INTERNATIONAL STANDARD

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Hydrogen generators using fuel processing technologies —

Part 1: **Safety**

Générateurs d'hydrogène utilisant les technologies de traitement du carburant —

Partie 1: Sécurité

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16110-1 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*.

ISO 16110 consists of the following parts, under the general title *Hydrogen generators using fuel processing technologies*:

— *Part 1: Safety*

— *Part 2: Procedures to determine efficiency*

Introduction

The machine concerned and the extent to which hazards, hazardous situations and events are covered are indicated in the scope of this part of ISO 16110.

This part of ISO 16110 provides requirements and recommendations relating to hydrogen generators using fuel-processing technologies so as to promote:

— safety of persons and property;

— consistency of control response; and

— ease of maintenance.

High performance is not to be obtained at the expense of the essential factors mentioned above.

Hydrogen generators using fuel processing technologies —

Part 1:
Safety

1 Scope

This part of ISO 16110 applies to packaged, self-contained or factory matched hydrogen generation systems with a capacity of less than 400 m^3/h at 0 °C and 101,325 kPa, herein referred to as hydrogen generators, that convert an input fuel to a hydrogen-rich stream of composition and conditions suitable for the type of device using the hydrogen (e.g. a fuel cell power system or a hydrogen compression, storage and delivery system).

It applies to hydrogen generators using one or a combination of the following input fuels:

— natural gas and other methane-rich gases derived from renewable (biomass) or fossil fuel sources, e.g. landfill gas, digester gas, coal mine gas;

— fuels derived from oil refining, e.g. diesel, gasoline, kerosene, liquefied petroleum gases such as propane and butane;

— alcohols, esters, ethers, aldehydes, ketones, Fischer-Tropsch liquids and other suitable hydrogen-rich organic compounds derived from renewable (biomass) or fossil fuel sources, e.g. methanol, ethanol, di-methyl ether, biodiesel;

— gaseous mixtures containing hydrogen gas, e.g. synthesis gas, town gas.

This part of ISO 16110 is applicable to stationary hydrogen generators intended for indoor and outdoor commercial, industrial, light industrial and residential use.

It aims to cover all significant hazards, hazardous situations and events relevant to hydrogen generators, with the exception of those associated with environmental compatibility (installation conditions), when they are used as intended and under the conditions foreseen by the manufacturer.

NOTE A list of significant hazards and hazardous situations dealt with in this part of ISO 16110 is found in Annex A.

This part of ISO 16110 is a product safety standard suitable for conformity assessment as stated in IEC Guide 104, ISO/IEC Guide 51 and ISO/IEC Guide 7.

2 Normative references

The following referenced documents are indispensable for the application 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 4080, *Rubber and plastics hoses and hose assemblies — Determination of permeability to gas*

ISO 4413, *Hydraulic fluid power — General rules relating to systems*

ISO 4414, *Pneumatic fluid power — General rules relating to systems*

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

ISO 10439, *Petroleum, chemical and gas service industries — Centrifugal compressors*

ISO 10440-1, *Petroleum and natural gas industries — Rotary-type positive-displacement compressors — Part 1: Process compressors (oil-free)*

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

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

ISO 12499:1999, *Industrial fans — Mechanical safety of fans — Guarding*

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

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

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

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

ISO 13943, *Fire safety — Vocabulary*

ISO 14121, *Safety of machinery — Principles of risk assessment*

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

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

ISO 16528 (all parts)[1)] , *Boilers and pressure vessels*

IEC 60079-0:2004, *Electrical apparatus for explosive gas atmospheres — Part 0: General requirements*

IEC 60079-10:2002, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas*

IEC 60146-1-1, *Semiconductor convertors — General requirements and line commutated convertors — Part 1-1: Specifications of basic requirements*

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

IEC 60335-1:2004, *Household and similar electrical appliances — Safety — Part 1: General requirements*

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

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

IEC 60529:2001, *Degrees of protection provided by enclosures (IP Code)*

IEC 60664 (all parts), *Insulation coordination for equipment within low-voltage systems*

IEC 60704-3, *Household and similar electrical appliances — Test code for the determination of airborne acoustical noise — Part 3: Procedure for determining and verifying declared noise emission values*

IEC 60730-1, *Automatic electrical controls for household and similar use — Part 1: General requirements*

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1) To be published.

