



DPC: 24 / 30442627 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Responsible committee: GEL/105 Fuel cell technologies

Interested committees:

Title: BS EN 62282-3-100 Fuel cell technologies
Part 3-100: Stationary fuel cell power systems - Safety

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

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THIS DRAFT IS NOT CURRENT BEYOND 22 January 2025**

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Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Committee Secretary: **Lilly Malik (BSI)**

Direct tel:

E-mail: lilly.malik@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



105/1090/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER:

IEC 62282-3-100 ED3

DATE OF CIRCULATION:

2024-11-29

CLOSING DATE FOR COMMENTS:

2025-02-21

SUPERSEDES DOCUMENTS:

105/872/RR

IEC TC 105 : FUEL CELL TECHNOLOGIES

SECRETARIAT:

Germany

SECRETARY:

Mr David Urmann

OF INTEREST TO THE FOLLOWING COMMITTEES:

HORIZONTAL FUNCTION(S):

ASPECTS CONCERNED:

Safety

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Recipients of this document are invited to submit, with their comments, notification of any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "In Some Countries" clauses. (SEE AC/22/2007 OR NEW GUIDANCE DOC).

TITLE:

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

NOTE FROM TC/SC OFFICERS:

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FUEL CELL TECHNOLOGIES –

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

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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- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

This third edition cancels and replaces the second edition published in 2019. This edition constitutes a technical revision.

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

- a) requirements included to address natural gas / hydrogen blends as a fuel source;
- b) updated definitions for improved clarity and alignment with IEV and ISO sources;
- c) requirements for protective devices, safety related control functions, safety shutdown functions, exhaust gas systems, and other general requirements have been updated for clarity;
- d) requirements for power electronic converter systems have been included;
- e) Updated Figures

1) Figure 1: *Typical stationary fuel cell power system*

2) Figure 2 – *Minimum test pressures*;

3) Figure 3- *Test wall with static pressure ports and vent terminal locations*;

4) Figure 4 – *Vent test wall*;

5) Figure 5 - *Piezo ring and details of typical construction*;

f) requirements for operation manuals now differentiate between manuals intended for use by qualified personnel and manuals for use by non-qualified personnel;

g) requirements of annex C for Small Fuel Cell Power Systems were integrated into the main document, annex C has been deleted.

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

FDIS	Report on voting

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
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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) Including all types of stationary fuel cell technologies, but not limited to:

- 1) alkaline fuel cells (AFC);
- 2) phosphoric acid fuel cells (PAFC);
- 3) polymer electrolyte fuel cells (PEFC);
- 4) molten carbonate fuel cells (MCFC); and
- 5) solid oxide fuel cells (SOFC).

b) intended for electrical connection to mains direct, or with a transfer switch, or to a stand-alone power distribution system;

c) intended to provide AC or DC power;

d) with or without the ability to recover useful heat;

e) intended for operation on the following input fuels:

- 1) natural gas, natural gas/hydrogen blends 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:

- a) micro fuel cell power systems;
- b) table fuel cell power systems;
- c) 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.

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

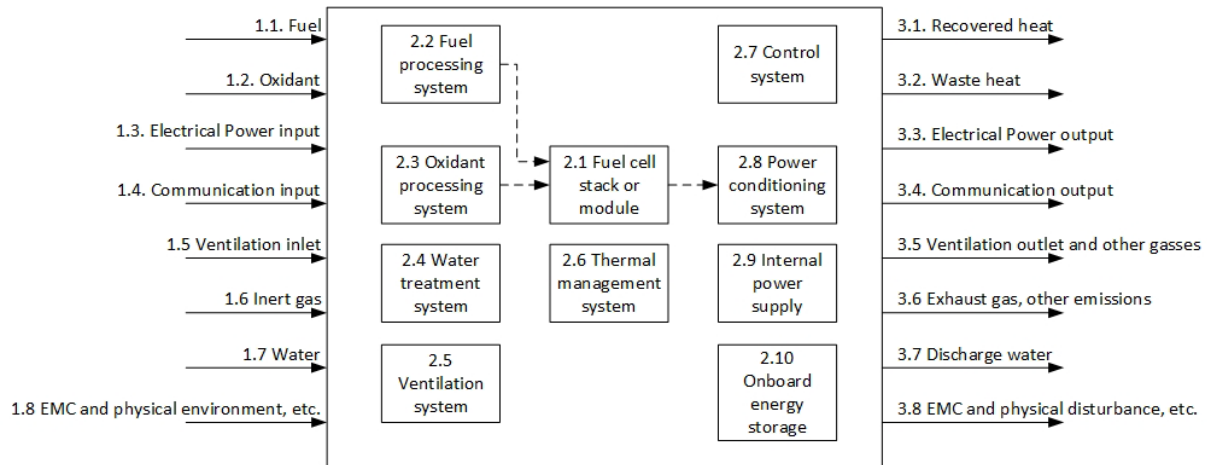


Figure 1 – Typical stationary fuel cell power system

NOTE The figure does not include all possible sub-systems or interfaces but is a representation of a typical fuel cell power system. Hence not all sub-systems and interfaces shown are required.

