IEC 62282-6-106

Edition 1.0 2024-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fuel cell technologies –
Part 6-106: Micro fuel cell power systems – Safety – Indirect Class 8 (corrosive) compounds**

**Technologies des piles à combustible –
Partie 6-106: Systèmes à micropiles à combustible – Sécurité – Composés (corrosifs) indirects de classe 8**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FUEL CELL TECHNOLOGIES –

Part 6-106: Micro fuel cell power systems – Safety – Indirect Class 8 (corrosive) compounds

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62282-6-106 has been prepared by IEC technical committee 105: Fuel cell technologies. It is an International Standard.

This first edition, together with the other parts of the IEC 62282-6-1XX series, cancels and replaces IEC 62282-6-100:2010 and IEC 62282-6-100:2010/AMD1:2012.

This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC 62282-6-100:2010 and IEC 62282-6-100:2010/AMD1:2012:

a) A new structure has been set up: IEC 62282-6-101 covers the general safety requirements common to all fuel types whereas IEC 62282-6-102 and subsequent parts of the IEC 62282-6-1XX series cover particular requirements for individual fuel types.

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

Draft	Report on voting
105/1017/FDIS	105/1025/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/publications.

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.

This document is to be used in conjunction with IEC 62282-6-101:2024 and is not to be used as a stand-alone document. This document provides additional requirements specific to corrosive fuel formulations, which apply in addition to the general requirements specified in IEC 62282-6-101:2024. The (sub)clause numbers in this document are aligned with those of IEC 62282-6-101:2024 and are intended to provide additional information and refined requirements, as appropriate.

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, or
- revised.

NOTE The attention of National Committees is drawn to the fact that equipment manufacturers and testing organizations may need a transitional period following publication of a new, amended or revised IEC publication in which to make products in accordance with the new requirements and to equip themselves for conducting new or revised tests.

It is the recommendation of the committee that the content of this publication be adopted for implementation nationally not earlier than 12 months from the date of publication.

FUEL CELL TECHNOLOGIES –

Part 6-106: Micro fuel cell power systems – Safety – Indirect Class 8 (corrosive) compounds

1 Scope

This part of IEC 62282 covers micro fuel cell power systems, micro fuel cell power units and fuel cartridges using hydrogen produced from UN Class 8 (corrosive) borohydride formulations as fuel. These systems and units use proton exchange membrane (PEM) fuel cell technologies. The designs include fuel processing subsystems to derive hydrogen gas from the corrosive fuel formulation.

IEC 62282-6-101:2024, Figure 1 is applicable.

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 62282-6-101:2024, *Fuel cell technologies – Part 6-101: Micro fuel cell power systems – Safety – General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62282-6-101 and the following apply.

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

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
fuel
corrosive (UN Class 8) formulation of borohydride compounds used as fuel for an indirect PEM micro fuel cell power system

Note 1 to entry: The formulation may contain a non-hazardous activator to facilitate the production of hydrogen, or an inhibitor, such as an alkali metal hydroxide, to modulate or inhibit the production of hydrogen from the corrosive fuel formulation or both. The formulation may be solid or liquid, or may include both solid and liquid components that are combined during fuel processing.

Note 2 to entry: This document only applies to corrosive (UN Class 8) compounds which can be processed to evolve hydrogen gas (e.g. through contact with water, non-hazardous or corrosive aqueous solutions, or an activator, or both).

Note 3 to entry: Guidance on the classification of materials, including mixtures, can be found in the current edition of the United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations.

3.2
borohydride compound
sodium or potassium borohydride, or a mixture thereof

3.3
liquid fuel component
Class 8 (corrosive), or non-hazardous, water solutions used to produce hydrogen within the fuel processing subsystem

3.4
fuel by-product
Class 8 (corrosive), or non-hazardous, compound produced after hydrogen or electricity, or both, is produced from fuel

3.5
activator
substance that facilitates the production of hydrogen from fuel, such as a catalyst

4 Safety principles

The safety principles included in IEC 62282-6-101:2024, Clause 4 apply in their entirety to technologies included in this document.

5 General safety requirements

5.1 General

The general safety requirements of IEC 62282-6-101:2024, 5.1 shall apply as written with the following addition.

NOTE The limited quantity exception for cargo transport of fuel cell cartridges containing corrosive fuel is 1 kg of solid fuel or 1 l of liquid fuel according to the UN Model Regulations. For passenger carriage in the aircraft cabin or in checked baggage the maximum quantity of corrosive fuel permitted inside the cartridge is 200 g of solid fuel or 200 g of liquid fuel according to the 2013 edition of the International Civil Aviation Organization (ICAO) Technical Instructions.