IEC 60730-2-5, *Automatic electrical controls for household and similar use — Part 2-5: Particular requirements for automatic electrical burner control systems*

IEC 60730-2-6, *Automatic electrical controls for household and similar use — Part 2-6: Particular requirements for automatic electrical pressure sensing controls including mechanical requirements*

IEC 60730-2-9, *Automatic electrical controls for household and similar use — Part 2-9: Particular requirements for temperature sensing controls*

IEC 60730-2-17, *Automatic electrical controls for household and similar use — Part 2-17: Particular requirements for electrically operated gas valves, including mechanical requirements*

IEC 60730-2-19, *Automatic electrical controls for household and similar use — Part 2-19: Particular requirements for electrically operated oil valves, including mechanical requirements*

IEC 60812, *Analysis techniques for system reliability — Procedure for failure mode and effects analysis (FMEA)*

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

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

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

IEC/TS 61000-3-5, *Electromagnetic compatibility (EMC) — Part 3: Limits — Section 5: Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16 A*

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

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

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

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

IEC 61025, *Fault tree analysis (FTA)*

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

IEC 61511-3, *Functional safety — Safety instrumented systems for the process industry sector — Part 3: Guidance for the determination of the required safety integrity levels*

IEC 61779-4, *Electrical apparatus for the detection and measurement of flammable gases — Part 4: Performance requirements for group II apparatus indicating up to 100 % lower explosive limit*

IEC 61779-6, *Electrical apparatus for the detection and measurement of flammable gases — Part 6: Guide for the selection, installation, use and maintenance of apparatus for the detection and measurement of flammable gases*

IEC 61882, *Hazard and operability studies (HAZOP studies) — Application guide*

IEC 62086-1, *Electrical apparatus for explosive gas atmospheres — Electrical resistance trace heating — Part 1: General and testing requirements*

3 Terms and definitions

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

3.1
air-rich condition
mixtures of fuel and air, in which the air content is greater than that of a stoichiometric mixture

NOTE Air-rich conditions are used when complete fuel reaction is intended (e.g. in flame burners).

3.2
air-rich system
system using air-rich conditions

3.3
ambient temperature
temperature of the medium surrounding a device, item of equipment or installation

3.4
auto-ignition
phenomenon in which a mixture of gases, vapours, mists, dusts or sprays ignites spontaneously with no external ignition source

[ISO/TR 15916:2004]

3.5
auto-ignition temperature
lowest temperature at which auto-ignition occurs

[ISO/TR 15916:2004]

3.6
auto-thermal reforming
coupling of partial oxidation and steam reforming

3.7
burner control system
system that monitors the operation of fuel burners, which is comprised of a programming unit and a flame detector, and which may include an ignition source and/or ignition device

3.8
cabinet
rigid structure that may contain the hydrogen generator that protects it against specific environmental and climatic conditions and incidental contact by people and livestock and that may also provide protection to people and livestock against incidental contact with hazardous parts or materials

3.9
catalytic partial oxidation
exothermic conversion of a hydrocarbon with a small quantity of air into hydrogen over a catalyst

3.10
combustible gas, liquid or vapour
gas, liquid or vapour which, when mixed with air or oxygen, is capable of propagating flame away from the source of ignition when ignited

3.11
commercial
relating to the use of hydrogen generators by laymen in non-manufacturing business facilities such as stores, hotels, office buildings, educational institutes and refilling stations

3.12
concealed location
location that cannot be accessed without damaging permanent parts of a building structure or a finish surface

NOTE Spaces above, below or behind readily removable panels or doors are not considered as concealed.

