

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Fuel cell technologies –
Part 3-100: Stationary fuel cell power systems – Safety**

**Technologies des piles à combustible –
Partie 3-100: Systèmes à piles à combustible stationnaires – Sécurité**



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NORME INTERNATIONALE



**Fuel cell technologies –
Part 3-100: Stationary fuel cell power systems – Safety**

**Technologies des piles à combustible –
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FUEL CELL TECHNOLOGIES –

Part 3-100: Stationary fuel cell power systems – Safety

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International Standard IEC 62282-3-100 has been prepared by IEC technical committee 105: Fuel cell technologies.

This second edition cancels and replaces the first edition published in 2012. This edition constitutes a technical revision.

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

- a) recognition that fuel carrying components qualified to leakage standards (soundness) need not be considered as potential flammable leak sources;
- b) new Annex C for small power systems; and
- c) clarifications for numerous requirements and tests.

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

FDIS	Report on voting
105/695/FDIS	105/705/RVD

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

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

A list of all parts in the 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 "<http://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- withdrawn,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
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INTRODUCTION

A typical stationary fuel cell power system is shown in Figure 1.

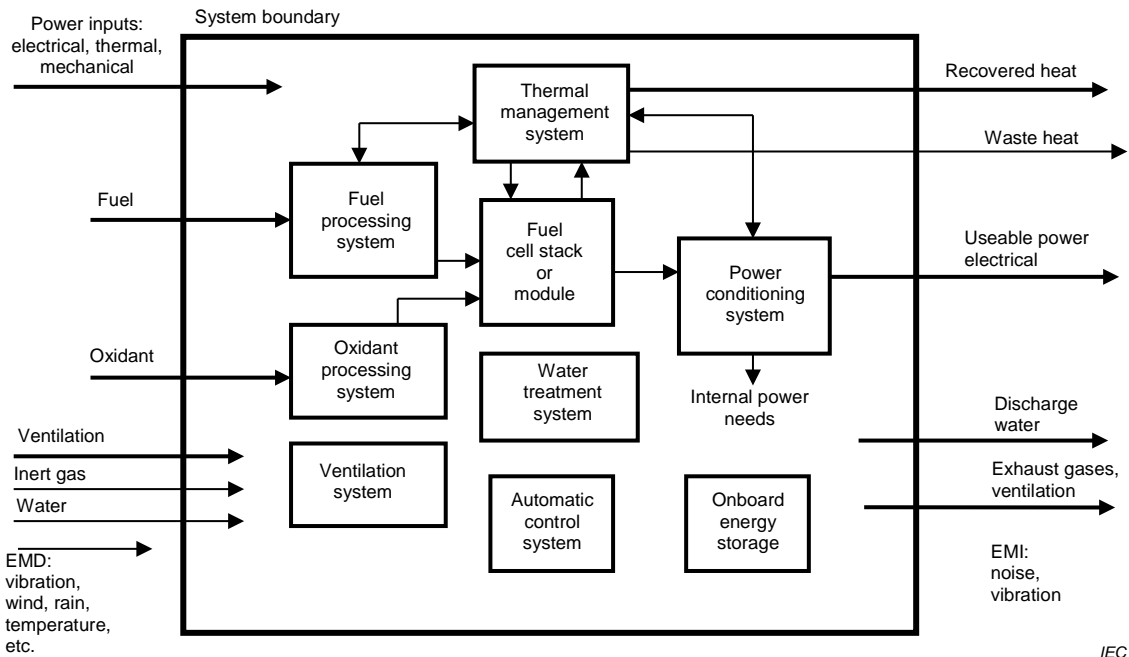


Figure 1 – Typical stationary fuel cell power system

The overall design of the power system anticipated by this document forms an assembly of integrated systems, as necessary, intended to perform designated functions, as follows.

