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Gaseous hydrogen — Fuelling stations

Carburant d'hydrogène gazeux — Stations-service

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Foreword

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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.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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ISO/TS 20100 was prepared by Technical Committee ISO/TC 197, *Hydrogen technologies*.

Gaseous hydrogen — Fuelling stations

1 Scope

This Technical Specification specifies the characteristics of outdoor public and non-public fuelling stations that dispense gaseous hydrogen used as fuel onboard land vehicles of all types.

Residential and home applications to fuel land vehicles are excluded from this Technical Specification.

The fuelling station may comprise, as applicable, the following as shown in Figure 1:

— Delivery of hydrogen by pipeline, trucked-in gaseous and/or liquid hydrogen;

— On-site hydrogen generators using water electrolysis process or hydrogen generators using fuel processing technologies;

— Liquid hydrogen storage, pumping and vaporizing systems;

— Gaseous hydrogen compression and purification systems;

NOTE When the fuelling station comprises an on-site hydrogen generator, the compressor/purifier system is commonly integrated into it.

— Gaseous hydrogen buffer storage;

— Gaseous hydrogen dispensers.

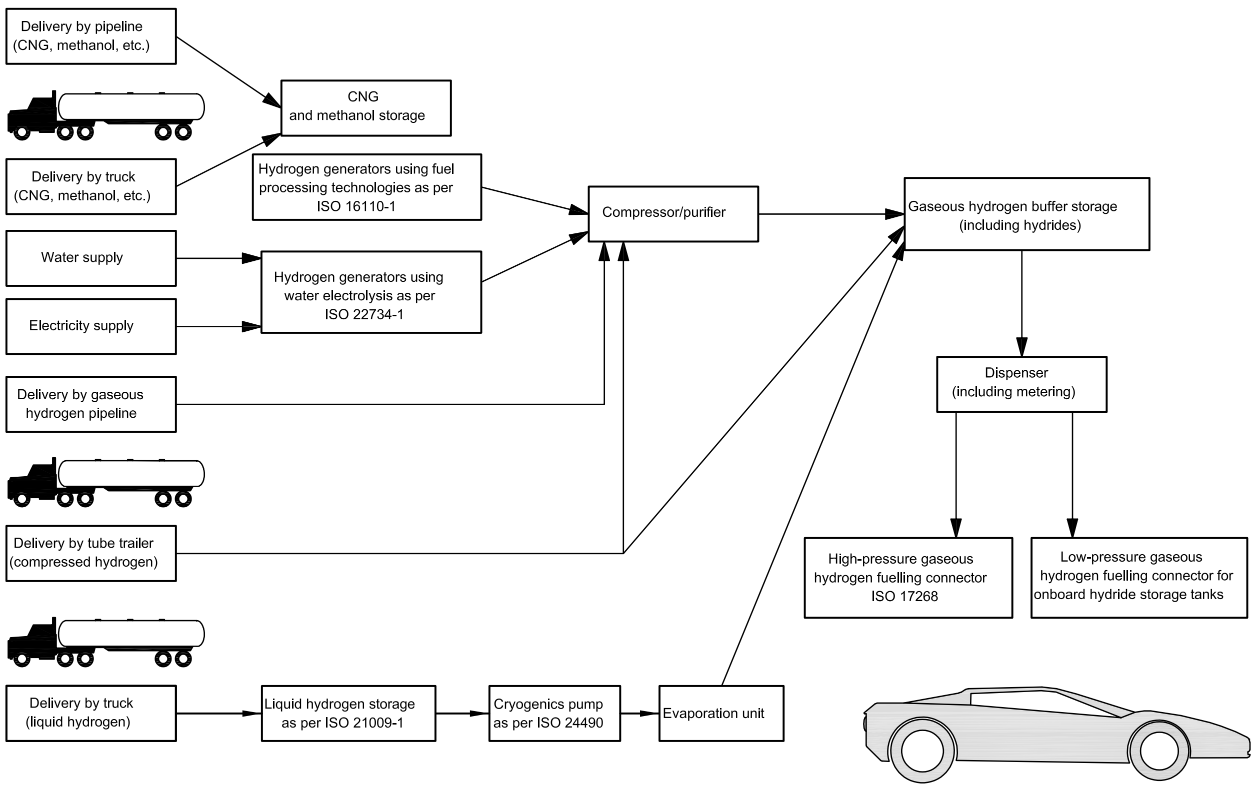


Figure 1 — Gaseous hydrogen — Fuelling station

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

ISO 7751, *Rubber and plastics hoses and hose assemblies — Ratios of proof and burst pressure to design working pressure*

ISO 14113, *Gas welding equipment — Rubber and plastic hoses assembled for compressed or liquefied gases up to a maximum design pressure of 450 bar*

ISO 14687 (all parts), *Hydrogen fuel — Product specification*

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

ISO 16110-1, *Hydrogen generators using fuel processing technologies — Part 1: Safety*

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

ISO 17268, *Compressed hydrogen surface vehicle refuelling connection devices*

ISO 21009-1, *Cryogenic vessels — Static vacuum-insulated vessels — Part 1: Design, fabrication, inspection and tests*

ISO 21011, *Cryogenic vessels — Valves for cryogenic service*

ISO 21012, *Cryogenic vessels — Hoses*

ISO 21013-1, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 1: Reclosable pressure-relief valves*

ISO 21013-2, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 2: Non-reclosable pressure-relief devices*

ISO 21013-3, *Cryogenic vessels — Pressure-relief accessories for cryogenic service — Part 3: Sizing and capacity determination*

ISO 22734-1, *Hydrogen generators using water electrolysis process — Part 1: Industrial and commercial applications*

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

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

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

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 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 60364-4-41, *Low-voltage electrical installations — Part 4-41: Protection for safety — Protection against electric shock*

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

IEC 60446, *Basic and safety principles for man-machine interface, marking and identification — Identification of conductors by colours or alphanumerics*

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

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

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

IEC 61069-7, *Industrial-process measurement and control — Evaluation of system properties for the purpose of system assessment — Part 7: Assessment of system safety*

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

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

IEC 62305-3, *Protection against lightning — Part 3: Physical damage to structures and life hazard*

3 Terms and definitions

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

3.1
accessory
part capable of performing an independent function and contributing to the operations of the equipment that it serves

3.2
authority having jurisdiction
organization, office or individual responsible for approving a facility along with an equipment, an installation or a procedure

3.3
bleed venting
expiration or inspiration of air or gas from, or to, one side of a diaphragm of any accessory, component or equipment such as a valve, pressure regulator or switch

3.4
buffer storage tanks
pressurized tanks, which can be located between a hydrogen generator and a compressor for an even flow of gas to the compressor or between the compressor and dispenser for accumulation of pressurized gas supply for vehicle fuelling

3.5
control system
system that is intended to automatically operate the fuelling station within its normal operating parameters

NOTE The control system includes the measuring, monitoring and reporting and recording functions, as applicable.

3.6
design pressure
maximum pressure permissible in a storage vessel (at its top) or a piping system for a designated temperature

NOTE 1 The design pressure is the basis for the pressure setting of the pressure relief devices protecting the vessel or piping system.

NOTE 2 The design pressure may also be the maximum allowable operating pressure rating of pressure vessels manufactured in accordance with national pressure vessel codes.

3.7
dispenser
parts of the pressurized-gas fuelling station via which the pressurized gas is dispensed to vehicles

NOTE As an example, the dispenser may include a dispenser cabinet, a gas flow meter, a fuelling hose and fuelling nozzle attachments.

3.8
dispenser cabinet
protective housing that encloses the dispenser gas containing equipment

3.9
dispensing system
system comprising all equipment necessary to carry out the vehicle fuelling operation, downstream of the hydrogen supply system

3.10
enclosure
structure that protects equipment from the environment, provides noise attenuation, or provides safety to the areas surrounding the equipment

3.11
fail-safe
design feature that ensures that safe operating conditions are maintained in the event of a malfunction of control devices or an interruption of a supply source

3.12
fill pressure
pressure attained at the end of filling

NOTE Fill pressure varies according to the gas temperature in the vehicle tank, which is dependent on the changing parameters and the ambient conditions.

3.13
forecourt
hard surfaced area at the front of the vehicle fuelling position, including any area underneath a canopy

3.14
fuelling connector
joined assembly of the fuelling nozzle and fuelling receptacle, which permits quick connect and disconnect of the fuel supply to the vehicle or storage system

3.15
fuelling hose
flexible conduit used for dispensing gaseous hydrogen to vehicles through a fuelling nozzle

3.16
fuelling nozzle
mating part of the fuelling connector at the fuelling station, including shut-off valves, that connects the fuelling hose to the vehicle fuelling receptacle for the transfer of hydrogen fuel

3.17
fuelling receptacle
mating part of the fuelling connector mounted on a vehicle

3.18
fuelling position
area adjacent to the hydrogen dispensers, where customers park their vehicles for fuelling

3.19
fuelling station
facility for the dispensing of compressed hydrogen, which includes all stationary equipment that supplies, compresses, stores and dispenses gaseous hydrogen to fuel a land vehicle

3.20
guard
part of a machine specially used to provide protection by means of a physical barrier

NOTE Depending on its construction, a guard may be called casing, cover, screen, door, enclosed guard, etc.

3.21
harm
physical injury or damage to the health of people, or damage to property or to the environment

3.22
hazard
potential source of harm

3.23
hazardous event
occurrence in which a hazardous situation results in harm

3.24
hazardous situation
circumstance in which people, property or the environment are exposed to one or more hazards

3.25
hose breakaway device
component installed downstream of the dispenser outlet connection to protect the dispenser assembly from damage by vehicles driving away while still connected to the dispenser nozzle

3.26
housing
section of a system that encloses, and is intended to protect, operating parts, control mechanisms, or other components, which need not be accessible during normal operation

3.27
hydrogen purifier
equipment to remove oxygen, moisture and other impurities from the hydrogen

3.28
manufacturer
person or organization responsible for the design, fabrication and testing of equipment and components

3.29
maximum fill pressure
maximum pressure to which a vehicle tank may be filled

3.30
mechanically actuating safety equipment
mechanically actuating equipment that prevents fuelling station operation outside specified acceptable maximum or minimum operating pressures or that prevents a gas leakage in the event of an incident

3.31
nominal working pressure
nominal working pressure is the vehicle tank pressure, as specified by the manufacturer, at a uniform gas temperature of 15 °C or as specified and at full gas content

3.32
non-public fuelling station
fuelling station that does not sell or dispense gaseous hydrogen to the general public, e.g. private or municipal vehicle fleet operation

3.33
operator
licensed person or organization responsible for the safe operation, maintenance and housekeeping of the fuelling station

3.34
outdoors
location outside of any building or structure, or locations under a roof, weather shelter, or canopy provided this area is not enclosed on more than two sides

3.35
plinth
raised area on the forecourt, supporting and protecting the dispensers and associated equipment

3.36
pressure relief device
device designed to open to prevent a rise of internal pressure in excess of a specified value due to emergency or abnormal conditions

NOTE The pressure relief device can be of the re-closing or other type, such as one having a rupture disk and/or fusible plug that requires replacement after each use.

3.37
public fuelling station
fuelling station that sells gaseous hydrogen to the general public

3.38
risk
combination of the probability of occurrence of harm and the severity of that harm

3.39
safeguarding
use of specific technical means to protect persons from the hazards which cannot reasonably be removed or sufficiently limited by design

3.40
safety
freedom from unacceptable risk

3.41
safety device
device other than a guard, which eliminates or reduces risk, alone or associated with the guard

3.42
safety distance
minimum separation between a hazard source and an object (human, equipment or environment), which will mitigate the effect of a likely foreseeable incident and prevent a minor incident from escalating into a larger incident

3.43
safety function
function to be implemented by a safety-instrumented system, other technology safety-related system or external risk reduction facilities, which is intended to achieve or maintain a safe state for the process with respect to a specific hazardous situation

3.44
safety-instrumented system
instrumented system used to implement one or more safety-instrumented functions

NOTE A safety-instrument system is composed of any combination of sensors, logic solvers, and final elements.

3.45
safety measures
combination of the measures incorporated at the design stage and those measures required to be implemented by the user

3.46
vaporizer
device other than a tank that receives hydrogen in a liquid form and adds sufficient heat to convert the liquid to a gaseous state

NOTE Hydrogen purifiers may comprise purification vessels, dryers, filters and separators.

4 General design requirements

The hydrogen fuelling station installation shall be sited to minimize risk to users, operating personnel, and neighbouring personnel, residents and property.

Consideration shall be given to any potential hazard or risk in relation to the location and operation of the facility.