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.

Inputs:

- 1.1 Fuel supply– Fuel supply according to the composition limits and supply characteristics of the fuels for which its design is intended.
- 1.2 Oxidant supply- the catalytic input to the chemical reaction in the fuel cell, most commonly air. The catalytic input to the chemical reaction in the fuel cell, most commonly air. May also be used to support combustion for fuel reforming.
- 1.3 Electrical Power input – Electrical input specified by the manufacturer, for controls and other supporting functions. See 4.2 for details.
- 1.4 Communication input - includes the providing of control signals, setpoint and operation instructions as well as remote access, parameter, software, and firmware updates.
- 1.5 Ventilation supply – air provided for the ventilation system.
- 1.6 Inert gas supply– non-reactive gas for system purging and protective pacification.
- 1.7 Water supply – water can be for cooling purposes, draining condensate, etc.
- 1.8 EMC and physical environment, etc. - the surrounding conditions affecting the fuel cell system, such as vibrations, temperature, wind, water, and pollution but also electromagnetic disturbances.

Within system boundaries:

- 2.1 Fuel cell stack(s) – assembly of cells, separators, cooling plates, manifolds and a supporting structure that electrochemically converts, typically, hydrogen-rich gas and air reactants to DC power, heat and other reaction products.
- Note: Box 2.1 may also be a fuel cell module which is an assembly incorporating one or more fuel cell stacks and, if applicable, additional components, that is intended to be integrated into a power system.

- 2.2 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.
- 2.3 Oxidant processing system – System that meters, conditions, processes and may pressurize the incoming supply for use within the fuel cell power system.
- 2.4 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, for e.g. cooling, etc.
- 2.5 Ventilation system – System that provides air through mechanical or natural means to the fuel cell power system.
- 2.6 Thermal management system – System that provides heating, cooling, or 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 during start-up.
- 2.7 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.
- 2.8 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, one component of which is a power electronic converter system.
- 2.9 Internal power supply – Generation of power needed to run the supporting functions and systems around the fuel cell module.
- 2.10 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.

Output:

- 3.1 Recovered heat - Thermal energy recovered for useful purposes.
- 3.2 Waste heat - Thermal energy not recovered for useful purposes.
- 3.3 Electrical Power output – The power produced from the system and provided to an external load or grid.
- 3.4 Communication output - Includes the transmission of operational state and other data collected or generated by the system.
- 3.5 Ventilation outlet and other gasses – Air-rich gas, used for transporting heat, fuel residue and other trace gasses from the system to the outside.
- 3.6 Exhaust gas, other emissions – Process emissions from the system.
- 3.7 Discharge water – Condensate or wastewater from the system.
- 3.8 EMC and physical disturbance, etc. – The effect the fuel cell power system has on its surroundings, which could include noise, vibrations, and electromagnetic disturbances, etc.

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*

- 204 IEC 60079-20-1, *Explosive atmospheres – Part 20-1: Material characteristics for gas and*
205 *vapour classification – Test methods and data*
- 206 IEC 60079-29-1, *Explosive atmospheres – Part 29-1: Gas detectors – Performance*
207 *requirements of detectors for flammable gases*
- 208 IEC 60204-1, *Safety of machinery– Part 1: General requirements*
- 209 IEC 60204-11, *Safety of machinery – Electrical equipment of machines - Part 11: Requirements*
210 *for equipment for voltages above 1000V AC or 1500V DC and not exceeding 36 kV*
- 211 IEC 60335-1, *Household and similar electrical appliances – Safety – Part 1: General*
212 *requirements*
- 213 IEC 60335-2-41, *Household and similar electrical appliances – Safety – Part 2-41: Particular*
214 *requirements for pumps*
- 215 IEC 60335-2-51, *Household and similar electrical appliances – Safety – Part 2-51: Particular*
216 *requirements for stationary circulation pumps for heating and service water installations*
- 217 IEC 60417 – *Graphical symbols for use on equipment*
- 218 IEC 60529, *Degrees of Protection Provided by enclosures (IP Code)*
- 219 IEC 60730-1:2022, *Automatic electrical controls – Part 1: General requirements*
- 220 IEC 60730-2-5, *Automatic electrical controls – Part 2-5: Particular requirements for automatic*
221 *electrical burner control systems*
- 222 IEC 60730-2-6, *Automatic electrical controls – Part 2-6: Particular requirements for automatic*
223 *electrical pressure sensing controls including mechanical requirements*
- 224 IEC 60730-2-9, *Automatic electrical controls – Part 2-9: Particular requirements for temperature*
225 *sensing control*
- 226 IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic*
227 *current emissions (equipment input current ≤ 16 A per phase)*
- 228 IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage*
229 *changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment*
230 *with rated current ≤ 16 A per phase and not subject to conditional connection*
- 231 IEC TS 61000-3-4, *Electromagnetic compatibility (EMC) – Part 3-4: Limits – Limitation of*
232 *emission of harmonic currents in low-voltage power supply systems for equipment with rated*
233 *current greater than 16 A*
- 234 IEC TS 61000-3-5, *Electromagnetic compatibility (EMC) – Part 3-5: Limits – Limitation of*
235 *voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated*
236 *current greater than 75 A*
- 237 IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage*
238 *changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with*
239 *rated current ≤ 75 A and subject to conditional connection*
- 240 IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity*
241 *standard for residential, commercial and light-industrial environments*

