Bureau de normalisation du Québec

CAN/BNQ 1784-000/2022

Canadian Hydrogen Installation Code

STANDARD

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Canadian Hydrogen Installation Code

Code canadien d'installation de l'hydrogène

Bureau de normalisation du Québec

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Except for notes presented as **normative notes**, which set out mandatory requirements and which appear in the lower portion of figures and tables only, all other **notes** are **informative** (non-mandatory) and provide useful information intended to facilitate understanding or clarify the intent of a requirement or to add clarification or further details.

Normative annexes provide additional requirements (mandatory) in order to comply with this document.

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FOREWORD

This document was developed in compliance with the Standards Council of Canada (SCC)'s Requirements and Guidance for standards development organizations and approved as a National Standard of Canada by the SCC. Its publication was approved by a Standards Development Committee, whose members were:

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1 At the time of publication of this document, the aforementioned person no longer worked for the Bureau de normalisation du Québec (BNQ).

CONTENTS

CANADIAN HYDROGEN INSTALLATION CODE

1 PURPOSE AND SCOPE

The purpose of this code is to establish the installation requirements for hydrogen-generating equipment for non-process end use, hydrogen utilization equipment, hydrogen-dispensing equipment, hydrogen storage containers, hydrogen piping systems, and their related accessories.

It applies to all gaseous and liquid hydrogen applications except the following:

a) hydrogen production or use in petroleum refineries and chemical plants as feedstock and directly in-process production;

b) industrial facilities where hydrogen is produced, handled and stored for off-site end use;

c) industrial installations producing hydrogen as a by-product that is vented to atmosphere;

d) cryogenic systems used for hydrogen liquefaction;

e) hydrogen installations on board vehicles for onboard use;

f) vehicles that use hydrogen for propulsion;

g) hydrogen transportation, including hydrogen utility pipeline distribution and transmission pipelines.

2 NORMATIVE REFERENCES

2.1 GENERAL

The references below (including any amendment or errata) are normative references, and are therefore considered mandatory. They are essential to the understanding and use of this document, and are cited in appropriate places in the text.

It should be noted that a dated normative reference refers to that specific edition of the reference, while a non-dated normative reference refers to the latest edition of the reference in question.

NOTE — This document also cites informative references, which are listed in an annex. A bibliography of references on topics covered in this document is also annexed.

2.2 DOCUMENTS FROM STANDARDS BODIES

ASME (American Society of Mechanical Engineers) [www.asme.org]

ASME BPVC	*Boiler and Pressure Vessel Code*.
ASME A13.1	*Scheme for the Identification of Piping Systems*.
ASME B31.1	*Power Piping*.
ASME B31.3	*Process Piping*.
ASME B31.12	*Hydrogen Piping and Pipelines*.

ASTM International [www.astm.org]

ASTM A240/A240M	*Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*.
ASTM A358/A358M	*Standard Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Stainless Steel Pipe for High-Temperature Service and General Applications*.
ASTM A403/A403M	*Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings*.

CGA (Compressed Gas Association) [www.cganet.com]

CGA G-5.4	*Standard for Hydrogen Piping Systems at User Locations*.
CGA G-5.5	*Hydrogen Vent Systems*.
CGA H-5	*Standard for Bulk Hydrogen Supply Systems*.
CGA P-50	*Site Security Standard*.

CGA P-74	*Standard for Tube Trailer Supply Systems at Customer Sites*.
CGA S-1.3	*Pressure Relief Device Standards — Part 3: Stationary Storage Containers for Compressed Gases*.

CSA Group [www.csagroup.org]

CSA/ANSI CHMC-1	*Test Methods for Evaluating Material Compatibility in Compressed Hydrogen Applications — Metals*.
CSA/ANSI CHMC-2	*Test Methods for Evaluating Material Compatibility in Compressed Hydrogen Applications — Polymers*.
CSA/ANSI FC 1:21/ CSA C22.2 No. 62282-3-100:21	*Fuel Cell Technologies — Part 3-100: Stationary Fuel Cell Power Systems — Safety* (Technologies des piles à combustible — Partie 3-100 : Systèmes à piles à combustible stationnaires — Sécurité.)
CSA/ANSI FC 3	*Portable Fuel Cell Power Systems*.
CSA/ANSI HGV 4.1	*Hydrogen-Dispensing Systems*.
CSA/ANSI HGV 4.2	*Hoses for Compressed Hydrogen Fuel Stations, Dispensers and Vehicle Fuel Systems*.
CSA/ANSI HGV 4.3	*Test Methods for Hydrogen Fueling Parameter Evaluation*.
CSA/ANSI HGV 4.4	*Gaseous Hydrogen — Fueling Stations — Valves.*
CSA B51	*Boiler, Pressure Vessel, and Pressure Piping Code*. (Code sur les chaudières, les appareils et les tuyauteries sous pression.)
CSA B72	*Installation Code for Lightning Protection Systems*. (Code d'installation des paratonnerres.)
CSA B339	*Cylinders, Spheres, and Tubes for the Transportation of Dangerous Goods*. (Bouteilles à gaz cylindriques et sphériques et tubes pour le transport des marchandises dangereuses.)

CSA B340	*Selection and Use of Cylinders, Spheres, Tubes, and Other Containers for the Transportation of Dangerous Goods, Class 2*. (Sélection et utilisation de bouteilles à gaz cylindriques et sphériques, tubes et autres contenants pour le transport des marchandises dangereuses, classe 2.)
CSA B401.1	*Natural Gas Vehicle (NGV) Maintenance Facilities Code*. (Code sur les établissements d'entretien de véhicules au gaz naturel [VGN].)
CSA C22.1	*Canadian Electrical Code — Part I: Safety Standard for Electrical Installations*. (Code canadien de l'électricité — Première partie : Norme de sécurité relative aux installations électriques.)
CSA C22.2 No. 60079-2	*Explosive Atmospheres — Part 2: Equipment Protection by Pressurized Enclosure "p"*. (Atmosphères explosives — Partie 2 : Protection du matériel par enveloppe à surpression interne « p ».)
CSA HGV 4.9	*Hydrogen Fueling Stations*.
CSA Z662	*Oil and Gas Pipeline Systems*. (Réseaux de canalisations de pétrole et de gaz.)
CSA Z767	*Process Safety Management*. (Gestion de la sécurité opérationnelle.)

IEC (International Electrotechnical Commission) [www.iec.ch]

IEC 60079-10-1	*Explosive Atmospheres — Part 10-1: Classification of Areas — Explosive Gas Atmospheres*. (Matériel électrique pour atmosphères explosives gazeuses — Partie 10 : Classement des emplacements dangereux.)
IEC 61511	*Functional Safety — Safety Instrumented Systems for the Process Industry Sector*. (Sécurité fonctionnelle — Systèmes instrumentés de sécurité pour le secteur des industries de transformation.)

ISO (International Organization for Standardization) [www.iso.org]

ISO 4126	*Safety Devices for Protection Against Excessive Pressure*. (Dispositifs de sécurité pour protection contre les pressions excessives.)

ISO 6718	*Bursting Discs and Bursting Disc Devices*. (Disques de rupture et dispositifs à disque de rupture.)
ISO 11119	*Gas Cylinders — Refillable Composite Gas Cylinders and Tubes — Design, Construction and Testing*. (Bouteilles à gaz — Bouteilles à gaz rechargeables en matériau composite et tubes — Conception, construction et essais.)
ISO 12100	*Safety of Machinery — General Principles for Design — Risk Assessment and Risk Reduction*. (Sécurité des machines — Principes généraux de conception — Appréciation du risque et réduction du risque.)
ISO 14687	*Hydrogen Fuel Quality — Product Specification*. (Qualité du carburant hydrogène — Spécifications de produit.)
ISO 16110-1	*Hydrogen Generators Using Fuel Processing Technologies — Part 1: Safety*. (Générateurs d'hydrogène faisant appel aux technologies du traitement du carburant — Partie 1 : Sécurité.)
ISO 17268	*Gaseous Hydrogen Land Vehicle Refuelling Connection Devices*. (Dispositifs de raccordement pour le ravitaillement des véhicules terrestres en hydrogène gazeux.)
ISO 19880-3	*Gaseous Hydrogen — Fuelling Stations — Part 3: Valves*. (Carburant d'hydrogène gazeux — Stations-service — Partie 3 : Vannes.)
ISO 19880-5	*Gaseous Hydrogen — Fuelling Stations — Part 5: Dispenser Hoses And Hose Assemblies*.
ISO 19880-8	*Gaseous Hydrogen — Fuelling Stations — Part 8: Fuel Quality Control*.
ISO 19881	*Gaseous Hydrogen — Land Vehicle Fuel Containers*.
ISO 22734	*Hydrogen Generators Using Water Electrolysis — Industrial, Commercial, and Residential Applications*. (Générateurs d'hydrogène utilisant le procédé de l'électrolyse de l'eau — Applications industrielles, commerciales et résidentielles.)

ISO 31000	*Risk Management — Guidelines*. (Management du risque — Lignes directrices.)
ISO/IEC 31010	*Risk Management — Risk Assessment Techniques*. (Management du risque — Techniques d'appréciation du risque.)
ISO/TR 15916	*Basic Considerations for the Safety of Hydrogen Systems*. (Considérations fondamentales pour la sécurité des systèmes à l'hydrogène.)

NFPA (National Fire Protection Association) [www.nfpa.org]

NFPA 13	*Standard for the Installation of Sprinkler Systems*.
NFPA 68	*Standard on Explosion Protection by Deflagration Venting*.
NFPA 704	*Standard System for the Identification of the Hazards of Materials for Emergency Response*.

SAE International [www.sae.org]

SAE J2600	*Compressed Hydrogen Surface Vehicle Fueling Connection Devices*.
SAE J2719	*Hydrogen Fuel Quality for Fuel Cell Vehicles*.

UL (Underwriters Laboratories) [www.ul.com]

UL 2245	*Standard for Below-Grade Vaults for Flammable Liquid Storage Tanks*.

2.3 GOVERNMENT DOCUMENTS

NATIONAL RESEARCH COUNCIL CANADA (NRC), Canadian Commission on Building and Fire Codes. *National Building Code of Canada 2015*, Ottawa, 2 volumes, [Online], 2015. [https://nrc-publications.canada.ca/fra/voir/td/?id=c8876272-9028-4358-9b42-6974ba258d99&dp=2&dsl=en].

NATIONAL RESEARCH COUNCIL CANADA (NRC), Canadian Commission on Building and Fire Codes. *National Fire Code of Canada 2015*, Ottawa, [Online], 2015. [https://nrc-publications.canada.ca/fra/voir/td/?id=cd32b653-318c-441a-bacd-08bd39332275&dp=2&dsl=en].

UNITED STATES. *Code of Federal Regulations.* "49 CFR 178.37 Specification 3AA and 3AAX seamless steel cylinders", [Online]. [www.govregs.com/regulations/expand/title49_chapterI-i1_part178_subpartC_section178.37#regulation_2].

3 DEFINITIONS

It is the responsibility of the reader to ensure that a defined term is understood in accordance with the intent of the relevant clause and in accordance with the authority having jurisdiction's interpretation.

For the purpose of this document, the following definitions shall apply:

approved, adj. Acceptable to the authority having jurisdiction (AHJ) [reference: CSA B149.1]. French: ***approuvé***, ***approuvée***.

authority having jurisdiction (abbrev.: **AHJ**), n. Body or agency that has been authorized by an empowering act or a regulation to enforce any part of this code. French: ***autorité compétente***.

building, n. Structure used or intended for supporting or sheltering any use or occupancy (reference: *National Building Code of Canada* [adapted wording]). French: ***bâtiment***.

Canadian Registration Number (abbrev.: **CRN**), n. Number allotted by a provincial or territorial authority in Canada that allows a pressure-retaining item to be used in that province or territory (reference: CSA B51, Part 1 [adapted wording]). French: ***numéro d'enregistrement canadien*** (abbrev.: ***NEC***).

certified, adj. Characteristic of any item investigated and identified by an accredited certification organization as conforming to recognized standards, requirements, or accepted test reports (reference: CSA B149.1 [adapted wording]). French: ***certifié***, ***certifiée***.

check valve, n. Valve that operates on differential pressure and allows flow in one direction only. French: ***clapet de non-retour***.

Class 2 unstable reactive gas, n. Gaseous matter that readily undergoes violent chemical change at elevated temperatures and pressures (reference: NFPA 55 [adapted wording]). French: ***gaz réactif instable de classe 2***.

Class 3 unstable reactive gas, n. Gaseous matter that in itself is capable of detonation or explosive decomposition or explosive reaction, but which requires a strong initiating source or which must be heated under confinement before initiation (reference: NFPA 55 [adapted wording]). French: ***gaz réactif instable de classe 3***.

Class 4 unstable reactive gas, n. Gaseous matter that in itself is readily capable of detonation or explosive decomposition or explosive reaction at normal temperatures and pressures (reference: NFPA 55 [adapted wording]). French: ***gaz réactif instable de classe 4***.

combustible material, n. Material failing to meet the acceptance criteria of the document CAN/ULC-S114 (reference: *National Building Code of Canada* [adapted wording]). French: ***matériau combustible***.

container, n. Pressure vessel that varies in shape, size, and material, used for the transport or storage of hydrogen. French: ***récipient***.

deflagration, n. Flame or chemical reaction moving through a flammable mixture at a rate less than the speed of sound in the unburned mixture (reference: ISO/TR 15916). French: ***déflagration***.

NOTE — Deflagrations are characterized by velocities in the hundreds of metres per second where confinement causes elevated pressures.

detonation, n. Shock-stabilized combustion process resulting in a combustion phenomenon propagating faster than the speed of sound (reference: ISO/TR 15916). French: ***détonation***.

NOTES —

1 A detonation is an explosion, but the reverse is not true.

2 The thermal energy of the reaction sustains the shock wave, and the shock wave compresses unreacted material, producing the high temperatures necessary to drive the reaction.

dispenser, n. (syn.: dispensing system, n.) Assembly intended to dispense hydrogen to vehicles that includes hardware and software to cool and transfer compressed hydrogen from station storage and/or compressor systems to the vehicle fuel tank. French: ***équipement de distribution***; ***système de distribution***.

dispensing point, n. Fixed location of the fuel transfer to a vehicle. French: ***point de distribution***.

electrolyser, n. Hydrogen-generating equipment using electrochemical reactions to decompose water to produce gaseous hydrogen and oxygen. French: ***électrolyseur***.

enclosure, n. Secondary room within or attached to a building in which equipment is installed, or a stand-alone structure that protects equipment from the environment or provides noise attenuation (reference: CSA B149.1 [adapted wording]). French: ***enceinte***.

explosion, n. Rapid equilibrium of pressure between the region of energy release and its surroundings (reference: ISO/TR 15916 [adapted wording]). French: ***explosion***.

NOTE — Explosions can occur through mechanical failure of high-pressure fluid containers or through rapid chemical reactions producing large volumes of hot gases.

external exposure, n. Exposure to hazards external to a hydrogen system. French: ***risque de contigüité***.

NOTES —

1 If a vehicle is part of a hydrogen system operation or service, it is excluded from requirements for external exposures.

2 The requirements for external exposures cover vehicles not involved in operation, service or fuelling. This includes general public parked vehicles, for example those parked at the fuelling station.

fast-acting valve, n. (syn.: quick-acting valve, n.) Automatic valve that has a closing time of less than five seconds when de-energized. French: ***robinet à manœuvre rapide***; ***robinet à fermeture instantanée***; ***robinet à action rapide***.

fire, n. Rapid chemical reaction or sustained burning as manifested by at least one of the following items: light, flame, heat, and smoke (reference: ISO/TR 15916 [modified wording]). French: ***feu***.

NOTE — Hydrogen flames are nearly invisible in daylight and smokeless unless other materials are entrained in the flames.

fire barrier, n. Partition made of fire-resistant material to prevent the spread of a fire and that has the prescribed fire-resistance rating as well as the structural stability to remain intact under fire conditions for the required fire-rated time (reference: *National Building Code of Canada* [adapted wording from the entry *firewall*]). French: ***coupe-feu***.

NOTE — The fire-resistance rating of a fire barrier is prescribed under the *National Building Code of Canada*.

fire-resistance rating, n. Time in minutes or hours that a material or assembly of materials will withstand the passage of flame and the transmission of heat when exposed to fire under specified test conditions and performance criteria, or as determined by extension or interpretation of information derived therefrom (reference: *National Building Code of Canada* [adapted wording]). French: ***degré de résistance au feu***.

NOTE — The *National Building Code of Canada* specifies the fire-resistance test conditions and performance criteria used to determine a fire-resistance rating, and prescribes such ratings.

fitting, n. Part of a piping system that is used as a connector, such as an elbow, return bend, tee, union, bushing, coupling, or cross, but does not include such functioning items as a valve or pressure regulator (reference: CSA B149.1). French: ***raccord***.

flame, n. Zone of burning gases or vapour and fine suspended matter associated with the combustion of a substance, usually hot and luminous (reference: ISO/TR 15916). French: ***flamme***.

NOTE — A flame may be stationary with the flammable mixture fed into the reaction zone, or a flame may propagate through the flammable mixture, as in a deflagration.

flammable, adj. Characteristic of an item capable of flaming under specified conditions (reference: ISO 13943). French: ***inflammable***.

flammable liquid, n. Liquid that has a flash point below 38 °C, and a vapour pressure not exceeding 276 kPa absolute at 38 °C (reference: CSA B149.1 [adapted wording]). French: ***liquide inflammable***.

flash point, n. Minimum temperature to which a material or a product is heated for the vapours emitted to ignite momentarily in the presence of flame under specified conditions (reference: ISO 13943). French: ***point d'éclair***.

fuel cell, n. Electrochemical device that converts the chemical energy of a fuel and oxidant, both externally supplied, to electrical energy and by-products, including heat (reference: ISO/TR 15916). French: ***pile à combustible***.

gas cabinet, n. Fully enclosed, noncombustible enclosure used to provide an isolated environment for compressed gas cylinders in storage and use (reference: NFPA 55). French: ***armoire à gaz***.

gas-tight, adj. Characteristic of any item with no detectable leak under the design operating conditions. French: ***étanche***.

hose, n. Flexible conduit. French: ***tuyau souple***.

hydride, n. Compound containing hydrogen and another element (reference: ISO/TR 15916). French: ***hydrure***.

NOTE — Hydrides are being investigated as potential storage media for hydrogen.

hydrogen, n. Mixture having at least 95% hydrogen and not more than 1% oxygen (percentage on a molar or volume basis). French: ***hydrogène***.