More specifically, measures to reduce fire and explosion risks shall be applied in the following order of priority:

— prevention of the formation of a flammable or explosive mixture and reduction of the explosion strength potential of explosive atmospheres generated by potential leaks or releases;

— avoidance of ignition sources;

— mitigation of the effects of a fire or explosion.

Installation and equipment design shall minimize the number of connections and other possible points of leakage or release to atmosphere.

Configurations generating the possibility of a hazardous confined explosive atmosphere shall be avoided.

Fire and explosion risk prevention shall take into account foreseeable malfunctions and misuse.

The installation shall be such that, for any foreseeable deviation involving fire and explosion hazards, it shall be possible to define a safe action towards prevention of escalation.

Where an explosive mixture could persist within a fuelling station enclosure after an accidental release of hydrogen despite existing means of detection, isolation and ventilation, explosion relief shall be provided to reduce the consequences of an explosion.

5 Hydrogen delivery systems

5.1 General

5.1.1 Access to the hydrogen delivery and storage areas

The installation shall be so designed that authorized personnel shall have easy access to and exit from the operating area of the installation at all times.

The hydrogen delivery and storage area shall be located so that it is readily accessible to mobile supply equipment at ground level and to authorized personnel. Suitable roadways or other means of access for emergency equipment, such as fire department apparatus, shall be provided.

Where fencing is provided to prevent access of unauthorized persons, the minimum clearance between the fence and the installation shall be 0,8 m to allow free access to and escape from the enclosure.

Adequate means of escape in the case of emergency shall be provided. In cases where authorized personnel can be trapped inside compounds, there shall be at least two separate outward opening exits, remote from each other, strategically placed in relation to the degree of hazard considered.

All gates shall be outward opening and wide enough to provide for the easy access and exit of authorized personnel. Gates shall not allow entry without a key during normal operation.

Consideration shall be given to the provision of an additional emergency exit where the size of the fenced area or equipment location necessitates this.

Access to the installation shall be prevented to all unauthorized persons. Warning notices shall support this.

Timber or other readily combustible materials shall not be used for fencing. The height of the fencing should be at least 2 m.

5.1.2 Electrical grounding

All delivery vehicles shall be electrically connected to the ground prior to flexible hose connection.

The effectiveness of the grounding connection shall be checked at least once every three years.

5.2 Gaseous hydrogen supply by tube trailers and multi cylinder packs

5.2.1 Tube trailers

Hydrogen tube trailers shall be stationed in an area that is accessible to hydrogen distribution tractors and fire-fighting services at all times.

Safety distances shall comply with those given in 13.2.2 for gaseous hydrogen systems.

Minimum clearance of 1 m shall be maintained on all sides of each tube trailer.

The tube trailer stationing area shall be level and horizontal. The front and rear ends of the tube trailer bays shall be kept open. A bump stop shall indicate normal tube trailer position.

The location of the pressure reducing station shall be accessible.

Hydrogen tube trailers shall not be stationed outside of the designated trailer unloading bays.

A designated temporary tube trailer parking location shall be provided for carrying out tube trailer exchange without interfering with fuelling operations, unless the fuelling activity is fully suspended during the tube trailer exchange operation.

These temporary tube trailer parking locations shall not be located near buildings where persons are present or near any potentially hazardous processes, sources of fuel, flammable gases or liquids.

5.2.2 Multi cylinder pack

Multi cylinder pack trailers shall be electrically connected to ground prior to flexible hose connection.

The storage area shall be fenced to prevent access of unauthorized persons. Activities other than those directly related to the hydrogen tube trailer operation shall not be permitted in the vicinity of the trailers.

5.3 Liquid hydrogen supply

5.3.1 Liquid hydrogen storage layout and design features

To minimize the consequence of an accidental leakage, liquid hydrogen storage tanks should not be enveloped or constricted by walls or buildings. Liquid hydrogen (storage tanks in 2- or 3-sided zone) should also be avoided as much as possible to prevent accidental gas confinement if leakage occurs.

Safety distances shall comply with those given in 13.2.1 for liquid hydrogen systems.

For access and inspection, a minimum clearance of 1 m shall be maintained on all sides of each storage tank.

Any firebreak walls or partitions shall be made of brick, concrete or any other suitable non-combustible material of 90 min rating.

The liquid hydrogen storage tanks shall be protected against vehicular impact by barriers or bollards.

Filling connections and equipment controls shall be accessible.

Connections and equipment controls necessary for filling purposes shall be located in close proximity to each other and in such a way that the storage tank and tanker controls are visible and accessible from the operator's position.

Dykes, diversion kerbs or grading shall be used to ensure that liquid leakage from adjacent combustible liquid or liquid oxygen storages installed at a higher level than the liquid hydrogen storage is prevented from accumulating within 15 m of the liquid hydrogen storage.

The liquid hydrogen storage tanks shall comply with ISO 21009-1.

5.3.2 Liquid hydrogen transfer area

The liquid hydrogen transfer area shall be designated a “NO PARKING” area.

The tanker, when in position for discharging to the installation, shall be in the open and not be in a walled enclosure from which the escape of liquid or cold vapour is restricted. Tankers shall have easy access to, and exit from, the installation at all times.

A concrete hard standing area shall be located adjacent to the fill coupling of the liquid hydrogen storage tank. The fill coupling shall be located within the area of the liquid hydrogen storage tank plinth.

The liquid hydrogen transfer area shall be clearly defined, and transfer of liquid shall only take place within the fuelling station premises.

5.3.3 Tank foundation and supports

Where liquid hydrogen storage tanks are required to be elevated, the tank supports shall be non-combustible structures capable of withstanding damage by cryogenic liquid spillage.

The tank foundation shall be designed to withstand the weight of the liquid hydrogen storage tank, its contents and other possible loads applied by wind, snow, etc.

The plinth on which the liquid hydrogen storage tank is installed shall be made of concrete or any other suitable non-combustible material.

5.3.4 Liquid hydrogen delivery lines

Flexible hoses used for liquid hydrogen delivery shall comply with ISO 21012.

Liquid hydrogen delivery lines shall include a non-return valve or an emergency isolating device preventing outflow in case of hose rupture.

5.3.5 Pressure relief devices

Pressure relief devices shall be provided to prevent over-pressure, including situations where liquid can be trapped.

Pressure relief devices and vent piping shall be designed or located so that moisture cannot collect and freeze in a manner which would interfere with proper operation of the pressure relief device.

A secondary pressure relief device shall be installed together with the primary pressure relief device of the liquid hydrogen storage tank.

Safety valves shall comply with ISO 21013-1. Bursting disks shall comply with ISO 21013-2. Sizing and capacity determination of safety valves and bursting disks shall meet the requirements of ISO 21013-3.

If a three-way valve is installed to accommodate two pressure relief devices operating either simultaneously or alternatively, the size of the three-way valve, regardless of the position of the actuating device, shall be such that the liquid hydrogen storage tank is adequately protected.

The three-way valve shall be provided with a position indicator, if appropriate, showing which pressure relief devices are “on line”.

Consideration shall also be given in the design of the installation to facilitate the periodic testing of the pressure relief devices.

Bursting disk material shall be compatible with hydrogen. Bursting disks shall be replaced every five years.

5.3.6 Cold hydrogen vents

All vents, including those of pressure relief devices and purge valves, shall be connected to a vent stack.

The vent stack shall be arranged to discharge in a safe place in the open air so as to prevent impingement of escaping gas onto personnel or any structure. The vent stack shall not discharge where accumulation of hydrogen can occur, such as below the eaves of buildings. Consideration shall be given to the prevention of accumulation of water, including that from condensation, in the vent stack outlet.

The position of the vent stacks shall be taken into account in the siting of the installation and reflected in the areas-classification drawing.

The vent stacks shall be dedicated to the liquid hydrogen installation and not be connected to other vent stacks to avoid any back feed into the hydrogen vent stacks.

The outlet of the vent stacks shall not be equipped with devices that disturb the natural buoyancy of hydrogen.

5.3.7 Piping, fittings, valves, regulator for cryogenic service

Means shall be provided to minimize exposure of personnel to piping operating at low temperatures and to prevent air condensate from contacting piping, structural members and surfaces not suitable for cryogenic temperatures.

Uninsulated piping and equipment which operates at below air condensation temperature shall not be installed above asphalt surfaces or other combustible materials in order to prevent contact of liquid air with such materials. For the purposes of this Technical Specification, asphalt and bitumastic paving shall be considered combustible. If expansion joints are used, fillers shall also be made of non-combustible materials. Drip pans may be installed under uninsulated piping and equipment to retain and vaporize condensed liquid air.

Valves used for cryogenic service is shall comply with ISO 21011.

5.3.8 Cryogenic pumps

Foundations and sumps for cryogenic pumps shall be designed and constructed to prevent frost heaving.

Surfaces located under the pump’s connections and under uninsulated hydrogen piping shall be constructed of non-combustible materials as specified in 5.3.7.

The following markings shall be clearly displayed and visible at all times near the cryogenic pump:

— LIQUID HYDROGEN;

— FLAMMABLE LIQUID;

— NO SMOKING;

— NO SOURCES OF IGNITION;

— AUTHORIZED PERSONS ONLY;

— Product identification.

Each cryogenic pump shall be provided with a vent and a pressure relief valve that will prevent over-pressurizing of the pump case under all conditions including the maximum possible rate of cool-down.

5.3.9 Vaporizer

The vaporizer and its piping shall be protected with pressure relief devices as required.

Pressure relief valves on heated vaporizers shall be located so that they are not subjected to temperatures exceeding 60 °C during normal operation unless they are designed to withstand higher temperatures.

The vaporizer shall be sized for the maximum flow requirement specified for cryogenic pumps. It shall be designed to function as required despite accumulation of ice due to condensation of ambient moisture.

Where necessary, a device shall be installed to ensure that cold gas temperature exiting the vaporizer cannot:

— cause damage to pipework and equipment downstream;

— affect the dispensing process.

All the liquid-hydrogen wetted parts of the vaporizer shall be made of austenitic stainless steel e.g. Type 316L.

Heat used in the vaporizer shall be indirectly supplied utilizing media such as air, steam, water, or water solutions.

A low temperature shut-off switch or valve shall be provided in the vaporizer discharge piping to prevent flow of liquid hydrogen in the event of the loss of the heat source.

The vaporizer shall be anchored and its connecting piping shall be sufficiently flexible to provide for the effect of expansion and contraction due to temperature changes.

Multiple vaporizers shall be manifolded such that both inlet and discharge block valves are installed on each vaporizer.

Suitable means shall be installed on the vaporizer discharge to avoid the possibility of liquid hydrogen entering a gaseous hydrogen container or other equipment not designed for liquid hydrogen temperatures. The combustion air required for the operation of the primary heat source for remote heated vaporizers shall be taken from outside an enclosed structure or building. A device shall be fitted after the hydrogen vaporizer to avoid back flow into the hydrogen system.

When a water bath or steam-heated vaporizer is used, the operator shall carry out regular visual examination of shell and external tube surfaces for signs of damage, excessive frosting, etc. Any defects shall be reported to the supplier.

5.3.10 Notices and instructions

Notices shall be clearly displayed, visible at all times, on or near the liquid hydrogen storage tank, particularly at access points, to indicate the following:

— LIQUID HYDROGEN

— FLAMMABLE LIQUID

— NO SMOKING

— NO NAKED FLAMES

— AUTHORIZED PERSONS ONLY

— DO NOT SPRAY WATER ON VENT STACK.

In order to facilitate control of an emergency, a sign shall be displayed at the compound showing:

— gas supplier's name and local address;

— gas supplier's local phone number;

— the phone number of the local emergency service.

This information shall also be available at a control point.

All displayed warning signs and labels shall be legible from outside the installation fence.

Operating and emergency instructions shall be supplied to the refuelling station owner before commissioning the installation.

5.3.11 Purging

Cold sections of liquid hydrogen installations shall be purged with warm hydrogen or helium prior to being purged with nitrogen.

Following installation or repair work, cold sections of liquid hydrogen installations shall be purged with helium or nitrogen. If nitrogen is used instead of helium to remove air in cryogenic sections, nitrogen shall be purged with helium or warm hydrogen prior to cool-down with cold hydrogen for start-up.

5.4 Pipeline

The interface between the hydrogen pipeline and the fuelling station shall include, as applicable, the following different functions: isolation for maintenance and/or for emergency, metering, pressure and/or flow regulation and filtration.

NOTE The interface between the hydrogen pipeline and the fuelling station is typically located within the fuelling station boundary.

6 On-site generation

6.1 Hydrogen generators using water electrolysis process

Hydrogen generators using water electrolysis process shall meet the requirements of ISO 22734-1.

6.2 Hydrogen generators using fuel processing technologies

6.2.1 Feed-stock storage

Storage of hydrocarbons shall be sited to minimize risk to personnel, local population and property. Consideration shall be given to the location of any potentially hazardous processes in the vicinity, which could jeopardize the integrity of the storage installation.

