

AS 62282.4.101:2024



STANDARDS
Australia



Fuel cell technologies

Part 4.101: Fuel cell power systems for electrically powered industrial trucks — Safety (IEC 62282-4-101:2022, (ED. 2.0) MOD)



AS 62282.4.101:2024

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- Australian Gas Association
- Australian Hydrogen Council
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- Energy Networks Australia
- Engineers Australia
- Gas Energy Australia
- Gas Technical Regulators Committee
- Institute of Electrical Inspectors
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- The University of Adelaide

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Preface

This Standard was prepared by the Standards Australia Committee ME-093, Hydrogen Technologies.

The objective of this document is to deal with safety of fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU).

This document covers safety requirements for fuel cell power systems intended to be used in electrically powered industrial trucks as defined in AS ISO 5053.1, except for:

- (a) Rough-terrain trucks.
- (b) Non-stacking low-lift straddle carriers.
- (c) Stacking high-lift straddle carriers.
- (d) Rough-terrain variable-reach trucks.
- (e) Slewing rough-terrain variable-reach trucks.
- (f) Variable-reach container handlers.
- (g) Pedestrian propelled trucks.

This document is an adoption with national modifications, and has been reproduced from IEC 62282-4-101:2022, *Fuel cell technologies — Part 4-101: Fuel cell power systems for electrically powered industrial trucks — Safety*. The modifications are additional requirements and are set out in [Appendix ZZ](#), which has been added at the end of the source text.

[Appendix ZZ](#) lists the modifications to IEC 62282-4-101:2022 for the application of this document in Australia.

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Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

Contents

Preface	ii
FOREWORD	vi
INTRODUCTION	viii
1 Scope	1
2 Normative references	2
3 Terms and definitions	5
4 Construction requirements for safety	9
4.1 General	9
4.2 Hydrogen and other fluid containing parts	9
4.2.1 General	9
4.2.2 Piping, hoses, tubing and fittings	9
4.2.3 Hydrogen pressure vessels	10
4.2.4 Metal hydride container	11
4.2.5 Methanol fuel tank	11
4.3 Refueling	12
4.4 Over-pressure and thermal protection	12
4.5 Regulators	14
4.6 Operating and shut-off valves	14
4.7 Filters	14
4.8 Pumps and compressors	14
4.9 Electrically operated pressure sensing and controlling devices	15
4.10 Ventilation to prevent the build up of flammable gases	15
4.11 Electrostatic discharge (ESD)	16
4.12 Discharges including methanol emissions and waste materials	16
4.13 Enclosures	16
4.14 Electrical system	17
4.14.1 General	17
4.14.2 Internal wiring	17
4.14.3 External wiring	18
4.14.4 Emergency switching off requirements (disconnection) for connections for fuel cell power system	19
4.14.5 Motors	19
4.14.6 Switches and motor controllers	20
4.14.7 Transformers and power supplies	20
4.14.8 Inverters, converters and controllers	20
4.14.9 Lamps and lampholders	20
4.14.10 Energy storage components	20
4.14.11 Electrical insulation	21
4.14.12 Limited power circuit	21
4.14.13 Electrical spacings	22
4.14.14 Separation of circuits	23
4.15 Control circuits	23
4.15.1 Safety controls	23
4.15.2 Start	24
4.15.3 Drive off	24
4.15.4 Emergency stop	24
4.16 Risk assessment and risk reduction	24
5 Performance requirements for safety and type tests	24
5.1 General	24
5.2 Vibration test	25
5.2.1 General	25
5.2.2 Vertical axis test	25