NOTE — This includes all isotopes of hydrogen on a molar basis.

hydrogen fuelling station, n. Facility for the dispensing of compressed hydrogen vehicle fuel, including the supply of hydrogen, and hydrogen compression, storage, and dispensers (reference: CSA HGV 4.9). French: ***centre de distribution d'hydrogène***.

hydrogen-generating equipment, n. Self-contained package or factory-matched package of integrated systems for generating hydrogen, which use either electrolysis, reforming, chemical reaction or other processes. French: ***équipement de production d'hydrogène***.

hydrogen storage system, n. Portion of a closed system used for retention of hydrogen gas or liquid upstream of the source valve (reference: NFPA 2 [adapted wording]). French: ***système de stockage d'hydrogène***.

hydrogen system, n. Assembly of piping, fittings, devices and equipment designed to generate, store, use, dispense or transport either liquid or gaseous hydrogen. French: ***système à hydrogène***.

hydrogen utilization equipment, n. Device that uses hydrogen as a fuel or raw material, or both. French: ***équipement fonctionnant à l'hydrogène***.

NOTE — Hydrogen utilization equipment includes items such as fuel cells and internal combustion engines.

ignitable, adj. Capable of being ignited (reference: ISO 13943). French: ***allumable***.

ignition, n. Condition of a substance that will continue to burn without additional application of external heat at a minimum temperature (reference: ISO/TR 15916 [adapted wording]). French: ***inflammation***.

ignition energy, n. Energy required to initiate a flame in a flammable mixture (reference: ISO/TR 15916). French: ***énergie d'inflammation***.

impact, n. Contact, irrespective of speed, between a vehicle and hydrogen equipment. French: ***impact***.

installer, n. Individual, firm, corporation, or company that, either directly or through a representative, is engaged in the installation, replacement, repair, or servicing of hydrogen piping, vent systems, equipment, components, or accessories, and whose representative is either experienced or trained, or both, in such work and complies with the qualification requirements of the authority having jurisdiction (reference: CSA B149.1 [adapted wording]). French: ***installateur***, ***installatrice***.

layer of protection, n. Special barrier designed in such a way that, if attacked, it functions in sequence as layers of defense, and events will terminate only if the attack is fully stopped (reference: *Risk Analysis and Control for Industrial Processes — Gas, Oil and Chemicals*). French: ***couche de protection***.

light duty vehicle, n. Motor vehicle that is primarily used to transport passengers and cargo (e.g., cars, vans, SUVs, pickup trucks), with a gross vehicle mass less than or equal to 3 500 kg. French: ***véhicule utilitaire léger***.

lower flammability limit (abbrev.: **LFL**), n. Minimum vapour concentration (expressed in percent by volume) of fuel in a flammable mixture that will ignite and propagate a flame (reference: ISO/TR 15916 [adapted wording]). French: ***limite inférieure d'inflammabilité*** (abbrev.: ***LII***).

NOTES —

1 This limit is a function of temperature, pressure, diluents, and ignition energy.

2 Below LFL, there is no danger of ignition because the mixture is too lean (approximately 4% hydrogen in air).

low-flow, mod. Characteristic of an item having a transfer rate of less than 1.5 kg/min. French: ***à faible débit***.

maintenance facility, n. Installation or part of an installation for repairing hydrogen-fuelled vehicles that involves routine maintenance, inspection, or repair work not involving work carried out in a primary repair garage. French: ***atelier d'entretien***.

maximum allowable quantity (abbrev.: **MAQ**), n. Threshold quantity of hydrogen that, once exceeded, requires the application of additional administrative procedures, construction features or engineered controls (reference: ISO 19880-1 [adapted wording]). French: ***quantité maximale permise*** (abbrev.: ***QMP***).

NOTES —

1 For practical approval purposes, a storage system consisting of up to two regular 44 l compressed gas bottles each containing approximately 6 m^3 (measured at 101 kPa and 20 °C) of hydrogen should be considered to be within the MAQ.

2 The MAQ is set at 1 kg of hydrogen in a single storage system or 1 kg per storage system in multiple storage systems that are at least 1.5 m apart.

maximum allowable working pressure (abbrev.: **MAWP**), n. Maximum gauge pressure permissible in a storage container (at its top) or piping system for a designated temperature (reference: ISO/TR 15916 [adapted wording]). French: ***pression maximale de service autorisée*** (abbrev.: ***PMSA***); ***pression de calcul***.

maximum fuelling pressure (abbrev.: **MFP**), n. Maximum pressure applied to a compressed system during fuelling (reference: GTR No. 13). French: ***pression d'avitaillement maximale***.

NOTE — The MFP is 125% of the nominal working pressure.

nominal working pressure (abbrev.: **NWP**), n. Gauge pressure that characterizes typical operation of a system (reference: GTR No. 13). French: ***pression de service nominale*** (abbrev.: ***PSN***).

NOTE — For compressed hydrogen gas containers, NWP is the settled pressure of compressed gas in fully fuelled container or storage system at a uniform temperature of 15 °C.

noncombustible material, n. Material meeting the acceptance criteria of the document CAN/ULC-S114 (reference: *National Building Code of Canada* [adapted wording]). French: ***matériau incombustible***.

occupancy, n. Use or intended use of a building or part thereof for the shelter or support of persons, animals or property. French: ***utilisation***.

other gas, n. Matter that is not a corrosive gas, flammable gas, oxidizing gas, pyrophoric gas, toxic gas, or Class 2, Class 3, or Class 4 unstable reactive gas (reference: NFPA 55 [adapted wording]). French: ***autre gaz***.

outdoor, adj. Characteristic of equipment or installation, whether sheltered or unsheltered, that has the equivalent of at least 25% of the total area of its perimeter walls open to the elements, and a roof designed so that it will not accumulate gas. French: ***extérieur***, ***extérieure***.

overpressure, n. Pressure within a containment structure that exceeds the maximum allowable working pressure of the containment structure (reference: ISO/TR 15916 [adapted wording]). French: ***surpression***.

oxidizing gas, n. Gaseous matter that can support and accelerate combustion of other materials (reference: NFPA 55). French: ***gaz oxydant***.

piping, n. System of pipes or tubes used to convey fluids. French: ***tuyauterie***.

portable, adj. Characteristic of any item capable of being moved by one person and not permanently connected to a fuel or electrical utility. French: ***portatif***, ***portative***; ***portable***.

pressure regulator, n. Device, either adjustable or nonadjustable, for controlling and maintaining, within acceptable limits, a uniform outlet pressure (reference: CSA B149.1 [adapted wording]). French: ***régulateur de pression***.

pressure-relief device, n. Basic safety device used to prevent the pressure from exceeding the maximum allowable working pressure within a system (reference: ISO/TR 15916 [adapted wording]). French: ***dispositif de sureté***.

NOTES —

1 This device is installed so that excessive pressure can be relieved before damage occurs to a container or hydrogen system.

2 A pressure-relief device is typically a spring loaded valve that will open at a set pressure or temperature, or a rupture disk that contains a membrane designed to rupture at a set pressure.

pressure-relief valve, n. Device including a valve that will open at a set pressure and reclose once the pressure drops below a set pressure. French: ***soupape de sureté***.

NOTE — Pressure-relief valves are typically spring loaded valves.

pressure vessel, n. Gas-tight vessel for containing, storing, distributing, transferring, distilling, processing, or otherwise handling a gas, liquid, or vapour (reference: CSA B51, Part 1 [adapted wording]). French: ***appareil sous pression***.

process area, n. Area where a hydrogen process occurs. French: ***aire de traitement***.

EXAMPLES — Compressor assembly, vehicle dispenser area, or generation area.

public station, n. Fuelling station where hydrogen is offered for sale to the general public (reference: CSA B108 [adapted wording]). French: ***station publique***.

purge, to, v. Action consisting in displacing the existing fluid (gaseous or liquid) in piping, equipment, or a container and replace it with a desired fluid (reference: CSA B149.1). French: ***purger***.

pyrophoric gas, n. Gaseous matter with an auto-ignition temperature in air at or below 54.4 °C (reference: NFPA 55). French: ***gaz pyrophorique***.

qualified personnel, n. Person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems relating to a particular subject matter, task, or project. French: ***personnel compétent***.

repair area, n. Area, booth, or room where repairs on vehicles occur. French: ***aire de réparation***.

repair garage, n. Building or part of a building used for repairing hydrogen-fuelled vehicles, and for working on the vehicle's fuel or hydrogen storage systems and which can involve open flames or defuelling. French: ***atelier de réparation***.

service pressure, n. Settled pressure at a uniform gas temperature of 21 °C and full gas content. French: ***pression de service***.

NOTE — The service pressure is the pressure expected under normal conditions and for which the equipment has been constructed.

source of ignition, n. Any object whose surface temperature exceeds 500 °C, or whose sparks exceed 0.019 MJ of energy. French: ***source d'inflammation***.

toxic gas, n. Lethal gaseous matter when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing from 200 g to 300 g each (reference: NFPA 55 [adapted wording]). French: ***gaz toxique***.

unattended, mod. Characteristic of any dedicated hydrogen equipment located in an enclosure or a gas cabinet that does not require constant monitoring or supervision, typically designed for outdoor installation. French: ***sans surveillance***.

underground nongassy mine, n. Underground location where there are no natural emanations from the orebody or geological formations around the orebody of flammable gas such as methane or other hydrocarbon gases of higher molecular weight than methane; or that a concentration of flammable gas emanating from the orebody or geological formations around the orebody, of 0.25% or more, is not detected 30 cm or more from the periphery of any open underground workings; or the mine is not connected to a gassy mine. French: ***mine non grisouteuse***.

unsheltered, adj. Characteristic of any equipment that is not installed under a roof, such as a canopy, or in a shed or indoor room. French: ***non abrité***, ***non abritée***.

unstable reactive gas, n. Gaseous matter that, in the pure state or as commercially produced, will vigorously polymerize, decompose, or condense, become self-reactive, or otherwise undergo a violent chemical change under conditions of shock, pressure, or temperature (reference: NFPA 55). French: ***gaz réactif instable***.

vacuum jacket, n. Thermal insulation using a double-wall construction technique in which the air or gas contained in the space between the two walls is evacuated, resulting in a vacuum between the inner wall and the outer wall. French: ***double enveloppe isolante***; ***isolation sous vide***.

valve, n. Device by which the flow of a fluid may be started, stopped, or regulated by a movable part that opens or obstructs passage (reference: CSA B149.1). French: ***robinet***.

vehicle storage tank, n. Hydrogen container permanently mounted on a vehicle and used for propulsion. French: ***réservoir de stockage d'un véhicule***.

ventilation, n. Removal of indoor air from the space in which the equipment is installed, to the outdoors, and the replacement of same by air from the outdoors. French: ***ventilation***.

4 GENERAL INSTALLATION REQUIREMENTS

4.1 RESPONSIBILITIES OF THE INSTALLER AND SUPPLIERS OF EQUIPMENT AND SYSTEMS

The installer or the supplier shall ensure that the installation of hydrogen equipment covered by this code is performed in accordance with the manufacturer's instructions and the requirements included in this code.

The installer or the supplier shall have any deviation from the equipment manufacturer's instructions approved in writing by the equipment manufacturer before proceeding to the installation work.

The installer or the supplier shall have any deviation from this code approved in writing by the authority having jurisdiction (AHJ) before proceeding to the installation work. This written approval shall apply only to the particular installation for which it is provided. When this is the case or when the AHJ makes a special request, the installer or the supplier of the equipment may be asked to include in its application to the AHJ additional information such as specific elements related to risk assessment and computational fluid dynamics (CFD) modeling or other risk assessment methodologies to support the application for deviation.

NOTE — Annex A provides guidelines for recommended risk assessment measures and public safety.

4.2 INSTALLER QUALIFICATIONS, AND OPERATOR TRAINING AND RESPONSIBILITIES

Only qualified personnel shall be responsible for the installation of hydrogen equipment covered by this code.

Upon completion of an installation, the installer shall train the system operator on the proper and safe use of all hydrogen equipment covered by this code and its related accessories. The installer shall provide the equipment manufacturer's instructions to the system operator.

At a minimum, system operator training shall cover basic hydrogen properties; safety aspects, including the safe handling and operation of hydrogen systems, and fire safety; relevant clauses

of this code; relevant pipe or tube fitting training by the equipment manufacturer; installation specifics; and other topics deemed relevant by the installer and the manufacturer of the hydrogen equipment.

Upon completion of training and prior to operating the hydrogen system, the system operator shall implement a process safety management system in accordance with the document CSA Z767 or an equivalent standard.

4.3 SAFETY CONSIDERATIONS

4.3.1 Basic safety considerations

When performing the installation or maintenance work, the installer shall take into account the guidelines provided in the document ISO/TR 15916.

4.3.2 Hydrogen installation safety requirements

The hydrogen installation shall be sited in a way to minimize risk to the public, users, operating personnel, properties, and the environment. The following elements of a hydrogen installation shall be considered potential hazard sources, as applicable:

a) on-site hydrogen production unit;

b) hydrogen delivery system, including remote fill points;

c) compressors;

d) storage;

e) piping;

f) dispensing units.

More specifically, the hydrogen installation shall include measures, as applicable, to reduce harm from the following hazards:

a) fires, deflagrations, detonations and blast waves;

b) asphyxiation (due to release of gaseous hydrogen or inert gases in confined spaces);

c) cryogenic burns (liquid hydrogen supply);

d) impact from pressure or debris;

e) any other additional hazards associated with the hydrogen system, including:

- electrocution;

- working at heights (e.g., roof-mounted equipment);
- injury from moving equipment or hose whip.

Risk-reduction measures related to the three stages of safety assurance shall be assessed:

a) prevention of accidents through a combination of the following:
   - using state-of-the-art technology;
   - following technical standards and simple handling procedures (users and system operators);
   - designing user-machine interfaces in a straightforward manner;
   - emphasizing training of personnel, and managing competence of personnel;
   - implementing Management of Change processes;
   - establishing preventative maintenance;

b) mitigation strategies through a combination of the following:
   - state-of-the-art technology;
   - barriers and layers of protection;
   - safety measures;
   - safety distances;

c) structured and effective emergency response (contingency planning) as part of which the following mitigation strategies shall be generally assessed:
   - minimization of the potential for the formation of a flammable or explosive mixture;
   - minimization of the potential for ignition (from both piloted and spontaneous ignition sources);
   - mitigation of the effects of a fire or explosion originating from the hydrogen system;

- mitigation of the impact to the hydrogen fuelling station installation from an external fire;

- reduction of the physical effects of the explosion strength potential of explosive atmosphere generated by potential leaks or releases.

4.3.3 Risk assessment

A risk assessment shall be completed.

Risk assessment is the overall process of risk identification, risk analysis, risk evaluation and risk mitigation. Risks can be assessed at an organizational level or departmental level, for projects, individual activities or specific risks. A risk assessment should be performed for hydrogen fuelling stations in accordance with one or a combination of the following documents: ISO 31000, ISO/IEC 31010, or ISO 12100, or other appropriate risk assessment methods.

A risk assessment shall identify the protection measures from over-temperatures and overpressures as well as from under-temperatures and negative pressure fluctuations.

A risk assessment shall prescribe the location of pressure-relief devices.

A risk assessment may be used as a flexible compliance option. Use of a risk assessment allows hydrogen station owners and designers to flexibly define station-specific mitigations that achieve an equal or better level of safety to those of prescriptive recommendations.

Methods used as part of a risk assessment can be qualitative, semi-quantitative or quantitative. The degree of detail required is dependent on the particular application, the availability of reliable data and the decision-making needs of the organization. Some methods and the degree of detail of the assessment may be prescribed by legislation.

A risk assessment carried out for hydrogen systems should use quantitative or semi-quantitative methods. Recommendations for the method, degree of detail, and source of information used as part of the assessment when carried out specifically for a hydrogen fuelling station are described in Annex A.1 of the document ISO 19880-1.

Qualitative assessment methods define consequence, probability and level of risk by magnitude levels such as “high”, “medium” and “low”; evaluate the resultant level of risk against qualitative criteria; and may combine consequence and probability.

Semi-quantitative assessment methods use detailed models and data for either consequence or probability, and qualitative treatment for the other.

NOTE — One example is a consequence-only assessment, which uses detailed consequence modelling and assumes the probability of a scenario to be 1.0.

Quantitative assessment methods use detailed models and data to estimate consequences and their probabilities, and produces values of the level of risk using both consequence and probability. Level of risk is expressed in specific units defined when developing the context.

4.3.4 Mitigation measures to improve hydrogen system safety

4.3.4.1 General — The risk assessment shall demonstrate that the mitigation measures are appropriate to achieve the desired reduction of the probability or consequences of each scenario. Mitigation measures that improve overall safety of the hydrogen system (as demonstrated by use of the quantitative risk assessment process defined above) may be used to:

a) reduce prescriptive safety distances through the risk-informed safety distance process;

b) relax existing prescriptive mitigation measures by carrying out a semi-quantitative or quantitative risk assessment.

Total system risk shall remain below the selected tolerability threshold (risk acceptance criteria).

Several mitigation measures affect the probability or impact of multiple aspects of the assessment (e.g., use of enclosures can reduce the probability of ignition, but could potentially increase the consequence of deflagrations). When credit is taken for a given mitigation measure, the entire assessment shall be re-run to ensure that total risk is sufficiently low.

Detailed guidance on mitigation measures to improve hydrogen system safety can be found in Clause 5.3 of the document ISO 19880-1.

4.3.4.2 Risk-informed mitigations — The estimated risk level shall be compared to the risk acceptance criteria.

If the estimated risk level is above the acceptance criteria, the person in charge of the assessment shall implement additional mitigation measures or increase safety distances to reduce the risk level, and re-run the assessment.

If the estimated risk level is below the acceptance criteria, the mitigation measure or safety distance may be reduced.

Analysts should discuss appropriate methods to account for uncertainty when compared to risk acceptance criteria. This should be addressed through use of conservative risk criteria, or sensitivity analysis or methods to propagate uncertainties.

4.3.5 Safety of the working area

When performing the installation or maintenance work, the installer shall coordinate with the system owner to ensure that the working area is safe. Whenever necessary, access to the working area shall be limited to personnel performing the installation.

4.3.6 Fire

Personnel shall be trained for the safe handling and operation of gaseous and liquid hydrogen systems to a level acceptable to the AHJ as per Clause 4.2.