Hydrocarbon storage tanks shall be designed and fabricated according to ISO 16528-1.

Piping containing hydrocarbon sources shall be designed and fabricated according to ISO 15649.

6.2.2 Hydrogen generators using fuel processing technologies

Hydrogen generators using fuel processing technologies shall meet the requirements of ISO 16110-1.

6.3 Shutdown control

During normal fuelling system shutdown, the hydrogen generators using water electrolysis process and the hydrogen generators using fuel processing technologies shall not rely on safety devices to shut down.

Actuation of any emergency shutdown device of the fuelling station shall shut down the hydrogen generators using water electrolysis process and the hydrogen generators using fuel processing technologies.

7 Hydrogen compressors

7.1 General

All types of compressors may be used, provided that they have been designed with particular reference to hydrogen service.

Valves shall be installed such that each compressor can be isolated for maintenance. Where compressors are installed for operation in parallel, each discharge line shall be equipped with a check valve.

7.2 Vibration and movement

Compensation for vibration and movement shall be provided between interconnected systems at a hydrogen fuelling station and between the hydrogen gas supply piping and the compressor suction piping. Any vibrations that may affect the strength of the piping shall not be transferred to the piping work.

7.3 Compressor enclosure ventilation

The compressor enclosure shall be of a design that will not accumulate leaked hydrogen and shall not be modified such as to reduce its intended ventilation.

7.4 Attachment to other buildings

Where a compressor enclosure shares one wall of an existing building, the shared wall shall be gas-tight and have at least a 2 h fire resistance rating.

7.5 Enclosure access doors

Compressor enclosures that are large enough to admit service personnel shall have an access door that opens outwards. If the access door is equipped with a latch, it shall be equipped on the inside with fast-release hardware that can be operated without a key.

7.6 Control and monitoring

7.6.1 General

Safety controls shall be installed to ensure temperature and pressure levels do not exceed or fall below set operating levels.

In addition to the instruments and controls normally provided for gas compressing systems, the following specific safeguards for hydrogen shall be considered.

7.6.2 Inlet pressure

The inlet pressure shall be monitored by a pressure indicator/switch to avoid a vacuum in the inlet line and consequent ingress of air. This pressure indicator/switch shall cause the compressor to shut down before the inlet pressure reaches atmospheric pressure.

7.6.3 Oxygen analysis

Where the hydrogen comes from a low-pressure source, or if there is a possibility of oxygen contamination, the oxygen content in the hydrogen shall be continuously measured. Should the oxygen content reach a volume fraction of 1 %, the compressor shall be automatically shut down.

The oxygen analyser may be placed either immediately before the suction inlet to the compressor, which is preferred, or after the first stage discharge if the suction inlet pressure is not sufficient for the analyser.

7.6.4 Discharge temperature

The temperature after the final stage of compression, or the temperature after the cooler, where fitted, shall be monitored by an indicator/alarm that shall be arranged to shut down the compressor at a predetermined maximum temperature.

7.6.5 Discharge pressure

The pressure after the final stage of compression shall be monitored by an indicator/alarm, which shall be arranged to shut down the compressor or initiate alternative actions such as recycling at a predetermined maximum pressure which is below that of the final pressure relief device.

7.6.6 Cooling water – low pressure alarm

A water pressure alarm shall be provided in the cooling water system, which shall indicate the need to shut down the compressor in case of low pressure of flow.

7.6.7 Purge gas on electrical equipment

Where the motor and auxiliary equipment are pressurized by an inert gas such as nitrogen, low pressure/flow shall be indicated by an alarm, which shall be arranged to shut down the motor and auxiliaries.

7.6.8 Pressurized crankcases

Where the compressor crankcase is pressurized by nitrogen or other inert gases, low pressure/flow shall be indicated by an alarm, which shall be arranged to shut down the compressor.

The compressor design shall prevent the formation of an air and hydrogen mixture in the compressor crankcase.

8 Filters and separators

Filters and, if applicable, separators shall be included if hydrogen is expected to contain function-impairing impurities (e.g. contaminates) that exceed the requirements of Clause 12.

The filters and separators shall be sized for the maximum hydrogen gas flow and for the expected impurities in the hydrogen gas, and shall be provided with sufficiently large sumps or collecting tanks. As far as possible, filters and separators should be combined in a single unit. The filters should have a specified separating capacity.

Clogging of the filter insert in the main hydrogen gas flow shall be monitored. This may be done by regular operational checks or by monitoring equipment, e.g. differential-pressure gauges indicating a maximum value, as specified by the filter supplier. The filters and separators shall be arranged and installed in such a way that it is possible to open and empty them in a safe manner. In the event of frequent opening and closing operations, the filters and separators should be fitted with quick opening and closing fittings.

For removing liquids (condensation products), a manual or an automatic discharging device, if applicable comprising a sump, shall be provided.

9 Hydrogen purifier

Hydrogen purification shall be provided as necessary to meet the requirements of Clause 12 in all operating conditions. The hydrogen purifier shall be designed taking into account possible contamination from the hydrogen supply system as well as from the dispensing system such as oil and vapour or liquid form.

If adverse effects on the performance and/or corrosion are to be expected because of the quantity of moisture, the hydrogen gas shall be dried such as to avoid water condensation at the highest pressure and in all operating conditions.

NOTE Excessive moisture in the gas may cause permanent damage to the vehicle storage system (e.g. stress-corrosion cracking with certain aluminium alloys).

10 Gaseous hydrogen buffer storage tanks

Buffer storage vessels for the storage of hydrogen gas shall be manufactured according to ISO 16528-1.

If buffer storage tanks of different design pressure are interconnected, they shall be protected in such a way that tanks rated for a lower pressure cannot be over-pressurized due to any malfunction.

If composite tanks are used for buffer storage, the design of the installation shall include means to prevent bursting in the case of fire. Suitable prevention methods may include fixed firewater protection, product venting and thermal shielding.

Layout design of the gaseous hydrogen buffer storage tanks shall prevent direct impingement of any gas leak onto an adjacent vessel.

Each group of the buffer storage tanks shall be equipped with their own set of safety devices, independent from the other groups.

11 Dispenser, fuelling assembly, and process control

11.1 Location and protection of dispensers

Dispensers shall be located outdoors. Dispensers shall not be located beneath a canopy nor within 0,9 m of the vertical projection of the canopy to the island, except where the canopy is not capable of accumulating gas in pockets or between the canopy ceiling and roof.

Dispensers shall either be located on a concrete island or plinth at least 120 mm above grade or attached to a structure at least 4,25 m above the fuelling position. The distance from the edge of the raised island to each side of the dispenser shall be 200 mm minimum.

The structural foundation of the dispenser and the fuelling area shall be adequate to support all components including vehicles to be fuelled. The dispenser shall be protected from vehicular impact.

Dispensers shall be secured against unauthorized use outside normal operating hours. This requirement shall be deemed to be met when the dispensers are securely locked or when their electrical power is switched off at a place that is not accessible to unauthorized persons.

11.2 Fuelling position

The vehicle fuelling position shall be level. The slope of the ground shall be such as to provide normal surface water drainage.

The vehicle fuelling pad shall be made of non-combustible materials allowing electrical grounding before the nozzle is connected to the vehicle. The maximum resistance between the fuelling pad and the fuelling station ground shall be 1×10^6 ohms. This requirement shall be deemed to be met when the vehicle fuelling pad is made of concrete and bonded to fuelling station ground.

Dispensers shall be located in such a way to prevent vehicles driving through potentially hazardous areas of other parts of the fuelling station, such as the buffer storage vessels.

11.3 Dispenser system design

11.3.1 General construction and assembly

All components used in compressed hydrogen gas dispensing systems shall be fit for the purpose and suitable for hydrogen service. All components shall be capable of operating in the full temperature range of the local conditions.

All components used in a dispenser system shall be assembled in such a manner so as to be secure against distortion, warping, or other damage, and shall be supported to maintain a fixed relationship with each other.

All parts that may be contacted during normal servicing and operation shall be free from sharp projections or edges and projecting screw ends.

All components that are routinely serviced shall be accessible for servicing and functional adjustment in position and shall be replaceable during normal servicing.

Dispensers shall be equipped with means to protect all operating controls and electrical wiring from climatic conditions.

Dispensers shall be equipped with means to secure and protect the fuelling nozzle and hose when not in use.

Means shall be provided to ensure that both the nozzle and the receptacle are at ground connection before connection.

The dispenser shall be provided with a manual purge or release valve that shall be protected by a locking mechanism or permanent closure so that it is inaccessible to the public.

11.3.2 Dispenser - General

A manually operated shut-off valve to isolate each dispenser shall be provided for maintenance purposes.

In addition, a fail-safe shut-off valve shall be provided upstream of the dispenser’s fuelling hose, to close automatically as soon as the control system detects the safe maximum filling conditions (i.e. pressure and temperature).

The dispenser shall be designed to be resistant to any particulate that can be expected in the dispensed fuel.

11.3.3 Dispenser cabinet

The dispenser cabinet shall be fit for the purpose.

The construction of the cabinet shall be such that it will not become warped, bent, loosened or otherwise damaged in normal operation. The dispenser cabinet shall:

— be able to withstand the expected service loads;

— be made from non-combustible and antistatic materials.

A recess or depression in the cabinet that may collect water shall contain means to drain the water to an area that will not cause an unsafe condition.

The dispenser cabinet shall afford space for making field connections of gas-carrying piping and electrical equipment. Openings shall be provided for making connections and for inspection and adjustment of the operating mechanism after installation. Openings shall require a key or tool to open.

11.3.4 Prevention of explosive gas atmosphere

The interior of the dispenser cabinet shall be adequately naturally- or force-ventilated. When naturally-ventilated, two openings of at least 100 cm^2, one at the top of the dispenser and one at the bottom, shall be provided. These two openings shall be positioned on opposite sides and at different elevations so as to ensure sufficient cross-ventilation.

Pressurized gases emerging from pressure relief devices shall be able to be ventilated and dissipated in a safe manner, avoiding any explosive gas atmosphere within the dispenser cabinet.

The dispenser shall be designed so as to prevent the release of any vented gas into the interior of the dispenser cabinet during any stage of vehicle fuelling operations.

Fail-safe means shall be provided to detect any leaks which could lead to an explosive atmosphere inside the dispenser cabinet. This can be done by a gas detector installed within the dispenser cabinet set to interrupt the gas supply when it detects a volume fraction of hydrogen in air greater than 1 %, or by means of frequent pressure integrity checks as indicated in 11.7.3.

11.3.5 Filters

If a hydrogen gas line filter is included as part of the dispenser, it shall be installed upstream of the hose breakaway device and upstream of all gas controls within the dispenser. The filter shall be of adequate size and construction for the application and shall be accessible for inspection, cleaning and replacement, without taking apart hydrogen gas lines or disturbing any part of the dispensing system.

The area adjacent to the filter shall be provided with a label or tag containing the following or equivalent warning:

WARNING – DISCONNECT ELECTRICAL POWER AND VENT GAS PER MANUFACTURER'S INSTRUCTIONS BEFORE SERVICING FILTER.

The filter shall be installed in such a manner that the force required to install or open the filter will not permanently distort the piping or other components of the dispenser.

11.3.6 Dispenser piping and fittings

Piping, tubing, fittings and piping components shall be suitable for use with compressed hydrogen gas and shall be rated over the dispenser temperature and pressure range.

Where used, tube fittings shall be chemically compatible with associated components and shall be designed to resist electrolytic action.

Ends of piping and tubing shall be free of obstructions or burrs.

11.4 Fuelling hose assembly

11.4.1 General

The fuelling hose assembly shall be

a) rated for the design pressure,

b) rated for the design temperature ranges and thermal stresses,

c) protected against abrasion and formation of kinks,

d) prevented from contacting the ground,

e) free of cuts, abrasions, kinks or any other damage, and

f) protected from damage by vehicles when in the stored position.

The fuelling hose assembly shall be strong enough to withstand reasonably expected loads (tensile and torsion) in normal use. The fuelling hose shall at all times be supported, to ensure against abrasion or kinks and to facilitate the easy withdrawal for use without contact with the ground.

Fuelling hoses shall only be used downstream of the emergency and isolation shut-off valve.

Provision shall be made for locking the fuelling shut-off valve when the station is unattended.

The length of the fuelling hoses shall not be more than 5 m and not less than 3 m.

When not in operational use, the fuelling hose shall not be in contact with the floor or walls.

11.4.2 Fuelling hose construction

The fuelling hose shall be made of, or lined with, materials that are resistant to

— hydrogen embrittlement,

— corrosion, and

— the actions of any contaminants in the hydrogen gas.