5.2.3	Longitudinal and lateral axes tests.....	25
5.3	Fuel container securement test.....	25
5.4	Endurance test.....	25
5.5	External leakage test.....	26
5.6	Dilution test.....	26
5.6.1	Releases.....	26
5.6.2	Setup and operation.....	26
5.6.3	Exhaust dilution.....	26
5.6.4	Dilution boundaries.....	26
5.7	Ultimate strength test.....	26
5.8	Potential failure modes test.....	27
5.9	Temperature test.....	27
5.10	Continuity test.....	29
5.11	Non-metallic tubing test for accumulation of static electricity.....	29
5.11.1	Passing criteria.....	29
5.11.2	Test method.....	29
5.12	Dielectric voltage – Withstand test.....	29
5.13	Limited power circuit test.....	30
5.14	Rated power output test.....	31
5.15	Abnormal operation test – Electric equipment failures.....	31
5.16	Emission of effluents test (only for methanol fuel cells).....	32
5.17	Environmental test.....	32
5.17.1	Rain test.....	32
5.17.2	Test of equipment – Exposure to wind.....	32
5.18	Enclosure tests.....	33
5.18.1	Enclosure loading test.....	33
5.18.2	Test for thermoplastic enclosures.....	33
5.19	Marking plate adhesion test.....	34
5.20	Test for elastomeric seals, gaskets and tubing.....	34
5.20.1	General.....	34
5.20.2	Accelerated air-oven ageing test.....	34
5.20.3	Cold temperature exposure test.....	34
5.20.4	Immersion test.....	34
5.21	Test for permeation of non-metallic tubing and piping.....	35
5.22	Test for electrical output leads.....	35
5.23	Emergency stop.....	35
6	Routine tests.....	35
6.1	External leakage.....	35
6.2	Dielectric voltage-withstand test.....	35
7	Markings.....	36
8	Instructions.....	37
8.1	General.....	37
8.2	Maintenance instructions.....	37
8.3	Operating instructions.....	37
8.4	Installation instructions.....	38
Annex A	(informative) Comparison of pressure terms.....	39
Annex B	(informative) Significant hazards, hazardous situations and events dealt with in this document.....	40
Bibliography		42
Appendix ZZ	(normative) Modifications to IEC 62282-4-101:2022 for Australia.....	45

List of Figures

Figure 1 — Fuel cell power systems for industrial trucks.....	2
---	---

Figure 2 — Example of a diagram with vent system covering components downstream of the regulator	13
Figure 3 — Example of a diagram with vent system covering all components	13
Figure 4 — Example of a diagram with vent system covering all components in a multiple storage vessel system	14

List of Tables

Table 1 — Appliance-wiring material	18
Table 2 — Spacings	22
Table 3 — Temperature rise limits	27
Table 4 — Limits for inherently limited power sources	30
Table 5 — Limits for power sources not inherently limited (overcurrent protection required)	30
Table 6 — Emission rate limits	32
Table A.1 — Comparison table of pressure terms	39

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62282-4-101 has been prepared by IEC technical committee 105: Fuel cell technologies.

This second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) revision of the title of this document;
- b) revision of reference standards;
- c) addition of new subclauses ([4.3](#), [4.14.5](#), [4.15.3](#), [4.15.4](#), [4.16](#), [5.6](#), and [5.23](#));

- d) previous [4.15](#) was revised as “4.16 Risk assessment and risk reduction”;
- e) revision of [4.6.3](#)), access to the manual shutoff valve;
- f) revision of requirements for battery terminals that are threaded ([4.14.10.1](#));
- g) revision of requirements for double layer capacitors ([4.14.10.2](#));
- h) revision of external leakage test ([5.5](#)) and ultimate strength test ([5.7](#));
- i) revision of temperature limits on capacitors depending on the temperature rating of the material ([Table 3](#));
- j) revision of markings that are not relevant ([Clause 7](#));
- k) added “Significant hazards, hazardous situations and events dealt with in this document” as a new informative annex ([Annex B](#)).

The text of this International Standard is based on the following documents:

Draft	Report on voting
105/912/FDIS	105/922/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts of IEC 62282 series, published under the general title *Fuel cell technologies*, can be found on the IEC website.

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

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

INTRODUCTION

The IEC 62282-4 series deals with categories such as safety, performance and interchangeability of fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU). Among the categories mentioned above, this document, IEC 62282-4-101, focuses on safety of electrically powered industrial trucks with fuel cell power systems because such applications are urgently demanded in the world. Future documents in this part of IEC 62282-4 will deal with other applications related to onboard vehicles other than road vehicles and auxiliary power units (APU).