Hydrogen fires shall not be extinguished until the supply of hydrogen is shut off because of the danger of re-ignition or explosion. In the event of fire, large quantities of water shall be sprayed onto adjacent equipment to cool the equipment and prevent involvement in the fire. Combination fog and solid stream nozzles shall be preferred to permit widest adaptability in fire control. Water shall not be sprayed onto the vent stack in the case of flare on the vent stack or venting through the vent stack. A notice shall be affixed on or by the vent stack in either French or English, or both, stating:

DO NOT SPRAY WATER ONTO VENT STACK IN CASE OF FLARE ON THE VENT STACK OR DURING VENTING

NE PAS ASPERGER D'EAU LA COLONNE D'ÉVACUATION EN CAS DE FLAMME SUR LA COLONNE OU À L'ÉVACUATION

NOTE — Flammable mixtures of air and hydrogen can auto-ignite if placed in contact with hot surfaces above 500 °C.

The fire protection required for a hydrogen system shall be determined by an assessment of local conditions of hazards within the installation, exposure to other properties, water supply, probable effectiveness of plant fire brigades, time of response and probable effectiveness of fire departments.

NOTE — Annex A provides guidelines on public safety.

5 HYDROGEN EQUIPMENT

5.1 HYDROGEN EQUIPMENT TO BE INSTALLED

Hydrogen-generating equipment for non-process end use, hydrogen utilization equipment, hydrogen-dispensing equipment, hydrogen storage containers, hydrogen piping systems and their accessories shall be certified or approved prior to installation.

5.2 SUITABILITY FOR USE

5.2.1 General requirements

Equipment covered by this code shall be suitable for hydrogen use over the full range of pressures and temperatures to which it can be subjected under its intended service conditions.

All designs and design modifications shall be made by a professional engineer. Professional engineers are not required to make in-kind replacements.

Where electronic systems are used for safety applications or risk mitigation, they shall be designed and installed in accordance with the document IEC 61511 or equivalent functional safety standards.

5.2.2 Material compatibility

Due consideration shall be taken regarding the selection of materials. Only materials that are suitable for hydrogen systems and the conditions to which they will be exposed shall be used. Materials that are in contact with other materials shall be compatible with each other as well as with hydrogen and the conditions of use.

Due consideration shall be given to selecting materials that are not susceptible to hydrogen embrittlement and hydrogen attack. In liquid hydrogen systems, due consideration shall also be given to selecting materials that are not susceptible to low-temperature embrittlement. The guidelines given in the documents ISO/TR 15916, ASME B31.12 or CSA/ANSI CHMC-1 for metals and CSA/ANSI CHMC-2 for plastics shall be considered in the selection of materials used in hydrogen systems.

5.3 ACCESSIBILITY TO HYDROGEN EQUIPMENT

5.3.1 Equipment shall be installed in accordance with the manufacturer's instructions with respect to the minimum clearance distance.

5.3.2 Equipment shall be installed so that it is accessible for performing maintenance operations. Minimum clearance distances for the replacement or repair of the equipment components and accessories shall be 610 mm. Where necessary, this shall be increased to permit the removal or opening of closures, casings or covers, as well as the replacement of parts.

5.3.3 The passageways to each piece of equipment or assembly of equipment shall be at least 1 m wide and 1 m high. In an assembly of equipment, an unobstructed space shall be provided such that valves and fittings for each piece of equipment have a 1 m zone of access.

5.3.4 Equipment that requires routine inspection and maintenance, and which is not accessible from floor level, shall be installed as to be reached by a permanently installed staircase, ladder, platform or other means, in accordance with workplace safety requirements of the jurisdiction where the equipment is installed.

5.4 PROTECTION OF HYDROGEN EQUIPMENT FROM PHYSICAL DAMAGE

Equipment covered by this code shall be protected against physical damage, blockage of ventilation and, when applicable, ice buildup, flooding, and vehicle impact.

Each mobile hydrogen supply units and trailers used as part of a hydrogen system shall be secured to prevent movement as indicated in the document CGA P-74.

5.5 PROTECTION FROM UNAUTHORIZED ACCESS

Hydrogen systems shall be protected to prevent unauthorized access as indicated the document CGA P-50. Warning signs shall be posted to that effect. A fence or wall shall be used to prevent access and it shall have a height of not less than 1.8 m above grade.

6 ELECTRICAL REQUIREMENTS

6.1 ELECTRICAL EQUIPMENT

6.1.1 General

All electrical components, equipment, accessories or materials used in hydrogen systems shall be of a type and rating certified for the specific purpose for which it shall be employed, and shall be installed in accordance with the manufacturer's instructions. All electrical components, equipment, accessories or materials and electrical installations shall comply with the document CSA C22.1.

6.1.2 Purge gas on electrical equipment

Where a motor and auxiliary equipment are pressurized by an inert gas such as nitrogen, any pressure or flow that does not meet the minimum requirements specified by the equipment manufacturer shall be indicated by an alarm that shall be arranged to shut down the motor and auxiliary equipment.

6.2 AREA CLASSIFICATION

6.2.1 General

Area classification shall be determined using the requirements of the document IEC 60079-10-1.

Where different and overlapping electrical classification areas are created by different components or systems, the most restrictive level shall apply.

6.2.2 Adjacent compartments

Compartments not containing systems that carry hydrogen, but containing electrical equipment, may be separated by an air gap or seal as per the applicable document IEC 60079-10-1, or be maintained at a positive pressure with respect to adjacent hydrogen compartments. Pressurization shall be in accordance with the document CSA C22.2 No. 60079-2. These separation techniques may be used to reduce the relative zoning of the electrical compartment from that of the adjacent hydrogen compartment.

6.2.3 Use of unrated non-sparking electrical equipment

Subject to the conditions of the document CSA C22.1, unrated electrical equipment may be used in a Class 1, Zone 2 area provided that no specific equipment suitable for the purpose is available, and it is interlocked with a hydrogen detector such that the unrated equipment along with the associated hydrogen process is de-energized upon a hydrogen concentration reaching 25% of the lower flammability limit (LFL), provided it does not generate arcs, sparks or hot surfaces capable of igniting hydrogen-air mixture. This system shall be approved.

6.3 EMERGENCY SHUTDOWN (ESD) SYSTEM

The requirements of Clauses 6.3.1 to 6.3.4 shall not apply to hydrogen storage systems with maximum allowable quantity (MAQ). In the case of multiple storage systems with less than the MAQ, the overall hydrogen content in one room shall be below 12.75 kg.

6.3.1 An ESD system shall be installed at each hydrogen installation to promptly shut down part or all of the facility in the event of a hazardous condition occurring. This ESD system shall be approved and its location shall be clearly identified. The installer should provide a means for guarding ESD system buttons to prevent their accidental activation.

The ESD system shall:

a) shut down the electrical power supply to non-essential equipment and services;

b) shut down the hydrogen supply;

c) close all valves that are referred to in Clauses 6.3.3, 7.5.1, 7.7.8.2, 7.9.2.2 and 8.4.1;

d) shut down the hydrogen system.

A means to activate the ESD system shall be located:

a) within 3 m of the hydrogen system;

b) within 1 m of a hydrogen dispensing point;

c) at a remote location where the ESD system can be safely activated when an emergency prevents access to the hydrogen system.

6.3.2 The control circuits shall be installed in such a way that when either a) the ESD system is activated, or b) the electrical power is shut down, or c) the hydrogen supply is shut down, then all non-essential systems that shut down shall remain off until they are manually reset, which shall be carried out after verifying that a safe situation has been restored.

6.3.3 In the case of indoor gaseous hydrogen installations, one fast-acting valve that shuts off the supply of hydrogen when de-energized shall be installed in the hydrogen supply between

the source of hydrogen and the hydrogen process. The fast-acting valve shall prevent operations when the area ventilation system does not operate as required in Clause 7.12.2.

6.3.4 All ESD systems shall fail safe. Critical safety devices shall be connected to ESD controls and alarms. ESD circuits shall be hard wired or use a separate safety instrumented system (SIS) in accordance with the document IEC 61511. Control circuits that shut down shall remain shut down until manually activated or reset after a safe shutdown is performed.

6.4 GROUNDING AND BONDING

All electrical equipment shall be grounded and bonded to earth. All grounding and bonding operations shall comply with the requirements of the document CSA C22.1.

Additionally, the following equipment shall be electrically grounded and bonded:

a) hydrogen containers of all sizes and hydrogen vent systems;

b) hydrogen piping system and flanges;

c) hydrogen equipment using hoses, such as dispensers.

Mobile hydrogen supply units and trailers shall be electrically bonded to the system before discharging or filling with hydrogen. Appropriate grounding for trailers shall be available. If practical, an installation-grounding grid should be used for this purpose.

7 GASEOUS HYDROGEN INSTALLATIONS

7.1 GASEOUS HYDROGEN-GENERATING EQUIPMENT

7.1.1 Electrolysers

Electrolysers and electrolysis systems packaged in a single, self-contained assembly, used in commercial, industrial and residential applications shall comply with the document ISO 22734. Electrolysers and electrolysis systems packaged in multiple, factory-matched assemblies shall comply with requirements equivalent to those prescribed in the document ISO 22734 as outlined in this code and other relevant standards.

Electrolysers used in residential applications shall be approved.

7.1.2 Reformers

Reformers shall comply with the document ISO 16110-1 unless the reformer is part of a fuel cell system designed as per Clause 7.2.1.

7.2 HYDROGEN UTILIZATION EQUIPMENT

7.2.1 Fuel cells

Stationary fuel cell systems shall comply with the document CSA/ANSI FC 1:21/CSA C22.2 No. 62282-3-100:21.

7.2.2 Internal combustion engines and gas turbines

Internal combustion engines and gas turbines using hydrogen as a fuel shall be approved.

7.3 MAXIMUM ALLOWABLE WORKING PRESSURE (MAWP)

The MAWP for hydrogen systems and equipment shall be specified by the hydrogen system supplier and shall not exceed 137 MPa.

7.4 GASEOUS HYDROGEN PIPING SYSTEM COMPONENTS

7.4.1 Design

7.4.1.1 All piping and fittings, and other pressure-retaining components in a hydrogen system or subsystem shall be designed for a pressure not less than the pressure at which the pressure-relief device protecting that system or subsystem is set to open. The design temperature ranges shall be from -20 °C to 65 °C for buried piping and from -40 °C to 65 °C for aboveground installations, unless the system is in a temperature-controlled enclosure. Where temperatures are expected to exceed these ranges, special provisions shall be applied by the manufacturer and installer, and shall be approved.

7.4.1.2 Gaseous hydrogen piping and fittings shall be designed and installed in accordance with the appropriate requirements of the documents ASME B31.1, ASME B31.3 or ASME B31.12 if requested or accepted by the AHJ. Gaseous hydrogen piping and fittings shall be registered in accordance with the document CSA B51, Part 1, if the regulation applied by the AHJ requires it.

7.4.1.3 It is recommended to limit the pressure boundary for the application of the document ASME B31.1 to the maximum pressure rating of the document ASME B16.5 Class 600 for a given temperature range and material group. This pressure boundary is generally below 10 MPa.

7.4.1.4 It is recommended to apply the requirements related to high pressure piping of the document ASME B31.3 when the MAWP exceeds the maximum pressure rating of the document ASME B16.5 Class 2500 for a given temperature range and material group. This pressure boundary is generally above 35 MPa.

7.4.1.5 Gaseous hydrogen piping of all pressure ranges shall conform to all requirements of the document ASME B31.12.

7.4.1.6 Hydrogen fittings shall be rated for pressure and temperature ranges equal to or greater than the MAWP and temperature ranges specified in Clause 7.4.1.1.

7.4.1.7 All other devices, pressure vessels (other than storage containers, discussed in Clause 7.8), and pressure-retaining components shall be designed and installed in accordance with the appropriate requirements of the document CSA B51, Part 1.

7.4.2 Materials

7.4.2.1 Piping for hydrogen applications shall be seamless and shall comply with the requirements of Table GR-2.1.1-1 in the document ASME B31.12 and with the requirements of the document ISO/TR 15916.

7.4.2.2 Fittings, flanges, valve bodies, and other piping component material for hydrogen applications shall comply with the requirements of Table GR-2.1.1-1 in the document ASME B31.12 and with the requirements of the document ISO/TR 15916.

7.4.3 Connections

7.4.3.1 **Aboveground gaseous hydrogen piping** — All piping that is located aboveground shall be either welded, brazed, threaded, threaded with back brazed, connected using compression fittings, or flanged connections. No flared connections shall be permitted for gaseous hydrogen piping.

The use of threaded connections should be limited as they have a higher probability of leakage.

Aboveground piping shall be protected against external corrosion and against mechanical damage.

Aboveground piping shall be supported and anchored in accordance with the documents ASME B31.1, ASME B31.3 or ASME B31.12 if requested or accepted by the AHJ.

7.4.3.2 **Buried gaseous hydrogen piping** — Buried gaseous hydrogen piping shall be welded. No threaded, flared or flanged connections, or compression fittings shall be permitted for buried gaseous hydrogen piping unless installed inside an access well. Proper drainage shall be provided for access wells.

Buried gaseous hydrogen piping shall come out of the ground immediately adjacent to the entrance or exit of a building.

A valve shall be installed outside and aboveground on the buried gaseous hydrogen piping immediately adjacent to its penetration point into the building or to its exit point from the building. The valve’s intended use shall be clearly identified.

All buried gaseous hydrogen piping shall be protected from corrosion; it shall be monitored in accordance with the document CSA Z662.

7.4.3.3 **Welded and brazed connections** — Welding and brazing procedures shall be performed in accordance with the document CSA B51, Part 1, or with the requirements applied

by the AHJ. The qualification of welders, welding operators and brazers shall comply with the requirements of Section IX of the document ASME BPVC.

7.4.4 Marking and labelling

Gaseous hydrogen piping shall be marked or labelled in accordance with the document ASME A13.1.

7.5 FLOW CONTROL MECHANISMS

7.5.1 Master shutoff valves

A fail closed, remotely activated master shutoff valve(s) shall be installed in the outlet piping immediately adjacent to hydrogen storage tanks, cylinders or systems, or pipeline connection points. The valve(s) shall be fast-acting valves, which shall isolate all downstream equipment from hydrogen storage containers. A manual shutoff valve may also be installed. The master shutoff valve or combination of valves shall be capable of:

a) shutting off the hydrogen supply to each individual occupied building;

b) being operated remotely by the ESD system switch as per Clause 6.3;

c) being locked off locally, but not locked on;

d) being operated manually (if a manual valve is installed).

The master shutoff valve(s) shall be accessible by authorized personnel only.

7.5.2 Emergency discharge device (EDD) and manual discharge valve for indoor and rooftop installations of occupied buildings

In addition to pressure-relief devices, at least one remotely activated EDD and one or several manual discharge valve(s) shall be provided for hydrogen storage tanks, cylinders, or systems installed indoors or on the rooftop of an occupied building.

The requirements of this clause shall not apply to outdoor, unattended dedicated hydrogen equipment enclosures regardless of their size.

The manual discharge valve(s) shall be installed on compressed hydrogen storage tanks, cylinders, systems, or manifold to allow discharge of hydrogen from all tanks or cylinders into the hydrogen vent system described in Clause 7.6.2.

The remotely activated EDD shall be installed in the hydrogen storage system and cause discharge of hydrogen from all tanks or cylinders through the vent system. The activator(s) shall be installed at an approved location such as on the fire annunciation panel or in an outdoor, key-locked box that is accessible to the building manager and fire department.

Activation of the remotely activated EDD shall cause shutdown of hydrogen generation or closing of the valve at the hydrogen delivery source.

A remotely activated EDD shall not be required for hydrogen storage systems with MAQ. In the case of multiple storage systems with MAQ, the overall hydrogen content in one room shall be below 12.75 kg.

7.5.3 Building isolation valve

When fuel is introduced into a building, a manual valve shall be installed outside the building wall and its use shall be identified.

7.5.4 Marking of valves

All valves shall be suitable for the full range of pressure, temperature and compatibility for the media to which they may be subjected. Valves shall be marked or labelled with the manufacturer's name and part number. Copies of piping and instrumentation diagrams (P&IDs) and valve cut sheets shall be made available upon request of the AHJ.

When installed, the master shutoff valve(s) and the remotely activated EDD shall be clearly marked or labelled with black letters of a minimum height of 20 mm on a white or contrasted background. The valves or valve labels shall indicate the direction of closing.

7.6 OVERPRESSURE PROTECTION AND HYDROGEN VENT SYSTEMS

7.6.1 Pressure-relief devices

Subject to risk assessment, all pressurized systems and equipment shall be protected from over-temperature (fire) and overpressure by means of one or more pressure-relief devices of the self-destructive type, such as rupture disks or diaphragms, or of the resealable type, such as spring-loaded pressure-relief valves.

Isolation valves shall not be installed in the relief path unless both of the following criteria are met:

a) an approved management system is implemented to control the operation of the isolation valve;

b) the installation has been approved.

Pressure-relief valves shall comply with the requirements of the documents ISO 4126, ASME B31.1, ASME B31.3, ASME B31.12, or one of the documents mentioned in the document ASME BPVC. Rupture disks shall meet the requirements of the document ISO 6718 or one of the documents mentioned in the document ASME BPVC. All pressure-relief devices shall be registered in accordance with the document CSA B51, Part 1, and as required by provincial and territorial regulations.

7.6.2 Hydrogen vent systems

The hydrogen vent systems' characteristics and location shall comply with the document CGA G-5.5.

The vent piping shall be constructed of pipe or tube materials suitable for hydrogen service as per Clause 7.4.2. The vent piping shall be designed in accordance with the document ASME B31.12 for the rated pressure, volume and temperature. The vent piping shall be designed for the maximum backpressure within the piping.

The vent piping shall be properly supported. Means shall be provided to prevent obstructions or restrictions to the design capacity of the vent piping due to water, ice and other debris from accumulating inside the vent piping or to place restricting elements into the vent piping that would alter the design capacity. The vent piping shall be located away from obstructions that would prevent hydrogen from dispersing vertically upward.

The vent exit elevation of the main vent stack (e.g., for compressed hydrogen storage) shall be at least 4.5 m above grade and 3 m above adjacent equipment and buildings located within a 3-m radius of the vent stack, and 2 m above adjacent equipment and buildings located within a 5-m radius of the vent stack. Additional vent stacks designed for a smaller flow than the main vent stack (e.g., vent stacks on top of hydrogen-generating equipment) could be of a lower height and proximity to adjacent buildings and equipment based on expected flow conditions.