The construction material shall provide resistance to permeation. Where outer sleeves are fitted, they shall be suitably pierced to prevent inflation.

The fuelling hose shall be resistant against cracking and crazing from ultraviolet exposure.

The fuelling hose assembly shall be constructed so as to provide an electrically conductive path between couplings at each end of the fuelling hose in order to dissipate static electricity.

The electrical resistance between the end fittings of the hose assembly shall not exceed 10 ohms.

The fuelling hose outer sleeves shall be constructed of non-electrically conductive materials.

On fuelling hose assemblies that incorporate a vent line, the vent line shall have a design pressure equal to or greater than that of the fuelling hose. The vent line shall also maintain or have the same electrical conductivity requirements as the fuelling hose.

Each fuelling hose shall have been hydraulically tested by the manufacturer and had a certificate issued to that effect. The fuelling hose shall be permanently marked with its date of manufacture and its maximum operating pressure.

11.4.3 Fuelling hose fittings

The fuelling hose assembly shall have suitable end fittings.

Fittings shall be made of corrosion-resistant metal or of steel provided with corrosion-resistant plating. Fittings shall be constructed from materials that are compatible for use in compressed hydrogen applications.

For design pressures in excess of 4 MPa, assembled fuelling hoses should be provided with a suitable restraining cable or device fitted to an anchor point to restrain hose movement in the event of a fuelling hose assembly failure.

11.4.4 Testing and marking

The fuelling hose and the fuelling hose assembly shall be tested according to ISO 14113 and as specified by ISO 7751.

The fuelling hose shall be marked with the manufacturer's name or trademark, date of manufacture, maximum operating pressure, operating temperature range and suitability for use with hydrogen. Markings shall be according to ISO 14113 or provided on a manufacturer's permanently attached tag.

The fuelling hose shall be visually inspected before use on any day when the hose is in service to check that the hose is free from damage, cuts, cracks, bulges or blisters, and kinks.

The fuelling hose shall be tested for leaks with soapsuds or the equivalent at six-month intervals. Any leakage shall be reason for rejection.

Cycling of the fuelling hoses shall be estimated based on the operation. Fuelling hoses shall be replaced before the manufacturer's specified service life is reached.

Fuelling hoses that fail visual inspection or leakage test shall be withdrawn from service.

11.5 Hose breakaway device

11.5.1 Design

A self-sealing hose breakaway device shall be fitted in the fuelling hose and vent line to prevent damage to the dispenser and filling lines with subsequent possibility of a serious hydrogen leak in the event a vehicle moves away with the fuelling hose still connected to the vehicle.

The hose breakaway device shall:

— be fit for the purpose; and

— disconnect when subjected to a maximum force of 660 N but not less than 220 N when the device is installed as specified by the manufacturer. This condition shall be met at all pressures.

NOTE The effect of any retrieval mechanism on the operation of the hose breakaway device should be considered in determining these values.

The hose breakaway device shall also automatically shut off the source of hydrogen gas to the nozzle when disconnected.

A method shall be provided to reconnect the hose breakaway device if it is not a 'one-time-use device'. In the event of a reconnection, the fuelling hose assembly shall be pressurized and leak tested under operating conditions before recommencing operation.

The volume of gas required to be vented shall be limited to the contents of the fuelling hose and the piping within the dispensing cabinet.

The hose breakaway device shall incorporate double shut-off features that isolate both sides of the connection when uncoupled.

The hose breakaway device shall be positioned such that it will release when the fuelling hose is pulled along its axis without incurring any damage to the dispenser cabinet.

11.5.2 Marking

Hose breakaway devices shall bear a permanent marking on which shall appear the following:

a) manufacturer's name, trademark or symbol;

b) model designation;

c) design pressure in MPa;

d) direction of gas flow;

e) if applicable, the statement ONE-TIME-USE DEVICE. DO NOT REUSE or equivalent;

f) the date and location of manufacture.

11.5.3 Electrical conductivity

The electrical resistance between the extreme ends of the hose breakaway device shall not exceed 10 ohms. The resistance shall be measured at atmospheric pressure and while being exposed to an internal pressure equal to the manufacturer's specified design pressure.

11.5.4 Durability

The hose breakaway device shall withstand 100 000 cycles of hydrogen gas pressure pulses without separation or leakage.

11.6 Fuelling connector

11.6.1 Design

Fuelling receptacles and nozzles for compressed gaseous hydrogen service shall comply with ISO 17268 for the rated pressure. The use of adapters shall be prohibited.

The fuelling nozzle for dispensing hydrogen shall be securely supported and protected from the accumulation of foreign matter (e.g. snow, ice or sand) that could impede operation.

The fuelling system (fuelling hoses, lines and fuelling connector) shall prevent the entry of air into the vehicle fuel system and fuelling station equipment.

11.6.2 Connection of the fuelling nozzle to the vehicle fuelling receptacle

The coupling shall be designed such that detaching from the vehicle can only take place once the pressure has been released. The released gases from the depressurization shall be vented in a safe manner.

Filler couplings shall be designed against any unintentional detachment, e.g. by actuating a locking device. The nozzle shall be equipped with an interlock device that prevents release while the fuelling hose and nozzle are connected or that has self-closing ends that automatically close upon disconnection. This interlock device shall prevent the escape of hydrogen when the nozzle is not properly engaged or becomes separated.

The dispenser shall prevent gas flowing from the dispenser unless the dispenser has been activated for the vehicle fuelling operation.

11.6.3 Depressurization of nozzles

A mechanism shall be provided to depressurize nozzles as required in ISO 17268.

The gas shall be vented to a safe area. If a separate hose is used for this, it shall also be fitted with a breakaway device designed to the same requirements as the hose breakaway device.

11.7 Fuelling process control

11.7.1 Gaseous hydrogen dispensing pressures

Vehicles shall be filled to a pressure not exceeding either of the following conditions:

a) a pressure that would settle to the vehicle storage nominal working pressure at a settled temperature of 15 °C;

b) 1,25 times the vehicle storage nominal working pressure service pressure immediately after filling, regardless of temperature.

The dispensed pressure shall be temperature compensated to prevent pressures from exceeding the maximum pressures that are defined above.

NOTE Target fill conditions are shown for a 70 MPa service pressure in Figure 2.

11.7.2 End of fill control

Dispensers shall be designed to stop the filling process at or before reaching the maximum fill density or pressure.

Dispensers shall be designed to stop the filling process at or before the onboard vehicle internal gas temperature reaches 85 °C.

11.7.3 Pressure integrity check

Dispensers shall be designed such that the pressure integrity of the gas delivery line, fuelling hose and fuelling nozzle are verified before the commencement of each fuelling operation. If the pressure integrity check is not successful, the design of the dispenser shall be such that fuelling cannot commence until trained personnel have checked the system, corrected any malfunction and successfully performed another pressure integrity check.

11.7.4 Control

The dispenser shall automatically stop the fuelling procedure when the vehicle storage system is full to prevent tank over-pressurization at all temperatures.

Automatic electronic systems shall stop fuelling in case of abnormal conditions or fuelling station or vehicle faults.

The dispenser shall be capable of indicating the fuelling pressure.

11.7.5 Metering

If required, the dispenser shall feature a metering device connected to a readout giving the quantity of hydrogen dispensed for each vehicle fuelling operation.

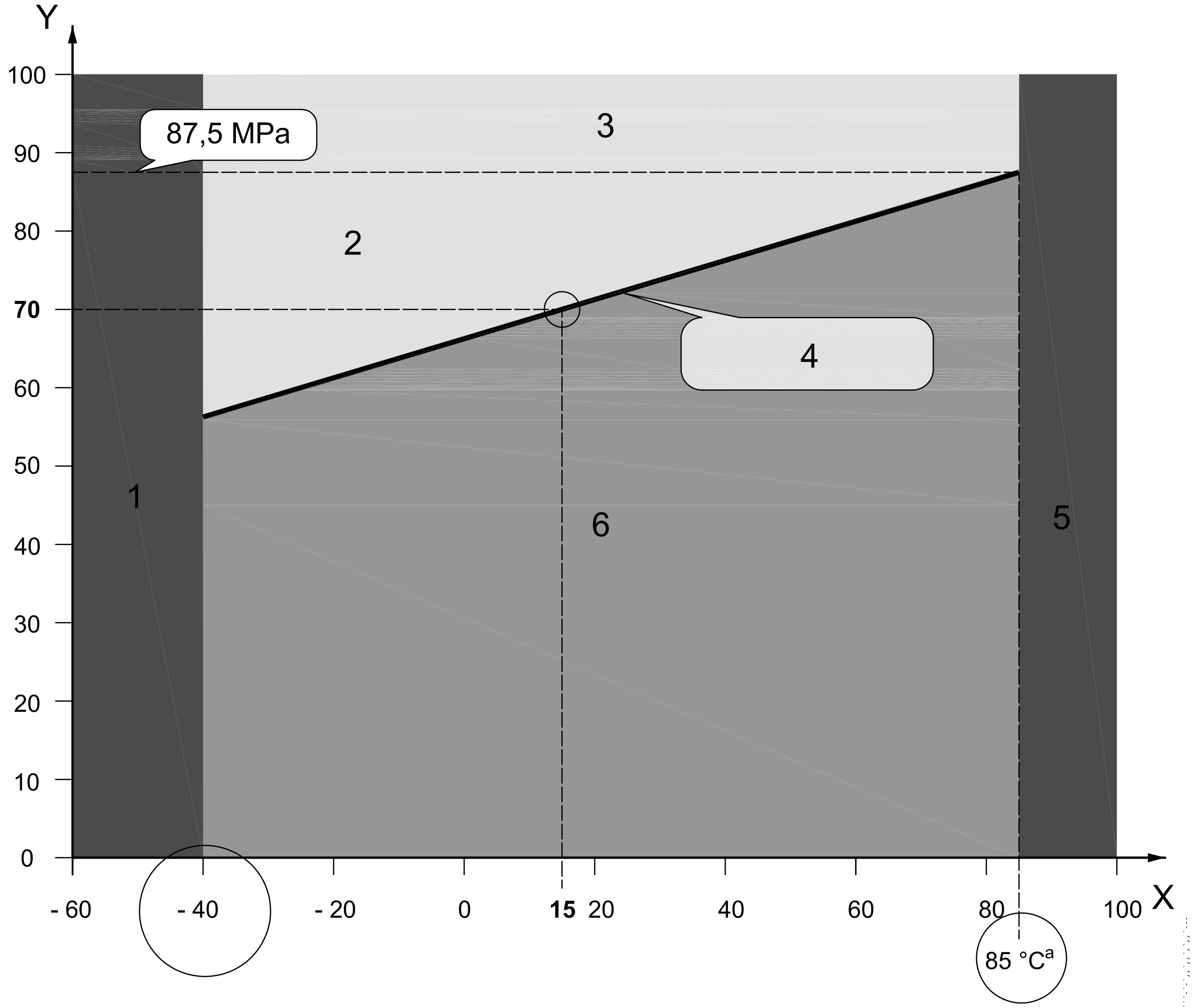
The dispenser shall also have a metering device giving the accumulated total quantity of hydrogen dispensed.

11.8 Dispenser safety devices

11.8.1 Over-pressure protection

A pressure relief valve on the dispensing line shall prevent over-pressurization of the vehicle storage. Means of protection against over-pressure shall be redundant if gas is stored in the dispensing system at a pressure greater than 150 % of the vehicle fuel tank nominal working pressure.

This pressure relief valve shall have a set pressure not greater than 1,38 times the nominal working pressure.



Key

X temperature (°C)
Y pressure (MPa)

1 over cooling
2 over filling
3 over pressure
4 target fill
5 over heating
6 operating window

a bulk.

Figure 2 — Target fill conditions for a 70 MPa vehicle storage

11.8.2 Limitation of hydrogen released in case of filling line break

Suitable means shall be provided upstream of the fuelling hose so as to limit the release of gas in the event of an uncontrolled increase in gas flow.

These means shall be such as to limit the amount of hydrogen released to less than 0,2 kg.

A manual operation subjected to restricted access shall be required to resume operation after such means have been activated.

This device shall be such as to limit the maximum amount of hydrogen released in case of fuelling hose rupture to less than 0,15 kg.

11.8.3 Dispensing emergency shut-down systems

The dispenser shall operate in conjunction with an emergency shutdown device (ESD). Activation of the ESD shall cause the dispenser to disable the flow of gas to the vehicle and shut off the electrical supply to the dispenser. The ESD, when activated, shall also shut off the power supply and the hydrogen supply to the compressor and the dispenser.

