test methods*

ISO 4210-5:2014, *Cycles — Safety requirements for bicycles — Part 5: Steering test methods*

ISO 4210-6:2015, *Cycles — Safety requirements for bicycles — Part 6: Frame and fork test methods*

ISO 4210-9:2014, *Cycles — Safety requirements for bicycles — Part 9: Saddle and seat-post test methods*

ISO 7010:2011, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

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

ISO 11451-2, *Road vehicles — Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 2: Off-vehicle radiation sources*

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

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

ISO 11452-4:2011, *Road vehicles — Component test methods for electrical disturbances from narrowband radiated electromagnetic energy — Part 4: Harness excitation methods*

ISO 11898-1, *Road vehicles — Controller area network (CAN) —Part 1: Data link layer and physical signalling*

ISO 11898-2, *Road vehicles — Controller area network (CAN) —Part 2: High-speed medium access unit*

ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

ISO 13849-2, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*

IEC 60034-1, *Rotating electrical machines — Part 1: Rating and performance*

IEC 60068-2-27, *Environmental testing — Part 2-27: Tests — Test Ea and guidance: Shock*

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

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 62133-1:2017, *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 — Part 1: Nickel systems*

IEC 62133-2:2017, *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Safety requirements for portable sealed secondary lithium cells, and for batteries made from them, for use in portable applications — Part 2: Lithium systems*

CISPR 12:2007 + A1:2009, *Vehicles, boats and internal combustion engines — Radio disturbance characteristics — Limits and methods of measurement for the protection of off-board receivers*

CISPR 16-1-1:2015, *Specification for radio disturbance and immunity measuring apparatus and methods — Part 1-1: Radio disturbance and immunity measuring apparatus — Measuring apparatus*

CISPR 25:2016, *Vehicles, boats and internal combustion engines — Radio disturbance characteristics — Limits and methods of measurement for the protection of on-board receivers*

EN 50604-1:2016, *Secondary lithium batteries for light EV (electric vehicle) applications — Part 1: General safety requirements and test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4210-1 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
cycle
any vehicle which has at least two wheels and is propelled by the muscular energy of the person on that vehicle, in particular by means of pedalling or the possibility of adding assistance provided by electric motor when pedalling

Note 1 to entry: Pedalling also refers to use of hand cranks or other similar devices.

3.2
electrically power assisted cycle
EPAC
cycle (3.1), equipped with pedals and an auxiliary electric motor, which cannot be propelled exclusively by means of this auxiliary electric motor, except in the walk assistance mode

3.3
mountain EPAC
electrically power assisted cycle (3.2) designed for use off-road on rough terrain, on public roads, and on public pathways, equipped with a suitably strengthened frame and other components, and, typically, with wide-section tyres with coarse tread patterns and a wide range of transmission gears

[SOURCE: ISO 4210-1:2014, 2.30, modified — bicycle has been changed to electrically power assisted cycle.]

3.4
braking device cut-off switch
device that cuts off the motor assistance while braking

3.5
continuous rated power
output power specified by manufacturer, at which the motor reaches its thermal equilibrium at given ambient conditions

3.6
assisted rate
ratio of between mechanical motor output-power and muscular human input-power

3.7
thermal equilibrium
temperatures of motor parts which do not vary more than 2 °C/h

3.8
assistance cut-off speed
speed at which the motor controller cuts off the assistance of the auxiliary electric motor

3.9
walk assistance mode
function by which the user can activate the auxiliary electric motor to propel the EPAC up to a defined maximum speed without pedalling

3.10
electromagnetic compatibility
ability of an EPAC or one of its electrical/electronic systems to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to anything in that environment

[SOURCE: IEC 60050-161:1990/AMD8:2018, IEV ref. 161-01-07, modified — an EPAC or one of its electrical/electronic systems have been specified.]

3.11
ESA
electronic subassembly
electrical subassembly
electronic and/or electrical component, or an assembly of components provided for installation into an EPAC, together with all electrical connections and associated wiring for the execution of several specific functions

3.12
motor controller
device or group of devices that serves to govern in some predetermined manner the performance of an electric motor

Note 1 to entry: Means for manual or automatic ON/OFF, selecting the drive direction, regulating the speed, limiting the torque and providing protection against faults.

3.13
fault condition
condition in which one or more fault is present which could cause hazard

3.14
charging configuration
sets of physical parameters which are predefined to control a charging process

3.15
battery management system
BMS
local energy management system for the battery system, protecting the battery system from damage, monitoring and increasing the lifetime, and maintaining the functional state

Note 1 to entry: BMS and BCU (according to ISO 12405) do not have the same functions.