7.7 COMPRESSORS AND COMPRESSOR PACKAGES

7.7.1 General

Only compressors that are designed for hydrogen systems shall be used.

Compressors that are an integral part of certified or approved hydrogen-generating equipment need not comply with the provisions of Clause 7.7.

7.7.2 Vibrations and movements

Vibrations from the compressor shall not be transferred to the gaseous hydrogen piping. Compensation shall be provided for vibrations and movements between interconnected systems, and between the compressor hydrogen supply and the compressor suction piping.

7.7.3 Compressor enclosure ventilation

The design of the compressor enclosure shall be such that leaked hydrogen cannot accumulate. The enclosure shall not be modified in any way that reduces the ventilation of the compressor enclosure. Compressor enclosure interiors shall be classified in accordance with Clause 6.2.1.

7.7.4 Attachment to buildings

When a compressor enclosure is attached to a building in such a way that it shares one wall with the building, the building wall that becomes part of the enclosure shall be gas-tight and have a fire-resistance rating of at least two hours.

7.7.5 Mounting of compressor packages

Compressor packages shall be placed on a slab of reinforced concrete or on an equivalent structure that may be an integral part of the compressor enclosure. Compressor packages shall be placed directly over an area designed by a professional engineer.

7.7.6 Compressor enclosure access doors

An access door that opens outwards shall be provided on all compressor enclosures that are large enough to admit service personnel. If the access door has a latch, it shall have fast-release hardware on the inside so that the access door can be opened without the use of a key.

7.7.7 Control and monitoring equipment

7.7.7.1 General — In addition to the instruments and controls normally provided for compressing systems, the need for specific safeguards specified in Clauses 7.7.7.2 to 7.7.7.7 shall be assessed for hydrogen compressing systems.

7.7.7.2 Inlet pressure — The inlet pressure shall be monitored by a pressure indicator or pressure switch to avoid a vacuum in the inlet line and the consequent ingress of air. This pressure indicator or pressure switch shall cause the compressor to shut down before the inlet pressure decreases enough to reach atmospheric pressure.

7.7.7.3 Oxygen analysis — If the hydrogen comes from a subatmospheric pressure source, 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 location of the oxygen analyzer shall be 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 oxygen analyzer.

7.7.7.4 Discharge temperature — The temperature after the final stage, or after the cooler, where fitted, shall be monitored by an indicator or alarm that shall cause the compressor to shut down at the predetermined maximum temperature specified by the compressor manufacturer.

7.7.7.5 Discharge pressure — The pressure after the final stage shall be monitored by an indicator or alarm, which shall cause the compressor to shut down, or initiate alternative actions, e.g., recycle at a predetermined maximum pressure, which is below that of the final pressure-relief device.

7.7.7.6 **Cooling water** — The water pressure or water flow in the cooling water system (if so equipped) shall be monitored by an indicator or alarm that shall cause the compressor to shut down at the predetermined low pressure or flow specified by the compressor manufacturer.

7.7.7.7 **Pressurized crankcases** — Where the compressor crankcase is pressurized by nitrogen or inert gas, low pressure or low flow shall be indicated by an indicator or alarm that shall cause the compressor to shut down. The compressor design shall preclude an ignitable air-hydrogen mixture from forming in the compressor crankcase.

7.7.8 Hydrogen compressor valves

7.7.8.1 In order to control the supply of hydrogen to the compressor, there shall be a manual shutoff valve located in an accessible location, either outside the compressor enclosure if within the secure area or inside the enclosure and accessible by authorized personnel only.

7.7.8.2 The inlet to the compressor shall be equipped with a self-closing valve that shall stop the supply of hydrogen during the following occurrences:

a) an activation of the ESD system as described in Clause 6.3;

b) an electrical power failure;

c) a shutdown of the electrical power to the compressor.

7.7.8.3 Downstream from the hydrogen compressor the following valves shall be installed:

a) a manual shutoff valve in the hydrogen supply line of all hydrogen storage tanks or cylinders, whether they are supplied individually or through a manifold;

b) a check valve along with a manual shutoff valve downstream from the check valve on the compressor outlet line.

NOTE — The manual valve specified in point b) may be the same as the manual shutoff valve specified in point a).

7.8 STORAGE CONTAINERS

7.8.1 Gaseous hydrogen storage containers

7.8.1.1 Containers for stationary storage of gaseous hydrogen shall have a Canadian Registration Number (CRN) and comply with Clause 7.8.1.2 or they shall comply with the additional requirements as per Clause 7.8.1.3 to satisfy the AHJ.

7.8.1.2 Containers for storage of gaseous hydrogen shall be registered in accordance with the document CSA B51, Part 1, and certified to one of the following documents:

a) ASME BPVC, Section VIII[1];

b) ASME BPVC, Section X;

c) CSA B51, Part 3.

7.8.1.3 Subject to the approval of the AHJ, stationary containers for compressed gaseous hydrogen storage originally intended for transportation and onboard use shall be certified to one of the following documents:

a) CSA B51, Part 2;

b) ISO 11119;

c) ISO 19881;

d) CSA B339, for vessels with a service pressure of at least 24.8 MPa at 21 °C, provided that they are selected, manufactured, and requalified in accordance with the requirements of the documents CSA B339 or CSA B340;

e) TC-3AAM specification of the document CSA B339 or to the 3AA specification of the regulation US 49 CFR 178.37, for steel vessels or to the 3AAX specification by Transport Canada or US DOT 49 CFR;

f) TC-3ALM specification of the document CSA B339, for aluminum vessels.

The AHJ may consider cylinders with equivalency of safety approvals from Transport Canada, or the US Department of Transportation. The AHJ may impose additional requirements, such as requalification requirements, or an expiry date that will take into account the design philosophy of these standards.

1 Users are cautioned that for containers designed to the requirements of the document ASME BPVC, the user's responsibilities include:

- preparing a "User's Design Specification" setting out the intended service conditions for the location where the container is to be installed;
- specifying whether a fatigue analysis of the container for cyclic service is required;
- retaining control of operation and maintenance during the useful life of the container, and ensuring that the service conditions specified in the "User's Design Specification" are met.

7.8.2 Metal hydride storage containers

Both simple and jacketed pressure containers used for the containment of metal hydrides for the storage or supply of gaseous hydrogen shall be designed in accordance with the appropriate sections of the document ASME BPVC, Section VIII, Division I, and registered in accordance with the document CSA B51, Part 1. The tolerability of the containment system to the unique stresses placed on the container by the expanding metal hydride shall be demonstrated to the AHJ.

7.8.3 Design life

Storage containers shall not be used for longer than their maximum design life. In addition, composite containers shall not be used beyond the manufacturer's expiry date at which time the containers shall be removed from service and destroyed.

7.9 HYDROGEN FUELLING STATIONS AND DISPENSING EQUIPMENT

7.9.1 General

7.9.1.1 Application — This clause shall be applied to the design, manufacturing, installation, operation and maintenance of outdoor gaseous hydrogen fuelling stations and dispensing equipment for vehicles up to a maximum fuelling pressure (MFP) of 87.5 MPa and shall comply with the requirements of Clause 7.3. The hydrogen fuelling station and dispensing equipment shall comply with the requirements in applicable clauses of Chapters 4 to 7 of this code. Hydrogen fuelling stations shall comply with the requirements of the document CSA HGV 4.9. Additional guidance can be found in the document ISO 19880-1. In the case of conflict, this code takes precedence.

Dispensers shall comply with the requirements of the document CSA/ANSI HGV 4.1. Dispenser validation testing for light-duty vehicles shall be performed in accordance with the document CSA/ANSI HGV 4.3.

> NOTE — The document CSA HGV 4.9 focuses on hydrogen key fuelling station components and protocols by setting requirements and referencing appropriate standards, e.g., documents SAE J2601 for hydrogen fuelling protocol, SAE J2799 for communication with a hydrogen-fuelled vehicle, CSA/ANSI HGV 4.1 for hydrogen dispensers and CSA/ANSI HGV 4.3 for hydrogen dispenser validation testing.

7.9.1.2 Maximum allowable working pressure (MAWP) — Hydrogen fuelling station storage pressure shall comply with the requirements of Clause 7.3. No dispensing equipment shall have a higher MAWP than 96.6 MPa, which is calculated as 137.5% of nominal working pressure (NWP). Dispensers rated to a lower MAWP are permitted. All the components of the dispenser shall be rated for the MAWP of the entire system for a given pressure class.

7.9.1.3 Ambient operating temperature — Dispensing equipment shall only be operated when the ambient temperature is greater than -40 °C and less than 50 °C. Dispensing equipment may be rated for a higher minimum ambient operating temperature or a lower maximum ambient operating temperature as long as the dispensing equipment prevents fuelling outside the maximum and minimum temperature range.

7.9.2 Hydrogen fuelling station components

7.9.2.1 Piping and fittings — All piping and fittings on the dispensing equipment shall comply with the requirements of Clause 7.4.

7.9.2.2 Hydrogen dispenser valves — Upstream from the hydrogen dispensing point, in a safe and secure location, there shall be a normally closed, automatic shutoff valve that shall, in the event of damage to the dispenser, limit the accidental discharge of hydrogen to a maximum of 2 kg. The dispenser valve shall comply with the requirements of the document ISO 19880-3.

NOTE — These normally closed, automatic shutoff valves are typically located upstream of the dispenser, between the dispenser and the hydrogen storage.

These normally closed, automatic shutoff valves shall close during the following occurrences:

a) a shutdown of the electrical power supply to the dispenser;

b) an activation of the ESD system as described in Clause 6.3;

c) a deactivation of the dispenser;

d) the dispenser is upset or sheared from its foundation.

7.9.2.3 Overpressure protection — Hydrogen fuelling station overpressure shall be constrained by hydrogen fuelling station requirements to less than or equal to 150% NWP.

NOTE — This requirement is based on dispensers designed to a MAWP of 137.5% NWP with overpressure protection set to activate the highest permitted value of 137.5% and limit dispensing faults to no more than 150% NWP.

7.9.2.4 Hydrogen vent — The hydrogen fuelling station equipment shall have a hydrogen vent that complies with the requirements of Clause 7.6.2.

7.9.2.5 Hydrogen storage containers — If the hydrogen fuelling station equipment contains hydrogen in storage tanks, cylinders, or systems, they shall comply with the requirements of Clause 7.8.

7.9.2.6 Dispensing hose — The dispensing hose that connects the dispensing equipment to the vehicle shall comply with the requirements of the documents CSA/ANSI HGV 4.2 or ISO 19880-5.

7.9.2.7 Dispensing nozzle — The dispensing nozzle that connects the dispensing equipment to the vehicle shall comply with the requirements of the documents ISO 17268 or SAE J2600.

7.9.2.8 Dispensing nozzle overpressure protection — The dispensing nozzle shall be rated to the MAWP of the hydrogen fuelling station. The dispensing nozzle shall be designed to prevent connection to a vehicle storage tank with a lower NWP.

7.9.2.9 Adapters — Adapters to connect the dispensing nozzle to the vehicle shall not be used.

7.9.2.10 Protection — The dispensing nozzle shall be supported and protected from any foreign matter (e.g., snow, ice or sand) that can accumulate and interfere with the dispensing nozzle operation.

7.9.2.11 Activation — The dispensing nozzle shall be equipped with an interlock device that prevents release while the line is open and automatically shuts flow upon disconnection. This interlocking device shall prevent the escape of hydrogen when the dispensing nozzle is not properly engaged or becomes separated from the vehicle receptacle.

7.9.2.12 Depressurization — The dispenser shall be equipped with a mechanism to ensure proper depressurization to the vent system.

7.9.2.13 Breakaway device — The dispensing equipment shall have a breakaway device to prevent the escape of hydrogen between the hose and the dispenser in the event that the hose is unintentionally separated from the dispenser. If the dispensing nozzle has a separate vent hose, it shall also have a breakaway device. All breakaway devices shall comply with the requirements of the documents CSA/ANSI HGV 4.4 or ISO 19880-3.

7.9.2.14 Electrical equipment and classification of areas — The electrical equipment shall comply with the requirements of Chapter 6.

The electrical classification of the dispensing equipment and its surrounding areas shall comply with the requirements of Clause 6.2.

7.9.3 Installation

7.9.3.1 General — The installation of hydrogen-dispensing equipment shall comply with the requirements in this clause and applicable requirements of Clauses 7.11 and 7.14.

7.9.3.2 Minimum clearance distances — The minimum clearance distances of the hydrogen-dispensing equipment shall comply with the requirements in Table 2 and the applicable requirements of Clause 7.11.4. If the hydrogen-dispensing equipment includes hydrogen storage, it shall comply with the requirements of Clause 7.11.1.

7.9.3.3 System testing — Prior to operation, the hydrogen-dispensing equipment shall comply with the requirements of Clauses 7.13 and 7.14.3.

7.9.3.4 Warnings at public points of transfer — Within a distance of 3 m of all public points of transfer for dispensing compressed hydrogen, the following warnings shall be clearly displayed, written in either French or English, or both, or using international symbols of at least 50 mm in diameter on a white background:

NO SMOKING OR VAPING WITHIN 5 METRES AND TURN OFF VEHICLE DURING FUELLING

WARNING: HYDROGEN COMPRESSED FLAMMABLE GAS

HYDROGEN HAS NO ODOR

DÉFENSE DE FUMER OU DE VAPOTER À MOINS DE 5 MÈTRES ET ÉTEINDRE LE MOTEUR DU VÉHICULE DURANT LE RAVITAILLEMENT

MISE EN GARDE : HYDROGÈNE COMPRIMÉ — GAZ INFLAMMABLE

L'HYDROGÈNE EST INODORE

The dispenser shall display instructions on how to fuel a vehicle that are understandable by an untrained user.

7.9.4 Fuelling protocol

7.9.4.1 General — The fuelling protocol and vehicle-to-dispenser communication systems for public dispensing equipment to light duty vehicles shall be authorized by the automotive industry and validated by the document CSA/ANSI HGV 4.3.

NOTE — The document CSA/ANSI HGV 4.3 verifies the requirements of the document SAE J2601, a fuelling protocol standard accepted by the automotive industry, and of the document SAE J2799, a vehicle-to-dispenser communication protocol standard accepted by the automotive industry.

7.9.4.2 Gas dispensing temperature — The gas dispensing temperature shall not exceed the rated temperature of the vehicle storage tank over all dispenser ambient temperatures.

The vehicle storage tank shall not be fuelled over its rated temperature.

NOTE — Most hydrogen tanks are rated to 85 °C.

7.9.4.3 Default fuelling protocol — The fuelling protocol authorized by the automotive industry shall be the default fuelling protocol for publicly accessible dispensing equipment.

7.9.4.4 Additional fuelling protocols — Dispensing equipment that has additional fuelling protocols not authorized by the automotive industry or is intended for non-light duty vehicles shall have two means to authorize fuelling.

NOTE — Means to authorize fuelling that can be easily traded among public users, such as PIN codes, are not recommended. A trained attendant may be used to authorize access to the dispensing equipment.

7.9.4.5 Fuelling termination — The dispensing equipment shall terminate fuelling and return to a safe condition if any alarms are detected or in the event of a controller failure.

7.9.5 Accessibility

7.9.5.1 Public dispensing equipment — Publicly accessible dispensing equipment shall be located outdoors and designed for operation by the public without any training.

7.9.5.2 Private and public dispensing equipment — Dispensing equipment shall have two means of ensuring the dispenser is unable to fuel a vehicle storage tank of a lower pressure class. The dispensing nozzle that meets the requirements of Clause 7.9.2.8 shall be one method of protection.

NOTE — Other means of protection can include having the dispenser limit the final pressure of the fuelling when communication is not operational, or having a trained attendant on-site to prevent unauthorized dispensing into containers that are either rated to a lower pressure than the dispenser rating or containers that are not compatible with the fuelling protocol, or other approved means.

7.9.6 Hydrogen quality

The hydrogen quality from the dispensing nozzles shall comply with the requirements of the documents ISO 14687 or SAE J2719 and shall be controlled per requirements of the document ISO 19880-8.

7.9.7 Outdoor, private refuelling from transport vehicles

Outdoor, private refuelling from transport vehicles shall be approved following the appropriate requirements of this code.

7.9.8 Maintenance plan

The maintenance plan for hydrogen fuelling station equipment shall include the following elements:

a) general system and components maintenance;

b) hose assembly maintenance;

c) modifications and calibration;

d) maintenance and testing needed to meet the hydrogen quality requirements of Clause 7.9.6.

The maintenance plan shall be available to the AHJ and to the original equipment manufacturers (OEM) of the hydrogen-fuelled vehicles upon request.

7.10 LOCATION

The location of gaseous hydrogen systems shall comply with the requirements of Table 1. Outdoor gaseous hydrogen installations shall comply with the specific requirements of Clause 7.11. Indoor gaseous hydrogen installations shall comply with the requirements of Clause 7.12.

7.11 SPECIFIC REQUIREMENTS APPLICABLE TO OUTDOOR INSTALLATIONS INCLUDING CLEARANCE DISTANCES

7.11.1 Hydrogen storage container siting requirements

7.11.1.1 Ground storage

7.11.1.1.1 Gaseous hydrogen storage containers or assemblies shall be supported on a slab of reinforced concrete or on an equivalent structure that may be an integral part of the storage container assembly. The gaseous hydrogen storage containers or assemblies shall be placed directly above an area that has been designed by a professional engineer.

7.11.1.1.2 Gaseous hydrogen storage containers that are located within 15 m of aboveground storage of any class of flammable or combustible liquid shall be located on ground that is higher than that which is used for the storage of the other liquids, except if there are dikes, diversion curbs, grading, or separating walls that prevent the accumulation of these liquids under the hydrogen storage.

7.11.1.1.3 Gaseous hydrogen storage containers shall be resistant to damage from the impact of a motor vehicle, or vehicle impact protection shall be provided in accordance with the requirements in Clause 5.4.

7.11.1.2 Belowground vaults

7.11.1.2.1 Below-grade containers — Underground containers for the storage of gaseous hydrogen shall be enclosed in vaults constructed in accordance with the document UL 2245.

Below-grade vaults may be constructed on site, provided that the design is in accordance with the *National Building Code of Canada,* and that special inspections are conducted to verify the structural strength and compliance of the installation with the approved design, in accordance with the *National Building Code of Canada*. Below-grade vaults that are constructed on site shall be designed by a professional engineer. Consideration shall be given to soil and hydrostatic loading on the floors, walls, and lid; anticipated seismic forces; uplifting by ground water or

flooding; and to loads imposed from above such as from vehicular traffic and equipment loading on the vault lid.