Australian Standard®

Fuel cell technologies

Part 4.101: Fuel cell power systems for electrically powered industrial trucks — Safety (IEC 62282-4-101:2022, MOD)

1 Scope

This document deals with safety of fuel cell power systems for propulsion other than road vehicles and auxiliary power units (APU).

This part of IEC 62282 covers safety requirements for fuel cell power systems intended to be used in electrically powered industrial trucks as defined in ISO 5053-1, except for:

- rough-terrain trucks;
- non-stacking low-lift straddle carriers;
- stacking high-lift straddle carriers;
- rough-terrain variable-reach trucks;
- slewing rough-terrain variable-reach trucks;
- variable-reach container handlers;
- pedestrian propelled trucks.

This document applies to gaseous hydrogen-fuelled fuel cell power systems and direct methanol fuel cell power systems for electrically powered industrial trucks.

The following fuels are considered within the scope of this document:

- gaseous hydrogen;
- methanol.

This document covers the fuel cell power system as defined in [3.8](#) and [Figure 1](#).

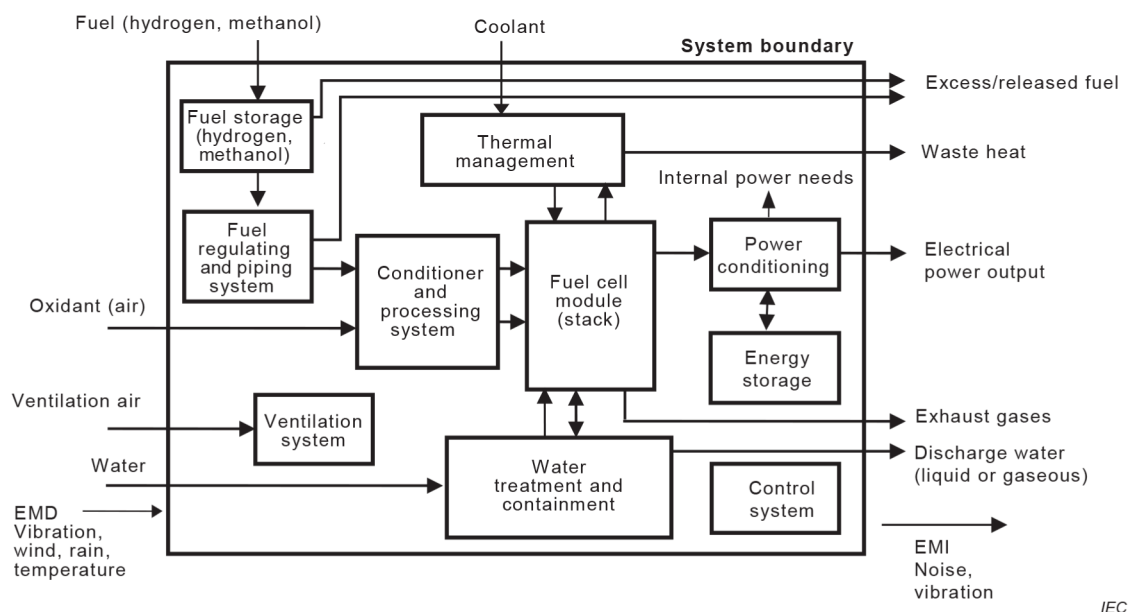
This document applies to DC type fuel cell power systems, with a rated output voltage not exceeding 150 V DC for indoor and outdoor use.

This document covers fuel cell power systems whose fuel source container is permanently attached to either the industrial truck or the fuel cell power system.

In accordance with IEC Guide 116, significant hazards, hazardous situations and events dealt with in this document are shown in [Annex B](#).

The following are not included in the scope of this document:

- detachable type fuel source containers;
- hybrid trucks that include an internal combustion engine;
- reformer-equipped fuel cell power systems;
- fuel cell power systems intended for operation in potentially explosive atmospheres;
- fuel storage systems using liquid hydrogen.



Key

EMD electromagnetic disturbance

EMI electromagnetic interference

NOTE A fuel cell power system can contain all or some of the above components.

Figure 1 — Fuel cell power systems for industrial trucks

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.