A manual ESD activation means shall be provided at the dispensing area and also at a location remote from the dispensing area. It shall be placed at 1,80 m above forecourt level and clearly identified. Additional manual ESD activation means shall be placed inside the fuelling station office and in compressor and storage areas.

ESD activation means shall be distinctly marked for easy recognition with a permanently affixed legible sign.

Control circuits shall be arranged so that, when an ESD is activated or electric power is cut off, systems that shut down shall remain shut down until they are manually activated or manually reset after a safe condition is restored. A manual operation shall be required for the dispenser to resume operation.

Each line between the hydrogen storage and the dispenser shall have a valve that closes when one of the following occurs:

a) the power supply to the dispenser is cut off;

b) an ESD is activated at the fuelling station.

The dispenser shall be equipped with a self-closing valve that closes each time the fuelling cycle is completed or when an ESD is activated.

Mechanically actuating safety equipment shall prevent the fuelling station from operating outside specified maximum or minimum operating pressures and prevent a gas leakage in the event of an incident. This safety equipment shall function without external power, such as spring-loaded safety valve or breakaway coupling.

11.9 Safety notices at fuelling point

One of the following safety notices shall be prominently displayed within 3 m of the fuelling point:

— the general purpose warnings NO SMOKING and TURN IGNITION OFF DURING VEHICLE FUELLING;

— international symbols for “NO SMOKING” and “IGNITION OFF” at least 50 mm in diameter and coloured red and black on a white background.

12 Hydrogen fuel specifications

The refuelling station shall distribute gaseous hydrogen that complies with the following specifications:

— Type I, Grade A, B or C as defined in ISO 14687-1;

— Type I, Grade D as defined in ISO 14687-2.

Each grade of fuel shall be identified on the dispenser. A warning shall inform the customer that only Grade D shall be used for road vehicles that are powered by proton exchange membrane (PEM) fuel cells.

13 Layout

13.1 General

The refuelling station layout shall be such that hydrogen systems are located so that they are readily accessible to fire-fighting services.

Consideration should be given to any potential hazards or risks in relation to the location and operation of the fuelling station. Adequate precautions, such as increased safety distances or properly designed physical walls, may be necessary in such cases.

Precautions to protect process equipment (compressor, buffer storage tanks, storage tanks, etc.) from vehicle impact and unauthorized entry shall be taken, e.g. the containment of process equipment in enclosures or the installation of security fences. Only authorized personnel shall be allowed to enter such areas.

Compressed gaseous hydrogen dispensers may be located within the operating area of other liquid or gaseous fuels dispensers, subject to the location of the dispensers and equipment complying with applicable requirements of 14.3 and 14.4.

Adequate means of escape in the case of emergency shall be provided. Where service personnel could be trapped inside the fuelling station compounds or buildings, there shall be not less than two separate outward opening exits, located at opposite locations from each other. Emergency exits shall be kept clear at all times.

The area within 3 m of any hydrogen process equipment shall be kept free of vegetation and combustible materials.

Lighting shall be provided for all operating and vehicle fuelling areas, such that operations can be carried out safely. The lighting equipment shall comply with the requirements of hazardous area classification of 14.3.

13.2 Safety distances

13.2.1 Safety distances from above-ground liquid hydrogen storage systems

Above-ground liquid hydrogen storage systems shall be kept away from different exposures by applying the minimum safety distances specified in Table 1.

Table 1 — Minimum safety distances for above-ground liquid hydrogen storage systems

Dimensions in metres

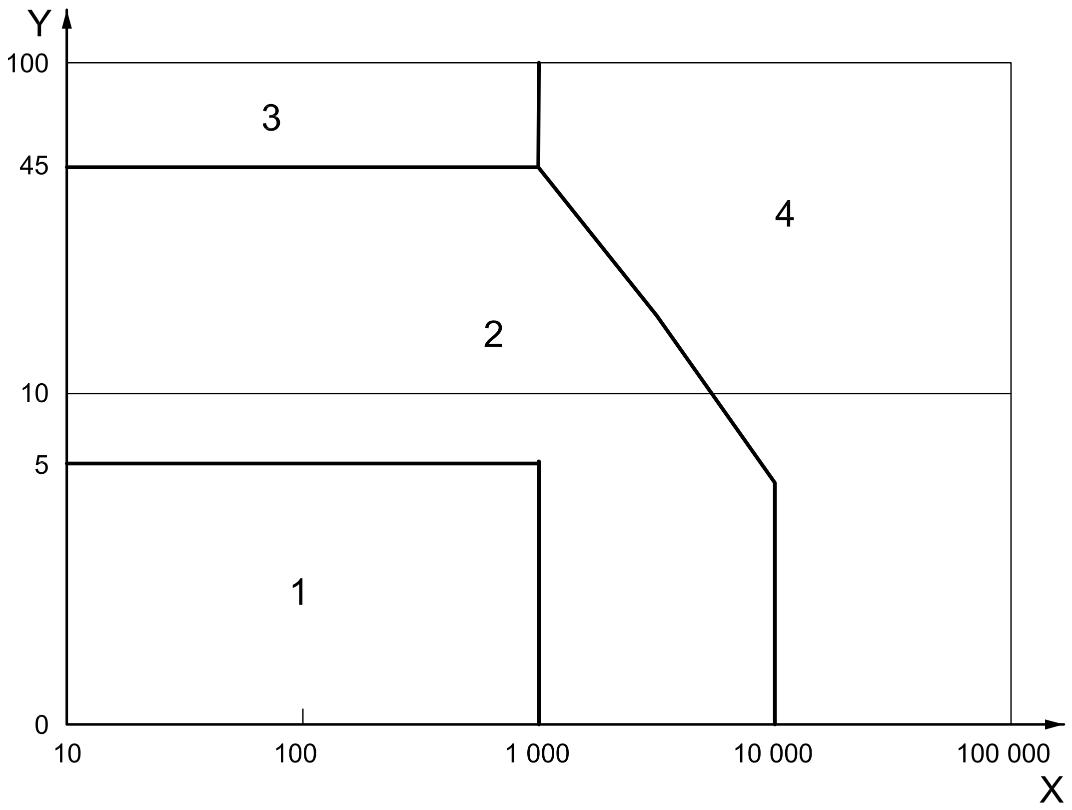
Storage category		L1 V ⩽ 500 l	L2 V > 500 l V ⩽ 2 000 l	L3 V > 2 000 l V ⩽ 8 000 l	L4 V > 8 000 l V ⩽ 60 000 l	L5 V > 60 000 l V ⩽ 300 000 l	Main escalation hazard addressed
Exposures	Building of non-combustible material (2 h resistant)	1,5	1,5	1,5	3	6	
	Building of combustible material	4	6	8	16	25	1) Hydrogen fire extending to building 2) Building fire impacting large storage
	Building wall opening	2	3	4	8	16	Explosive atmosphere in building due to hydrogen leak
	Small[a] flammable liquids above ground	n/a	2	3	6	12	1) Hydrogen fire impingement resulting in escalation 2) Flammable liquid fire radiation on hydrogen storage resulting in escalation
	Flammable liquids above ground	2	3	4	8	16	
	Flammable liquids below ground – vent and fill opening	3	3	4	6	6	Flammable liquid fire radiation on hydrogen storage
	Flammable gas storage > 500 m^3	2	3	4	8	16	1) Hydrogen fire impingement resulting in escalation 2) Flammable material fire radiation on hydrogen storage resulting in escalation
	Stocks of combustible material, e.g. timber	2	3	4	8	16	
	Open flame	2	3	4	8	16	Delayed ignition of explosive atmosphere resulting from leak
	Air conditioning & air compressor intake	2	3	4	8	16	Intake of explosive air/hydrogen mixture in building or air system
	Non-fuelling-related activities (e.g. car wash, vehicle maintenance and workshop)	2	3	4	8	16	Explosive atmosphere/flame impingement/radiation potential in case of leak
	Places of public assembly	4	6	8	16	25	Immediate exposure of untrained persons to major incident
	Public sidewalks and parked vehicles, lot line	2	3	4	8	16	Explosive atmosphere/flame impingement/radiation potential in case of leak
	Trolley, train and high voltage power line vertical plane	4	6	8	16	25	Further escalation of large incident involving passing train
	Other overhead electrical wire vertical plane	1,5	1,5	2	4	8	Line failing on hydrogen system

[a] Capacity smaller than hydrogen storage category low capacity threshold.

13.2.2 Safety distances from gaseous hydrogen systems

13.2.2.1 Safety distances from gaseous hydrogen storage systems

For the purpose of defining safety distances, four storage categories are defined according to the water volume of the storage tank, the service pressure and the stored quantity of gaseous hydrogen, as shown in Figure 3.



Key

X water volume (l)

Y service pressure (MPa)

Category 1: Water volume not greater than 1 000 l and operating pressure not greater than 5 MPa

Category 2: Water volume not greater than 1 000 l and operating pressure greater than 5 MPa but not greater than 45 MPa; or water volume greater than 1 000 l but not greater than 10 000 l and stored quantity not greater than 30 kg

Category 3: Water volume not greater than 1 000 l and operating pressure greater than 45 MPa

Category 4: Water volume greater than 1 000 l and stored quantity greater than 30 kg; or water volume greater than 10 000 l

Figure 3 — Gaseous hydrogen storage classification for determination of safety distances

Gaseous hydrogen storage systems shall be kept away from different exposures by applying the minimum safety distances specified in Table 2.

Table 2 — Minimum safety distances for gaseous hydrogen storage systems

Dimensions in metres

	Storage category	**1** **V ⩽ 1 000 l** **& P ⩽ 5 MPa**	**2** **V ⩽ 1 000 l** **& P ⩽ 5 MPa** **or** **1 000 < V ⩽ 10 000 l** **& Q ⩽ 30 kg**	**3** **V ⩽ 1 000 l** **& P > 45 MPa**	**4** **V ⩽ 1 000 l** **& Q > 30 kg** **or** **V > 10 000 l**	**Main escalation hazard addressed**
Exposures	Building of non-combustible material (2 h resistant)	Separation as required for maintenance and inspection access			1,5	
	Building of combustible material	2	4	6	6	1) Hydrogen fire extending to building 2) Building fire impacting large storage
	Wall opening not above hydrogen system	1	2	3	3	Explosive atmosphere in building due to hydrogen leak
	Wall opening above hydrogen system	1,5	3	4	4	Explosive atmosphere in building due to hydrogen leak
	Flammable liquids above ground < 4000 l	1,5	3	4	4	1) Hydrogen fire impingement resulting in escalation 2) Flammable liquid fire radiation on hydrogen storage resulting in escalation
	Flammable liquids above ground > 4000 l	2	4	6	8	
	Flammable liquids below ground – vent and fill opening	2	3	3	4	Flammable liquid fire radiation on hydrogen storage
	Flammable gas storage > 500 m^3	1,5	3	4	4	1) Hydrogen fire impingement resulting in escalation 2) Flammable material fire radiation on hydrogen storage resulting in escalation
	Stocks of combustible material, e.g. timber	2	3	3	4	
	Open flame	1,5	3	4	4	Delayed ignition of explosive atmosphere resulting from leak
	Air conditioning & air compressor intake	1,5	3	4	4	Intake of explosive air/hydrogen mixture in building or air system
	Non-fuelling-related activities (e.g. car wash, vehicle maintenance and workshop)	1,5	3	4	4	Explosive atmosphere/flame impingement/radiation potential in case of leak
	Places of public assembly	2	4	6	8	Immediate exposure of untrained persons to major incident
	Public sidewalks and parked vehicles, property bound	1,5	3	4	4	Explosive atmosphere/flame impingement/radiation potential in case of leak
	Trolley, train and high voltage power line vertical plane	3	6	8	12	Further escalation of large incident involving passing train
	Other overhead electrical wire vertical plane	1,5	1,5	1,5	1,5	Line failing on hydrogen system

For metal hydride storage systems, the above distances shall be applied by replacing the 1 000 l and 10 000 l thresholds respectively by a stored quantity threshold of 5 kg and 30 kg. For gaseous hydrogen storage systems of up to 1 000 l, safety distances shall be defined from points of potential leak such as valves and non-welded pipe connections.

For gaseous hydrogen storage systems of more than 1 000 l, safety distances shall be counted from all the components of the storage system containing hydrogen up to the first automatic or remotely operated isolation safety device. Piping satisfying $PS \times ND^2 < 100$, where PS is the service pressure in MPa, and ND the nominal diameter in mm, may be excluded.

If there is more than one storage system, and if connection between storage systems is such that hydrogen will be released from only one of the subsystems in the case of a pipe component failure, the safety distances shall be calculated considering each system individually. If a pipe component failure is likely to result in hydrogen being released from a set of storage systems, the safety distances shall be calculated by considering the set of storage systems as a whole.

No safety distance shall be required between two hydrogen storage systems of less than 1 000 l.

