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Hydrogen generators using water electrolysis —

Part 1:
Safety

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*,, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/CLC/JTC 6, *Hydrogen in energy systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This first edition of ISO 22734-1 cancels and replaces ISO 22734:2019.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The electrochemical cells of a hydrogen generator system dissociate water molecules (H_2O) into two hydrogen (H_2) gas molecules and one oxygen (O_2) gas molecule when direct electrical current (e-) is applied. H_2 gas forms at the negative (-) cathode electrode and O_2 gas forms at the positive (+) anode electrode. An ion transport medium between the electrodes, a solid electrolyte membrane or a liquid electrolyte held in a microporous diaphragm, additionally functions to keep product H_2 and O_2 gases separate.

Water electrolysis hydrogen generator systems include the cell(s), electrical conditioning, gas processing, feed water, electrolyte management, cooling, ventilation, and control equipment. Gas compression, feed water conditioning, and other auxiliary equipment can be included. These systems can scale from small self-contained appliances to a group of factory-matched modules comprising large plant size installations.

This document is intended to assess water electrolysis hydrogen generator safety and may be used be used for certification purposes.

NOTE See ISO/IEC 17000 for further guidance on certification.

Hydrogen generators using water electrolysis —

Part 1: Safety

1 Scope

1.1 General

This document specifies the safety requirements of hydrogen gas generation appliances or systems that use electrochemical reactions to electrolyse water to produce hydrogen, herein referred to as hydrogen generators.

1.2 Applicable hydrogen generators

This document is applicable to:

— hydrogen generator appliances or systems (containerised, or skid mounted, complete hydrogen generation systems);

— factory-matched modules (supplied by the same manufacturer) that, when connected together, form a complete hydrogen generation system;

— hydrogen generators intended for industrial, commercial and residential applications;

— hydrogen generators intended for indoor or outdoor environments.

NOTE When this document is applied to hydrogen gas generation appliances or systems intended for installation into buildings, additional requirements for the design of the building are likely to apply. These building requirements are not addressed in this document. Additionally, the hydrogen generator enclosure requirements in this document do not necessarily translate to requirements for a building.

Guidance for hydrogen generators that also provide oxygen used for industrial and commercial applications is provided in this document, however additional considerations can apply.

1.3 Applicable ion transport mediums

This document is applicable to hydrogen generators that use the following types of ion transport medium:

— aqueous alkaline (basic) electrolytes, such as solutions of potassium hydroxide or sodium hydroxide;

— aqueous acidic electrolytes, such as dilute sulphuric acid;

— solid polymeric materials with acidic function group additions, such as acid proton exchange membrane (PEM);

— solid polymeric materials with basic function group additions, such as anion exchange membrane (AEM).

1.4 Applicability to large scale hydrogen generators

This document is applicable to large scale hydrogen generators assembled on site.

NOTE 1 Large scale water electrolysis systems typically have a production rate of 100 kg/hour or more and can be assembled using modules or equipment from various manufacturers.

NOTE 2 Building requirements are not addressed in this document and the hydrogen generator enclosure requirements in this document do not necessarily translate to requirements for a building.

1.5 Applicability to certain hydrogen generator subassemblies

This document is applicable to:

— electrochemical cell stacks (as stand-alone products);

— modules (sub-systems) for integration into larger hydrogen generation systems.

In such cases, the entirety of this document will not be applicable, and the specific sections relevant to the product are established in order to develop a product conformance strategy.

1.6 Excluded hydrogen generators

This document is not applicable to the following:

— residential hydrogen generators that also supply oxygen as a product;

— hydrogen generators that can also be used to generate electricity, such as reversible fuel cells (refer to IEC 62282-8-101, IEC 62282-8-102 and IEC 62282-8-201);

— hydrogen generators that use solid oxide electrolyte (refer to IEC 62282-8-101 and IEC 62282-8-201).

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.

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

ISO 4126-1, *Safety devices for protection against excessive pressure — Part 1: Safety valves*

ISO 4126-2, *Safety devices for protection against excessive pressure — Part 2: Bursting disc safety devices*

ISO 4126-6, *Safety devices for protection against excessive pressure — Part 6: Application, selection and installation of bursting disc safety devices*

ISO 4126-9, *Safety devices for protection against excessive pressure — Part 9: Application and installation of safety devices excluding stand-alone bursting disc safety devices*

ISO 4126-10, *Safety devices for protection against excessive pressure — Part 10: Sizing of safety valves and bursting discs for gas/liquid two-phase flow*

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

ISO 7866, *Gas cylinders — Refillable seamless aluminium alloy gas cylinders — Design, construction and testing*