IEC 60050–485, *International Electrotechnical Vocabulary (IEV) – Part 485: Fuel cell technologies*

IEC 60079–0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079–10–1, *Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres*

IEC 60079–29–1, *Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases*

IEC 60079–29–4, *Explosive atmospheres – Part 29-4: Gas detectors – Performance requirements of open path detectors for flammable gases*

IEC 60204–1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60227–3, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 3: Non-sheathed cables for fixed wiring*

IEC 60227–5, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 5: Flexible cables (cords)*

IEC 60335–2–41, *Household and similar electrical appliances – Safety – Part 2-41: Particular requirements for pumps*

IEC 60335–2–80, *Household and similar electrical appliances – Safety – Part 2-80: Particular requirements for fans*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-4-41:2005/AMD1:2017

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

IEC 60584-1, *Thermocouples – Part 1: EMF specifications and tolerances*

IEC 60664-1, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60695 (all parts), *Fire hazard testing*

IEC 60695-1-30, *Fire hazard testing – Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Preselection testing process – General guidelines*

IEC 60695-10-2, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test method*

IEC 60695-11-4, *Fire hazard testing – Part 11-4: Test flames – 50 W flame – Apparatus and confirmational test method*

IEC 60695-11-10, *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*

IEC 60730-1:2013, *Automatic electrical controls – Part 1: General requirements*

IEC 60730-1:2013/AMD1:2015

IEC 60730-1:2013/AMD2:2020

IEC 60812, *Failure modes and effects analysis (FMEA and FMECA)*

IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-5-1, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60950-1:2005, *Information technology equipment – Safety – Part 1: General requirements*

IEC 60950-1:2005/AMD1:2009

IEC 60950-1:2005/AMD2:2013

IEC 61025, *Fault tree analysis (FTA)*

IEC 61204-7, *Low-voltage switch mode power supplies – Part 7: Safety requirements*

IEC TS 61430, *Secondary cells and batteries – Test methods for checking the performance of devices designed for reducing explosion hazards – Lead-acid starter batteries*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61558-1, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 62477-1, *Safety requirements for power electronic converter systems and equipment – Part 1: General*

IEC 62133-1, *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 62282-2-100, *Fuel cell technologies – Part 2-100: Fuel cell modules – Safety*

IEC 62391-1, *Fixed electric double-layer capacitors for use in electric and electronic equipment – Part 1: Generic specification*

IEC 62391-2, *Fixed electric double-layer capacitors for use in electronic equipment – Part 2: Sectional specification – Electric double layer capacitors for power application*

IEC 62619, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

IEC/ISO 31010, *Risk management – Risk assessment techniques*

ISO 179 (all parts), *Plastics – Determination of Charpy impact properties*

ISO 180, *Plastics – Determination of Izod impact strength*

ISO 877 (all parts), *Plastics – Methods of exposure to solar radiation*

ISO 1419, *Rubber- or plastics-coated fabrics – Accelerated-ageing tests*

ISO 1421, *Rubber- or plastics-coated fabrics – Determination of tensile strength and elongation at break*

ISO 1798, *Flexible cellular polymeric materials – Determination of tensile strength and elongation at break*

ISO 2440, *Flexible and rigid cellular polymeric materials – Accelerated ageing tests*

ISO 2626, *Copper – Hydrogen embrittlement test*

ISO 3691-1, *Industrial trucks – Safety requirements and verification – Part 1: Self-propelled industrial trucks, other than driverless trucks, variable-reach trucks and burden-carrier trucks*

ISO/TS 3691-7, *Industrial trucks – Safety requirements and verification – Part 7: Regional requirements for countries within the European Community*

ISO/TS 3691-8, *Industrial trucks – Safety requirements and verification – Part 8: Regional requirements for countries outside the European Community*

ISO 3864-1, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings*

ISO 4038, *Road vehicles – Hydraulic braking systems – Simple flare pipes, tapped holes, male fittings and hose end fittings*

ISO 4080, *Rubber and plastics hoses and hose assemblies – Determination of permeability to gas*

ISO 4675, *Rubber- or plastics-coated fabrics – Low-temperature bend test*

ISO 5053-1, *Industrial trucks – Vocabulary – Part 1: Types of industrial trucks*