7.11.1.2.2 Design and construction — The vault walls shall be higher than the gaseous hydrogen storage containers contained therein. There shall be no openings in the vault enclosure except those necessary for access, inspection, filling, emptying, ventilation and vent of the gaseous hydrogen storage container. The top of an at-grade or below-grade vault shall be designed to allow for the escape of leaked gaseous hydrogen. If installed at grade and subject to vehicle loading, the top shall have a metal grating with sufficient strength to carry vehicle loading, or another top surface designed by a professional engineer.

7.11.1.2.3 Internal clearance — There shall be sufficient clearance between the gaseous hydrogen storage containers and the vault to allow for visual inspection and maintenance of the containers and their accessories.

7.11.1.2.4 Arrangement — Adjacent vaults shall be permitted to share a common wall. The common wall shall be liquid-tight and vapour-tight, and designed to withstand the load imposed by either vault being filled with water.

7.11.1.2.5 Ventilation — Vaults shall be open to the atmosphere and allow for the escape of gaseous hydrogen.

7.11.1.2.6 Pressure-relief devices — Pressure-relief devices shall be discharged to a safe location through a hydrogen vent system, as specified in Clause 7.6.2.

7.11.1.2.7 Accessway — Vaults shall be provided with an approved personnel accessway with a minimum area of 0.5 m^2 and with a permanently affixed nonferrous ladder. Accessways shall be designed to be nonsparking. Travel distance from any point inside a vault to an accessway shall not exceed 6 m. At each entry point, a warning sign indicating the need for procedures for safe entry into confined spaces shall be posted. Entry points shall be secured against unauthorized entry and vandalism.

7.11.1.3 Hydrogen fuelling station canopy-top storage

7.11.1.3.1 Location — Gaseous hydrogen storage containers may be located on top of hydrogen fuelling station canopies provided the installation comply with the requirements of Clauses 7.11.1.3.2 and 7.11.1.3.3.

7.11.1.3.2 Construction — Canopies shall be constructed in accordance with the *National Building Code of Canada*, and comply with construction requirements and the applicable parts of Clause 7.11.3.

7.11.1.3.3 Warnings — Signage with black letters of 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 stating in either French or English, or both:

CANOPY TOP GASEOUS HYDROGEN STORAGE

STOCKAGE D'HYDROGÈNE GAZEUX SUR LE TOIT DE L'AUVENT

7.11.2 Dispenser siting requirements

Dispensers shall be placed at least 0.9 m from the vertical projection of a canopy, except when the canopy is built in such a way that gaseous hydrogen cannot accumulate in pockets, or between the ceiling and top, of the canopy.

Hydrogen fuelling stations at private commercial or industrial locations may use alternate approved means to protect the dispenser and other hydrogen equipment from impact and damage.

Where present, a sump shall be designed to address the collection of liquids (e.g., water, fuels, coolants) or heavier-than-air vapours (e.g., gasoline vapours), or both as per the application.

7.11.3 Rooftop installation of gaseous hydrogen systems

7.11.3.1 General — Hydrogen equipment covered by this code may be located on roofs of buildings provided that the installation complies with the requirements of Clauses 7.11.3.2 to 7.11.3.7.

7.11.3.2 Location on roofs and access — Hydrogen equipment covered by this code shall only be permitted to be located on horizontal roofs of buildings of the following occupancies: A4, B1, B2, B3, C, D, E, F1, F2, and F3 as specified in the *National Building Code of Canada*.

Rooftop hydrogen equipment covered by this code shall be located at a minimum distance from external exposures listed in Clause 7.11.4. The roof surface shall not be considered as being part of a building for the consideration of minimum clearance distances.

For personnel safety purposes, the hydrogen-generating equipment, hydrogen utilization equipment, hydrogen-dispensing equipment, hydrogen storage containers, hydrogen piping systems and their related accessories, and their mounting structure(s) shall not extend to within 3 m of the roof edge. The distance can be reduced to 1 m if 1 m or higher guardrails are provided at 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, or a stairway leading to a ladder not exceeding 4 m in height.

7.11.3.3 Roof structural requirements — The roof structure supporting the hydrogen equipment and containers shall be constructed in compliance with the *National Building Code of Canada* with due consideration for the added weight of the equipment in addition to other loadings.

7.11.3.4 Mounting of gaseous hydrogen storage containers — Gaseous hydrogen storage containers shall be mounted in accordance with the container manufacturer's instructions. They shall be individually supported in a cradle or similar structure, or within a rack that provides individual container support.

The container mounting structure shall be securely affixed to the roof. The maximum quantities stored on a roof shall be approved.

7.11.3.5 Mounting of other hydrogen equipment — Other hydrogen equipment and control panels shall be securely mounted on the gaseous hydrogen storage container mounting structure or separately mounted on the roof.

7.11.3.6 Mounting of gaseous hydrogen piping — Gaseous hydrogen piping shall be mounted on the building in compliance with the document ASME B31.3.

7.11.3.7 Fire protection — Gaseous hydrogen equipment and storage containers on the roof of an occupied building shall comply with at least one of the following requirements:

a) the supporting roof structure and columns below the hydrogen equipment, and the storage footprint area shall have a minimum fire-resistance rating of one hour, but not less than that required by the type of construction of the building;

b) the ceiling area below the hydrogen equipment and storage footprint shall be fitted with certified fire detection devices that activate at a maximum temperature of 110 °C and cause the opening of the EDD to discharge the hydrogen stored from all containers as per Clause 7.5.2. The spacing of the fire detection devices shall comply with the requirements of the *National Building Code of Canada*.

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, storage container valve, and manifold leaks by a minimum one-hour fire-resistant barrier or equivalent protection from hydrogen flame impingement. The barrier or equivalent protection shall be located on the roof, below potential hydrogen leak sites and shall extend at least 1 m horizontally on either side.

Noncombustible roofs require no barriers.

7.11.4 Minimum clearance distances to external exposures

The minimum distance from a hydrogen storage system of specified storage capacity located outdoors to any specified external exposure shall be in accordance with the requirements of Table 2.

The distances for points 2A, 9 and 11 through 13 inclusive in Table 2 shall not apply for total hydrogen storage up to 12.5 kg, and shall be approved to be reduced by one half for total hydrogen storage greater than 12.5 kg where fire barriers, without openings or penetrations and having a minimum fire-resistance rating of two hours, interrupt the line of sight between the hydrogen system and the external exposure. The configuration of the fire barriers shall allow for natural ventilation to prevent the accumulation of flammable gas concentrations.

The distances for points 1, 2B through 8 inclusive and 14 in Table 2 shall not apply where fire barriers, without openings or penetrations and having a minimum fire-resistance rating of two hours, interrupt the line of sight between the hydrogen system and the external exposure. The configuration of the fire barriers shall allow for natural ventilation to prevent the accumulation of flammable gas concentrations.

The distances to air intakes for point 10 in Table 2 shall not be reduced by a fire barrier.

Unloading connections on delivery equipment shall not be positioned closer to any of the specified exposures than the minimum distances cited in Table 2.

7.11.5 Protection requirements

Outdoor gaseous hydrogen installations shall be protected against lightning in accordance with the requirements of the document CSA B72.

Outdoor gaseous hydrogen installations shall be fenced or have walls to prevent entry by unauthorized personnel as defined in Clause 5.5. These installations shall also be protected against impact from moving vehicles as defined in Clause 5.4.

7.11.6 Marking and labelling

7.11.6.1 Gaseous hydrogen piping — Gaseous hydrogen piping shall be marked and labelled in accordance with the document ASME A13.1. Gaseous hydrogen piping shall be marked and labelled with the following signs in either French or English, or both (see Clause 7.4.4), and clearly indicating the direction of the flow:

HYDROGEN

HYDROGÈNE

7.11.6.2 **Warnings** — Outdoor gaseous hydrogen installations shall be marked and labelled with the following signs in either French or English, or both:

HYDROGEN — FLAMMABLE GAS

NO SMOKING OR VAPING — NO OPEN FLAMES

AUTHORIZED PERSONNEL ONLY

HYDROGÈNE — GAZ INFLAMMABLE

DÉFENSE DE FUMER OU DE VAPOTER — FLAMME NUE INTERDITE

ACCÈS RÉSERVÉ AU PERSONNEL AUTORISÉ

The signs mentioned in Clauses 7.11.6.1 and 7.11.6.2 shall be in black letters of a minimum height of 50 mm on a white or contrasted background. Identification requirements for gaseous hydrogen specified in the document NFPA 704 shall be followed.

7.11.7 Unattended outdoor hydrogen equipment enclosures

7.11.7.1 Fully enclosed, unattended outdoor hydrogen equipment enclosures shall be equipped with a hydrogen detection system as per Clauses 7.12.3.1 to 7.12.3.5.

7.11.7.2 Activation of the hydrogen detection system at 25% of the LFL shall activate a visual alarm. The alarm annunciation shall be conducted via a system dedicated fire panel. The alarm shall stay in operation until the hydrogen leak has been corrected and the hydrogen system has been manually reset by authorized personnel.

7.12 SPECIFIC REQUIREMENTS APPLICABLE TO INDOOR INSTALLATIONS INCLUDING CLEARANCE DISTANCES

7.12.1 Indoor hydrogen storage systems

7.12.1.1 **Indoor hydrogen storage systems of 35 kg of hydrogen or more** — When the quantity of hydrogen is equal to or exceeds 35 kg, a separate building shall be exclusively used for the hydrogen storage. The separate building shall be constructed of noncombustible materials. Window glazing of thermoplastic material may be used. Two doors shall be located so as to be readily accessible in the event of an emergency and open outward. Any latch on an exit door shall be of either magnetic or friction type.

Ventilation to the outdoors shall be provided, as well as hydrogen detection, as specified respectively in Clauses 7.12.2 and 7.12.3.

The exterior walls of the building necessary for explosion relief shall be constructed of lightweight materials or panels designed by a professional engineer in accordance with the document NFPA 68.

NOTE — The document NFPA 69 provides additional information for the proper design of explosion prevention systems.

There shall be no sources of ignition from open flames, electrical equipment or heating equipment.

Heating, if provided, shall be by steam, hot water, or by indirect means. Electrical heating may be used if it complies with Clause 6.1.

7.12.1.2 Indoor hydrogen storage systems of less than 35 kg of hydrogen and not less than 12.75 kg of hydrogen — When the quantity of hydrogen is equal to or greater than 12.75 kg and less than 35 kg, a special room shall be exclusively used for the hydrogen storage.

Floor, walls, and ceiling of the special room shall be constructed of noncombustible materials. Window glazing of thermoplastic material may be used. Interior walls or partitions shall have a fire-resistance rating of at least two hours, be continuous from floor to ceiling, and be securely anchored. At least one wall shall be an exterior wall. Windows shall be installed on exterior walls. A minimum of two doors shall be installed on exterior walls and be located so as to be readily accessible in the event of an emergency and open outward. One single door can be used, if approved. Any latch on an exit door shall be of either magnetic or friction type.

Heating, if provided, shall be by steam, hot water, or indirect means. Electrical heating may be used if it complies with Clause 6.1.

Roof and exterior walls shall have provision for explosion relief towards the outside, calculated in accordance with the document NFPA 68 by a professional engineer. Explosion venting shall be provided in exterior walls or in roof only. Vents shall consist of any one or any combination of the following:

a) walls of light material;

b) lightly fastened hatch covers;

c) lightly fastened, outward-opening, swinging doors in exterior walls;

d) lightly fastened walls or roofs.

Where applicable, snow loads shall be considered.

The walls, doors and roofs that are not intended for relieving explosions and shall be designed for containing deflagration, in accordance with the document NFPA 68.

NOTE — The document NFPA 69 provides additional information for the proper design of explosion prevention systems.

Ventilation to the outdoors shall be provided, as well as hydrogen detection, as specified respectively in Clauses 7.12.2 and 7.12.3.

There shall be no sources of ignition from open flames, electrical equipment and heating equipment.

7.12.1.3 Indoor hydrogen storage systems of less than 12.75 kg and greater than the MAQ of hydrogen — Hydrogen systems of less than 12.75 kg and greater than the MAQ specified in Table 1 need not be installed in a separate building as per Clause 7.12.1.1 or in a special room as per Clause 7.12.1.2. Nevertheless, the hydrogen system shall be:

a) separated from the incompatible materials listed in Table 3, using the minimum clearance distances specified in Table 3;

b) located at least 5 m from open flames and other open sources of ignition;

c) located at least 3 m from intakes of ventilation, air-conditioning equipment, and air compressors located in the same room or area as the hydrogen system, provided the conditions of Clauses 7.12.2 and 7.12.3 are met;

d) located 5 m from other flammable gas storage;

e) provided with ventilation to the outdoors and hydrogen detection as specified respectively in Clauses 7.12.2 and 7.12.3.

More than one hydrogen system of less than 12.75 kg shall be permitted to be installed in the same room or area provided the systems are separated by at least 5 m, or by a full-height fire barrier, continuous from floor to ceiling, having a minimum fire-resistance rating of two hours and located between the systems.

The clearance distance between multiple hydrogen systems of less than 12.75 kg shall be approved to be reduced to 5 m in buildings where the space between storage areas is free of combustible materials and protected with a sprinkler system designed in accordance with the document NFPA 13 for Extra Hazard, Group 1.

7.12.1.4 Indoor hydrogen storage systems of less than or equal to the MAQ of hydrogen — No special separation provisions need to be applied for hydrogen systems of less than or equal to the MAQ of hydrogen.

7.12.2 Ventilation system

7.12.2.1 Ventilation to the outdoors shall be provided for single storage hydrogen systems with a capacity greater than the MAQ of hydrogen, or for multiple storage systems, each having a total hydrogen content of less than the MAQ, but located less than 1.5 m from each other.

7.12.2.2 For storage hydrogen systems less than the MAQ, ventilation shall be provided, except where the hydrogen volume is less than 1% of the room or enclosure volume.

7.12.2.3 Cabinets, storage areas, enclosures or rooms containing hydrogen control or operating equipment shall be ventilated to minimize accumulation of hydrogen. The minimum ventilation rate shall afford either six air changes per hour or 0.3 m^3/min per square metre of floor area, or meet other similar criteria that prevent the accumulation of quantities of hydrogen-air concentrations from exceeding 25% of the LFL of hydrogen. If the ventilation rate requirements are met, the ventilation may be achieved by natural convection.

7.12.2.4 Inlet openings for fresh air intakes shall be located near the floor in exterior walls in such a way as to not reintroduce air previously evacuated from the process area. Consideration for preventing the blockage of air intake by snow, vegetation or other site uses must be taken into account in the ventilation design. Outlet openings shall be located at the highest point of the room in exterior walls or the roof. Inlet and outlet openings shall each have a minimum total area of 1 m^2 for every 305 m^3 of room volume. Discharge from outlet openings shall be directed or conducted to a safe area.

7.12.2.5 The ventilation system shall be constructed and installed in such a way as to preclude the presence of mechanical and electrical sparking within 5 m of hydrogen-containing equipment. The selection of equipment to be used shall be made by a professional engineer, who shall also design the installation.

7.12.2.6 The ventilation system shall be interlocked with the hydrogen process equipment to prevent the process equipment from working in the absence of ventilation. It is not required to use an interlock if 25% of the LFL inside the ventilated area is not exceeded after a 15-minute discharge of the full capacity of the hydrogen process or equipment. The ventilation system shall be equipped with an audible and visual alarm in order to warn personnel in case of failure. The audible alarm may be stopped by authorized personnel, whereas the visual alarm shall stay in operation as long as the ventilation system is defective.

7.12.2.7 When the hydrogen equipment enclosure is attached to a building in such a way that it shares a wall with the building and is separated from the interior of the building by a door, the door shall be equipped with an interlock so that the door shall be fully closed before the hydrogen equipment can operate. In the event that the door is opened during the operation of the hydrogen equipment, the hydrogen flow shall automatically stop. For access doors for personnel, which are required to be self-closing in accordance with the *National Building Code of Canada*, this interlock is not required.

7.12.3 Hydrogen detection systems

7.12.3.1 A hydrogen detection system shall be provided for a single storage system with a capacity greater than the MAQ of hydrogen, or for a case where multiple storage systems each have a total hydrogen content of less than the MAQ but are located less than 1.5 m from each other.

7.12.3.2 Hydrogen detection systems shall consist of a hydrogen detector, or any other approved device. The hydrogen detectors, or other approved devices shall be properly calibrated in accordance with the manufacturer's instructions and installed according to hazardous area

classification as specified in Clause 6.2. The hydrogen detectors, or approved devices shall be tested and calibrated at regular intervals, as recommended by the manufacturers.

7.12.3.3 Hydrogen detection systems shall be scaled from 0% to 100% of the LFL of hydrogen. The lower limit alarm set point of the hydrogen detection system shall be set at a maximum value of 25% of the LFL. The hydrogen detection system shall be interlocked to shut down the process at a maximum value of 40% of the LFL.

NOTE — A lower detection level (between 2.5% and 5% of the LFL) is recommended as it permits the investigation of the leak condition while hydrogen concentration in the air is significantly below the LFL and thus does not present a flammable hazard. This may permit the leak to be repaired, thus preventing an escalation leading to the shutdown of the equipment or system upon reaching 40% of the LFL.

7.12.3.4 The hydrogen detection system shall be installed giving due consideration to having sensors:

a) mounted as close as practical to the ceiling or at the highest possible point in the ventilated area;

b) positioned to detect the most probable leaks;

c) positioned in areas where hydrogen is most likely to accumulate.

Multiple sensors shall be separated from one another and positioned in accordance with the manufacturer's instructions.

7.12.3.5 Activation of the hydrogen detection system at 25% of the LFL shall:

a) close the automatic valves referred to in Clause 6.3.3;

b) deactivate the hydrogen-dispensing equipment, if applicable;

c) shut off the hydrogen supply.

7.12.3.6 Activation of the hydrogen detection system at 25% of the LFL shall activate an audible and visual alarm. The audible and visual alarm shall operate inside the room in a building or enclosure where the hydrogen system is located, and outside every entrance door of the room or enclosure. The audible alarm may be stopped by authorized personnel, or may stop automatically when the hydrogen concentration goes below 25% of the LFL. The visual alarm shall stay in operation until the hydrogen leak has been corrected and the hydrogen system has been manually reset by authorized personnel.

7.12.4 Gaseous hydrogen piping installation

Gaseous hydrogen piping shall not be installed in a closed stairway, stair landing or exit, or a heating or ventilation plenum unless welded pipes without connectors, fittings or valves are used. Gaseous hydrogen piping shall not be placed in any shaft containing a moving object such as an elevator, a dumb waiter, etc.