3.13
conformity assessment
demonstration that specified requirements relating to a product, process, system, person or body are fulfilled

NOTE The subject of conformity assessment includes activities defined in ISO/IEC 17000, such as testing, inspection and certification, as well as the accreditation of conformity assessment bodies.

3.14
critical failure mode
failure mode of a software or hardware item, which can result in unacceptable risk of harm

3.15
maximum allowable pressure
maximum pressure for which equipment is designed

3.16
design temperature
temperature value applied to the design of pressure-containing components

3.17
direct ignition
ignition which is applied directly to the main burner without the use of a pilot

3.18
explosion limits
maximum and minimum concentrations of a gas, vapour, mist, spray or dust, in air or oxygen, for stable detonation to occur

NOTE 1 The limits are controlled by the size and geometry of the environment, the concentration of the fuel, as well as the means by which ignition occurs.

NOTE 2 The terms “explosive limit” and “flammable limit” are widely used as equivalent while in fact they are not identical. The only substance for which the explosive limit is significantly different from the flammable limit is hydrogen.

[ISO/TR 15916:2004]

3.19
explosive atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, mist or dust in which, after ignition, combustion spreads throughout the unconsumed mixture

[IEC 60079-10:2002]

3.20
explosive gas atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour in which, after ignition, combustion spreads throughout the unconsumed mixture

NOTE Although a mixture which has a concentration above the upper explosive limit (UEL) is not an explosive gas atmosphere, it can readily become so and, in certain cases for area classification purposes, it is advisable to consider it as an explosive gas atmosphere.

[IEC 60079-10:2002]

3.21
factory matched unit
system components 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

3.22
Fischer-Tropsch liquids
liquids derived through a technology based on the Fischer-Tropsch synthesis

EXAMPLES Gas-to-liquids (GTL), methanol-to-gasoline (MTG), methanol-to-olefins (MTO), methanol-to-propylene (MTP), methanol-to-olefins-to-gasoline and distillates (MOGD), dimethyl ether (DME) processes, etc.

3.23
flame detector
device that provides a signal indicating the presence or absence of flame

NOTE A flame detector includes a flame sensor and may include an amplifier and a relay for signal transmission. The amplifier and the relay may be embedded in the detector's housing or combined with a programming unit.

3.24
flame sensor
primary device in a flame detector, which detects the presence of flame

EXAMPLES Optical sensors and flame electrodes (flame rods).

3.25
flame failure lock-out time
period of time between the signal indicating an absence of flame and lock-out

3.26
flammability limit
lower (LFL) and upper (UFL) vapour or gas concentration of fuel in air within which a flammable mixture will ignite and propagate a flame

NOTE 1 These limits are functions of temperature, pressure, diluents and ignition energy.

NOTE 2 These limits are usually expressed as percent (volume fraction).

[ISO/TR 15916:2004]

3.27
flashback
recession of a flame into the mixing chamber or further upstream

3.28
frame
assembly of structural members held together through permanent (weldment, riveting) or screw-type joints, carrying the hydrogen generator body and its equipment and components, providing accuracy of location, strength and rigidity of support

3.29
fuel processing system
sequence of catalytic or chemical reactors that convert an input fuel to a hydrogen-rich stream of pre-specified composition and conditions

3.30
fuel-rich condition
mixture of fuel and air, in which the fuel content is greater than that of a stoichiometric mixture

NOTE Fuel-rich conditions are used when complete air reaction is intended (e.g. in catalytic partial oxidation, preferential oxidation or auto-thermal reactors).

3.31
fuel-rich system
system operating under fuel-rich conditions

3.32
harm
physical injury or damage to the health, or damage to property or the environment

[ISO/IEC Guide 51]

3.33
hazard
potential source of harm

NOTE The term hazard can be qualified in order to define its origin or the nature of the expected harm (e.g. electric shock hazard, crushing hazard, cutting hazard, toxic hazard, fire hazard, drowning hazard).