- 242 IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity*
243 *standard for industrial environments*
- 244 IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission*
245 *standard for equipment in residential environments*
- 246 IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission*
247 *standard for industrial environments*
- 248 IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-*
249 *related systems*
- 250 IEC 61511-1, *Functional safety – Safety instrumented systems for the process industry sector*
251 *– Part 1: Framework, definitions, system, hardware and application programming requirements*
- 252 IEC 62061, *Safety of machinery – Functional safety of safety-related control systems*
- 253 IEC 62109-1, *Safety of power converters for use in photovoltaic power systems – Part 1:*
254 *General requirements*
- 255 IEC 62109-2, *Safety of power converters for use in photovoltaic power systems – Part 2:*
256 *Particular requirements for inverters*
- 257 IEC 62282-3-300, *Fuel cell technologies – Part 3-300: Stationary fuel cell power systems -*
258 *Installation*
- 259 IEC 62477-1, *Safety requirements for power electronic converter systems and equipment – Part*
260 *1: General*
- 261 IEC 62477-2, *Safety requirements for power electronic converter systems and equipment – Part*
262 *2: Power electronic converters from 1000 V AC or 1500 V DC up to 36 kV AC or 54 kV DC*
- 263 IEC CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances,*
264 *electric tools and similar apparatus Part 1: Emission*
- 265 IEC CISPR 14-2, *Electromagnetic compatibility – Requirements for household appliances,*
266 *electric tools and similar apparatus Part 2: Immunity*
- 267 ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles*
268 *for product safety labels*
- 269 ISO 4413, *Hydraulic fluid power – General rules and safety requirements for systems and their*
270 *components*
- 271 ISO 4414, *Pneumatic fluid power – General rules and safety requirements for systems and their*
272 *components*
- 273 ISO 5388, *Stationary air compressors – Safety rules and code of practice*
- 274 ISO 7000, *Graphical symbols for use on equipment – registered symbols*
- 275 ISO 10439 (all parts), *Petroleum, petrochemical and natural gas industries – Centrifugal*
276 *compressors*
- 277 ISO 10440-1, *Petroleum, petrochemical and natural gas industries – Rotary-type positive-*
278 *displacement compressors – Part 1: Process compressors*

- 279 ISO 10440-2, *Petroleum and Natural Gas Industries - Rotary-type positive-displacement*
280 *compressors – Part 2: Packaged air compressors (oil-free)*
- 281 ISO 10442, *Petroleum, Chemical and Gas Service Industries Packaged, Integrally Geared*
282 *Centrifugal Air Compressors*
- 283 ISO 12100, *Safety of machinery – General principles for design – Risk assessment and risk*
284 *reduction*
- 285 ISO 12499, *Industrial fans – Mechanical safety of fans – Guarding*
- 286 ISO 13631, *Petroleum and natural gas industries – Packaged reciprocating gas compressors*
- 287 ISO 13707, *Petroleum and natural gas industries – Reciprocating compressors*
- 288 ISO 13709, *Centrifugal pumps for petroleum, petrochemical and natural gas industries*
- 289 ISO 13849 (all parts), *Safety of machinery – Safety-related parts of control systems*
- 290 ISO 13850, *Safety of machinery – Emergency stop function – Principles for design*
- 291 ISO 14847, *Rotary positive displacement pumps – Technical requirements*
- 292 ISO 15649, *Petroleum and natural gas industries – Piping*
- 293 ISO 16110-1, *Hydrogen generators using fuel processing technologies – Part 1: Safety*
- 294 ISO 16111, *Transportable gas storage devices – Hydrogen absorbed in reversible metal hydride*
- 295 ISO 22967, *Forced draught gas burners*
- 296 ISO 23550, *Safety and control devices for gas and/or oil burners and appliances – General*
297 *requirements*
- 298 ISO 23551-1, *Safety and control devices for gas burners and gas-burning appliances –*
299 *Particular requirements – Part 1: Automatic and semi-automatic valves*
- 300 ISO 23553-1, *Safety and control devices for oil burners and oil-burning appliances – Particular*
301 *requirements – Part 1: Automatic and semi-automatic valves*
- 302 ISO 26142, *Hydrogen detection apparatus – Stationary applications*
- 303 CSA/ANSI Z21.47:21/CSA 2.3:21, *Gas-fired central furnaces*

304 **3 Terms and definitions**

305 For the purposes of this document, the following terms and definitions apply.
306 ISO and IEC maintain terminological databases for use in standardization at the following
307 addresses:

- 308 a) IEC Electropedia: available at <http://www.electropedia.org/>
309 b) ISO Online browsing platform: available at <http://www.iso.org/obp>

310 **3.1**

311 **accessible**

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

- 313 a) access can be gained without the use of a tool;
314 b) the means of access is deliberately provided to the user;
315

c) the user is instructed to enter regardless of whether or not a tool is needed to gain access

NOTE The terms "access" and "accessible", unless qualified, relate to an area deemed accessible as defined above.