3.16
narrow-band emission
emission which has a bandwidth less than that of a specific receiver or measuring instrument

3.17
no load current point
current measured at battery output with no change to the operating status of any auxiliary systems during the test

3.18
safety extra-low voltage
SELV
voltage not exceeding ripple-free 60 V d.c. between conductors and earth, the no load voltage not exceeding ripple-free 60 V d.c.

3.19
anti-tampering measures
technical requirements and specifications which prevent, as far as possible, unauthorized modifications of the EPAC's drive system which may prejudice functional safety

3.20
maximum permissible load
maximum permissible weight of rider and luggage as defined by the manufacturer

3.21
proprietary system
manufacturer-specific system

3.22
non-proprietary system
non manufacturer-specific system

3.23
charger inlet
inlet on the EPAC or battery side for charging

[SOURCE: IEC 60050-714:1990, IEV ref. 714-03-04, this source is only for “inlet”]

3.24
charger connector
connector on charger side for charging

[SOURCE: IEC 60050-151:2001, IEV ref. 151-12-19, this source is only for “connector”]

3.25
rigid seat-post
seat-post that cannot be raised or lowered independently of the seat tube clamp, while riding, and does not provide controlled axial flexibility to reduce the transmission of road shocks to the rider.

3.26
suspension seat-post
seat-post incorporating controlled, axial flexibility to reduce the transmission of road shocks to the rider

3.27
dropper seat-post
seat-post that can be raised or lowered independently of the seat tube clamp while riding

3.28
suspension dropper seat-post
seat-post incorporating controlled, axial flexibility to reduce the transmission of road shocks to the rider and incorporating the capability of raising and lowering independently of the seat tube clamp while riding

4 Abbreviated terms

See Table 1.

Table 1 — Abbreviated terms

Abbreviation	Description	Definition or occurrence
AC	Alternating current	C.3.1.1
ACK	Acknowledge	C.2.5.3.1
ALSE	Absorber-lined shielded enclosure	B.3.4
AM	Amplitude modulation	A.4.6.1
BCI	Bulk current injection	B.2.6.3
BCU	Battery control unit	3.15
BMS	Battery management system	3.15
BPSK	Biphase shift keying	C.2.5.4.1
CAN	Controller area network	C.3.1.1
CC	Constant current mode	Table C.10
CCF	Common cause failure	F.2.4.1.2
CDB	Command descriptor block	C.2.6.3.1
CSMA/CR	Carrier sense multiple access with collision resolution	C.3.1.2

Table 1 *(continued)*

Abbreviation	Description	Definition or occurrence
CV	Constant voltage mode	Table C.10
DA	Destination address	Figure C.10
DC	Direct current	C.2.1.1
DFMEA	Design failure mode and effect analysis	5.2
DLC	Data length code	C.3.6.2.1
DUT	Device under test	F.2.3.4.2
EMC	Electromagnetic compatibility	6.12
EPAC	Electrically power assisted cycle	Introduction
ESA	Electronic/electrical subassembly	3.11
FCS	Frame check sequence	Table C.9
FMEA	Failure mode and effect analysis	5.2
FTA	Fault tree analysis	5.2
HMI	Human machine interface	Figure C.20
MPU	Micro processing unit	Figure C.1
NDN	Network device number	Table C.10
NM	Network management	C.3.6.2.4
NRZ	Non-return-to-zero	C.2.5.4.2
PC	Page control	Table C.40
PL	Performance level	5.3.2.2.2
PLC	Power line communication	Figure C.1
PM	Pulse modulation	A.4.6.1
PnP	Plug and play	C.2.6.2
PS	Parameter saveable	C.2.6.5.12
RA	Risk assessment	5.2
RF	Radio frequency	B.3.3
R-map	Risk-map	5.2
rms	Root mean square	A.2.6.3
RT	Room temperature	F.2.4.1.3
SA	Source address	Figure C.12
SELV	Safety extra low voltage	Clause 1
SOPC	Sub operation code	Table C.33
SP	Save pages	C.2.6.5.12
TLS	Transmission-line-system	A.4.6.3
ToR	Type of request	C.2.6.5.7.2
VDD	Voltage drain	Figure C.1

5 General requirements

5.1 Lighting systems, reflectors and warning device

EPACs shall be in accordance with the requirements of ISO 4210-2:2015, 4.20 and 4.21.

5.2 Risk assessment

EPAC shall be designed using principles of Risk Assessment (RA) in accordance with ISO 12100.

The following RA methodology may be used, but is not limited to:

— fault tree analysis (FTA);

— failure mode and effect analysis (FMEA);

— design failure mode and effect analysis (DFMEA);

— risk-map (R-map).

EPAC shall be designed in accordance with the principles of ISO 12100 for relevant hazards which are not dealt with by this document. This includes evaluation of such risks for all relevant components.