5.2 Chemical safety requirements

Consistent with IEC 62282-6-101:2024, Table 4, the following limits given in Table 1 shall apply for the emission and gas loss measurements for micro fuel cell power systems and fuel cartridges tested in accordance with this document.

Table 1 – Emission and gas loss limits

Constituent	Concentration limit[a] (Operating devices)	Gas loss rate limit[b] (Operating devices)	Gas loss rate limit[c] (Non-operating devices)
Non-hazardous aqueous solutions	Unlimited for pH between 3,5 and 10,5	Unlimited for pH between 3,5 and 10,5	Unlimited for pH between 3,5 and 10,5
Hydrogen	0,8 g/m^3	0,8 g/h total 0,016 g/h from single point leak[d]	0,003 2 g/h total (impermissible H_2 gas loss)
Formaldehyde[e g]	0,000 1 g/m^3	0,000 6 g/h	0,000 6 g/h
CO[g]	0,029 g/m^3	0,290 g/h	0,290 g/h
CO_2[g]	9 g/m^3	60 g/h[f]	60 g/h[f]
Methyl formate[g]	0,245 g/m^3	2,45 g/h	0,4 g/h

[a] The concentration limit for chemical compounds of interest shall be based on internationally recommended values. All toxicity based limits listed in this Table 1 are based on long-term, time-averaged limits, for instance TWA for ICSC’s occupational limit. The gas loss rate limit shall be obtained using similar computation as used in this Table 1 to ensure that overall gas loss rates do not exceed time-averaged limits for the constituent of interest. For such constituents, short-term increases in gas loss rate may be permissible, provided that the transient rate does not exceed the short-term exposure limit (STEL) for that constituent and the overall gas loss rate does not exceed the time-averaged rate specified in this Table 1.

[b] The "operating" emission rate limit was based on 10 m^3 ACH, selected as the product of the reference volume times the air changes per hour (ACH) because it covers the reasonably foreseeable environments where micro fuel cell power systems will be used. The interior space in a small car and the minimum volume per person on a commercial aircraft is at 1 m^3. The minimum ACH used on a passenger aircraft is 10 and the lowest ventilation setting in cars is 10 ACH. Homes and offices may have ACH levels as low as 0,5 but the per-person volume is over 20 m^3, so a product of 10 is conservative.

[c] The non-operating limits have been chosen based on a scenario of devices in an enclosed space with no ventilation. The space chosen has a volume of 0,28 m^3, or approximately 10 cubic feet. The criterion has been specified so that a concentration of greater than 25 % of the lower flammability limit (LFL) is not permitted to develop over a twenty-four hour (24 h) period, if three devices are in the enclosed space. For example, this criterion is applied for the determination of a maximum gas-loss rate based on the emission of flammable constituents from non-operating micro fuel cell power systems. Note that the control volume for non-operating systems should not be applied using toxicity limits, as the core principle of this enclosed space is that of a storage space, not one that a person can spend time in. For the determination of non-operating limits for constituents with both flammable and toxic properties, the lower of the flammability based limit for the "non-operating" control volume and the toxicity based limit for the "operating" control volume shall apply.

[d] 0,016 g/h reflects an emission rate lower than the limit reported by Swain, et al, (Proceedings of the 2001 DOE Program Review; NREL/CP-570-30535; M.R. Swain and M.N. Swain, Codes and Standards Analysis, 2001 (USA); available at: http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/30535bc.pdf) wherein "no hole was able to support a hydrogen flame at less than 3.5 cc/min." (3.5 cc/min ≈ 0,018 g/h). This value was chosen in conformance with the guidelines in IEC 62282-6-101:2024, Table 3.

[e] The WHO guideline limit is 0,000 1 g/m^3. Background levels are 0,000 03 g/m^3. The emission limit cannot push the background level above the guideline limit

[f] A seated human adult has a CO_2 emission rate of 30 g/h. The fuel cell plus human adult emission rates are limited such that the CO_2 concentration does not reach the WHO eight-hour concentration limit of 9 g/m^3. In an environment with 10 m^3 ACH, this limits the contribution from the fuel cell to 60 g/h.

[g] Testing for the presence of these constituents may be omitted for micro fuel cell power systems and fuel cartridges that do not contain, or have the potential to evolve, carbon-based compounds. In such cases, the rationale for such omission shall be documented in the hazard analysis and risk assessment.