3.2

air-rich operation

mixtures of fuel and air, in which the air content is greater than that of a stoichiometric mixture
Note 1 to entry: Air-rich operations are used when complete fuel reaction is intended (e.g. in flame burners).

[SOURCE: ISO 16110-1, modified to correct the term "air-rich operation"]

3.3

anode exhaust catalytic reactor

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

3.4

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 The various functions of the system may be in one or more housings.

3.5

burner port

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

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 can degrade the performance of a device, equipment or system, or adversely affect living or inert matter

NOTE An electromagnetic disturbance can be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

[SOURCE: IEC 61010-1, modified: note 2 and note 3 are removed]

3.9

electromagnetic interference

EMI

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

NOTE In English, the terms "electromagnetic disturbance" and "electromagnetic interference" designate respectively the cause and the effect, and should not be used indiscriminately.

[SOURCE: IEC 61010-1, modified: note 1 and 2 are removed]

3.10**electrical equipment**

item used for generation, conversion, transmission, distribution or utilization of electric energy

Note Examples of such items are electric machines, transformers, switchgear and controlgear, measuring instruments, protective devices, wiring systems current-using equipment.

[SOURCE: IEC 826-16-01]

3.11**electromagnetic compatibility****EMC**

ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment

[SOURCE: IEC 161-01-07]

3.12**exhaust gas**

gases ejected from the fuel utilization equipment plus dilution air.

3.13**flame failure lock-out time****flame failure response time**

period of time between the signal indicating absence of flame and lock-out

[SOURCE: IEC 60730-2-5:2021, 2.3.107]

3.14**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

NOTE: The fuel and oxidant are typically stored outside of the fuel cell and transferred into the fuel cell as they are consumed

[SOURCE: IEC 485-08-01]

3.15**fuel cell power system**

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

[SOURCE: IEC 485-09-01]

3.16**fuel compartment**

compartment with internal sources of flammable gas/vapour release

3.17**fuel-rich operation**

mixture of fuel and air, in which the fuel content is greater than that of a stoichiometric mixture
Note 1 to entry: Fuel-rich operations are used when complete air reaction is intended (e.g. in catalytic partial oxidation, preferential oxidation or auto-thermal reactors)

[SOURCE: ISO 16110-1]

3.18**gas carrying circuit**

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

3.19**igniter**

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

3.20**ignition device**

any means used to ignite the fuel at the ignition burner or at the main burner

[SOURCE: ISO 22967]

3.21**ignition system timings****3.21.1****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 This may be applicable to proof of the ignition source or main burner flame, or both.

[SOURCE: IEC 60730-2-5:20xx, 2.3.113, modified: “main” is removed from the title and the definition]

3.21.2**ignition activation period**

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

3.21.3**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

3.21.4**purge time**

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

3.21.4.1**pre-purge time**

period during which purge takes place at the proven air rate prior to energizing the ignition device

[SOURCE: ISO 22967]

3.21.5**recycle time**

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

[SOURCE: IEC 60730-2-5:20xx, 2.3.120, modified: include “of the supervised ignition source or”]

3.22

interlock (for safeguarding)

arrangement that interconnects guard(s) or device(s) with the control system and/or all or part of the electrical supply to the machine

3.23

lock-out

Safety related shutdown condition requiring a manual operation to restart the fuel cell power system

[IEC 60335-2-102:2017, 3.101, modified]

3.24

lock-out time

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

3.25

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.

3.26

permissive

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

3.27

pilot

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

3.27.1

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

3.27.2

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

3.27.3

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

3.28

process gas

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

3.29**purge**

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

3.30**recovered heat**

thermal energy that has been recovered for useful purposes

NOTE 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.

3.31**reformer**

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

[SOURCE: IEC 485-07-03. Modified – The note to the entry has been deleted]

3.32**safety related shutdown**

de-energization of the main fuel flow means as the result of the action of a limiter, a cut-out or the detection of an internal fault of the system

NOTE Safety related shutdown may include additional actions by the system. See 4.9.2.3.2 for examples.

[SOURCE: IEC 60730-2-5:Ed.4.2, 2.3.32, modified: included in the title “related” after safety, replaced “main” in front of “fuel flow means”]

3.33**start-up lock-out time**

period of time between the signal to energize the fuel flow means and lock-out

NOTE For systems which control two separate fuel flow means, two different start-up lock-out times are possible (first and second start-up lock-out times).