The safety distance between two hydrogen storage systems, where at least one has a capacity greater than 1 000 l, shall be determined by applying the safety distances prescribed for the storage piping systems, assuming the latter to be individual subsystems as specified in 13.2.2.2.

13.2.2.2 Safety distances from gaseous hydrogen process subsystems including the dispenser

The safety distances specified in Table 3 shall be applied to process subsystems with a maximum operating pressure greater than 5 MPa, where more than 0,1 kg of hydrogen may be potentially released.

Evaluation of the quantity of hydrogen present shall take into account all hydrogen piping elements and components connected to the subsystem up to the safety isolation devices that will either close automatically or that may be actuated manually from a point located at a distance of 3 m minimum from the subsystem perimeter.

Safety distances shall be defined from points of potential leak such as valves, non-welded pipe connections, and temporary connections (e.g. dispenser nozzle to vehicle).

Permanent connections where leak-tightness is achieved by a metal-to-metal contact without permanent deformation of the sealing surfaces do not need application of safety distances.

Table 3 — Minimum safety distances for gaseous hydrogen process subsystems

Dimensions in metres

Service pressure		$5 < P \leqslant 45$ MPa	$P > 45$ MPa	Main escalation hazard addressed
Exposures	Building of non-combustible material (2 h resistant)	Separation as required for maintenance and inspection access		None
	Building of combustible material	4	6	Hydrogen fire extending to building
	Wall opening not above hydrogen system	2	3	Explosive atmosphere in building due to hydrogen leak
	Wall opening above hydrogen system	3	4	Explosive atmosphere in building due to hydrogen leak
	Flammable liquids or gas storage above ground[a]	4	6	Hydrogen fire impingement resulting in escalation
	Stocks of combustible material, e.g. timber	3	3	Hydrogen fire impingement resulting in escalation
	Open flame	3	4	Delayed ignition of explosive atmosphere resulting from leak
	Air conditioning & air compressor intake	3	4	Intake of explosive air/hydrogen mixture in building or air system
	Non-fuelling-related activities (e.g. car wash, vehicle maintenance and workshop)	3	4	Explosive atmosphere/flame impingement/radiation potential in case of leak
	Places of public assembly	4	6	Immediate exposure of untrained persons to major incident
	Public sidewalks and parked vehicles[b], lot line	3	4	Explosive atmosphere/flame impingement/radiation potential in case of leak
	Trolley, train and high voltage power line vertical plane	6	8	Further escalation of large incident involving passing train
	Other overhead electrical wire vertical plane	1,5	1,5	Line failing on hydrogen system

[a] Including hydrogen storage and canopy storage.

[b] Excludes vehicles to be fuelled.

13.2.2.3 Assumptions pertaining to the validity of safety distances from the hydrogen dispenser

With regards to the dispenser, the safety distances specified in Table 3 are defined on the basis of the assumptions listed in Table 4, and are expected to be valid for fuelling stations complying with this Technical Specification.

Table 4 — Assumptions pertaining to the validity of safety distances from the hydrogen dispenser

Hydrogen leak event	Assumption
Leak at dispenser nozzle	Leak passage diameter greater than 0,5 mm very unlikely
Any dispensing hose failure	Release of more than 0,5 kg of hydrogen very unlikely

The prescribed safety distances do not address the opening of the pressure relief device of the vehicle's hydrogen storage while fuelling. This event can be considered unlikely if the dispenser design follows the prescriptions of this Technical Specification. If leaks from the hose or the nozzle cannot be considered improbable, fuelling procedure and user instructions shall aim at keeping persons clear of the hazardous situation generated by such leaks when the hose is pressurized with hydrogen.

13.2.2.4 Impact of fire barriers

The safety distances specified in Tables 2 and 3 shall not apply where a fire barrier having a minimum fire resistance rating of 2 h is located between the gaseous hydrogen system and any part of the exposure in such a way as to interrupt the line of sight between the two systems.

When used in conjunction with an outdoor gaseous hydrogen storage system, the fire barrier shall not have an enveloping form, shall not be used on more than two sides of the hydrogen storage system (a building counting as such a structure) and shall only be less than 1,5 m away from the hydrogen system on one single side.

14 Fire and explosion hazard protection requirements

14.1 General requirements

Hydrogen fuelling stations shall be manufactured and assembled such that unintentional flammable gas releases during normal operation are precluded.

14.2 Area classification

Areas around the hydrogen fuelling station equipment shall be classified according to IEC 60079-10.

14.3 Protection requirements for equipment within classified areas

Equipment within classified areas shall comply with the requirements of IEC 60079-0 and the appropriate parts of IEC 60079 for the type(s) of protection used, or with IEC 60079-30-1.

14.4 Prevention of the accumulation of ignitable mixtures indoors and in enclosures

Hazardous explosive atmospheres resulting from anticipated hydrogen leaks or releases shall be prevented indoors and in enclosures.

Passive prevention methods include but are not limited to:

- use of joints that are permanently secured and so constructed that they limit the maximum release rate to a predictable value;
- natural ventilation.

Active prevention methods include but are not limited to:

- active ventilation;
- a flammable gas detection system;
- other means of leak detection (e.g. through pressure measurements relative to control settings).

Where passive or active ventilation is relied upon for preventing ignitable mixtures, the ventilation rate shall maintain a volume fraction of hydrogen below 1 % or 25 % of the lower flammability limit (LFL) of any other flammable gases.

NOTE 1 Small dilution volumes where the structural integrity of the enclosure would not be affected in case of ignition based on the maximum anticipated flammable gas leak rate into the enclosure as determined by the manufacturer may be exempted from this requirement. The manufacturer shall demonstrate that the equipment is fit for the purpose.

This rate of ventilation need not be permanently present if it is initiated by a flammable gas detection system complying with the requirements of 14.8 upon measurement of a volume fraction of 0,4 % hydrogen or 10 % of the LFL of any other flammable gases. However, the rate of ventilation necessary to prevent the formation of an explosive atmosphere due to normal and expected releases (e.g. natural leaks from fittings or hydrogen permeation through non-metallic materials) shall be maintained whenever the process contains hydrogen under pressure, whether the system is in operation or not.

Failure of active ventilation or detection of flammable gas indoors or in an enclosure shall cause shut-off of supply of hydrogen and other flammable gases and the de-energization of non-classified electrical equipment at the maximum hydrogen volume fraction of 1 % or 25 % of the LFL of any other flammable gases. Equipment that remains energized in such an event, such as the hydrogen gas detection system and ventilation systems, shall be suitable for use in classified areas as per 14.3.

Computational fluid dynamics analysis using calculation tools validated for hydrogen, tracer gas or similar methods given in IEC 60079-10 may be used to design the means of active and/or passive ventilation and the means of hydrogen detection for providing the required protection.

NOTE 2 Sudden and catastrophic failure of vessels or piping systems need not be considered a leak scenario in this analysis when protection against such failures has already been contemplated in the tank and piping design.

Area classification determined as per 14.2 and the protection requirements for equipment in classified areas as per 14.3 may be adjusted taking into account the means of ventilation and the means of flammable gas detection that are present. In all cases, electrical apparatus operating in dilution volume that can exist near potential sources of release (leak points) shall be protected in accordance with 14.3.

NOTE 3 Even with sufficient overall ventilation of an enclosure, dilution volumes can exist near potential sources of release (leak points). IEC 60079-2[14] provides additional information.

Enclosures shall be designed so as to avoid high points where hydrogen can accumulate.

14.5 Ventilation specification

Whenever active ventilation is used as per 14.4, the minimum required ventilation rate and the operating pressure of the ventilation system shall be specified.

14.6 Start-up purge

Enclosures that rely on active ventilation for protection against accumulation of ignitable mixtures as per 14.4 shall be purged with a minimum of five air changes prior to the energization of any devices that are not suitable for the area classification.

Any equipment which may be energized prior to purging or in order to accomplish purging, shall be suitable for the area classification. Purging need not to be performed if it can be demonstrated by design and verified by operation that the atmosphere within the enclosure and associated ducts is non-hazardous prior to energization of the electrical equipment.

14.7 Areas adjacent to hazardous areas

Flammable gases shall be prevented from entering adjacent areas or compartments unless the equipment within the adjacent area or compartment is suitable for the resulting area classification.

Methods to prevent flammable gases from entering an adjacent area or compartment include but are not limited to:

— sealing;

— maintaining the adjacent area or compartment at a relative pressure higher than the area or compartment containing the flammable gas.

NOTE One approach is to use “negative pressure” when ventilating an area containing a flammable gas.

14.8 Hydrogen detection systems

Flammable-gas detectors shall be installed where a flammable gas release may lead to dangerous flammable gas accumulations (e.g. confined spaces).

Flammable-gas detectors may also be used for leak detection where such leaks will produce increased concentrations in predictable locations.

NOTE 1 Sensors detecting hydrogen by catalytic oxidation do not detect hydrogen in nitrogen or other inerting gases.

NOTE 2 This section does not apply to flammable-gas detectors or detection systems provided for other non-safety purposes such as diagnostics.

Flammable-gas detectors used for safety shall comply with IEC 60079-29-1 and shall incorporate appropriate safety factors as prescribed by the manufacturer's safety analysis to ensure that the alarm threshold lies outside the limits to be registered, taking into account, in particular, the operating conditions of the installation and possible faults in the measuring system.

The flammable-gas detectors used for safety shall be so designed and constructed as to be reliable and suitable for their intended use. They shall be independent of other functions, unless their safety functions cannot be affected by such other functions.

The manufacturer shall ensure that the selection, installation, use and maintenance of flammable-gas detectors are in accordance with IEC 60079-29-2. The flammable-gas detectors shall be installed in optimum locations to provide the earliest detection of flammable gas such that their protective function can be proven.

The design of the flammable-gas detector control circuits shall be in accordance with IEC 61069-7 and IEC 61511-1.

The design of a flammable-gas detector control circuit shall be such that failure of critical functional components will cause the hydrogen fuelling equipment to go to a safe condition, where either

a) the circuit will act to safely interrupt the intended function under its control, or

b) the circuit will allow the completion of an operational cycle but will fail to start or will lock out on the subsequent cycle.

The flammable-gas detector control circuit shall ensure that the interchange of the electrical installation and service connection leads or terminals of the critical functional component that failed, when physically interchangeable without alteration, will neither activate the component nor result in normal operation of the component.

Self-verification means shall be provided for hydrogen gas detectors used for safety purposes.

Inspections, calibration tests and maintenance shall be carried out according to a regular scheme. The tests and maintenance may be executed according to IEC 60079-29-1 and IEC 60079-29-2.

14.9 Safety of personnel

In enclosures, safe means of escape from any point where personnel may be present when the system is under hydrogen pressure shall be provided.

15 Hydrogen storage siting requirements

15.1 Ground storage

Gaseous hydrogen buffer storage tanks or assemblies shall be situated in the open air and supported on a reinforced concrete slab or an equivalent structure, which may be integral to the buffer storage tank assembly, and placed directly above an area that has been designed by a competent person.

Gaseous hydrogen buffer storage tanks within 15 m of above-ground storage of all classes of flammable and combustible liquids shall be located on ground higher than such storage, except where bunds or dikes, diversion curbs, grading or separating solid walls are used to prevent accumulation of these liquids under the gaseous hydrogen buffer storage tanks.

Gaseous hydrogen buffer storage tanks shall be resistant to damage from vehicular impact or protected from vehicular impact.

15.2 Below-ground vaults

15.2.1 General

Below-ground vaults constructed on site shall be permitted provided that the design is in accordance with a national building code and the vaults are designed by a competent person and that special inspections are conducted to verify the structural strength and compliance of the installation with the approved design. Consideration shall be given to soil and hydrostatic loading on the floors, walls and roof, anticipated seismic forces, uplifting by ground water or flooding, and loads imposed from above such as traffic and equipment loading on the vault roof.

15.2.2 Design and construction

The vault walls shall be higher than the gaseous hydrogen buffer storage tanks contained therein. There shall be no openings in the vault enclosure except those necessary for access to, inspection of, and filling, emptying, ventilation and venting of the gaseous hydrogen buffer storage tanks. The top of at-grade or below-grade vaults shall be designed to allow the escape of leaked hydrogen gas. Ingress of water shall be prevented. If installed at grade and subject to vehicle loading, the top shall have a metal grating or another roof with sufficient strength to carry vehicle loading.

15.2.3 Location of accessories

Manually operated valves, controls, pressure relief devices and instrumentation shall be located above ground and accessible to authorized personnel only.

15.2.4 Internal clearance

There shall be sufficient clearance between the gaseous hydrogen buffer storage tanks and the vault to allow for visual inspection and maintenance of the tanks and their appurtenances.