Gaseous hydrogen piping shall be protected against external corrosion and mechanical damage.

Gaseous hydrogen piping shall not be concealed in hollow walls.

When gaseous hydrogen piping passes through an exterior wall of masonry or concrete aboveground, it shall be sealed watertight and the portion of piping that runs through the wall shall be sleeved or double wrapped. It shall be tested for leaks prior to its installation, and signs shall indicate that hydrogen piping is present inside the wall as per the document ASME A13.1.

When gaseous hydrogen piping passes through an exterior wall of metal siding aboveground, it shall be sealed watertight and the portion of piping that runs through the wall shall run through a grommet style fitting. It shall be tested for leaks prior to its installation, and a sign shall indicate that gaseous hydrogen piping is present on both sides of the penetration as per the document ASME A13.1.

7.12.5 Specific requirements for gaseous hydrogen indoor fuelling

7.12.5.1 General — Clause 7.12.5 provides the requirements for hydrogen fuelling stations of vehicles using gaseous hydrogen as a motive fuel within a building that has primary functions other than fuelling. Public stations are not covered by Clause 7.12.5.

7.12.5.2 Maximum transfer rate and pressure — The maximum transfer rate of gaseous hydrogen into the fuelling area shall be no greater than 1.2 kg/min. Maximum settled pressure on board hydrogen-fuelled vehicles shall not exceed 350 bar indoors.

7.12.5.3 Hydrogen fuelling area and dispenser location

7.12.5.3.1 General — The hydrogen fuelling area shall be clearly marked on the floor and shall allow for unobstructed entrance and exit of indoor operating vehicles.

A hydrogen dispenser should be located at least 5 m away from building walls. If, for practical reasons, a dispenser is installed by or attached to a building wall, fuelled vehicles shall be at least 5 m from another wall.

When the building ventilation is deemed insufficient to provide adequate air exchange or circulation around the fuelling area, as per Clause 7.12.2.2, a separate air circulation fan(s) shall be installed above the dispenser to provide air curtain type ventilation within the hydrogen fuelling area. The dispensing equipment installer and operator shall make provisions so as to preclude fuel from dispensing in cases where air circulation fans are not functioning.

Minimum clearance distances to specified exposures shall comply with the requirements of Clause 7.12.1.3.

7.12.5.3.2 Declaration by manufacturer or installer — For all dispensers, the manufacturer or installer shall indicate in the instructions for the system owner how fuelling is achieved (fuelling protocol), and provide maintenance instructions to ensure that the requirements are maintained.

The manufacturer's or installer's declaration and the installation shall be verified by a professional engineer to confirm that the fuelling system complies with the fuelling protocol requirements.

7.12.5.3.3 Instructions — A copy of the instructions used to verify that the system complies with the requirements for fuelling, along with any test results conducted as part of the verification, shall be kept by the system owner for verification by the AHJ.

7.12.5.3.4 Marking — The manufacturer or installer shall display the following information on the equipment in a position clearly visible to the AHJ and maintenance personnel in either French or English, or both:

> THIS EQUIPMENT COMPLIES WITH THE REQUIREMENTS FOR LOW-FLOW INDOOR FUELLING IN ACCORDANCE WITH THE CODE CAN/BNQ 1784-000. REFER TO THE SYSTEM'S MAINTENANCE INSTRUCTIONS FOR DETAILS.
>
> CET ÉQUIPEMENT EST CONFORME AUX EXIGENCES CONCERNANT LES SYSTÈMES DE RAVITAILLEMENT INTÉRIEUR À FAIBLE DÉBIT DU CODE CAN/BNQ 1784-000. POUR PLUS D'INFORMATION, VEUILLEZ CONSULTER LES DIRECTIVES D'ENTRETIEN DU SYSTÈME.

7.12.5.4 Hydrogen storage containers and other hydrogen pressurized equipment — Only the hydrogen dispenser and hose shall be installed in the fuelling area. The hydrogen storage system and all other hydrogen pressurized equipment shall be installed outdoors in accordance with Clause 7.11.

7.12.5.5 Clearance around vehicle — There shall be a space of at least 1 m around the perimeter of the vehicle being fuelled, excluding the proximity to the dispenser, to allow for free egress.

7.12.5.6 Exits from building and fuelling area

7.12.5.6.1 Exits from building — There shall be at least two exit doors for personnel in the portion of the building where the fuelling area is located.

7.12.5.6.2 Exits from fuelling area — The fuelling area shall have two or more personnel exit areas, which comply with the *National Building Code of Canada*. These areas shall be kept clear to provide an emergency egress.

7.12.5.7 Automatic fire detection system — The fuelling area shall be provided with an approved automatic fire detection system that is connected to an annunciator at a location where personnel is are present.

7.12.5.8 Warnings — The following warnings shall be permanently displayed at the entrance to the fuelling area in either French or English, or both:

AUTHORIZED PERSONNEL ONLY

NO SMOKING OR VAPING

FLAMMABLE GAS

ACCÈS RÉSERVÉ AU PERSONNEL AUTORISÉ

DÉFENSE DE FUMER OU DE VAPOTER

GAZ INFLAMMABLE

These warnings shall be clearly displayed using one of the two methods described below:

a) the warnings shall be in black letters of a minimum height of 25 mm and a white or contrasted background measuring at least 220 mm by 280 mm;

b) international symbols shall be used that are red and black with a minimum diameter of 100 mm on a white background.

7.12.5.9 Visual indicators — A visual indicator shall be installed in the following locations:

a) near all entrances to the fuelling area in order to indicate when a fuelling operation is in process;

b) inside the fuelling area in order to indicate to the vehicle's driver when a fuelling operation is in process.

7.12.6 Specific requirements for reformers

Reformer exhaust gases shall be vented outdoors in accordance with the manufacturer's instructions. Precautions shall be taken to avoid water condensation in the exhaust system. If some condensation is unavoidable, the material shall be corrosion-resistant and the design of the exhaust system shall include provisions to collect or dispose of condensate.

An outdoor air supply shall be provided to any reformer installed inside a building in order to ensure its adequate operation. When the air supply to the reformer is provided by mechanical means, or requires the opening of a damper, louver or trap, the operation of the reformer shall be interlocked in such a way that it will operate only when adequate air supply is provided.

7.12.7 Mining applications

7.12.7.1 General

The requirements of this code apply to nongassy mines only.

The application of hydrogen power in surface and underground nongassy mines shall take the following aspects into consideration:

a) mine safety regulations issued by a provincial or territorial mining jurisdiction;

b) underground mining conditions such as atmosphere, opening periphery rock mass stability, location of sparking;

NOTE — Dampness and certain mineral dusts, among other atmospheric conditions, can increase the risk of corrosion.

c) underground and surface mine installations featuring industrial activities and mobile heavy equipment;

d) shock and vibration imposed to infrastructure and vehicles (blasting, poor roadway surface).

7.12.7.2 Mine hydrogen installations

7.12.7.2.1 Mine hydrogen installations shall comply with the requirements of Chapters 4 to 7 and the requirements of Clauses 7.12.7.2.2 to 7.12.7.2.13.

7.12.7.2.2 All mine hydrogen equipment covered by this code shall comply with the provincial or territorial mining jurisdiction’s regulations in effect.

7.12.7.2.3 It is recommended that conflict resolution or clarification requirements between the installation requirements of this code and the provincial or territorial mining jurisdiction’s regulations be discussed at a joint meeting between the mine regulatory authority, the hydrogen installation authority, and the mine operators.

NOTE — The mining jurisdiction regulates safety-related issues for metal mines.

7.12.7.2.4 Installation drawings, plans and specifications shall comply with the provincial or territorial mining jurisdiction’s regulations and be readily available at mine sites.

7.12.7.2.5 Upon completion of an installation, the installer shall inform the system owner, operation personnel and regional mine rescue personnel of the correct and safe use of all mine hydrogen equipment and piping systems, and their accessories to a level acceptable by the AHJ and the provincial or territorial mining authority. The installer shall ensure that a copy of the manufacturer’s instructions provided with the equipment are left with the system owner, regional mine rescue personnel and mine regulatory authority.

7.12.7.2.6 The results of scheduled maintenance and other installed equipment inspections shall be kept at the mine site and transmitted to the mining regulatory authority.

7.12.7.2.7 All mine hydrogen equipment shall be suitable for hydrogen use over the expected range of temperatures and other environmental conditions as well as for hydrogen distribution distances of a metal mine.

7.12.7.2.8 In addition to clearance distance requirements specified in Table 2, all mine hydrogen equipment shall have sufficient clearance distance from fixed mine infrastructure and mobile mining equipment circulation paths, as determined by the mine operator and approved by the mining regulatory authority.

7.12.7.2.9 All mine hydrogen equipment shall be outfitted with visual and audible alarms sufficient for the environment in which they are placed.

7.12.7.2.10 In addition to the provisions of this code, all electrical equipment associated with mine hydrogen equipment shall be subject to the provincial or territorial mining jurisdiction's regulations.

7.12.7.2.11 In addition to the requirements of Clause 6.3, an ESD system shall be outfitted with an audible alarm and a warning light that activate at each of the surface installations.

7.12.7.2.12 Hydrogen distribution piping shall be seamless and have physical characteristics that distinguish it from all other piping.

7.12.7.2.13 A hydrogen detection system shall be provided inside the gaseous hydrogen operating installation and inside the hydrogen fuelling stations. It shall be installed in accordance with the provincial or territorial mining authority in effect and be inspected for mineral dust accumulation. It shall be interlocked with an ESD system to shut down the surface gaseous installation and dispensing equipment, and to activate visual (warning light) and audible alarms.

7.12.7.3 Specific requirements for underground mine hydrogen installations

7.12.7.3.1 Application — Requirements for underground mine hydrogen installations are limited to the underground distribution of compressed hydrogen through a pipeline network feeding underground hydrogen fuelling stations. All other mine hydrogen equipment shall be installed at surface level. The confined underground conditions necessitate special requirements with respect to the design of the pipeline pathway in underground openings, the fuelling area location, the rock mass opening, the equipment positioning and the ventilation system.

7.12.7.3.2 Underground fuelling of compressed hydrogen-fuelled mining vehicles — The installation for underground hydrogen fuelling stations shall be designed following the assessment of:

a) provincial or territorial underground mining safety regulations;

b) signage, identification and warning systems;

c) underground conditions;

d) underground network distances in relation to gaseous hydrogen piping features;

e) location of underground hydrogen fuelling station, its distance from the mining area, and fuelling area entrance protocols;

f) design and creation of hydrogen fuelling station cavity;

g) location of dispensing equipment and clearances around vehicle fuelling locations where an operator works;

h) protection of gaseous hydrogen piping and dispensing equipment;

i) basic mine, hydrogen fuelling station, and emergency discharge ventilation requirements;

j) hydrogen detection system and detector sensor requirements;

k) electrical requirements;

l) emergency shutdown requirements;

m) underground fire protection;

n) safety exits.

Underground fuelling of compressed hydrogen-fuelled mining vehicles shall be subject to approval by the mining regulatory authority.

7.12.8 Exceptions for small hydrogen systems

For small gaseous hydrogen systems meeting the following criteria, the specific requirements of this code are limited as follows:

a) Systems containing no more than 1 g of hydrogen shall only be required to be clearly identified as containing hydrogen.

b) Systems containing more than 1 g of hydrogen but not more than MAQ shall comply with Clauses 7.12.2.1 and 7.12.2.2. If such a system processes more than 1 kg/h of hydrogen, the requirements of Clause 7.12.2.3 shall apply.

NOTE — Exceptions for small hydrogen systems do not imply any exemptions from other applicable requirements (e.g., electrical safety codes, pressure system codes).

7.12.9 Parking garages and carports for compressed hydrogen-fuelled vehicles

The requirements for parking garages and carports for compressed hydrogen-fuelled vehicles shall meet the same requirements as those for vehicles using conventional fuels.

7.12.10 Repair garages and maintenance facilities for compressed hydrogen-fuelled vehicles

7.12.10.1 Storage — Vehicle storage tanks in a repair garage shall not be included in determining the MAQ.

7.12.10.2 Multiple fuels — The requirements for repair garages and maintenance facilities for vehicles using hydrogen and other fuels shall comply with the requirements for all fuels used.

7.12.10.3 Maintenance facilities — The requirements for maintenance facilities for compressed hydrogen-fuelled vehicles shall comply with the same requirements as vehicles using compressed natural gas as per the document CSA B401.1.

If a vehicle storage tank contains less than 1 kg of hydrogen and is sealed, work that is typically performed in a repair garage may be carried out in a maintenance facility without any modifications.

7.12.10.4 Areas used for hydrogen repairs — If a repair area, such as a booth or room, in a repair garage is used to isolate the hydrogen repairs, the requirements set out in Clause 7.12.9 shall only apply to that area.

The repair area shall be separated from other operations by a minimum of 1 m and this separation shall remain clear. This requirement shall not apply to walls of an adjoining room or exterior walls of a building.

A repair area shall be designed in such a way to ensure that hydrogen levels in the surrounding area do not exceed 25% of the LFL in the event of a full release of hydrogen, based upon the largest vehicle storage tank that can be serviced in the repair area.

7.12.10.5 Walls and ceilings — The walls and ceilings of a repair garage that has a repair area dedicated to hydrogen repairs shall be constructed of material with a fire-resistance rating of one hour. The walls shall be smooth to facilitate ventilation.

7.12.10.6 Defuelling — Defuelling equipment shall be provided for repair garages. The equipment shall be provided by the vehicle manufacturer, and listed, or approved.

The defuelling equipment shall be grounded and bonded to the vehicle storage tank(s) in accordance with the document CSA C22.1.

The defuelling equipment shall be a) indoors, and discharged to an approved storage container or to atmosphere in accordance with Clause 7.6.2. If discharged to an approved storage container,

the container shall be rigidly supported to resist movement; or b) outdoors, and defuelling of vehicles shall meet the minimum clearance distances indicated in Table 2.

7.12.10.7 Hydrogen detection system — Each repair area shall have a hydrogen detection system that complies with the requirements of Clause 7.12.3. The hydrogen detectors shall be located at one or more inlets of the hydrogen ventilation system, high points in the repair garage, and at inlets of the building ventilation system.

Activation of the alarm shall occur at 25% of the LFL or failure of the system and result in the following:

a) audible and visible alarms;

b) deactivation of any unclassified heating, ventilation or air conditioning (HVAC) systems that draw air from the hydrogen area;

c) activation of hydrogen ventilation system, if continuous ventilation is not used;

d) activation of the building fire alarm system, if connected.

7.12.10.8 Heating, ventilation and air conditioning (HVAC) — Heaters and inlet openings for HVAC systems shall be located 500 mm from the ceiling measured from the bottom of the heaters or openings.

Heaters shall comply with the requirements of Clause 5.6 of the document CSA B401.1. Heaters with open flames or surfaces generating temperatures greater than 400 °C shall not be installed.

7.12.10.9 Hydrogen exhaust systems — Each repair area shall have a hydrogen ventilation system that complies with the requirements of Clause 7.12.2.

The minimum ventilation rate shall prevent the accumulation of quantities of hydrogen-air concentrations from exceeding 25% of the LFL of hydrogen, based upon the serviced vehicle storage tank capacity.

Equivalent, approved natural ventilation shall be permitted to replace a mechanical ventilation system.

7.12.10.10 Electrical equipment — Electrical equipment in a repair garage shall comply with the requirements of Clause 6.1.1.

All electrical equipment mounted within 500 mm of the ceiling of a repair room, booth or area shall be designated a Class 1, Zone 2.

Classified electrical equipment is not required if continuous mechanical hydrogen ventilation is used to comply with the requirements of Clause 7.12.10.7.

Adjoining areas to the classified locations, which are unlikely to have flammable gases, shall be unclassified if the mechanical hydrogen ventilation requirement complies with the requirements of Clause 7.12.10.7.

7.12.10.11 Other requirements — The following activities shall comply with the requirements of the document CSA B401.1:

a) storage and handling of flammable and combustible gases and liquids;

b) welding and open-flame operations;

c) spray painting and undercoating;

d) apparatus drying;

e) parts cleaning;

f) chassis cleaning;

g) housekeeping.

7.13 GASEOUS HYDROGEN INSTALLATION INSPECTION AND TESTING

7.13.1 Visual inspection

Prior to the commissioning of an installation, the installer and the system owner shall perform a visual inspection of the installation.

This inspection shall be carried out with the intent of checking the conformity of the installation to drawings, equipment lists and specifications.

Inspection records must be signed, filed and retained by the system owner.

7.13.2 Non-destructive examination

7.13.2.1 Except for joints in interstage compressor pipes, butt-welded joints on tubes over 15 mm in diameter shall be examined radiographically over their full length, using procedures in accordance with the document ASME BPVC, Section V. The acceptance criteria of the document ASME B31.3 shall be met.

7.13.2.2 Butt-welded joints in interstage compressor piping shall be examined radiographically or using an approved method.

7.13.2.3 Socket-welded joints shall be visually examined. Weld size and surface finish shall be approved.

7.13.3 Pressure test

7.13.3.1 General — Prior to commissioning, the installation shall be subjected to either a hydrostatic test or pneumatic test. Any evidence of leakage shall be considered unacceptable. All defects discovered during the pressure test shall be rectified, and the system retested.

If part of the system is buried or inaccessible for inspection, the test pressure shall be held for one hour, and shall show no pressure drop.

The pressure test fluid and ambient temperature shall be recorded for the duration of the test, and these records shall be retained for the life of the installation.

Step-by-step instructions contained in the appropriate sections of the documents ASME B31.3 and ASME B31.12 shall be followed to gradually increase the test system pressure to the maximum test pressure indicated in Clauses 7.13.3.2 and 7.13.3.3.

7.13.3.2 Hydrostatic test — If a hydrostatic test is performed, the pressure shall be gradually increased in steps until 150% of the MAWP is reached, then held at this level for at least 30 minutes.

Care shall be taken to dry out the system properly after the test. This shall be carried out by removing the air from the system with an inert gas as indicated in Clause 7.14.2. Due to the difficulty of removing moisture from gaseous hydrogen piping for sensitive-to-water-content uses and the proper functioning of equipment, it is recommended that hydrostatic tests are performed only for vent stacks and associated piping. A pneumatic test is recommended for all other piping (see Clause 7.13.3.3).