[SOURCE: IEC 60730-2-5]

3.34**state****3.34.1****cold state**

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

[SOURCE: IEC 485-21-01]

3.34.2**operational state**

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

[SOURCE: IEC 485-21-02]

3.34.3**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

[SOURCE: IEV 485-21-03]

3.34.4

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

[Source: IEV 485-21-04]

3.34.5

steady state <in fuel cells>

state of a physical system in which the relevant characteristics remain constant with time

[SOURCE: IEV 485-21-05. 485-21-05]

3.34.6

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, electric energy or an inert atmosphere, or any combination thereof, in order to prevent deterioration of the components

3.35

stationary fuel cell power system

fuel cell power system that is connected and fixed in place

[SOURCE IEV 485-09-24]

3.36

supply gas

gas supplied externally to the stationary fuel cell power system

3.37

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

3.38

thermal equilibrium

state reached when the temperature of the parts of a component or equipment operating in a given environment no longer varies faster than a specified limit

[SOURCE IEV 151-16-33]

3.39

ventilation

3.39.1

forced ventilation

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

[Source: IEC 485-09-16]

3.39.2

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]

3.40

venting system

a continuous open passageway conveying exhaust from the gas utilization equipment to the outside atmosphere

4 Safety requirements and protective measure

4.1 General safety strategy

The manufacturer shall perform in written form a risk assessment in accordance with the basic concepts and principles of ISO 12100 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 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.

Where safety related control functions are required by the risk assessment to lower the risks to an acceptable level, they shall be designed according to the applied relevant functional safety standard(s) in 4.9.

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

- a) IEC 60812;
- b) SAE J1739;
- c) IEC 61025.

4.2 Physical environment and operating conditions

4.2.1 General

The fuel cell power system and protective systems shall be so designed and constructed as to be capable of performing their intended function(s) in the physical environment and operating conditions specified in 4.2.2 to 4.2.8.

4.2.2 Electrical power input

The fuel cell power system shall be designed to operate correctly with the conditions of electrical power input specified in the relevant electrical product application standard as given in 4.7 or as otherwise specified by the manufacturer.

4.2.3 Physical environment

The manufacturer shall specify the physical environment conditions for which the fuel cell power system is suitable. Consideration should be given to:

- a) indoor/outdoor use;
- b) the altitude above sea-level up to which the fuel cell power system must be capable of operating correctly;
- c) the range of air temperatures and humidity within which the fuel cell power system must be capable of operating correctly;
- d) the seismic zone where it may be sited.

4.2.4 Fuel input

The fuel cell power system shall be designed to operate correctly within the composition limits and supply characteristics of the fuels for which its design is intended (for example, pipeline natural gas).

4.2.5 Water input

The quality and supply characteristics of the water to be used in the fuel cell power systems shall be specified by the manufacturer.

4.2.6 Vibration, shock and bump

The undesirable effects of vibration, shock and bump (including those generated by the machine and its associated equipment and those created by the physical environment) shall be avoided by the selection of suitable equipment, by placing the fuel cell power system away from such sources, or by the use of anti-vibration mountings. This does not include the effects of seismic shock, which shall be addressed separately if the manufacturer deems it appropriate for its product (see 4.2.3).

4.2.7 Handling, transportation, and storage

The fuel cell power system shall be designed to withstand, or suitable precautions shall be taken to protect against, the effects of transportation and storage temperatures within a range of $-25\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$ and for short periods not exceeding 24 h at up to $+70\text{ }^{\circ}\text{C}$. Alternative temperature ranges may be specified by the manufacturer.

The fuel cell power system or each component part thereof shall

- a) be capable of being handled and transported safely, and when necessary, be provided with suitable means for handling by cranes or similar equipment,
- b) be packaged or designed so that it can be stored safely and without damage (for example, with inherent adequate stability, provided with special supports).

The manufacturer shall specify special means for handling, transportation and storage if required.

4.2.8 System purging

Means shall be provided in fuel cell power systems to purge where, for safety reasons, a passive state is required after shutdown or prior to start-up, as specified by the manufacturer. The system purging shall not create a hazardous situation.

4.3 Selection of materials

4.3.1

All materials shall be suitable for the intended purpose.

4.3.2

When materials used to construct the fuel cell power system are known to pose hazards under certain circumstances, the manufacturer shall implement the measures and provide the information necessary to sufficiently minimize the risk of endangering persons' safety or health.

4.3.3

Asbestos or asbestos-containing material(s) shall not be used in the construction of a fuel cell power system. The use of other hazardous substances such as lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyl, polybrominated diphenyl ether and polychlorinated biphenyl shall be addressed in accordance with national and regional regulations.