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

ISO 10380, *Pipework – Corrugated metal hoses and hose assemblies*

ISO 10442, *Petroleum, chemical and gas service industries – Packaged, integrally geared centrifugal air compressors*

ISO 10806, *Pipework – Fittings for corrugated metal hoses*

ISO 11114-4, *Transportable gas cylinders – Compatibility of cylinder and valve materials with gas contents – Part 4: Test methods for selecting metallic materials resistant to hydrogen embrittlement*

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

ISO 13226, *Rubber – Standard reference elastomers (SREs) for characterizing the effect of liquids on vulcanized rubbers*

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*

ISO 14113, *Gas welding equipment – Rubber and plastics hose and hose assemblies for use with industrial gases up to 450 bar (45 MPa)*

ISO 15649, *Petroleum and natural gas industries – Piping*

ISO/TR 15916, *Basic considerations for the safety of hydrogen systems*

ISO 16010, *Elastomeric seals – Material requirements for seals used in pipes and fittings carrying gaseous fuels and hydrocarbon fluids*

ISO 16111:2018, *Transportable gas storage devices – Hydrogen absorbed in reversible metal hydride*

ISO 17268, *Gaseous hydrogen land vehicle refuelling connection devices*

ISO 19881, *Gaseous hydrogen – Land vehicle fuel containers*

ISO 19882, *Gaseous hydrogen – Thermally activated pressure relief devices for compressed hydrogen vehicle fuel containers*

ISO 20898, *Industrial trucks – Electrical requirements*

ISO 21927-3, *Smoke and heat control systems – Part 3: Specifications for powered smoke and heat exhaust ventilators*

ISO 23551-1, *Safety and control devices for gas burners and gas-burning appliances – Particular requirements – Part 1: Automatic and semi-automatic valves*

UN GTR No. 13, *Global Technical Regulation concerning the hydrogen and fuel cell vehicles*

UN Regulation No. 134, *Uniform provisions concerning the approval of motor vehicles and their components with regard to the safety-related performance of hydrogen-fuelled vehicles (HFCV)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-485 and the following 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 <http://www.iso.org/obp>

3.1

abnormal operation

operation of the fuel cell power system with any one mechanical, electrical or control component malfunction or failure, in any failure mode regarded as reasonably probable in the failure mode and effects analysis (FMEA) but excluding accidental rupture or breakdown of the containers of flammable liquids, and/or gases

3.2

equipotential bonding

permanent joining of conductive parts to form a positive electrically conductive path that provides electrical continuity between non-current carrying conductive parts and is capable of conducting any fault current that can occur

Note 1 to entry: This applies to bonding within the fuel cell system and between the fuel cell system and truck and does not refer to the means to earth the truck itself, such as with an earthing strap or with tires.

3.3

check-valve

fluid control device that allows fluids to flow in only one direction

3.4

limited power circuit

circuit involving a potential greater than 42,4 V peak (30 V RMS) or 60 V DC and whose power after 60 s of operation complies with the values outlined in Table 2B and Table 2C of IEC 60950-1:2005 and IEC 60950-1:2005/AMD2:2013

Note 1 to entry: A circuit that is low voltage under both normal and single fault conditions is referred to in IEC 60950-1 as a safety extra low voltage (SELV).

3.5

low-voltage circuit

circuit involving a peak open-circuit potential of not more than 42,4 V (30 V RMS) or 60 V DC supplied by a battery, a fuel cell, a transformer having a rated power output rating of less than 100 VA and a maximum secondary output of 30 V AC or by a combination of a transformer and a fixed impedance that, as a system, complies with IEC 61558-1

Note 1 to entry: A circuit derived by connecting a resistance in series with a voltage supply circuit as a means of limiting the voltage and current is not considered to be a low-voltage circuit.

3.6

dilution boundary

extent of a flammable area or zone created by a limited release of flammable gas, internal to the fuel cell power system or truck in which it is mounted, and controlled by mechanical ventilation or other effective means

Note 1 to entry: This is outlined in IEC 60079-10-1.