- Fuel processing system – System of chemical and/or physical processing equipment plus associated heat exchangers and controls required to prepare, and if necessary, pressurize, the fuel for utilization within a fuel cell power system.
- Oxidant processing system – System that meters, conditions, processes and may pressurize the incoming supply for use within the fuel cell power system.
- Thermal management system – System that provides heating or cooling and heat rejection to maintain the fuel cell power system in the operating temperature range, and may provide for the recovery of excess heat and assist in heating the power train during start-up.
- Water treatment system – System that provides all the necessary purification treatment of the recovered or added water for use within the fuel cell power system.
- Power conditioning system – Equipment that is used to adapt the electrical energy produced by the fuel cell stack(s) to application requirements as specified by the manufacturer.
- Automatic control system – System(s) that is composed of sensors, actuators, valves, switches and logic components that maintain the fuel cell power system parameters within the manufacturer’s specified limits including moving to safe states without manual intervention.
- Ventilation system – System that provides air through mechanical or natural means to the fuel cell power system’s enclosure.
- Fuel cell modules – Equipment assembly of one or more fuel cell stacks which electrochemically converts chemical energy to electric energy and thermal energy intended to be integrated into a power generation system.

- Fuel cell stack – Equipment assembly of cells, separators, cooling plates, manifolds and a support structure that electrochemically converts, typically, hydrogen rich gas and air reactants to DC power, heat and other reactant bi-products.
- Onboard energy storage – System of internal electric energy storage devices intended to aid or complement the fuel cell module in providing power to internal or external loads.

FUEL CELL TECHNOLOGIES –

Part 3-100: Stationary fuel cell power systems – Safety

1 Scope

This part of IEC 62282 applies to stationary packaged, self-contained fuel cell power systems or fuel cell power systems comprised of factory matched packages of integrated systems which generate electricity through electrochemical reactions.

This document applies to systems

- a) intended for electrical connection to mains direct, or with a transfer switch, or to a stand-alone power distribution system;
- b) intended to provide AC or DC power;
- c) with or without the ability to recover useful heat;
- d) intended for operation on the following input fuels:
 - 1) natural gas and other methane rich gases derived from renewable (biomass) or fossil fuel sources, for example, landfill gas, digester gas, coal mine gas;
 - 2) fuels derived from oil refining, for example, diesel, gasoline, kerosene, liquefied petroleum gases such as propane and butane;
 - 3) alcohols, esters, ethers, aldehydes, ketones, Fischer-Tropsch liquids and other suitable hydrogen-rich organic compounds derived from renewable (biomass) or fossil fuel sources, for example, methanol, ethanol, di-methyl ether, biodiesel;
 - 4) hydrogen, gaseous mixtures containing hydrogen gas, for example, synthesis gas, town gas.

This document does not cover:

- micro fuel cell power systems;
- portable fuel cell power systems;
- propulsion fuel cell power systems.

NOTE For special applications such as “marine auxiliary power”, additional requirements can be given by the relevant marine ship register standard.

This document is applicable to stationary fuel cell power systems intended for indoor and outdoor commercial, industrial and residential use in non-hazardous areas.

This document contemplates all significant hazards, hazardous situations and events, with the exception of those associated with environmental compatibility (installation conditions), relevant to fuel cell power systems, when they are used as intended and under the conditions foreseen by the manufacturer.

This document deals with conditions that can yield hazards on the one hand to persons, and on the other to damage outside the fuel cell power system only. Protection against damage to the fuel cell power system internals is not addressed in this document, provided it does not lead to hazards outside the fuel cell power system.

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 60079-2, *Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "p"*

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/IEEE 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*

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

IEC 60335-1:2016, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60335-2-51, *Household and similar electrical appliances – Safety – Part 2-51: Particular requirements for stationary circulation pumps for heating and service water installations*

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

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

IEC 60730-2-5, *Automatic electrical controls – Part 2-5: Particular requirements for automatic electrical burner control systems*

IEC 60730-2-6, *Automatic electrical controls – Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

IEC 60730-2-9, *Automatic electrical controls – Part 2-9: Particular requirements for temperature sensing control*

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

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*

IEC TS 61000-3-4, *Electromagnetic compatibility (EMC) – Part 3-4: Limits – Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A*

IEC TS 61000-3-5, *Electromagnetic compatibility (EMC) – Part 3-5: Limits – Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 75 A*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