ISO 9809-1, *Gas cylinders — Design, construction and testing of refillable seamless steel gas cylinders and tubes — Part 1: Quenched and tempered steel cylinders and tubes with tensile strength less than 1 100 MPa*

ISO 10286, *Gas cylinders — Terminology*

ISO 11119-1, *Gas cylinders — Design, construction and testing of refillable composite gas cylinders and tubes — Part 1: Hoop wrapped fibre reinforced composite gas cylinders and tubes up to 450 l*

ISO 11119-2, *Gas cylinders — Design, construction and testing of refillable composite gas cylinders and tubes — Part 2: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with load-sharing metal liners*

ISO 11119-3, *Gas cylinders — Design, construction and testing of refillable composite gas cylinders and tubes — Part 3: Fully wrapped fibre reinforced composite gas cylinders and tubes up to 450 l with non-load-sharing metallic or non-metallic liners or without liners*

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

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

ISO 15534-1, *Ergonomic design for the safety of machinery — Part 1: Principles for determining the dimensions required for openings for whole-body access into machinery*

ISO 15534-2, *Ergonomic design for the safety of machinery — Part 2: Principles for determining the dimensions required for access openings*

ISO 15534-3, *Ergonomic design for the safety of machinery — Part 3: Anthropometric data*

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

ISO 16528-1, *Boilers and pressure vessels — Part 1: Performance requirements*

ISO 17398, *Safety colours and safety signs — Classification, performance and durability of safety signs*

ISO 20485, *Non-destructive testing — Leak testing — Tracer gas method*

ISO 26142, *Hydrogen detection apparatus — Stationary applications*

ISO 80079-36, *Explosive atmospheres — Part 36: Non-electrical equipment for explosive atmospheres — Basic method and requirements*

ISO 80079-37, *Explosive atmospheres — Part 37: Non-electrical equipment for explosive atmospheres — Non-electrical type of protection constructional safety "c", control of ignition sources "b", liquid immersion "k"*

IEC 31010:2019, *Risk management — Risk assessment techniques*

IEC 60068-2-18:2017, *Environmental testing — Part 2-18: Tests — Test R and guidance: Water*

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

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

IEC 60079-14, *Explosive atmospheres - Part 14: Electrical installations design, selection and erection*

IEC 60079-17, *Explosive atmospheres - Part 17: Electrical installations inspection and maintenance*

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

IEC 60079-29-2, *Explosive atmospheres - Part 29-2: Gas detectors - Selection, installation, use and maintenance of detectors for flammable gases and oxygen*

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 60335-1:2020, *Household and similar electrical appliances — Safety — Part 1: General requirements*

IEC 60445, *Basic and safety principles for man-machine interface, marking and identification — Identification of equipment terminals, conductor terminations and conductors*

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

IEC 60730-1:2022, *Automatic electrical controls — Part 1: General requirements*

IEC 60947-1, *Low-voltage switchgear and controlgear — Part 1: General rules*

IEC 60998-2-2, *Connecting devices for low-voltage circuits for household and similar purposes — Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units*

IEC 60999-1, *Connecting devices — Electrical copper conductors — Safety requirements for screw-type and screwless-type clamping units — Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm2 up to 35 mm2 (included)*

IEC 60999-2, *Connecting devices — Electrical copper conductors — Safety requirements for screw-type and screwless-type clamping units — Part 2: Particular requirements for clamping units for conductors above 35 mm2 up to 300 mm2 (included)*

IEC 61010-1:2010/AMD1:2016, *Safety requirements for electrical equipment for measurement, control, and laboratory use — Part 1: General requirements*

IEC 61131-1, *Programmable controllers — Part 1: General information*

IEC 61131-2, *Programmable controllers — Part 2: Equipment requirements and tests*

IEC 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
cell separator
material that provides gas separation between the anode and cathode, either a *membrane* (3.27) or a *diaphragm* (3.7)

3.2
certification
third-party attestation related to products, processes, systems, or persons

[SOURCE: IEC 60050: 902-04-05, modified — removed Notes to entry 1 & 2.]

3.3
clean air
air that is essentially free of combustible dust, and contains no more than trace amounts of flammable vapour or gas

[SOURCE: IEC 60079-13:2017, 3.3.]

3.4
commercial
use of hydrogen generators by laypersons in non-manufacturing business facilities, such as stores, hotels, office buildings, educational institutes, filling stations, warehouses, and other non-residential locations

3.5
containment system
part of the equipment containing a flammable substance that may constitute a source of release

[SOURCE: IEC 60050: IEV 426-09-06, modified — removed “an internal” before “source of release”.]