7.13.3.3 Pneumatic test — If a pneumatic test is selected, the test fluid shall have a minimum of 5% helium and shall be mixed with a suitable inert gas (e.g., nitrogen or argon) if less than 100% helium. The pressure shall be gradually increased in steps and the installation inspected after each step, until 120% of the MAWP is reached, except in the case of a 70 MPa or higher-pressure system where the maximum pressure should be limited to 100% of the MAWP. The pressure shall be held for at least 30 minutes. All joints shall be examined for leakage with a suitable leak-detecting solution or a calibrated helium detector.

Care shall be taken during the test due to the high quantity of energy stored in the compressed gas.

Step-by-step instructions contained in the appropriate sections of the documents ASME B31.3 and ASME B31.12 shall be followed to gradually increase the test system pressure.

7.14 GASEOUS HYDROGEN INSTALLATION COMMISSIONING

7.14.1 General

Commissioning shall only be carried out by qualified personnel and in accordance with written instructions.

7.14.2 Inert gas purge

Following the pressure test described in Clause 7.13.3 and prior to the introduction of hydrogen into proper portions of the installation, oxygen shall be eliminated from the equipment. For example, this can be achieved by pressurizing and depressurizing the system with an inert gas

(helium or nitrogen) until the residual oxygen is less than a volume fraction of 0.5%. If this method is selected, at the end of each depressurization, the system shall be kept at a positive pressure to prevent air ingress.

7.14.3 Leak test

When the installation has been put into hydrogen service, the pressure shall be raised to the expected service pressure and all joints, connections, etc. shall be checked for leaks.

7.14.4 Release of the gaseous hydrogen installation to the owner

Upon completion of the installation, the installer shall demonstrate to the owner that the hydrogen system works as designed. The installer shall correct any system malfunctions before releasing the hydrogen system to the owner.

7.15 GASEOUS HYDROGEN INSTALLATION OPERATION

7.15.1 General

The installation shall be approved prior to operation.

The installation shall be operated only by qualified personnel.

7.15.2 Operating instructions

7.15.2.1 General

Operating instructions shall be available to the system operator along with the as-built process and instrumentation drawings. Written instructions shall define the safe operating limits and actions to be taken in case of abnormal or emergency conditions.

7.15.2.2 Operating procedures for dispensing equipment

The operating procedures for the dispensing equipment shall include detailed instructions for the following points as applicable:

a) general provisions;
b) leak check;
c) overfilling protection;
d) fuelling protocols;
e) vehicle/dispenser communication;
f) pressure compatibility;
g) public dispensing;
h) private dispensing.

Such procedures shall be available to the AHJ and hydrogen-fuelled vehicle's OEMs upon request.

7.15.3 Employee training records

The system owner shall keep a record of each employee's training history. Each proof of training must be signed by the employee.

7.16 MAINTENANCE

7.16.1 Maintenance program

A maintenance program shall be established for gaseous hydrogen installations. The details of the maintenance program shall reflect the equipment that is installed and the layout on the site. The maintenance program shall be designed to mitigate the possibility of the following:

a) mechanical or electrical failure that could cause injury to persons;

b) failure that could result in an unplanned release of hydrogen;

c) failure that could cause a safety system to malfunction;

d) failure that could result in damage to properties owned by other parties.

The maintenance program shall minimally include the maintenance activities specified in Table 4, for applicable items, and the maintenance tasks recommended by the equipment manufacturers. All maintenance activities that shall be undertaken by the system owner shall be specified, along with their frequency, in an operator's manual.

Maintenance of liquid and gaseous hydrogen installations shall be minimally performed as per the manufacturer's recommendations, and supported by industry in-field experience and logged equipment data and observations.

The maintenance program shall be presented for approval to the AHJ, upon request.

7.16.2 Personnel

Maintenance shall be performed by qualified personnel only, who are trained to the requirements of this code and the manufacturer's instructions for the installed equipment. The manufacturer's instructions shall be consulted for details on how to perform any specific maintenance operation.

7.16.3 Permanent records

Permanent records of maintenance activities and repairs shall be kept for each gaseous hydrogen installation for a minimum period of four years. The records shall include at least the following information: date (format must be consistently recorded in all maintenance records), description of the work done, and the name of the person who performed the work.

On a fully automated installation, some maintenance activities may be fulfilled remotely. In these cases, the record keeping systems shall be approved.

7.16.4 Control system software

Any control system software shall be stored in a non-volatile memory storage and only be accessible to authorized personnel.

7.16.5 Electronic system check

Where the dispensing pressure is controlled by an electronic temperature-compensating and a pressure-limiting device, the system owner shall ensure the electronic system is checked at least once every six months and shall:

a) record the date of the system check, the ambient temperature, the dispensing pressure, and the temperature-compensated dispensing pressure;

b) keep the record at the site for at least two years;

c) produce the record, upon request, for examination by the AHJ.

8 LIQUID HYDROGEN INSTALLATIONS

8.1 APPLICABILITY

Chapter 8 defines the installation requirements of liquid hydrogen storage, piping, accessories and vaporizers up to their outlets. As indicated in Chapter 1, the production and transportation of liquid hydrogen are excluded. Storage container filling at the installation site is included.

8.2 STORAGE CONTAINERS

Liquid hydrogen shall be stored in a vacuumed jacketed container.

The inner vessel shall be designed and constructed in accordance with the document ASME BPVC, Section VIII, Division 1 or Division 2, and registered in accordance with the document CSA B51, Part 1. Materials used for the inner vessel shall be as per the document ASTM A240/A240M, Type 304 or 316L with a design temperature ranging from -254 °C to 38 °C. Identification requirements for liquid hydrogen specified in the document NFPA 704 shall be followed.

The outer vessel shall be built of carbon steel or stainless steel having a design temperature of at least -29 °C to 38 °C. The outer vessel shall be designed to withstand an outer pressure of twice the atmospheric pressure.

The annular space between the inner and outer vessels shall be under vacuum and insulated with composite, multilayer, perlite or an equivalent insulation.

The liquid hydrogen storage container shall have at least the following circuits:

a) top filling;

b) bottom filling;

c) liquid withdrawal;

d) pressure building;

e) economizer;

f) level gauge;

g) pressure gauge;

h) pressure-relief device;

i) full trycock.

A bayonet-type connector shall be used for storage container filling.

Purging shall be performed by qualified personnel at each filling to expel air from the piping and hoses between the tanker's offloading valve and the tank's fill valves.

The following signs, including the product identification number, in black letters of a minimum height of 50 mm on a white or contrasted background in either French or English, or both, shall be clearly displayed and visible at all times near the liquid hydrogen storage container:

LIQUID HYDROGEN

FLAMMABLE GAS

NO SMOKING OR VAPING

NO SOURCES OF IGNITION

AUTHORIZED PERSONNEL ONLY

UN 1966

HYDROGÈNE LIQUIDE

GAZ INFLAMMABLE

DÉFENSE DE FUMER OU DE VAPOTER

SOURCES D'ALLUMAGE INTERDITES

ACCÈS RÉSERVÉ AU PERSONNEL AUTORISÉ

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8.3 LIQUID HYDROGEN PIPING SYSTEM COMPONENTS

Piping shall be designed and constructed in accordance with the documents ASME B31.1, ASME B31.3 or ASME B31.12 and registered in accordance with the document CSA B51, Part 1. Material used for liquid hydrogen piping systems shall be in accordance with the document ASTM A358/A358M, Type 316L.

Fittings shall be made of Type 316L materials in accordance with the document ASTM A403/A403M, and shall be registered in accordance with the document CSA B51, Part 1.

Cast, ductile, malleable or high-silicon iron pipes, valves and fittings shall not be used.

Thermal expansion and contraction shall be allowed for the piping system design.

Piping for pumps or liquid hydrogen applications shall have a vacuum jacket. Piping to the vaporization system may be bare and uninsulated; however, the use of vacuum jacketed pipe is recommended for withdrawals deemed to be high volume by the professional engineer. The external part of uninsulated liquid hydrogen piping shall be cleaned as for oxygen service as per the document CGA G-5.4.

Gaskets and packing used in liquid hydrogen piping systems shall be made of material meeting the temperature, pressure and material compatibility requirements, such as polytetrafluoroethylene (PTFE), with or without silica, or polychlorotrifluoethylene (PCTFE).

Liquid hydrogen piping shall be identified in accordance with the document ASME A13.1.

8.4 FLOW CONTROL MECHANISM

8.4.1 Master shutoff valve

One or more master shutoff valve(s) shall be installed as indicated in Clause 7.5.1.

If Clause 7.5.1 does not apply (i.e., outdoor fuelling application), a manual valve shall be installed outside the area of liquid hydrogen storage and secured.

8.4.2 Liquid hydrogen storage valves

Each liquid hydrogen storage container shall have a fast-acting storage isolation valve installed in the outlet piping immediately adjacent to and downstream of the liquid hydrogen storage container to enable individual shutoff and isolation of each liquid hydrogen storage container. This valve shall be located within the secure area of the installation.

Devices such as normally closed valves with fusible links shall be used to isolate the liquid withdrawal circuit from the storage container.

A device shall be installed in the liquid hydrogen piping system to prevent back flow into the hydrogen system.

Clause 7.5.1 applies to the liquid hydrogen storage system if gaseous hydrogen storage tanks or cylinders are used as part of a liquid hydrogen supply system.

8.4.3 Valve marking and labelling

All valve marking and labelling shall be as per Clause 7.5.4.

8.5 OVERPRESSURE PROTECTION AND VENT SYSTEMS

8.5.1 Pressure-relief devices

8.5.1.1 General — Pressure-relief valves shall be installed where liquid hydrogen or cryogenic gaseous hydrogen can be trapped. The setting of the pressure-relief valve shall be as specified in the documents ASME B31.1, ASME B31.3 or ASME B31.12.

All pressure-relief valves shall be registered in accordance with the document CSA B51, Part 1.

8.5.1.2 Inner vessel of the liquid hydrogen storage containers — The inner vessel shall be protected from overpressure by an independent safety system that consists of a pressure-relief valve and a rupture disk assembly (see Figure 1) suitable for cryogenic service as per the document ASME BPVC, Section VIII, and sized accordingly.

This safety system shall be duplicated and connected by a three-way diverter valve that allows the system to switch from one independent safety system to another, as needed, to ensure continuous protection of the vessel during pressure-relief valve inspections, relief device change-outs, etc.

The pressure setting of pressure-relief valves shall not exceed the MAWP of the inner vessel. Rupture discs shall be sized and selected based on the requirements of the documents CGA S-1.3 and ASME BPVC, Section VIII.

When used as part of a liquid hydrogen supply system, pressure safety valves installed on gaseous hydrogen storage containers shall comply with the requirements of Clause 7.6.1.

8.5.2 Hydrogen vent systems

All vents, including liquid pressure relief devices, shall be connected to vent stacks. They shall be arranged to discharge in the open air so as to prevent impingement of escaping hydrogen upon personnel or structures. The vent exit elevation shall be at least 4.5 m above grade and 3.0 m above adjacent equipment and buildings.

When hydrogen gas and cold vapour are discharged in the same vent stack, the vent stack design shall follow cold vapour vent stack requirements.

The design of hydrogen vent systems shall be in accordance with the document CGA G-5.5.

The outlet of hydrogen vent systems shall not be equipped with devices that disturb the flow of hydrogen.

8.6 LIQUID HYDROGEN VAPORIZERS

All wetted parts of a liquid hydrogen vaporizer shall be selected as indicated in the document CGA H-5. It is recommended to use austenitic stainless steel, Type 316L for these components.

Heat used in a liquid hydrogen vaporizer shall be indirectly supplied using media such as air, steam, water, or water solutions applied to the vaporizing chamber tubes, pipe coils or heat exchanger surface containing the liquid hydrogen. Equipment used for heating the medium shall be classified as per Clause 6.2.1.

Low-temperature protection shall be provided in the liquid hydrogen vaporizer discharge piping to prevent flow of liquid hydrogen in the event of loss of heat source.

8.7 LOCATION

Storage containers and piping for liquid hydrogen shall be located outdoors. If pipes or tubes with welded connections are installed indoors, they shall not be provided with any connectors, fittings or valves.

Uninsulated piping and equipment, which operate 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. Drip pans may be installed under uninsulated piping and equipment to retain and vaporize condensed liquid air.

Surfaces located under the fill connections and delivery vehicle’s uninsulated gaseous hydrogen piping shall be constructed of noncombustible materials. For the purposes of this code, asphaltic and bitumastic paving shall be considered combustible. If expansion joints are used, fillers shall also be constructed of noncombustible materials.

Diking shall not be used to contain a liquid hydrogen spill.

8.8 CLEARANCE DISTANCES

The minimum distance from liquid hydrogen systems to specified external exposures shall be in accordance with Table 5.

The distances for points 1, 4, 6, 7, 8 and 11 of Table 5 shall be approved to be reduced by two-thirds, but not to less than 1.5 m, for insulated portions of the liquid hydrogen system.

Unloading connections on delivery equipment shall not be positioned closer to any of the external exposure than the minimum distances cited in Table 5. The distances to points 2, 3, 9, 10 and 11 can be reduced to 15 m when the following active mitigation measures are implemented and employed as standard practice at the liquid hydrogen storage site:

a) The installed liquid hydrogen system shall include equipment to allow for connection of both liquid transfer hose and a separate trailer head space vent hose to connect to the storage system vent stack.

b) All liquid hydrogen delivery trailers shall utilize a vent hose connection method to vent the trailer head space to the storage vent stack system at the end of the liquid hydrogen transfer process.

c) The liquid hydrogen delivery procedures shall incorporate the physical changes required in this clause to eliminate end-of-transfer venting at the trailer vent stack.

d) All liquid hydrogen delivery trailers transferring at the site shall be equipped with an ESD system and a fast-acting liquid hydrogen shutoff valve that will isolate the trailer in the event of an emergency during the transfer process.

e) A sign indicating that the trailer head space must be connected to the liquid hydrogen system vent stack before transferring hydrogen to the system shall be installed at the liquid hydrogen connection.

Active control systems or design functions beyond base code requirements that mitigate the risk of system leaks and failures shall be permitted to be used as a means to reduce separation distances where approved.

The minimum distance of container transfer connections from parked vehicles shall be as per Table 5.

8.9 PROTECTION

Liquid hydrogen installations shall be protected against lightning in accordance with the requirements of the document CSA B72.

Installations shall be fenced or walled to prevent entry by unauthorized personnel as per Clause 5.5.

Sites shall also be protected against impact from moving vehicles as defined in Clause 5.4.

8.10 MARKING AND WARNINGS

Liquid hydrogen installations shall be adequately identified with the following sign in either French or English, or both:

LIQUID HYDROGEN — FLAMMABLE GAS

NO SMOKING OR VAPING — NO OPEN FLAMES

AUTHORIZED PERSONNEL ONLY

HYDROGÈNE LIQUIDE — GAZ INFLAMMABLE

DÉFENSE DE FUMER OU DE VAPOTER — FLAMME NUE INTERDITE

ACCÈS RÉSERVÉ AU PERSONNEL AUTORISÉ

The warnings shall be as indicated in Clause 7.12.5.8.

8.11 LIQUID HYDROGEN INSTALLATION INSPECTION AND TESTING

8.11.1 Visual inspection

Prior to the commissioning of the installation, the installer and the system owner shall perform a visual inspection as per Clause 7.13.1.

8.11.2 Non-destructive test

Radiography and dye penetrant testing shall be carried out by qualified testing agencies in accordance with the document ASME B31.3.

8.11.3 Pressure test

Prior to commissioning, the installation shall be subjected to either a hydrostatic test or pneumatic test as per Clause 7.13.3. If part of the system is buried or inaccessible for testing, the test pressure shall be held for 24 hours without any pressure drop other than what is expected due to temperature fluctuations.

8.12 LIQUID HYDROGEN INSTALLATION COMMISSIONING

8.12.1 General

Prior to the commissioning of the installation, the following activities shall be carried out: inert gas purge, hydrogen purge and cool down.

Commissioning shall only be carried out by qualified personnel and in accordance with written instructions.

8.12.2 Inert gas purge

Following the pressure test described in Clause 8.11.3 and prior to the introduction of hydrogen into proper portion of the installation, oxygen shall be eliminated from the equipment.

This can be achieved by pressurizing and depressurizing the system with an inert gas (helium or nitrogen) until the residual oxygen is less than a volume fraction of 0.5%. At the end of each depressurization, the system shall be at a positive pressure to prevent air ingress.

8.12.3 Hydrogen purge

If nitrogen was used as the inert gas purge, only hydrogen warmer than -190 °C shall be used to eliminate the nitrogen.

If helium was used as the inert gas purge, cold gaseous hydrogen can be used to eliminate the helium.

All the installation circuits and equipment shall be properly purged according to the required product specification before the introduction of liquid hydrogen.

8.12.4 Leak test

When the installation has been put into hydrogen service, the pressure shall be raised to the expected service pressure, and all joints, connections, etc. shall be checked for leaks. It is also recommended that visual leak checks be performed on components that are on the liquid or cryogenic hydrogen sides.

8.12.5 Cool down

Liquid or cold gaseous hydrogen shall be slowly introduced into the installation to ensure that the cool down does not create any abnormal stresses in any part of the installation.

8.12.6 Release of the liquid hydrogen installation to the system owner

Upon completion of the installation, the installer shall demonstrate to the system owner that the hydrogen system works as designed. The installer shall correct any system malfunctions before releasing the hydrogen system to the system owner.

8.12.7 Acceptance by the AHJ

The installation shall be approved.

8.13 LIQUID HYDROGEN INSTALLATION OPERATION

The installation shall be operated only by personnel trained to a level acceptable to the AHJ. Operating instructions shall be supplied along with the as-built process and instrumentation drawings. Written instructions shall define the safe operating limits and actions to be taken in case of abnormal or emergency conditions. The system owner shall keep a record of each employee's training history. Each proof of training must be signed by the employee.

Appropriate safety equipment shall be worn by all personnel performing duties in the vicinity of liquid hydrogen storage systems and facilities. This equipment shall include fire retardant coveralls, safety boots, gloves, safety glasses or face shield, and hard hat.

8.14 MAINTENANCE

Maintenance of liquid hydrogen installations shall be performed in accordance with the requirements of Clause 7.16.

Maintenance of liquid hydrogen installations shall be minimally performed as per the equipment manufacturer's recommendations, and supported by industry in-field experience and logged equipment data and observations.

The liquid hydrogen system owner shall develop a maintenance program based on the information stated in Chapter 8.