15.2.5 Arrangement

Adjacent vaults shall be permitted to share a common wall. The common wall shall be liquid- and vapour-tight and shall be designed to withstand the load imposed when the vault on either side of the wall is filled with water.

15.2.6 Ventilation

Vaults shall be open to the atmosphere and allow the escape of hydrogen gas.

15.2.7 Pressure relief devices

Pressure relief devices shall be piped to a safe location as specified in Clause 17.

15.2.8 Access way

Vaults shall be provided with a personnel access way with a minimum side dimension of 0,5 m and with a permanently affixed, non-ferrous ladder. Access ways shall be designed to be non-sparking. Travel distance from any point inside a vault to an access way shall not exceed 6 m. At each entry point, a warning sign indicating the need for following procedures for safe entry into confined spaces shall be posted. Entry points shall be secured against unauthorized entry and vandalism.

15.3 Fuelling station canopy-top storage

15.3.1 Location

Gaseous hydrogen buffer storage tanks may be located on top of fuelling station canopies provided the installation meets the requirements of 15.3.2 and 15.3.3.

15.3.2 Construction

Canopies shall be constructed with due consideration for the added weight of the equipment in addition to other static and dynamic loadings, in accordance with a national building code and the applicable parts of 15.4.

15.3.3 Signage

Signage having black letters with a minimum height of 50 mm on a white or contrasted background shall be affixed at a conspicuous location on the exterior of the canopy structure and shall state the following:

CANOPY-TOP HYDROGEN STORAGE

15.4 Roof-top installation of gaseous hydrogen systems

15.4.1 General

Hydrogen generators, hydrogen dispensers, gaseous hydrogen buffer storage tanks, hydrogen piping systems and their related accessories may be located on building or canopy roofs provided the installation meets the requirements of 15.4.

15.4.2 Location on roof and access

Hydrogen generators, hydrogen dispensers, gaseous hydrogen buffer storage tanks, hydrogen piping systems and their related accessories shall only be allowed to be located on horizontal single-story building roofs as instructed by the local national building code.

Rooftop hydrogen generators, hydrogen dispensers, gaseous hydrogen buffer storage tanks, hydrogen piping systems and their related accessories shall be located at the minimum safety distances specified in 13.2.2. The roof surface shall not be considered as being part of a building for consideration in minimum safety distances.

For personnel safety purposes, the hydrogen generators, hydrogen dispensers, gaseous hydrogen buffer storage tanks, hydrogen piping systems and their mounting structure(s) shall not extend to within 3 m of the roof edge.

Fixed access to the roof shall be provided for elevations exceeding 4 m. For elevations exceeding 8 m, the fixed access shall be provided by a stairway leading to a ladder not exceeding 4 m in height.

15.4.3 Roof structural requirements

The roof structure supporting the hydrogen equipment and tanks shall be constructed in compliance with the local national building code with due consideration for the added weight of the equipment in addition to other static and dynamic loadings.

15.4.4 Gaseous hydrogen storage mounting

Gaseous hydrogen buffer storage tanks shall be mounted according to the tank manufacturer's instructions. They shall be individually supported in a cradle or similar structure or within a rack that provides individual tank support.

The tank mounting structure shall be securely affixed to the roof. The maximum quantities that may be stored on a roof shall be approved by the authority having jurisdiction.

15.4.5 Other hydrogen equipment mounting

Other hydrogen equipment and control panels shall be securely mounted on the gaseous hydrogen storage mounting structure or separately mounted to the roof.

15.4.6 Mounting of hydrogen piping

Hydrogen piping shall be mounted on the building in compliance with 16.2.

15.4.7 Fire protection

Gaseous hydrogen equipment and buffer storage tanks on a roof of an occupied building shall meet at least one of the following requirements.

— The supporting roof structure and columns below the hydrogen equipment and storage footprint area shall have a 1 h fire-resistant rating but not less than that required by the type of construction for the building.

— The ceiling area below the hydrogen equipment and storage footprint shall be fitted with fire detection devices that activate at 110 °C and cause opening of the emergency device to discharge hydrogen storage from all tanks as per 20.4. The spacing of the fire detection devices shall meet the requirements of the local national building code.

NOTE The hydrogen equipment and storage footprint is defined as the hydrogen equipment and storage footprint area plus 50 % of the width and length.

Combustible roof surfaces shall be protected from potential flame impingement from hydrogen equipment and buffer storage tank valves and manifold connection leaks by a 1 h fire-resistant barrier or an equivalent protection from hydrogen flame impingement. The barrier shall be located on the roof, below potential hydrogen leak sites, and shall extend 1,2 m horizontally on either side.

Non-combustible roofs require no barrier.

15.4.8 Minimum safety distances

The minimum distance from a hydrogen system of indicated capacity to any specified exposure shall be in accordance with 13.2.

Portions of wall less than 3 m (measured horizontally) from any part of a system shall have a fire resistance rating of at least 1 h.

When determining the minimum distance between the hydrogen system and adjacent fire-rated walls, windows and doors shall be excluded from the fire rating determination.

15.4.9 Markings

Rooftop installations of gaseous hydrogen systems shall be identified with the following signs:

— HYDROGEN – FLAMMABLE GAS

— NO SMOKING – NO OPEN FLAMES

The signs shall be in black letters having a minimum height of 50 mm on a white or contrasted background.

16 General equipment requirements

16.1 Materials

16.1.1 General requirements

The use of dissimilar metals in tubing, fittings and other components should be avoided. Care shall be taken to prevent contact between dissimilar metals to prevent electrolytic corrosion. Special consideration shall be given to prevent contact between components of lower noble metals with higher noble ones. Metal fittings shall be compatible with metal tubing materials.

Flanged joints shall have a metal-to-metal seal or a gasket of a material such as graphite, which will maintain its integrity when subjected to elevated temperatures such as fire conditions.

Elastomers and plastics shall not be used for gaskets and packing or other sealing elements where their failure due to elevated temperature can cause hydrogen leakage, except for internal valve seats and O-rings.

16.1.2 Hydrogen compatibility

Components in which hydrogen or hydrogen-containing fluids are processed, as well as all parts used to seal or interconnect the same, shall be resistant to the chemical and physical action of hydrogen at the operating conditions. In particular, when selecting materials and manufacturing methods, due account shall be taken of resistance to hydrogen-assisted corrosion.

Due considerations shall be given when selecting ferrous materials for hydrogen service. Further information on the selection of materials, particularly choice of steels resistant to hydrogen embrittlement corrosion, can be found in ISO/TR 15916.

NOTE Hydrogen embrittlement is commonly addressed by surface finish, material selection and conservative design (avoid yielding).

Cast iron pipe and fittings shall not be used. Castings shall not be used due to the permeability of hydrogen and the possibility of porosity in the casting.

16.1.3 Hydrogen and material compatibility at cryogenic temperatures

Equipment and components that are to be used for handling liquid hydrogen and other gases under cryogenic conditions shall meet the material requirements of the equipment and component standards specified in 5.3.

16.2 Piping carrying gaseous hydrogen

Piping for all the tie-ins of the various systems of the hydrogen fuelling station shall be in accordance with ISO 15649. Piping components shall have adequate pressure and temperature ratings and be made of materials compatible for hydrogen service.

Hydrogen piping shall be clearly and permanently marked by means of colour coding and/or labels.

Where it is necessary to run gaseous hydrogen piping in the same duct or trench used for electrical cables, all joints in the hydrogen piping in the ducted/trenched section shall be welded. The hydrogen piping shall be run at a higher elevation than other piping.

Where ammonia or chlorine are likely to be present as an atmospheric contaminant, copper and copper/tin/zinc base alloys shall not be used for piping or fittings since these materials are susceptible to be attacked by these contaminants. Consideration shall also be given to the possibility of other contaminants being present.

16.3 Pressure relief devices for gaseous hydrogen systems

All pressurized gaseous hydrogen systems and equipment shall be protected from over-pressure by means of one or more pressure relief devices of the self-destructive type, such as rupture disks and diaphragms, or of the resealable type, such as spring-loaded pressure relief valves.

Pressure relief devices shall be directly connected to the equipment, which is the potential source of over-pressure with no interconnected isolation devices.

Pressure relief valves shall meet the requirements of ISO 4126-1 or of one of the standards recognized in ISO 16528-1.

Rupture disks shall meet the requirements of ISO 4126-2 or of one of the standards recognized in ISO 16528-1.

16.4 Protection from the accumulation of static charges

All sources that are able to cause static charges shall be addressed, and measures shall be taken to remove them completely or reduce the probability of their occurrence. At the design stage, the fuelling station shall be examined to identify possible electrostatic hazards and the requirements of earthing shall be determined.

NOTE Electrostatic charges may occur when mechanical separation of similar or different substances takes place and also when a gas containing droplets or dust particles flows past the surface of a solid, e.g. valve openings, hose or pipe connections. If the accumulation of electric charges is released suddenly, the resulting electric spark can be sufficiently strong to ignite hydrogen.

Earthing devices shall:

— be recognized as such and be accepted as essential to the safe operation of the fuelling station;

— either be clearly visible or be essential to the correct functioning of the fuelling station, so that any shortcomings are quickly detected;

— be robust and so installed that they are not affected by high resistive contamination, e.g. by corrosion products or paint.

The fuelling station shall be provided with a device or system to earth the cylinders mounted on vehicles.

The use of non-conductive materials shall be restricted in some hazardous areas.

In zone 1, non-conductive solid materials shall only be used if charging mechanisms capable of generating hazardous potentials will not occur either during normal operation (including maintenance and cleaning) or in the case of likely malfunctions.

In zone 2, non-conductive solid materials should only be used unless their use results in the occurrence of frequent incentive discharges during normal operation.

16.5 Equipment grounding and bonding

Hydrogen tanks, associated piping and systems shall be electrically grounded and bonded as required by IEC 60204-1. Flanges shall be electrically bonded.

NOTE IEC 60204-1 provides requirements for both protective and operational bonding.

All exposed conductive parts of the electrical equipment and other conductive equipment shall be connected to the protective bonding circuit. Where a part is removed for any reason (e.g. routine maintenance), the protective bonding circuit for the remaining parts shall not be interrupted.

The protective bonding circuit shall not incorporate a switching device, an over-current protective device or means for current detection for such devices.

For protection of equipment and human beings in the fuelling station, all kinds of equipments shall be connected to a common potential. This shall be applied for tanks and piping transferring liquids and gas, as well as for electric equipment connected to these units.

16.6 Valves for gaseous hydrogen

Valves used in piping systems for gaseous hydrogen shall be designed in accordance with ISO 15649. Valve materials should comply with EN 1503-2.

NOTE EN 1503-2 gives a listing of steel types for valves, bodies and covers, according to ASTM standards.

Isolation valves with lockout capabilities shall be used to isolate portions of the piping system in emergencies and for routine maintenance. An isolation valve shall be installed at an accessible location in the hydrogen piping so that the hydrogen flow can be shut off when necessary.

16.7 Instruments and cabinets

Instruments and gauges shall be designed and located such that, in the event of a leakage or rupture and possible subsequent fire, the risk to personnel is minimized. Safety “glass” and blowout backs on pressure gauges should be used.

Cabinets or housings containing hydrogen control equipment shall be designed to prevent any accumulation of hydrogen gas.

17 Gaseous hydrogen vent systems

Hydrogen systems shall be equipped with vents or bleed venting connections to direct vented hydrogen to a location where it may be safely discharged to the atmosphere. The vents shall be designed both for the operational and emergency discharge. The vent piping shall be sized so that the vent line pressure will not reduce the relieving capacity of the pressure relief devices. The vent line shall be sized to maintain a very low resistance for the low-pressure vent system. The vent system shall be designed so that all components will be suitable in size, pressure rating and materials for the service conditions intended.

Separate vent systems should be used for high- and low-pressure sources.

A vent pipe that will divert gas flow to the atmosphere shall be installed on the installation for purging purposes.

Vents, including those of pressure relief devices, shall be arranged to discharge in a safe place in the open air so as to prevent impingement of escaping gas onto personnel or any structure, tank, valve or fitting. Vents shall be piped individually, and manifolding should not be used. Vents shall not discharge where accumulation of hydrogen can occur, such as below the eaves of buildings.

The vent lines shall be designed and constructed for the rated pressure, volume and temperature. The vent pipe shall be properly supported. A means shall be provided to prevent water, ice and other debris from accumulating inside the vent pipe or obstructing the vent pipe. The outlet of the hydrogen vent stacks shall not be equipped with devices that disturb the natural buoyancy of hydrogen or limit or obstruct the gas flow from venting vertically upwards.

18 Instrumentation control and safety systems

18.1 General

The hydrogen fuelling station shall be equipped with control and safety systems that are designed and constructed so that any facility on the hydrogen fuelling station is safe and reliable. The control and safety systems shall also prevent hazardous conditions from occurring.