Metallic and non-metallic materials used to construct internal or external parts of the fuel cell power system, in particular those exposed directly or indirectly to moisture or that contain process gas or liquid streams, as well as all parts and materials used to seal or interconnect the same, for example, welding consumables, shall be suitable for all physical, chemical and thermal conditions which are reasonably foreseeable within the scheduled lifetime of the equipment and for all test conditions. In particular:

- a) they shall retain their mechanical stability with respect to strength (fatigue properties, endurance limit, creep strength) when exposed to the full range of service conditions and lifetime as specified by the manufacturer;
- b) they shall be sufficiently resistant to the chemical and physical action of the fluids that they contain and to environmental degradation;
- c) the chemical and physical properties necessary for operational safety shall not be significantly affected within the scheduled lifetime of the equipment unless replacement is foreseen;
- d) when selecting materials and manufacturing methods, due account shall be taken of the material's corrosion and wear resistance, electrical conductivity, impact strength, aging resistance, the effects of temperature variations, the effects arising when materials are put together (for example, galvanic corrosion), the effects of ultraviolet radiation, and to the degradation effects of hydrogen including hydrogen embrittlement on the mechanical performance of a material.

NOTE Guidance to account for the degradation effects of hydrogen on the mechanical performance of a material can be found in ISO/TR 15916, ASME B31.12 and Annex B.

4.3.4

Where conditions of erosion, abrasion, corrosion or other chemical attack may arise, adequate measures shall be taken to:

- a) minimize that effect by appropriate design, for example, additional thickness, or by appropriate protection, for example, use of liners, cladding materials or surface coatings, taking due account of the intended and reasonably foreseeable use;
- b) permit replacement of parts which are most affected;
- c) draw attention, in the maintenance instructions referred to in 7.4.5, to the type and frequency of inspection and maintenance measures necessary for continued safe use; where appropriate, it shall be indicated which parts are subject to wear and the criteria for replacement.

4.4 General requirements**4.4.1**

In so far as their purpose allows, accessible parts of the fuel cell power system shall have no sharp edges, no sharp angles and no rough surfaces likely to cause injury.

4.4.2

The fuel cell power system, or parts of it where there is a reasonable expectation of access, shall be designed and constructed to prevent persons slipping, tripping or falling on or off these parts.

4.4.3

The fuel cell power system, components and fittings thereof shall be so designed and constructed such that they are stable for use without risk of overturning, falling or unexpected movement, under the foreseen operating and climatic conditions.

4.4.4

The moving parts of the fuel cell power system shall be designed, built and laid out to avoid hazards or, where hazards persist, fixed with guards or protective devices in such a way as to prevent all risk of contact which could lead to injury.

4.4.5

The various parts of the fuel cell power system and their linkages shall be so constructed that, when used normally, no instability, distortion, breakage or wear likely to impair their safety can occur.

4.4.6

The fuel cell power system shall be so designed, constructed and/or equipped such that risks due to gases, liquids, dust or vapours released during its operation or maintenance are avoided.

4.4.7

All parts shall be securely mounted or attached and rigidly supported. The use of shock-mounts is permitted when suitable for the application.

4.4.8

All safety related shutdown system components, as well as components whose failure may result in a hazardous event as identified by the risk assessment in 4.1, shall be in compliance with the relevant standard considering the intended use.

4.4.9

The manufacturer shall take steps to eliminate any risk of injury caused by contact with, or proximity to, external surfaces of the fuel cell power system enclosure, handle, grips or knobs at high temperatures.

4.4.10

If external surfaces of the fuel cell power system's enclosure, handles, grips, knobs or similar parts may be contacted by users without personal protective equipment, the manufacturer shall either limit the temperature of these surfaces at all times according to Table 1 or the manufacturer shall fix guards or protective devices in such a way as to prevent risk of contact that could lead to injury.

Table 1 – Allowable surface temperature rises

Part	Temperature rise K
External enclosures, except handles held in normal use	60
Surfaces of handles, knobs, grips and similar parts which are held for short periods only in normal use	
– of metal	35
– of porcelain	45
– of moulded material (plastic), rubber or wood	60
NOTE 1 The values in the table are the maximum surface temperature rises above ambient of external surfaces that can be contacted during operation by people without personal protective equipment. The above values are referenced in Table 3 of IEC 60335-1:2016.	
NOTE 2 The values in the table are based on an ambient temperature not normally exceeding 298,15 K but occasionally reaching 308,15 K. However, the temperature rise values specified are based on 298,15 K.	

The temperatures on walls, floor and ceiling adjacent to a stationary fuel cell power system shall not exceed 50 °C above ambient temperature under the test conditions of 5.12 b).

4.4.11

The fuel cell power system shall be so designed and constructed that the emission of airborne noise is reduced to a level suited for the intended use or location in compliance with applicable regional or national airborne noise codes and standards.

4.4.12

The fuel cell power system exhaust to atmosphere, under normal steady state operating conditions, shall not contain volume fraction of carbon monoxide in excess of 0,03 % by volume in an air-free sample of the effluents, which is a sample that has its effluent carbon monoxide (CO) volume fraction mathematically corrected as though there was zero percent excess air.

