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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Rolling stock – Power supply with onboard energy storage system – Part 1: Series hybrid system

Applications ferroviaires – Matériel roulant – Alimentation équipée d'un système embarqué de stockage de l'énergie – Partie 1: Système hybride série

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Part 1: Series hybrid system

FOREWORD

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International Standard IEC 62864-1 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

The text of this standard is based on the following documents:

FDIS	Report on voting
9/2154/FDIS	9/2176/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62864 series, published under the general title *Railway applications – Rolling stock – Power supply with onboard energy storage system*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

There is an increasing need for efficient use of energy due to the decrease in fossil fuel based energy sources as well as the need to reduce emissions (e.g. CO_2, NO_x, PM, etc.) that contribute to global climate change. The railway system, which is essentially an energy-efficient transportation system, should also meet these requirements. In addition to saving energy, it is necessary to achieve a reduction in peak power, voltage stabilization and the ability to run without collecting power in scenic reserve areas, and the running capability to safely reach the next station in the event of electrical power failure onboard or at power supply system. To address these issues, hybrid systems are appearing in railway vehicles. These hybrid system vehicles are equipped with an energy storage system that allows effective use of regenerative energy. A hybrid system should be required to improve energy efficiency by actively controlling the power flow among the engine or power supply system, auxiliary power supply, traction and braking system, the energy storage system, etc.

The purpose of introducing hybrid systems includes:

- reducing energy consumption;
- improving vehicle performance;
- providing the ability to run with energy stored onboard; and
- improving environmental characteristics.

The aim of this standard is to establish the basic system configuration for series hybrid systems (electrically connected) and the tests to verify effective use of energy, as well as to provide railway operators and manufacturers with guidelines for manufacturing and evaluating hybrid systems.

The hierarchy of relevant standards related to hybrid systems are summarized in Figure 1. The standards listed in Figure 1 are not exhaustive.