Safety requirements shall be established for all safety barriers on a hydrogen fuelling station. For safety-instrumented systems, IEC 61508 shall be considered for specification, design and operation of such systems.

The control system shall provide for the running of the hydrogen fuelling station within normal, specified parameters. The safety system shall counteract or restrict development of hazardous situations, and shall activate automatically by detection of abnormal states of any process. The safety system shall override the control system. The safety system shall be based on the fail-safe principle. The extent and design of control and safety systems shall be established according to the risk potential.

As a main principle, there shall be separate signal input units for process control and process safety systems. This principle does not imply the same for the output signal suppliers.

The signal input units shall be connected to communication net transforming the signals of the alarms and other relevant instruments to the monitors in a central control unit.

All safety functions shall be executed in the equipment unit where the input and output signals are connected.

When there is a system fault on the process safety system, the output signals shall turn into power-free mode the equipment units concerned, bring the valves, etc. to a fail-safe mode and give a stop signal to the electrical equipment.

All equipment units within the limits of the hydrogen fuelling station shall be fitted with devices which will ensure safe operation of these units and of the fuelling station as a whole under all modes of operation, maintenance, inspection and demolition.

The safety system can be activated automatically as well as manually. Systems and equipment connected to a safety system shall include:

— pressure relief devices;

— redundant power supply;

— trip systems;

— interlocks;

— emergency power supply;

— fire-fighting system (e.g. water irrigation).

Emergency systems that are dependant on supply of energy or utilities (such as electricity, fuel, cooling water, fire water, purge gas, instrument air) shall be documented.

Test procedures for safety systems shall be available. Frequency and extent of testing shall be described.

Operations requiring that safety systems be non-functional shall lead to a consequence analysis being executed and documented before the start of the specific operation.

The control of the dispenser system and the fuel supply from storage to the dispenser shall have its own control system isolated from the other operations/functions of the fuelling station.

18.2 Master system

A master system shall manage the control system, the safety system and the emergency system. There shall be restrictions regarding admittance to these systems through the master system by using password protection for certain kinds of service operators.

All alarms, measurements and action from an operator shall be registered in a system's history database.

NOTE IEC 60204-1 gives a large number of general requirements that may be applicable to electrical equipment controlling various types of mechanical equipment and gives an overview of relevant references made for various issues appearing in this area.

The configurations of all systems operating within the hydrogen fuelling station domain shall be documented.

18.3 Alarms

Any alarm shall require an action by the supervisor or operator in charge.

Regarding trips of equipment, every trip shall be warned by an alarm, giving the supervisor sufficient time to intervene before the trip is actualized.

Trips of equipment executed by safety systems shall be followed by an alarm.

Faults on critical units of electric and automatic instruments systems shall release an alarm signal.

18.4 Pneumatics

Instrument air shall be supplied through control valves from an air compressor. If the supply lapses, the pressure level of air shall be kept by a buffer volume for some time. Pneumatic equipment and systems shall satisfy the requirements of ISO 4414.

Pneumatic systems shall be designed so that no hazard may result from pressure losses or pressure drops.

All elements of the pneumatic system, and especially pipes and hoses, shall be protected against harmful external effects.

All elements which remain under pressure after isolation of an equipment unit from its electrical power supply shall be provided with clearly identified exhaust devices and a warning label drawing attention to the necessity of depressurizing those elements before setting or performing maintenance activities on the equipment unit.

18.5 Safety systems

The safety system shall be able to bring a hazardous situation under development to a safe mode, and bring all kinds of control equipment into fail-safe position. Emergency safeguarding shall remain effective for all operating modes. The emergency system shall override all other functions and operations in all modes, which could prevent the emergency stop routine.

There shall not be a category 0 when an emergency function is activated, according to IEC 60204-1. There are two states of emergency: emergency stop and emergency switch-off. IEC 60364-4-41 treats details for these states.

Control and monitoring systems that can operate safely in the hazardous situation may be left energized to provide system information.

Manual devices for emergency stop shall be readily accessible. The emergency stop devices shall be located at each operator control station and other locations where the initiation of an emergency stop can be required.

18.6 Instrumentation

Instruments dedicated for various functions on the fuelling station shall be tested and proved fit for their intended purpose. Instruments intended for operation within hazardous zones shall be protected as per 14.3. The equipments and components shall be in accordance with specific standards mentioned in IEC 60079-14. Those requirements come in addition to the requirements for installations in non-hazardous areas.

18.7 Safety functions control

In the event of an emergency, the ESD system shall also shut off the liquid supply and power to the liquid hydrogen transfer equipment necessary for producing gaseous hydrogen from liquid hydrogen. In the event of an ESD shutdown, the design shall allow for pressure relief within any closed system.

19 Electrical systems (electrical equipment and wiring)

19.1 General requirements

Electrical equipment, components and devices shall be:

— suitable for their intended use;

— installed and used within their applicable hazardous or non-hazardous zone ratings and as per manufacturer's instructions.

Electrical safety shall ensure protection against electrical shock, fire and burns during operation and routine mechanical activities.

Wiring methods shall comply with the requirements of IEC 60204-1. Wire for power circuits shall be colour coded to allow for consistent identification. Conductors shall be identified as per IEC 60446. Equipment terminals shall be identified as per IEC 60445.

Electrical installations in hazardous areas shall comply with the requirements of IEC 60079-14.

19.2 Power supply

The control system shall have redundant power supplies for all units where lapsing of power can influence the supplies of fuel, safety and the environment. All central units of the control system shall be supplied from a redundant uninterruptible power supply (UPS) system that will keep the power for minimum 30 min after a lapse.

19.3 Electromagnetic compatibility and interference (EMC)

Electrotechnical and electric equipment shall not generate electromagnetic disturbances above levels appropriate for their intended places of use. In addition, electrotechnical and electric equipment shall have a level of immunity to electromagnetic disturbances that will ensure that they can operate correctly in their intended environment.

Electrotechnical and electric equipment shall meet the requirements of IEC 61000-6-1 and 61000-6-3.

20 Safety systems

20.1 Emergency principles and operations

Full emergency procedures shall be established for each particular fuelling station in consultation with local fire authorities. Periodic drills shall be carried out.

The following safety systems shall be provided as applicable to respond to hazardous situations resulting from an accidental release of hydrogen:

— hydrogen detection;

— hydrogen fire detection;

— emergency isolation systems;

— emergency ventilation or inerting systems;

— fire fighting systems.

Where a risk remains that critical hydrogen equipment can be dangerously exposed to fire conditions which may originate from non-hydrogen-related equipment despite all the means that can reasonably be taken at design level, the following safety systems shall be considered:

- water sprinklers for the cooling of equipment exposed to fire;
- means for the emergency venting of gaseous hydrogen buffer storage tanks as per 20.4.

20.2 Fire detection systems

Means of detection of hydrogen fires shall be provided to avoid escalation due to flame impingement on neighbouring equipment.

Ultraviolet emission sensors may be used for hydrogen fire detection.

Means shall also be provided to detect fires (e.g. smoke detectors) in equipment that have particular fire hazards (e.g. high-current electrical equipment) if such fires can directly affect pressurized gaseous hydrogen storage systems.

20.3 Safety and emergency shut-off systems

Emergency isolation valves shutting off hydrogen supply in case of emergency shall be provided. Their means of actuation shall be readily accessible and located outside the hazardous zone initially generated by foreseeable incidents.

Emergency isolation valves of liquid hydrogen lines shall be self-closing.

Where hydrogen is used in enclosed areas, actuation means shall be provided outdoors.

A manual shut-off valve to isolate a hydrogen source shall be provided in a safe location.

Where hydrogen compressors or liquid hydrogen pumps are used, a manual emergency shutdown device shutting off both the power supply and the hydrogen supply shall be provided.

Operation of all pumps and compressors shall cease when the fuelling station's ESD system is initiated.

The location of safety shut-off valves in liquid hydrogen service shall be such that their actuators do not risk being blocked by accumulation of ice in case of a foreseeable hydrogen leak or release.

Where hoses (vehicle dispensing and road tanker discharge) are used, means of isolation shall be provided so that in case of rupture, the resulting leak may be safely isolated.

20.4 Emergency release of gas from gaseous hydrogen buffer storage tanks

If gaseous hydrogen buffer storage tanks may be exposed to fire conditions that could lead to rupture, thermally activated or manually activated valves may be provided to safely vent all the content of the hydrogen buffer storage.

In this case, the vent system shall be designed accordingly.

20.5 Fire-fighting systems

The location and quantity of fire-fighting equipment shall be determined depending on the size of the hydrogen fuelling station and in consultation with the local fire authorities.

Water shall be available in adequate volume and pressure for fire protection (fire-fighting and cooling of fire-affected equipment) as determined in consultation with the local fire authorities.

For fire-fighting purposes, suitable fire-extinguishing appliances shall be placed in readiness in the vicinity of hazardous areas. Details are to be co-ordinated with the local fire authorities.

21 Protection from external effects

21.1 General principles

A hazard and risk assessment (see ISO Guides 51 and 73) shall be carried out for all stages in the life cycle of the gaseous hydrogen fuelling station and to all types of hazards encountered. The results of the hazard and risk assessment process shall be used both to evaluate the consequences of hazardous events and to determine appropriate risk reduction. The achievements of risk reduction shall be based on:

- using inherently safe technologies;
- applying safety principles when designing control systems;
- limiting exposure to hazards through reliability of equipment;
- safeguarding;
- regular service and maintenance of the equipment.

21.2 Lightning protection

Fuelling stations shall be protected against lightning in accordance with IEC 62305-3.

Major metallic structures and items of equipment such as a tank or a vent stack shall be bonded directly to the earth point and not rely upon piping as a means to ground.

Protective measures against lightning shall not impair cathodic corrosion protection measures.

21.3 Protection from environmental conditions

Equipment enclosures shall be designed and tested for the intended installation environment as classified in IEC 60529. As a minimum, the enclosure shall meet the IP 56W rating defined in IEC 60529.

NOTE 1 Components and equipment individually protected to the levels required by this Technical Specification (or better) do not need to be enclosed.

NOTE 2 IEC 60529 does not directly address ice, sleet, snow or other conditions that may be encountered in outdoor applications. A “W” in the third character of the IP code indicates “weather conditions”, however no specific requirements are provided. IEC 60068-1 contains additional guidance on environmental testing.

22 Tests

22.1 Pressure test

Means of pressure indication suitable for the test pressure shall be installed before the test. Precautions shall be taken to prevent excessive pressure in the system during the test. Following any hydraulic test, the system/equipment shall be drained and thoroughly dried out and checked.

Where a pneumatic test is specified, a mixture composed of nitrogen with a minimum volume fraction of 5 % helium shall be used. The pressure in the system shall be increased gradually up to the test pressure. Any defects found during the test shall be rectified in an approved manner.

Testing shall be repeated until satisfactory results are obtained.

The pressure test shall be witnessed by a qualified person and documented. A suitable pressure test certificate shall be signed and issued. Records of pressure tests and certificates shall be maintained and filed for future reference.

Any subsystems that have been tested prior to their installation do not need to be subjected to the pressure test. Permanent connections of such subsystems to the hydrogen fuelling station do not need to be tested if they are rated for the appropriate temperature and pressure.

NOTE Instruments and controls are normally isolated from the pressure test.

22.2 Leak test

A leak test shall be conducted on hydrogen subsystems, on the interconnections and on the whole system. The design pressure shall be used as the leak test pressure.

Depending on the complexity, the leak test may be executed subsystem by subsystem or for all the subsystems at the same time when the whole assembly has been connected and prepared for commissioning.

Equipment made for liquids may be leak-tested by water and eventually afterwards by the liquids meant for it.

Hydrogen subsystems, interconnections and the whole system should be leak tested by a mixture composed of nitrogen and a minimum volume fraction of 5 % helium. For a flange, the helium detector shall be moved at a perpendicular distance of 2 cm to 3 cm from the flange all around.

All leakages shall be marked out and repaired. The leak test shall be repeated after repairs. For systems meant for hydrogen, the leak test may be repeated with hydrogen afterwards. In this last case, leaks shall be measured using hydrogen sensors or detectors.

The leak detectors shall be used as calibrated for the anticipated measuring range. The leak test shall not be carried out when the weather conditions are very windy.

22.3 Testing of electrotechnical control/safety/emergency systems and components

Equipment and components within systems (control system, process safety system/emergency system) shall be tested according to the manufacturer's requirements.

Each system loop and the total systems shall be tested for all possible modes of operation and all other modes. The fuelling station shall be ready for start-up when every function is proved without any faults. All tests shall be documented and filed.

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