3.6
critical function component
one part of a system in which a single fault or failure would result in the system entering an unsafe state

3.7
diaphragm
porous material that provides separation between oxygen and hydrogen product gases while allowing ionic transport within the cell electrolyte

3.8
dilution
mixing of flammable vapour or gas with *clean air* (3.3) or a *protective gas* (3.36) which, over time, will reduce the flammable concentration

[SOURCE: IEC 60079-10-1:2020, 3.5.2, modified — addition of "protective gas" as an option, and clarification on need for "clean air".]

3.9
dilution volume
volume in the vicinity of a source of release where the concentration of flammable gas or vapour is not diluted to a safe level

Note 1 to entry: A "safe level" is typically the lower flammability limit (LFL) or lower, and in some cases the safe level is defined as 2 % vol. or 1 % vol. of hydrogen in air, which corresponds to 50 % or 25 % of the LFL. See Annex B for information on the flammability limits of hydrogen. For further information about a suitable factor to use for defining a safe level, see IEC 60079-10-1.

[SOURCE: IEC 60079-10-1:2020, 3.5.3, modified — replaced Note 1 to entry.]

3.10
effective ignition source
potential ignition source that is able to ignite an explosive atmosphere when consideration is taken of when it occurs (i.e. in normal operation, expected malfunction or rare malfunction)

Note 1 to entry: This is important for establishing the EPL.

Note 2 to entry: An effective ignition source is a potential ignition source which can ignite the explosive atmosphere if protective measures are not used.

Note 3 to entry: For example, the frictional heat that can be produced by a bearing is a possible ignition source. This is an equipment-related ignition source if the piece of equipment contains a bearing. If the energy that can be produced by the friction in the bearing is capable of igniting an explosive atmosphere, then this is a potential ignition source. Whether this potential ignition source is effective depends on the likelihood that it will occur in a particular situation.

[SOURCE: IEC 60050: IEV 426-28-01]

3.11
electrochemical cell
assembly of electrodes, fluid containment, flow means, and electrical current conduction means, that may include a *cell separator* (3.1), for the purpose of producing hydrogen or oxygen from water

3.12
electrochemical cell stack
assembly of two or more *electrochemical cells* (3.11)

Note 1 to entry: A bipolar cell stack is an assembly of two or more electrochemical cells electrically connected in series and fluidically connected in parallel within a supporting structure, within or without a process containment vessel.

Note 2 to entry: A unipolar or monopolar cell stack may be an assembly of electrochemical cell electrodes, connected in electrical parallel, where anode and cathode electrode assemblies are contained within a single electrolyte vessel or tank, These modules may then interconnected in series if it is desired to raise connected service voltage.

3.13
enclosure
part of an assembly providing a specified degree of protection of equipment against external influences and a specified degree of protection against approach to or contact with hazardous parts of the hydrogen generator

Note 1 to entry: In the case of large hydrogen generator systems installed into a building, the building, or rooms within the building, can be regarded in the same way as an enclosure, although additional requirements will apply, and the requirements for enclosures will not necessarily apply to buildings, or rooms in buildings.

[SOURCE: IEC 60050:IEV 441-13-01, modified — added of Note 1 to entry.]

3.14
enriched oxygen atmosphere
gas that contains a volume fraction of more than 23,5 % oxygen with the remainder of its constituents being inert

3.15
factory-matched
engineered in a factory to correspond with each other and work together, separately packed for storage and transportation, and intended to be assembled together at the point of utilization

[SOURCE: ISO 16110-1:2007, 3.21, modified —term has been changed from "factory matched unit" to "factory-matched"; the words "system components" have been removed.]

3.16
gas crossover
gas permeation or leakage across *cell separators* (3.1) in a water electrolysis *electrochemical cell* (3.11)

Note 1 to entry: Excessive oxygen crossover into hydrogen cell compartments or hydrogen crossover into oxygen cell compartments can form flammable gas mixtures.

3.17
harm
injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1.]

3.18
hazard
potential source of *harm* (3.17)

Note 1 to entry: The term “hazard” may be qualified in order to define its origin or the nature of the expected harm (for example, electric shock hazard, crushing hazard, cutting hazard, toxic hazard, fire hazard, drowning hazard).

[SOURCE: ISO/IEC Guide 51:2014, 3.2, IEC 60050:IEV 351-57-01.]

3.19
hazardous area
three-dimensional region or space in which an explosive atmosphere is present, or can be expected to be present, in quantities such that special precautions for the construction, installation and use of equipment are required

Note 1 to entry: IEC 60079-10-1 gives a classification of hazardous areas containing explosive gas atmospheres (see IEV 426-03-03, IEV 426-03-04 and IEV 426-03-05).

[SOURCE: IEC 60050:IEV 426-03-01, modified — term combines IEV 426-03-01 and IEV 426-03-28, and removes Note 2 to entry.]