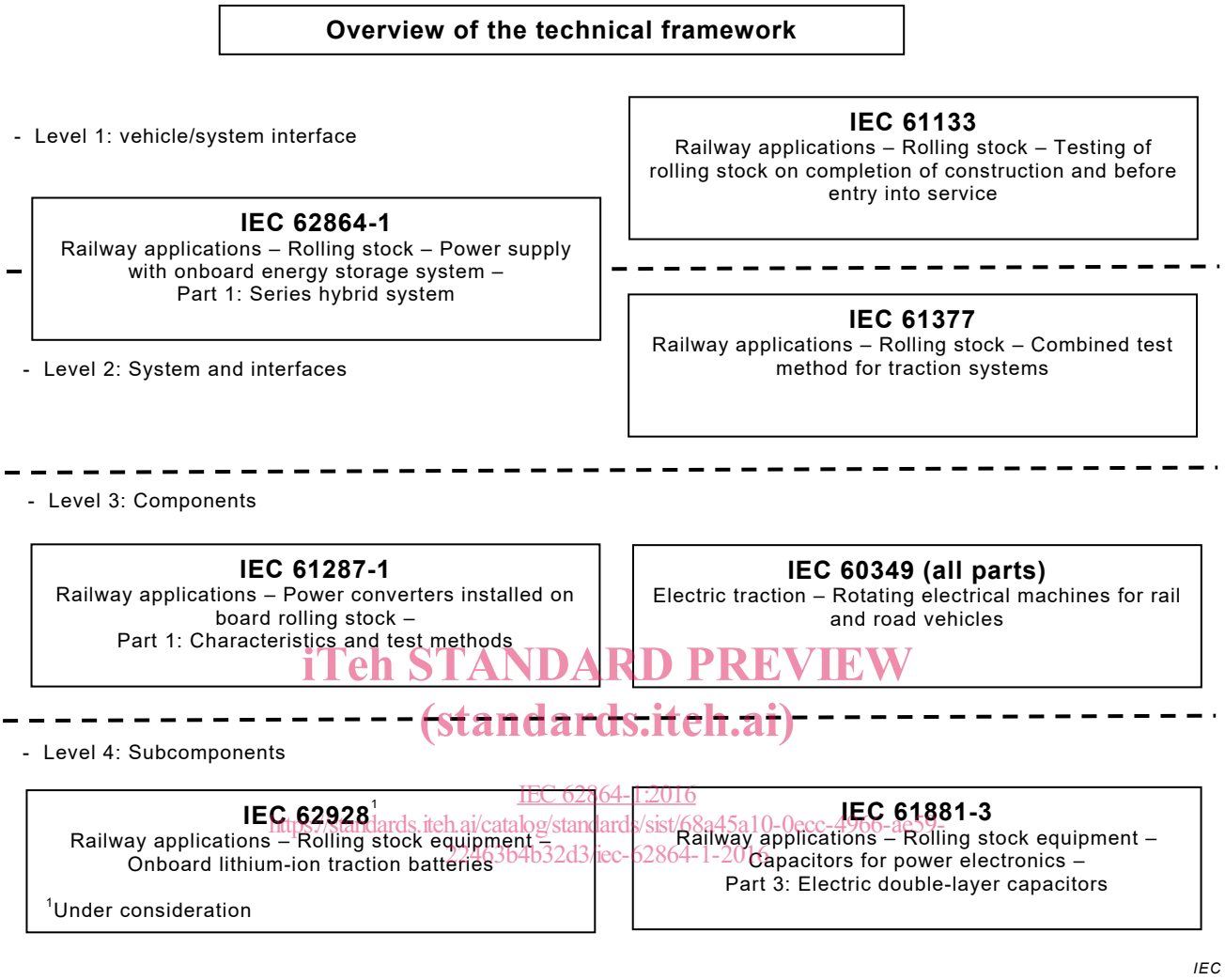

Figure 1 – Hierarchy of standards related to IEC 62864-1

In this standard, the hybrid system has the following four levels of hierarchy:

a) vehicle/system interface (level 1);
b) systems and interfaces (level 2);
c) components (level 3); and
d) subcomponents (level 4).

Detailed descriptions of the levels are described in 7.1.

E.g. subcomponent (level 4) is a cell, module etc. (for a battery, a subcomponent is defined in IEC 62620).

RAILWAY APPLICATIONS – ROLLING STOCK – POWER SUPPLY WITH ONBOARD ENERGY STORAGE SYSTEM –

Part 1: Series hybrid system

1 Scope

This part of IEC 62864 applies to series hybrid systems (electrically connected) with onboard energy storage (hereinafter referred as hybrid system).

A hybrid system has two (or more) power sources including energy storage system (ESS) on board to achieve the following features by combining converter and motors and performing energy management control:

- improving energy and fuel efficiency, improving acceleration characteristics, increasing running distance and uninterrupted running in the event of the loss of the primary power source (PPS), by using an ESS in addition to the primary power source under conditions where the power and capacity of the power source including regenerative power are limited, thus alleviating those limitations;
- reducing fuel consumption, reducing emissions (e.g. CO_2, NO_x, PM, etc.);
- reducing environmental impact (e.g. visible obstruction, noise, etc.).

By extension, systems that have only onboard ESS, without other PPSs, is also considered in this standard.

This standard intends to specify the following basic requirements, characteristics, functions and test methods for hybrid systems:

- energy management to control the power flow among primary power source, energy storage system and power converters;
- energy consumption, energy efficiency and regenerated energy;
- vehicle characteristics achieved by energy storage system;
- test methods of combined test; and
- test methods of completed vehicles based on factory (stationary) and field (running) tests.

NOTE Converter in this standard means combined equipment consisting of one or more converters (e.g. rectifier, inverter, chopper, etc.).

The interfaces between the following power sources are covered:

- external electric power supply system;
- onboard ESSs (including pure onboard energy storage);
- fuel cell, diesel electric generator; and
- other power sources.

As for the combination of inverters and motors, this standard applies to asynchronous motors or synchronous motors that are powered via voltage-source inverters.

Power source systems and combination of inverters and motors are not limited to the listed above, but this standard can also be applied to future systems.

This part of IEC 62864 covers electrically connected systems (series hybrid), and not systems that mechanically transmit the driving force (parallel hybrid).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-811, *International Electrotechnical Vocabulary (IEV) – Chapter 811: Electric traction*

IEC 60349-2, *Electric traction – Rotating electrical machines for rail and road vehicles – Part 2: Electronic converter-fed alternating current motors*

IEC 60349-4, *Electric traction – Rotating electrical machines for rail and road vehicles – Part 4: Permanent magnet synchronous electrical machines connected to an electronic converter*

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

IEC 61133:2016, *Railway applications – Rolling stock – Testing of rolling stock on completion of construction and before entry into* service

IEC 61287-1, *Railway applications – Power converters installed on board rolling stock – Part 1: Characteristics and test methods*

IEC 61373, *Railway applications – Rolling stock equipment – Shock and vibration tests*

IEC 61377:2016, *Railway applications – Rolling stock – Combined test method for traction systems*

IEC 61881-3, *Railway applications – Rolling stock equipment – Capacitors for power electronics – Part 3: Electric double-layer capacitors*

IEC 61991, *Railway applications – Rolling stock – Protective provisions against electrical hazards*

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

IEC 62498-1:2010, *Railway applications – Environmental conditions for equipment – Part 1: Equipment on board rolling stock*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms and definitions given in IEC 60050-811, as well as the following, apply.