5.3 Significant hazards and safety functions

5.3.1 Significant hazards

The following significant hazards of EPACs have been considered in this document:

a) mechanical hazards: deceleration, acceleration, instability, kinetic energy, rotating elements and moving elements, rough or slippery surfaces, sharp edges;

b) electrical hazards: electromagnetic phenomena, electrostatic phenomena, overload, short-circuit, thermal radiation;

c) thermal hazards: explosion, flame, radiation from heat sources, objects or materials with a high or low temperature;

d) ergonomic hazards: effort, local lighting, posture;

e) hazards associated with the environment in which the EPAC is used: water (dust).

5.3.2 Safety function for control system of EPACs

5.3.2.1 General

The EPAC control system risk shall be assessed in accordance with the series of ISO 13849.

The following methodology may be used, but is not limited to:

— IEC 61508 (all parts);

— R-map.

5.3.2.2 Requirements

5.3.2.2.1 Safety related parts of the mechanical, hydraulic control systems

The necessary performance levels and requirements which are related to the identified hazards are covered by Clause 7.

5.3.2.2.2 Safety related parts of the electrical control systems

The safety requirements of Table 2 shall be necessary for an EPAC. If necessary, the manufacturer shall add more safety requirements and determine the necessary PL or safety level for each of these safety requirements and the related safety functions.

Table 2 — Safety functions related to defined hazards

Safety function	Performance Level
Prevention of electric motor assistance functions without pedalling, and without activation of the walk assistance mode	PLr c
Prevention of risk of fire in case of management system failure for batteries with electric energy above 100 Wh	PLr c

5.3.2.3 Verification of the safety functions

The whole procedure for achieving functional safety shall be in accordance with the series of ISO 13849.

System suppliers shall document this process and take measures to achieve the required performance level (see Table 2).

The minimum set of safety related functions shall be implemented at least by both system suppliers and the manufacturer to achieve conformity with this document.

5.4 Prevention of unauthorized use

Means shall be provided to the user to prevent an unauthorized use of the electric assistance/walk assistance mode of the EPAC e.g. key, locks, electronic control device.

5.5 Failure mode

5.5.1 Requirement

It shall be possible to ride the EPAC by pedalling even if the assistance failed. This requirement shall be checked as described in 5.5.2.

5.5.2 Test method

a) Remove or disconnect the battery pack.

b) Ride the EPAC up to 10 km/h.

6 Electrical requirements

6.1 Motor controller

The motor controller shall be designed so that it switches off the power to the electric motor if a fault condition occurs.

Subsequent switch on shall only be possible after user interaction.

6.2 Controls and symbols

A control device shall be fitted to switch on and off the assistance.

The control device shall be apparent, easy to reach and unmistakable. This control device shall be activated by voluntary action.

Designs of the On/Off symbol, lighting symbol and audible warning device symbol shall be in accordance with Annex D.

6.3 Batteries

The EPAC and batteries shall be designed in accordance with Annex F to avoid risk of fire and mechanical deterioration resulting from abnormal use.

In case the EPAC batteries may be subjected to country-specific regulations, batteries should conform to the country-specific regulations.

Batteries and the charger unit shall be labelled or be uniquely designed in order to ensure their compatibility and prevent incorrect plugging.

6.4 Battery charger

6.4.1 Requirements for proprietary system

A proprietary system consists of batteries and chargers, that are not interoperable. By design intended only to operate in combination with each other. A proprietary plug system shall assure that the EPAC batteries are only to be charged with the dedicated charger. The specific combination of charger and battery shall be considered for the hazard and risk analysis, as well as in the implementation of the safety functions.

The battery charger for proprietary system shall be in accordance with the requirements of IEC 60335-2-29.

6.4.2 Requirements for non-proprietary system

6.4.2.1 General

For non-proprietary systems, interoperable charging may be possible. The safety and risk analysis shall consider charging processes where battery and charger are released independently from each other. Therefore the safety requirements for the charging process on the EPAC side and on the charger side shall be described. To guarantee a safe charging process of the EPAC for a non-proprietary system, safety requirements shall be taken into consideration to prevent:

a) overvoltage and overcurrent;

b) over temperature;

c) hot disconnect;

d) short circuit.

For the charging configuration it is important, that the roles between the EPAC and the charger are uniquely defined. The EPAC shall be the master and the charger shall be the slave. This means that the EPAC controls the charging current and charging voltage at any time.

It shall only be possible to charge the EPAC, after a communication between the EPAC and the charger has been established. If this communication is interrupted, the charging process shall be stopped and the power lines shall become zero potential immediately.

The interface between EPAC and charger consists of a standardized plug system and a communication protocol.

6.4.2.2 Protocol requirements

The following protocol requirements shall be satisfied:

a) heart beat: for bilateral continuous presence detection of the EPAC and the charger. The EPAC shall transmit a heartbeat signal to the charger every 10 ms and the charger shall transmit a heartbeat signal to the EPAC every 200 ms;