3.7

electrostatic discharge

ESD

transfer of electric charge between bodies of different electrostatic potentials in proximity or through direct contact

[SOURCE: IEC 60050-561:2014, 561-03-06]

3.8

fuel cell power system

generator system that uses one or more fuel cell modules to generate electric power and heat

Note 1 to entry: See [Figure 1](#) for a block diagram of a fuel cell power system. The fuel cell power system for use with industrial trucks will be in one of the forms as outlined in [3.9](#) and [3.10](#).

[SOURCE: IEC 60050-485:2020, 485-09-01, modified – addition of the Note to entry.]

3.9

self-contained system

complete system incorporated into its own housing that is intended to replace or combine with a battery system to power an industrial truck

Note 1 to entry: Display and control functions can be located outside the system's housing in proximity to the operator's compartment. However, if counterweight is required outside the system's housing or direct communication is required between the system and the truck controller, then it will be considered an integrated system (see 3.10).

3.10

integrated fuel cell power system

complete system of fuel cell components and parts that are incorporated into the industrial truck with the various parts of the system potentially distributed throughout the truck

3.11

hazardous zone

any work area or space where combustible dust, ignitable fibres, or flammable, volatile liquids, gases, or mixtures are or can be present in the air in quantities sufficient to produce explosive or ignitable mixtures as defined by IEC 60079-10-1

3.12

integral

something that is either contained within the fuel cell power system or is external to it, but is a part of the fuel cell power system

3.13

lower flammability limit

LFL

minimum concentration of fuel in a fuel-air mixture where a combustion can be ignited by an ignition source

Note 1 to entry: A fuel-air mixture is flammable when combustion can be started by an ignition source. The main component concerns the proportions or composition of the fuel-air mixture. A mixture that has less than a critical amount of fuel, known as the lower flammability limit (*LFL*) or more than a critical amount of fuel, known as the rich or upper flammability limit (*UFL*), will not be flammable.

3.14

maximum allowable working pressure

MAWP

maximum gauge pressure at which a fuel cell or fuel cell power system can be operated

Note 1 to entry: See [Annex A](#) for a comparison table of pressure terms.

Note 2 to entry: The maximum allowable working pressure is expressed in Pa.

Note 3 to entry: The maximum allowable working pressure is the pressure used in determining the setting of pressure limiting/relieving devices installed to protect a component or system from accidental over-pressuring.

[SOURCE: IEC 60050-485:2020, 485-17-03, modified – addition of new Note 1 to entry.]

3.15

maximum operating pressure

MOP

highest gauge pressure of a component or the system that is expected during normal operation

Note 1 to entry: See [Annex A](#) for a comparison table of pressure terms.

3.16

normal release

limited localized volumes of hydrogen concentrations released during normal operation that can include fuel cell purge

3.17**normal operation**

all operating and non-operating modes encountered during product use that are not the result of a malfunction or failure

3.18**pressure relief device****PRD**

pressure and/or temperature activated device used to prevent the pressure from rising above a predetermined maximum and thereby prevent failure of a pressurized part or system

3.19**thermally activated pressure relief device****TPRD**

pressure relief device (3.18) activated by temperature

3.20**risk assessment**

overall process comprising a risk analysis and a risk evaluation

3.21**risk analysis**

systemic use of available information to identify hazards and to estimate the risk

3.22**risk evaluation**

procedure based on the risk analysis to determine whether a tolerable risk has been achieved

3.23**safety control**

automatic controls and interlocks including relays, switches, sensors and other auxiliary equipment used in conjunction therewith to form a safety control system, which is intended to prevent unsafe operation of the controlled equipment

3.24**safety critical component**

component, device, circuit, software or similar part whose failure would affect the safety of the fuel cell power system as determined in 4.16

3.25**service pressure****nominal working pressure**

pressure, as specified by the manufacturer, at a uniform gas temperature of 15 °C and with full gas content

Note 1 to entry: This term only relates to the hydrogen pressure vessel.

Note 2 to entry: See [Annex A](#) for a comparison table of pressure terms.

3.26**zone system of classification**

means for classifying areas within the fuel cell power system using the methods outlined in IEC 60079-10-1