3.1 Terms and definitions

3.1.1
hybrid
system that combines two (or more) different types of components for a specific purpose

Note 1 to entry: An approach for using multiple motive power sources and one for using multiple electric power sources exist for rolling stock applications.

3.1.2
parallel hybrid
system for transmitting power from multiple motive power sources to the wheels

Note 1 to entry: The driving force from the engine and that from the motor are transferred to the wheels via the transmission system.

3.1.3
hybrid
series hybrid
system which drives a motor supplied via the power converter for combined operation of electric power from multiple power sources

Note 1 to entry: The wheels are driven by the driving force from the motor only.

3.1.4
hybrid vehicle
vehicle that can store energy in an onboard ESS and is driven by using the stored energy as well as electric power from a generator or overhead lines

3.1.5
subsystem <of a series hybrid system>
constituent of a series hybrid system

EXAMPLE Primary power source, energy storage system, traction equipment.

3.1.6
component <of a series hybrid system>
constituent of a subsystem in a series hybrid system

EXAMPLE Converter, motor, diesel electric generator, ESU.

3.1.7
subcomponent <of a series hybrid system>
constituent of a component in a series hybrid system

EXAMPLE Lithium ion battery, electric double-layer capacitor.

3.1.8
energy consumption
total energy consumption of the entire vehicle for a specified operation (duration, distance, speed, etc.)

3.1.9
specific energy consumption
energy consumption for a specific distance and weight

Note 1 to entry: The value is obtained by dividing the energy consumption by the distance and the vehicle weight or number of vehicles. This value can be expressed, e.g. in kWh/(t·km), kWh/(car·km), kWh/(person·km) or kWh/(seat·km), etc.

Note 2 to entry: If an onboard power source, e.g. diesel generator set or fuel cell, is used, the unit may be l/(t·km), l/(car·km), l/(person·km) or l/(seat·km), etc. depending on the type of fuel.

3.1.10
power source
equipment that supplies power to a traction unit and/or APS and/or ESSs via a converter

Note 1 to entry: Converters (such as chopper for fuel cell (FC.CH)) for power generation and converters (such as ESS chopper (ESS.CH)) for energy storage units/systems are considered as power sources, but traction converters and converters for APS are not considered as power sources.

3.1.11
primary power source
PPS
subsystem in a series hybrid system the primary purpose of which is to supply electric energy to other subsystems in the series hybrid system by either consuming the fuel stored onboard or taking in energy from external sources

3.1.12
traction equipment
subsystem in a series hybrid system the primary purpose of which is to consume electrical energy and to output tractive effort so that the railway vehicle is propelled

3.1.13
state of charge
SOC
remaining capacity to be discharged, normally expressed as a percentage of full capacity as expressed in relevant standards

Note 1 to entry: Practical definitions of SOC are dependent upon chosen technologies. SOC is applicable to batteries. See Annex A.

3.1.14
state of energy
SOE
remaining energy to be discharged, normally expressed as a percentage of full energy as expressed in relevant standards

Note 1 to entry: Practical definitions of SOE are dependent upon chosen technologies. SOE is applicable to both batteries and capacitors. See Annex A.

3.1.15
end of life
EOL
point at which the ESU cannot fulfil the required functionality or operational pattern as initially agreed among the user and the manufacturers

3.1.16
beginning of life
BOL
point at which the ESU has the rated capacity or energy fully available as minimum performance at manufacturer's delivery

3.1.17 Definition of capacity

3.1.17.1
capacity
electrical charge that can be delivered from ESU

Note 1 to entry: In case of the battery the electrical charge is often expressed in ampere-hours (A·h).

Note 2 to entry: In case of the capacitor the electrical charge is often expressed in coulombs (C).

Note 3 to entry: Capacitance is measured in farads (F),which is charge (C) divided by voltage (U), and is different from capacity.

3.1.17.2
theoretical capacity
maximum capacity available without loss