5.3 Material requirements

The requirements of IEC 62282-6-101:2024, 5.3 shall apply as written.

5.4 Mechanical design requirements

5.4.1 General

The requirements of IEC 62282-6-101:2024, 5.4.1 shall apply as written, with the following additions.

5.4.1.1 Structural integrity

The general requirements of IEC 62282-6-101:2024, 5.4.1.1 shall apply as written with the following addition:

In addition, fuel cartridges intended to contain or evolve hydrogen at greater than atmospheric pressure shall also be capable of withstanding fire testing in accordance with 8.3.1 through 8.3.12.

5.4.2 Micro fuel cell power system

The general requirements of IEC 62282-6-101:2024, 5.4.2.1 and 5.4.2.2 shall apply as written.

5.4.3 Fuel cartridge

The general requirements of IEC 62282-6-101:2024, 5.4.3 shall apply as written with the following additions.

In addition, the following fuel specific requirements shall apply:

- In cases where materials (either solid or liquid) are present and are incompatible with either the borohydride fuel or liquid fuel component, the design of the fuel cartridge and micro fuel cell power system shall provide a means for preventing inadvertent or uncontrolled mixing of these materials.
- Two independent means for preventing inadvertent or uncontrolled mixing of these materials shall be provided during transportation and storage prior to use. Illustrative examples of these means include but are not limited to: positive activation by the control system; physical removal of an impermeable barrier preventing contact; opening of a normally closed manually controlled valve preventing contact. For at least one of these means for preventing uncontrolled mixing, it shall be necessary for the user to take positive action to remove or deactivate it prior to use.
- At least one means for preventing uncontrolled mixing of these materials shall be provided during use and storage after use. This means may include active control by system electronics, subject to the hazard analysis and risk assessment of 5.6.

5.4.4 Fuel valves and connections

The general requirements of IEC 62282-6-101:2024, 5.4.4.1 and 5.4.4.2 shall apply as written.

5.5 Electrical requirements

The general requirements of IEC 62282-6-101:2024, 5.5 shall apply as written.

5.6 Hazard analysis and risk assessment

The general requirements of IEC 62282-6-101:2024, 5.6 shall apply as written.

5.7 Functional safety requirements

The general requirements of IEC 62282-6-101:2024, 5.7 shall apply as written.

5.8 Small parts

The general requirements of IEC 62282-6-101:2024, 5.8 shall apply as written.

6 Abnormal operating and fault conditions testing and requirements

The general requirements of IEC 62282-6-101:2024, Clause 6 shall apply as written.

7 Instructions and warnings for micro fuel cell power systems and fuel cartridges

The general requirements of IEC 62282-6-101:2024, Clause 7 shall apply as written with the following addition.

In addition, both fuel cartridges and micro fuel cell power systems shall also include the following marking:

"MAY CONTAIN FLAMMABLE GAS."

8 Type tests for micro fuel cell power systems and fuel cartridges

8.1 General

The general requirements of IEC 62282-6-101:2024, 8.1 shall apply as written.

8.2 General leakage and gas loss measurement protocols

8.2.1 General protocols

The general requirements and principles of IEC 62282-6-101:2024, 8.2 shall be applied as appropriate for each of the type tests required in IEC 62282-6-101:2024, 8.3 with the following additional requirements.

For fuel cartridges and micro fuel cell power systems tested in accordance with this document, in general, concentration-based measurements are recommended over mass-based measurements. It is possible that mass-based measurements will not be appropriate for fuel cartridges containing water-reactive fuel, as leakage can be indicated by an increase in overall mass (e.g. absorption of water) rather than mass loss. If mass-based measurements are utilized for any type test, the test method shall be verified and validated prior to use for assessing compliance.

8.2.2 Tests

8.2.2.1 General

Following each type test, all test samples shall be checked for leakage and gas loss in accordance with the following procedures.

8.2.2.2 Leakage and gas loss test procedures for fuel cartridges

1) Perform a visual inspection of all possible leak locations as follows:
   a) The method for the detection of accessible hazardous liquids given in IEC 62282-6-101:2024, 8.2.8, or an equivalent method, shall be used to detect any hazardous liquid leakage.
   b) Accessible fuel, fuel by-products, electrolyte or liquid fuel component, or crystals on the exterior of the fuel cartridge are indications of leakage. If fuel, fuel by-products,