[ISO/IEC Guide 51]

3.34
hazardous area
area in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of apparatus

[IEC 60079-10:2002]

3.35
hazardous situation
circumstance in which people, property or the environment are exposed to one or more hazards

[ISO/IEC Guide 51]

3.36
ignition activation period
period of time between energizing the main gas valve and deactivation of the ignition means

3.37
incident
event or chain of events that can, but does not necessarily, result in harm

3.38
industrial
relating to the use of hydrogen generators by qualified and experienced personnel in a controlled manufacturing or processing environment, e.g. a chemical plant or a mine

3.39
input fuel
chemical substance fed to the hydrogen generator as a reactant or as input energy, usually composed of natural gas, other hydrocarbons, alcohols or other organic compounds

3.40
intermittent pilot
pilot which is automatically ignited when an appliance is called on to operate, which remains continuously ignited during each period of main burner operation, and which is automatically extinguished when each main burner operating cycle is complete

3.41
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

3.42
light industrial
relating to the use of a hydrogen generator by personnel with limited qualification and experience in manufacturing environments with limited dedicated controls, e.g. computer and electronics manufacturing facilities

3.43
limit gases
test gases representative of the extreme variations in the characteristics of the gases for which appliances have been designed

3.44
lock-out
safety shutdown in which the system goes into a volatile or non-volatile lock-out

3.45
lower explosive limit
LEL
concentration of flammable gas or vapour in air below which the gas atmosphere is not explosive

3.46
main flame establishing period
the period of time between the signal to energize the main fuel flow means and the signal indicating presence of the main burner flame

3.47
ventilation
movement of air and its replacement with fresh air by artificial suction means, for example fans, and applied to a general area

3.48
non-hazardous area
area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of apparatus

3.49
non-volatile lock-out
safety shutdown condition of the system, such that a restart can only be accomplished by a manual reset of the system and by no other means

3.50
normal operation
situation when the equipment is operating within its design parameters

NOTE 1 Minor releases of flammable material may be part of normal operation. For example, releases from seals which rely on wetting by the fluid that is being pumped are considered to be minor releases.

NOTE 2 Failures (such as the breakdown of pump seals, flange gaskets or spillages caused by accidents) which involve urgent repair or shutdown are not considered to be part of normal operation nor are they considered to be catastrophic.

NOTE 3 Normal operation includes start-up and shutdown conditions.

3.51
operating mode
preset condition of functioning of the system

3.52
packaged unit
skid or cabinet containing system components pre-assembled in a factory and engineered to work together in one skid or cabinet

3.53
permissive
condition within a logic sequence that must be satisfied before the sequence is allowed to proceed to the next phase

3.54
pilot
flame, smaller than the main flame, which is utilized to ignite the main burner or burners

3.55
pressure gradient monitor
device, fail-safe by design, installed in a heat exchanger to prevent heat exchange fluids from mixing where necessary, and that operates by isolating the heat exchanger when the positive pressure gradient between the fluids is less than a minimum predefined pressure threshold

NOTE A pressure gradient monitor can be used to protect the quality of potable water when the other fluid is a contaminant such as a toxic heat transfer fluid.

3.56
purge time
period during which air is introduced to displace any remaining air/fuel mixtures or products of combustion from the combustion zone and flue ways

3.57
pyrophoric material
material capable of igniting spontaneously when brought into contact with air

[ISO 13943]

3.58
reaction failure lock-out time
time between the moment of reaction failure detection and the automatic shut-off of the fuel supply for air-rich operation, or the automatic shut-off of the supply of all reactants for fuel-rich operations

3.59
reaction initiation failure time
time between the recognition of failure of reaction initiation and the automatic shut-off of the fuel supply for air rich operation, or for fuel-rich operation, of the supply of all reactants