The CO volume fraction of the dry, air-free combustion products is given by the formula

$$\text{CO} = (\text{CO})_{\text{avg}} \times (\text{CO}_2)_{\text{max}} / (\text{CO}_2)_{\text{avg}}$$

where

CO is the carbon monoxide concentration of air-free combustion products in percent;

(CO₂)_{max} is the maximum carbon dioxide concentration of the dry, air-free combustion products for test fuel in percent;

(CO)_{avg} and (CO₂)_{avg} are the average values of measured concentrations in the sample taken at least 3 times during the test, both expressed in percent;

or

$$\text{CO} = (\text{CO})_{\text{avg}} \times (21 \%) / (21 \% - (\text{O}_2)_{\text{avg}})$$

where

(CO)_{avg} and (O₂)_{avg} are the average values of measured concentrations in the sample taken at least 3 times during the test, both expressed in percent.

4.4.13

Where explosive, flammable, or toxic fluids are contained in the piping, appropriate precautions shall be taken in the design and marking of sampling and take-off points.

4.4.14

The maximum temperatures of components and materials, as installed in the fuel cell power system, shall not exceed their temperature ratings.

4.4.15

The manufacturer shall give consideration to the suitability of the fuel cell power system to operate where contaminants (for example, dust, salt, smoke, and corrosive gases) are present in the physical environment.

4.4.16

The fuel cell power system enclosure shall be designed to safely contain any anticipated hazardous liquid leaks (see 4.5.2 f) for liquid fuel. The containment means shall have a capacity of 110 % of the maximum volume of fluid anticipated to leak.

4.4.17

The manufacturer shall take measures to ensure against condensate accumulation. The manufacturer shall take measures to ensure that exhaust gas does not escape through condensate drain lines. For outdoor parts of the installation, the risk assessment, according to 4.1, determines whether this requirement is applicable.

4.4.18

Shut-off valves shall be provided for all equipment and systems where containment or blockage of the process fluid flow is necessary during shutdown, testing, maintenance, upset, or emergency conditions.

4.4.19

All fuel supplied to the fuel cell power system shall pass through at least two automatic valves, in series, each of which serves as a safety shut-off valve and may serve as an operating control valve.

Any fuel supplied directly to fuel-fired equipment, such as a start-up boiler or a reformer start burner, shall also pass through at least two automatic valves, in series, each of which serves as an operating valve and a safety shut-off valve. These valves may or may not be contained in a single control body.

When fuel gases are recycled from appliances using the fuel cell power system output gas, the connection may be exempt from employing shut-off valves if demonstrated to be safe according to the risk assessment of 4.1.

4.4.20

If shaft seals leak hazardous fluids, the manufacturer shall provide hazardous fluid containment or dilution means as necessary to avoid risks to health or safety.

4.5 Pressure equipment and piping**4.5.1 Pressure equipment**

Pressurized vessels, such as reactors, heat exchangers, gas-fired tube heaters and boilers, electric boilers, coolers, accumulators and similar containers, and associated pressure relief mechanisms, such as relief valves and similar devices, shall be constructed and marked in accordance with applicable regional or national pressure equipment codes and standards.

Vessels such as tanks and similar containers that fall outside the scope of national pressure equipment standards shall be constructed of suitable materials in accordance with 4.3 and shall meet the applicable requirements of 4.4. Such vessels, and their related joints and fittings, shall be designed and constructed with adequate strength for functionality and leakage resistance to prevent unintended releases.

Hydrogen stored in metal hydrides assemblies shall comply with ISO 16111.

4.5.2 Piping systems

Piping and its associated joints and fittings shall conform to the applicable clauses of ISO 15649.

Piping systems designed for internal gauge pressure at or above zero but less than 105 kPa, handling fluids that are non-flammable, non-toxic and not damaging to human tissue and having a design temperature from -29 °C through 186 °C are not included in the scope of ISO 15649. Piping systems under these conditions shall be constructed of suitable materials in accordance with 4.3 and shall meet the applicable requirements of 4.4. Such pipes, and their related joints

and fittings, shall be designed and constructed with adequate strength for functionality and leakage resistance to prevent unintended releases.

The design and construction of both rigid and flexible pipes and fittings shall consider the following aspects.

- a) Materials shall meet the requirements specified in 4.3.
- b) The internal surfaces of piping shall be thoroughly cleaned to remove loose particles and the ends of piping shall be carefully reamed to remove obstructions and burrs.
- c) If fluid condensate or sediment accumulation inside gaseous fluid piping could cause damage from water hammer, vacuum collapse, corrosion and uncontrolled chemical reactions during start-up, shutdown and/or use, the manufacturer shall provide means for drainage and removal of deposits from low areas and for access during cleaning, inspection and maintenance. In particular, the manufacturer shall take measures to ensure against sediment or condensate accumulation in fuel gas controls. Sediment traps or filters shall be installed or adequate guidelines shall be provided in the product's technical documentation.
- d) The manufacturer shall take measures to ensure against sediment accumulation in liquid fuel controls. Sediment traps or filters shall be installed or adequate guidelines shall be provided in the technical documentation of the product.
- e) Non-metallic piping used to convey combustible gases shall be protected against the possibility of overheating and mechanical damage. Measures as required by the risk assessment specified in 4.1 shall be provided to prevent the temperature of components conveying combustible gases from surpassing their design temperatures.
- f) Liquid fuel cell power systems shall include provisions for capturing, recycling or safe disposal of released liquid fuel. Drip pans, spill guards, or double-walled pipe shall be designed to prevent uncontrolled releases.