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

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

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

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

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

IEC 61511-1, *Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements*

IEC 62040-1, *Uninterruptible power systems (UPS) – Part 1: Safety requirements*

IEC 62061, *Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems*

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*

ISO 4413, *Hydraulic fluid power – General rules and safety requirements for systems and their components*

ISO 4414, *Pneumatic fluid power – General rules and safety requirements for systems and their components*

ISO 5388, *Stationary air compressors – Safety rules and code of practice*

ISO 10439 (all parts), *Petroleum, petrochemical and natural gas industries – Axial and centrifugal compressors and expander-compressors*

ISO 10440-1, *Petroleum, petrochemical and natural gas industries – Rotary-type positive-displacement compressors – Part 1: Process compressors*

ISO 10440-2, *Petroleum and natural gas industries – Rotary-type positive-displacement compressors – Part 2: Packaged air compressors (oil-free)*

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

ISO 12499, *Industrial fans – Mechanical safety of fans – Guarding*

ISO 13631, *Petroleum and natural gas industries – Packaged reciprocating gas compressors*

ISO 13707, *Petroleum and natural gas industries – Reciprocating compressors*

ISO 13709, *Centrifugal pumps for petroleum, petrochemical and natural gas industries*

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

ISO 13850, *Safety of machinery – Emergency stop function – Principles for design*

ISO 14847, *Rotary positive displacement pumps – Technical requirements*

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

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

ISO 23550, *Safety and control devices for gas and/or oil burners and appliances – General requirements*

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

ISO 23553-1, *Safety and control devices for oil burners and oil-burning appliances – Particular requirements – Part 1: Automatic and semi-automatic valves*

ISO 26142, *Hydrogen detection apparatus – Stationary applications*

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 <http://www.iso.org/obp>

3.1

accessible

area to which, under normal operating conditions, one of the following applies:

- a) access can be gained without the use of a tool;
- b) the means of access is deliberately provided to the user;
- c) the user is instructed to enter regardless of whether or not a tool is needed to gain access

Note 1 to entry: The terms "access" and "accessible", unless qualified, relate to an area deemed accessible as defined above.

Note 2 to entry: Only service personnel are allowed into non-accessible areas. Service personnel may need to have proper personal protective equipment as noted in the maintenance manual.

3.2

anode exhaust catalytic reactor

catalyst reactor which oxidizes hydrogen-rich gas used for hydrogen fuel cell power systems

3.3

automatic burner control system

system which includes a programming unit, a flame detector and may include an ignition source and/or ignition device and which monitors the operation of fuel burners

Note 1 to entry: The various functions of the system may be in one or more housings.

3.4

burner port

opening in a burner head through which gas or gas-air mixture is discharged for ignition

3.5

combustible material

item capable of being ignited and burned

Note 1 to entry: Such materials are considered combustible even though flame-proofed, fire-retardant treated, or plastered.

Note 2 to entry: When pertaining to materials adjacent to, or in contact with, heat-producing appliances, vent connectors, flue gas vents, steam and hot water pipes, and warm air ducts, combustible materials are those materials made of or surfaced with wood, compressed paper, plant fibres, or other materials that are capable of being ignited and burned.

3.6

design pressure

highest pressure that may occur under any and all operating modes, including steady state and transient

3.7

effluent

products of combustion plus the excess air being discharged from gas utilization equipment

3.8

electromagnetic disturbance

EMD

electromagnetic phenomenon that may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

Note 1 to entry: This note applies to the French language only.

3.9

electromagnetic interference

EMI

degradation of the performance of an equipment, transmission channel or system caused by an electromagnetic disturbance

Note 1 to entry: This note applies to the French language only.

3.10

electrical equipment

material, fittings, devices, appliances, fixtures, apparatus and the like used as part of, or in connection with, an electrical installation

**3.11
emergency shutdown
safety shutdown**

control system actions, based on process parameters, taken to stop the fuel cell power system and all its reactions immediately to avoid damage to equipment and/or persons

**3.12
fuel cell**

electrochemical device that converts the chemical energy of a fuel and an oxidant to electrical energy (DC power), heat and other reaction products

[SOURCE: IEC TS 62282-1:2013, 3.43, modified — In the definition, "other" has been added.]