4.5.3 Exhaust venting system

The fuel cell power system shall be provided with a venting system to convey exhaust gas from the system to the outside atmosphere. The manufacturer shall either supply a vent pipe system that meets the requirements or provide in the product's technical documentation adequate instructions to allow selection of a vent pipe system meeting these requirements.

- a) Materials shall meet the requirements specified in 4.3. In particular, the venting system shall be constructed of material resistant to corrosion by condensate. Non-metallic material shall be judged on its temperature limitation, strength and resistance to the action of condensate.
- b) The venting system parts of a fuel cell power system shall be durable. Venting system parts, including parts within the fuel cell power system, shall not break, disassemble or become damaged to the extent that they permit unsafe fuel cell power system operation.
- c) The vent pipe shall be properly supported and shall be provided with a rain cap or other feature that would not limit or obstruct the gas flow from venting.
- d) Means, such as drainage, shall be provided to prevent water, ice and other debris from accumulating inside the vent pipe or obstructing the vent pipe.
- e) A venting system for a fuel cell power system shall be leak-tight.
- f) The fitting piece of the fuel cell power system shall be sized to accommodate a commercially available venting system or to accommodate a venting system which is specified by the manufacturer.
- g) If a pressure switch is used to prove exhaust gas flow, it shall be factory set or set by qualified personnel at the construction site according to the manufacturer's specification. The adjustment means shall then be secured. A pressure switch shall bear a marking indicating clearly the appliance manufacturer's or distributor's part number or appropriate documentation which correlates to the locked pressure setting.
- h) Parts of a pressure switch in contact with exhaust gas condensate shall be corrosion-resistant to exhaust gas condensate at the normal operating temperatures.

i) The fuel cell power system shall be capable of starting up and then shall operate with without exceeding the maximum carbon monoxide (CO) level according to 4.4.12 while testing to 5.13.

j) When the fuel cell power system is provided with a venting system, the temperature of the exhaust gases conveyed by that venting system shall not exceed temperatures acceptable for the materials used to construct the venting system.

k) The venting system length shall be within the limits bounded by the testing carried out in 5.

4.5.4 Gas-conveying parts

The gas-conveying parts shall be gas-tight such that the tightness cannot be undermined under ordinary transportation, installation and use.

There are no external leakage requirements for parts or segments of the gas circuit that operate at all operating conditions below ambient air pressure.

Control systems used to ensure that a gas circuit operates below ambient air pressures shall comply with the requirements for control systems and protective components in 4.9.1.

4.6 Protection against fire or explosion hazards

4.6.1 Prevention against fire and explosion hazards in fuel cell power systems provided with enclosures

For parts of the gas carrying circuit where the internal gas pressure is above the ambient air pressure, the following applies.

a) The integrated systems of the fuel cell power system shall be assembled so as to prevent hazards associated with flammable atmosphere accumulations within the fuel cell power system.

b) The boundary for dilution of normal internal releases to below 25 % of the lower flammability limit (LFL) may be determined by computational fluid dynamic analysis, tracer gas, or similar methods, such as those given in IEC 60079-10-1. All devices installed within dilution boundaries shall meet the requirements specified in 4.6.1 e). The volume within dilution boundaries shall be classified according to IEC 60079-10-1. The LFL of typical gases are provided in IEC 60079-20-1.

NOTE 1 Examples of normal internal releases are fuel cell stack leak at the seals without a fault condition and do not include leak tight components. See 4.6.1 g) 2).

NOTE 2 Normal internal releases may be derived by the leak tests in 5.4.

c) Enclosures with internal sources of flammable gas/vapour release are defined as fuel compartments. Fuel compartments shall be designed to

1) maintain gas mixtures below 25 % (LFL), except in dilution boundaries, and

2) limit the extent of dilution boundaries to within the fuel compartment.

d) Methods to maintain normal internal releases below 25 % (LFL), except in dilution boundaries, include the following.

1) Controlled oxidation of normal internal releases

This may be accomplished by the provision of a continuous and reliable ignition and oxidant sources that ensures the combustion of the released gases or the utilization of catalytic oxidation units.

The manufacturer shall ensure that the maximum credible release, when reacted, produces pressures and temperatures that can be contained within the fuel compartment and tolerated by the components exposed to such conditions.

2) Air dilution of normal internal releases