**3.13
fuel cell power system**

generator system that uses one or more fuel cell module(s) to generate electric power and heat

[SOURCE: IEC TS 62282-1:2013, 3.49]

**3.14
fuel compartment**

compartment with internal sources of flammable gas/vapour release

**3.15
flue gas vent**

passageway for conveying vent gas from gas utilization equipment or their vent connectors to the outside atmosphere

Note 1 to entry: See also 3.33.

**3.16
gas carrying circuit**

assembly of parts of the stationary fuel cell power system that carry or contain supply gas or process gas

**3.17
igniter**

device which utilizes electrical energy to ignite gas at a pilot burner or main burner

**3.18
ignition device**

device mounted on or adjacent to a burner for igniting fuel at the burner

EXAMPLE Pilot burners, spark electrodes and hot surface igniters.

**3.19
ignition system timings****3.19.1
flame-establishing period**

period of time between the signal to energize the fuel flow means and the signal indicating presence of the burner flame

Note 1 to entry: This may be applicable to proof of the ignition source or main burner flame, or both.

**3.19.2
ignition activation period**

period of time between energizing the main gas valve and deactivation of the ignition means prior to the lock-out time

3.19.3**start-up lock-out time**

period of time between the initiation of gas flow and the action to shut off the gas flow in the event of failure to establish proof of the supervised ignition source or the supervised main burner flame

3.19.4**purge time**

period of time intended to allow for the dissipation of any unburned gas or residual products of combustion

3.19.4.1**pre-purge time**

purge time which occurs at the beginning of a burner operating cycle prior to initiating ignition

3.19.4.2**post-purge time**

purge time which occurs at the end of a burner operating cycle

3.19.5**recycle time**

period of time between the signal to de-energize the gas supply following loss of the supervised ignition source or the supervised flame and the signal to begin a new start-up procedure

3.20**interlock**

control to prove the physical state of a required condition and to furnish that proof to the safety related control device which performs the safety shutdown

3.21**lock-out time**

period of time between the signal indicating absence of flame and the action to shut off the fuel supply

3.22**main burner**

device or group of devices essentially forming an integral unit for the final conveyance of gas or a mixture of gas and air to the combustion zone, and on which combustion takes place to accomplish the function for which the equipment is designed

3.23**manifold**

conduit(s) which supplies fluid to or collects it from the fuel cell or the fuel cell stack

[SOURCE: IEC TS 62282-1:2013, 3.70, modified — The notes to entry have been deleted.]

3.24**permissive**

condition within a logic sequence that has to be satisfied before the sequence is allowed to proceed to the next phase

3.25**pilot**

small gas flame used to ignite the gas at the main burner

3.25.1**continuous pilot**

pilot that burns without turning off throughout the entire time the burner is in service, whether the main burner is firing or not

3.25.2**intermittent pilot**

pilot which is automatically lit each time there is a signal for initialization and burns during the entire period that the main burner is firing

3.25.3**interrupted pilot**

pilot which is automatically ignited prior to the admission of fuel to the main burner and which is automatically extinguished when the main flame is established

3.26**process gas**

supply gas that has been transformed to a gas containing predominantly hydrogen

3.27**purge**

protective operation to remove gases and/or liquids, such as fuel, hydrogen, air or water, from a fuel cell power system

3.28**recovered heat**

thermal energy that has been recovered for useful purposes

Note 1 to entry: The recovered heat is measured by determining the temperatures and flow rates of heat recovery fluid (water, steam, air or oil, etc.) entering and leaving the thermal energy recovery subsystem at the interface point of the small fuel cell power system.

3.29**reformer**

reactor to produce a hydrogen rich gas mixture from a raw fuel

3.30**small fuel cell power system**

fuel cell power system with rated electrical output less than 10 kW, and maximum pressure of less than 0,1 MPa (gauge) for fuel and oxidant passages

Note 1 to entry: Replacement subclauses for small fuel cell power systems are given in Annex C.

3.31**state****3.31.1****cold state**

state of a fuel cell power system at ambient temperature with no power input or output

3.31.2**operational state**

state of a fuel cell power system with substantial electrical active output power available

3.31.3**passive state**

state of the fuel cell power system when the fuel and oxidant systems have been purged with steam, air or nitrogen or per manufacturer's instructions

3.31.4**pre-generation state**

state of a fuel cell power system being at sufficient operating temperature and in such an operational mode, with zero electrical output power, that the fuel cell power system is capable of being promptly switched to an operational state with substantial electrical active output power

3.31.5**steady state condition**

<small fuel cell power system> condition when the fluctuation of electric power output is within ± 2 % of rated power output

3.31.6**storage state**

state of a fuel cell power system being non-operational and possibly requiring, under conditions specified by the manufacturer, the input of thermal and/or electric energy and/or an inert atmosphere in order to prevent deterioration of the components

3.32**thermal equilibrium conditions**

stable temperature conditions indicated by temperature changes of no more than 3 K or 1 % of the absolute operating temperature, whichever is higher between three readings 15 min apart

3.33**supply gas**

gas supplied externally to the stationary fuel cell power system

3.34**supply gas circuit**

assembly of parts of the stationary fuel cell power system that carry or contain the supply gas between the gas inlet connection and the outlet of the safety shut-off valves

3.35**vent connector**

portion of the venting system which connects the flue outlet of gas utilization equipment to the flue gas vent or single-wall metal pipe

3.36**vent gas**

products of combustion from gas utilization equipment plus excess air, plus dilution air in the venting system

3.37**vent terminal**

vent cap

fitting at the end of the vent pipe that directs the flue products into the outside atmosphere

3.38**ventilation****3.38.1****mechanical ventilation**

movement of air and its replacement with fresh air by mechanical means

3.38.2**natural ventilation**

movement of air and its replacement with fresh air due to the effects of wind and/or temperature gradients

[SOURCE: IEC 60050-426:2008, 426-03-07]

3.39

venting system

flue gas vent and vent connector if used, assembled to form a continuous open passageway from the flue collar of gas utilization equipment to the outside atmosphere for the purpose of removing vent gases

4 Safety requirements and protective measures

4.1 General safety strategy

The manufacturer shall perform in written form a risk assessment to ensure that:

- a) all reasonably foreseeable hazards, hazardous situations and events and foreseeable misuse throughout the anticipated fuel cell power system's lifetime have been identified. Annex A provides a list of hazards that have been dealt with in this document;
- b) the risk for each of these hazards has been estimated from the combination of probability of occurrence of the hazard and of its foreseeable severity;
- c) the two factors which determine each one of the estimated risks (probability and severity) have been eliminated or reduced to a level not exceeding the acceptable risk level through application of:
 - 1) inherently safe design of the construction and its methods; or
 - 2) guards and protective devices provided
 - i) by passive control of energy releases without endangering the surrounding environment (for example, burst discs, release valves, thermal cut-off devices), or
 - ii) by active control of energy (for example, by electronic control equipment included in the fuel cell power system, which enforces adequate countermeasures based on the evaluation of the sensor signal and by safety related control functions);
- d) for residual risks which could not have been reduced by the measures according to c), provisions such as labels, warnings, or requirements of special training shall be taken, considering that such measures need to be understood by the persons who are in the area of the hazards.

For functional safety, the required severity level, performance level or the class of control function shall be determined and designed in accordance with:

- 1) IEC 62061 and, if applicable, ISO 13849-1 or IEC 61508 (all parts) in conjunction with IEC 61511-1 for applications according to IEC 60204-1;
- 2) IEC 60730-1 or ISO 23550 for appliances according to IEC 60335-1, IEC 60950-1, IEC 62368-1 or IEC 62040-1;
- 3) IEC 61508 (all parts) in conjunction with IEC 61511-1 for other applications.

For failure mode and effects analysis (FMEA) and fault tree analysis methods the following standards can be used as guidance:

- IEC 60812;
- SAE J1739;
- IEC 61025.