9 RESIDENTIAL INSTALLATIONS

9.1 APPLICABILITY

Chapter 9 addresses the installation requirements for hydrogen equipment covered by this code intended to be used in detached one- and two-family dwellings and multiple single-family dwellings not more than three stories in height with a separate means of egress, and their accessory structures.

Chapter 9 does not apply to natural gas and propane distribution systems upstream of the hydrogen utilization equipment, which are covered under the document CSA B149.1.

Where Chapter 9 does not provide specific guidance for installation requirements, the provisions of this code shall apply.

> NOTE — The specific focus of this chapter is on stationary hydrogen-generating equipment and hydrogen utilization equipment. A complex system of compressors, piping, and pressure vessels within a residential environment was not considered.

9.2 INDOOR RESIDENTIAL INSTALLATIONS

9.2.1 Installation in dwelling rooms or spaces

With the exception of direct-vent appliances that obtain all process air directly from the outdoors, hydrogen-generating equipment shall not be located in, nor obtain process air from any of the following dwelling rooms or spaces:

a) bedrooms;

b) bathrooms;

c) washrooms;

d) storage closets.

Hydrogen utilization equipment may be located in a dwelling room or space provided the room or space has a volume of more than 10 m^3, and the ratio of the volume of gaseous hydrogen at 20 °C and 101.325 kPa to the volume of the room or space is less than 1/10 (e.g., 1 m^3 of hydrogen for a room volume of 10 m^3).

Hydrogen utilization equipment shall not be located in buildings of unusually tight construction unless labelled, and certified with an oxygen-depletion safety shutoff system. The oxygen-depletion safety shutoff system shall interrupt hydrogen utilization equipment operation when the oxygen in the surrounding atmosphere is depleted to the percent concentration specified by the manufacturer, but not lower than 19.5% as per provincial occupational health and safety acts.

9.2.2 Installation in private garages

In private garages containing hydrogen-generating equipment or hydrogen utilization equipment, equipment and appliances having a source of ignition shall be located in such a way that the source of ignition is at least 500 mm below the ceiling. For the purpose of this clause, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

The above requirements shall not apply where private garages are ventilated in accordance with Clause 7.12.2.

The two following points are a reminder of the requirements of Clause 7.12.2

a) Ventilation system shall be designed to maintain the maximum concentration of flammable gas below 25% of the LFL of hydrogen for the expected room temperature.

b) Continuous ventilation shall be provided at a rate of not less than 0.3 m^3/min per square metre of floor area.

9.2.3 Ventilation system

A ventilation system complying with the requirements of Clause 7.12.2 shall be installed in the room or space in which the hydrogen-generating equipment or hydrogen utilization equipment is installed.

The exhaust outlets of the ventilation system shall be located at least 3 m from HVAC air intakes; windows; doors; and other openings into buildings.

The exhaust outlets shall not be directed onto walkways or other paths of travel for pedestrians.

9.2.4 Hydrogen detection system

A hydrogen detection system complying with the requirements of Clause 7.12.3 shall be installed in the hydrogen-generating equipment or hydrogen utilization equipment enclosure, in the ventilation exhaust system, or in the room or space in which the hydrogen-generating equipment or hydrogen utilization equipment is installed.

9.3 OUTDOOR INSTALLATIONS

Hydrogen-generating equipment and hydrogen utilization equipment installed in outdoor locations shall be either certified or approved for outdoor use or provided with a protection from outdoor environmental factors that complies with the equipment manufacturer’s installation instructions.

9.4 STORAGE

The provisions of Clause 7.8 shall apply, with the following exception: no single hydrogen container shall contain more than 0.6 kg of hydrogen.

9.5 RESIDENTIAL HYDROGEN-GENERATING EQUIPMENT

9.5.1 Applicability

Clause 9.5.1 defines the additional requirements applicable to the installation of residential electrolyzers and reformers used to generate hydrogen from water or hydrocarbons, and store the hydrogen within the equipment in a separate storage system, or dispense it into a vehicle.

Only hydrogen-generating equipment that is connected to a hydrogen delivery system, itself connected to electrical power of no greater than 240 V, and that has a combined reservoir capacity of no more than 4 kg/h, shall be installed in residential buildings.

9.5.2 Isolation of hydrogen-generating equipment from hydrogen storage/piping

Hydrogen-generating equipment shall be individually isolated from hydrogen storage or piping by an automatic valve. The automatic valve shall fail normally closed so that the hydrogen-generating

equipment is isolated from the storage and piping when the hydrogen-generating equipment is shut down.

A manual valve shall be located between the automatic valve and the hydrogen storage or piping system in order to isolate the hydrogen-generating equipment from the hydrogen storage or piping.

9.5.3 Hydrogen dispensing

The hydrogen-generating equipment shall be installed in such a way that the ambient temperature sensor of the hydrogen-generating equipment is at the same ambient temperature as the hydrogen storage and the dispensing point.

Residential hydrogen dispensing equipment shall meet the applicable requirements in Clauses 7.9.2, 7.9.4 and 7.9.6.

Where vehicles being fuelled are at a lower temperature than the stored hydrogen, the dispensed pressure shall be reduced to prevent fatigue stress in the vehicle's hydrogen storage system. The degree of reduction in the dispensed pressure will depend on the relative temperature difference between the vehicle and the dispensing unit, and on the properties of the vehicle's hydrogen storage system. The dispensing unit shall be adjusted based on the instructions provided by the vehicle manufacturer.

There is no requirement for any minimum clearance distance between the hydrogen storage and the dispensing point.

9.5.4 Criteria for electrical shutoffs

An electrical shutoff shall be:

a) within sight of the hydrogen-generating equipment;

b) within 9 m of the hydrogen-generating equipment;

c) readily accessible.

9.5.5 Emergency shutdown devices

One or more emergency shutdown device(s) shall be installed to shut off the flow of hydrogen to the dispensing point. A manual shutoff valve is acceptable.

10 PORTABLE EQUIPMENT

10.1 APPLICABILITY

Since portable systems are, by nature, not installed, or fixed in place, the requirements of Chapter 10 apply only to the use of portable equipment, in both indoor and outdoor applications.

NOTE — The requirements of Chapter 10 do not apply to larger transportable equipment, which, by definition, is generally moved from one location to another using vehicles.

10.2 PORTABLE HYDROGEN UTILIZATION EQUIPMENT

Portable fuel cells shall comply with the requirements of the document CSA/ANSI FC 3. Portable fuel cells incorporating fuel-processing systems capable of producing carbon monoxide shall be for outdoor use only, and marked as per the document CSA/ANSI FC 3.

10.3 HYDROGEN STORAGE CONTAINERS — LIMITATIONS FOR INDOOR STORAGE AND USE

The aggregate capacity of hydrogen stored within portable hydrogen-generating equipment or within a portable fuel cell shall not exceed the limits for a building described in Subsection 3.2.8 of the *National Fire Code of Canada*.

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TABLE 1

LOCATION OF GASEOUS HYDROGEN SYSTEMS
(Clauses 7.10 and 7.12.1.3)

Location	Quantity of Hydrogen			
	≤ MAQ	From > MAQ to < 12.75 kg	From ≥ 12.75 kg to < 35 kg	≥ 35 kg
Outdoors	Allowed	Allowed	Allowed	Allowed
Indoors, in a separate building in accordance with Clause 7.12.1.1	Allowed	Allowed	Allowed	Allowed
Indoors, in a special room, in accordance with Clause 7.12.1.2	Allowed	Allowed	Allowed	Not allowed
Indoors, in accordance with Clause 7.12.1.3	Allowed	Allowed	Not allowed	Not allowed
Indoors, in accordance with Clause 7.12.1.4	Allowed	Not allowed	Not allowed	Not allowed

TABLE 2

MINIMUM CLEARANCE DISTANCE FROM OUTDOOR GASEOUS HYDROGEN STORAGE SYSTEMS TO EXTERNAL EXPOSURES

(Clauses 7.9.3.2, 7.11.4, 7.12.7.2.8 and 7.12.10.6)

[pane 1 of 2]

Type of External Exposures	Total Gaseous Hydrogen Storage		
	< 12.75 kg	From ≥ 12.75 kg to < 35 kg	≥ 35 kg
	Minimum Clearance Distance,		
	in m	in m	in m
1. Building or structure			
A. Wall(s) constructed of noncombustible materials			
a) Nonfire rated sprinklered building or structure, or unsprinklered building or structure with noncombustible contents	0	1.5	1.5
b) Unsprinklered building or structure with combustible contents			
• Adjacent wall(s) with fire-resistance rating of less than two hours	1.5	3.0	5.0
• Adjacent wall(s) with fire-resistance rating of two hours or greater	0	1.5	1.5
• Adjacent wall(s) with fire-resistance rating of four hours or greater	0	0	0
B. Wall(s) constructed of combustible materials	3.0	4.0	5.0
2. Wall openings in building and structure			
A. Operable openings	5.0	5.0	5.0
B. Inoperable openings	4.0	4.0	4.0
3. All classes of flammable and combustible liquids aboveground	3.0	4.0	5.0
4. All classes of flammable and combustible liquids below ground	1.5	3.0	4.0
5. Flammable gas storage (other than hydrogen), either above or below ground	1.5	3.0	4.0
6. Oxygen storage	5.0	5.0	5.0
7. Fast-burning solids such as ordinary lumber, excelsior, or paper	4.0	4.0	4.0
8. Slow-burning solids such as heavy timber or coal	4.0	4.0	4.0

TABLE 2
(pane 2 of 2)

Type of External Exposures	Total Gaseous Hydrogen Storage		
	< 12.75kg	From ≥ 12.75 kg to < 35 kg	≥ 35 kg
	Minimum Clearance Distance,		
	in m	in m	in m
9. Open flames, welding or other sources of ignition	5.0	5.0	5.0
10. Air compressor intakes or inlets to ventilating or air-conditioning equipment	5.0	5.0	5.0
11. Exposed persons other than technical personnel	1.5	3.0	4.0
12. Public streets, alleys, ways and parked vehicles	1.5	3.0	4.0
13. Line of adjoining property that can be built upon	1.5	3.0	5.0
14. Encroachment by overhead utilities			
A. Horizontal distance from the vertical plane below the nearest overhead wire of an electric trolleybus, train, or bus line	5.0	5.0	5.0
B. Horizontal distance from the vertical plane below the nearest overhead electrical wire of building service	4.0	4.0	4.0
C. Piping containing other hazardous materials	4.0	4.0	4.0

NOTES —

1 The distances in this table are harmonized as much as practical with Tables 7.6.2 and 10.4.2.2.1 (a) of the document NFPA 55.

2 Subject to approval, the distances may be calculated based on piping ID and pressure using Tables 10.4.2.2.1 (b) and 10.4.2.2.1 (c) of the document NFPA 55 as well as validated risk assessment toolkits such as Hydrogen Risk Assessment Models (HyRAM).

NORMATIVE NOTES —

A The distances in points 2A, 9 and 11 through 13 inclusive shall not apply for total hydrogen storage up to 12.5 kg and shall be approved to be reduced by one half for total hydrogen storage greater than 12.5 kg where fire barriers, without openings or penetrations and having a minimum fire-resistance rating of two hours, interrupt the line of sight between the hydrogen system and the external exposure. The configuration of the fire barriers shall allow for natural ventilation to prevent the accumulation of flammable gas concentrations.

B The distances in points 1, 2B through 8 inclusive and 14 shall not apply where fire barriers, without openings or penetrations and having a minimum fire-resistance rating of two hours, interrupt the line of sight between the hydrogen system and the external exposure. The configuration of the fire barriers shall allow for natural ventilation to prevent the accumulation of flammable gas concentrations.

C The distances in point 10 to air intakes shall not be reduced by a fire barrier.

TABLE 3

MINIMUM CLEARANCE DISTANCES FROM INDOOR GASEOUS HYDROGEN SYSTEMS OF LESS THAN MAQ TO NONCOMBUSTIBLE MATERIALS

(Clause 7.12.1.3)

Clearing Distances, in m					
Class 2, Class 3, or Class 4 Unstable Reactive Gas	**Corrosive Gas**	**Oxidizing Gas**	**Pyrophoric Gas**	**Toxic Gas**	**Other Gas**
6.0	6.0	6.0	6.0	6.0	No clearance distance is required.

NOTES —

1 The minimum 6.0 m clearance distance may be reduced without limit where the hydrogen system and the incompatible materials are separated by a barrier of noncombustible materials at least 1.5 m high with a fire-resistance rating of at least 30 minutes.

2 The minimum 6.0 m clearance distance may be reduced to 1.5 m where one of the gases is stored in a gas cabinet, or without limit where both gases are stored in gas cabinets.

TABLE 4

MANDATORY MAINTENANCE ITEMS
(Clause 7.16.1)

Item	Maintenance Requirement
General	Verify that system pressure and temperature are within the design values. Record inspection, pressure and temperature.
General	Visually inspect general site including all barriers, fences, walls, doors and other items to verify site compliance with code requirements. Record inspection and noncompliance, if any.
Valves, piping	Visually inspect valves and piping connections for leaks and abnormalities. Record inspection and leaks or abnormalities, if any.
Compressor packages	Verify that the pressure and level of the compressor oil and any other liquid-lubricated equipment are within specifications. Record inspection, pressure, levels of the compressor oil and any other liquid-lubricated equipment.
Compressor packages	Visually inspect general condition of compressor packages. Check condition of hoses, drive belts, etc. Record inspection and replacement of parts, if needed.
Compressor packages	Drain recovery tank and filter bowls. Record inspection and quantity of unexpected volumes of liquid, if present.
Compressor packages	Verify that compressor shuts down at the correct output pressure. Record inspection.
Dispenser	Verify that fuelling hoses and nozzles are in good condition. Replace if they are on a pre-set schedule. Record inspection and replacement of parts, if needed.
Dispenser	Inspect and lubricate dispenser breakaways. Record inspection.
Dispenser	Observe a fuelling process for each dispenser hose to ensure compliance with this code. Record inspection and noncompliance, if any.
ESD system	Verify correct functioning of ESD system. Record inspection.
Ventilation	Verify correct functioning of ventilation system including visual and audible alarms. Record inspection.
Hydrogen detection system	Verify correct functioning and calibration of hydrogen detection system including visual and audible alarms. Record inspection.
Instrumentation and controls	Check set points and calibrate all instrumentation (pressure and temperature switches, oil level switches, etc.). Record inspection and all values.
Leak test	Leak test all piping and verify for absence of leaks. Record inspection and leaks, if any.
Hydrogen storage containers	Retest or requalify hydrogen storage containers. Record retest or requalification.
Pressure-relief devices	Visually inspect all pressure-relief devices ensuring all tags are in place. Record inspection.
Pressure-relief valves	Recertify all pressure-relief valves. Record recertification.
Mandatory replacement items	Verify all components with an expiry date. Record inspection and replacement of components with an expired date.

TABLE 5

MINIMUM CLEARANCE DISTANCE FROM LIQUID HYDROGEN SYSTEMS TO EXPOSURES

(Clause 8.8)

[pane 1 of 2]

Type of External Exposures	Total Liquid Hydrogen Storage		
	From 150 l to 13 250 l	From 13 251 l to 56 781 l	From 56 782 l to 283 906 l
	Minimum Clearance Distance,		
	in m	in m	in m
1. Building or structure			
A. Wall(s) adjacent to system constructed of noncombustible materials			
a) Sprinklered building or structure, or unsprinklered building or structure with noncombustible contents	1.5	1.5	1.5
b) Unsprinklered building or structure with combustible contents			
• Adjacent wall(s) with fire-resistance rating of less than three hours	7.6	15.0	23.0
• Adjacent wall(s) with fire-resistance rating of three hours or greater	1.5	1.5	1.5
B. Wall(s) adjacent to system constructed of combustible materials			
a) Sprinklered building or structure	15.0	15.0	15.0
b) Unsprinklered building or structure	15.0	23.0	30.5
2. Wall openings			
A. Operable	23.0	23.0	23.0
B. Inoperable	7.6	15.0	15.0
3. Air compressor intakes or inlets for air-conditioning or ventilating equipment	23.0	23.0	23.0
4. All classes of flammable and combustible liquids*(aboveground, and vent or fill openings, if below ground)	15.0	23.0	30.5
5. Stationary liquid hydrogen containers	1.5	1.5	1.5
6. Flammable gas storage other than hydrogen	15.0	23.0	23.0
7. Liquid oxygen storage and other oxidizers	23.0	23.0	23.0
8. Combustible solids	15.0	23.0	30.5
9. Open flames, welding or other sources of ignition	15.0	15.0	15.0

TABLE 5
(pane 2 of 2)

Type of Outdoor Exposure	Total Liquid Hydrogen Storage		
	From 150 l to 13 250 l	From 13 251 l to 56 781 l	From 56 782 l to 283 906 l
	Minimum Clearance Distance,		
	in m	in m	in m
10. Places of public assembly	23.0	23.0	23.0
11. Public ways, railroads, and property lines	7.6	15.0	23.0
12. Inlet to underground sewers	1.5	1.5	1.5
13. Encroachment by overhead utilities			
A. Horizontal distance from the vertical plane below the nearest overhead wire of an electric trolleybus, train, or bus line	15.0	15.0	15.0
B. Horizontal distance from the vertical plane below the nearest type of overhead electrical wire other than those noted above	1.5	1.5	1.5
C. Piping containing other hazardous materials	4.6	4.6	4.6

* The minimum clearance distances for Class IIIB combustible liquids may be reduced to 4.6 m.

NORMATIVE NOTES —

A The distances for points 1, 4, 6, 7, 8 and 11 shall be approved to be reduced by two-thirds, but not to less than 1.5 m, for insulated portions of the system.

B Unloading connections on delivery equipment shall not be positioned closer to any of the external exposure than the minimum distances cited in this table. The distances to points 2, 3, 9, 10 and 11 can be reduced to 15 m when the following active mitigations measures are implemented and employed as standard practice at the liquid hydrogen storage site:

- The installed liquid hydrogen system shall include equipment to allow for connection of both liquid transfer (fill) hose and a separate trailer head space vent hose to connect to the storage system vent stack.
- All liquid hydrogen delivery trailers shall utilize a vent hose connection method to vent the trailer head space to the storage vent stack system at the end of the liquid hydrogen trans-fill process.
- The liquid hydrogen delivery procedures shall incorporate the physical changes required in this note to eliminate end-of-trans-fill venting at the trailer vent stack.
- All liquid hydrogen delivery trailers trans-filling at the site shall be equipped with an ESD system and a fast-acting liquid hydrogen shutoff valve that will isolate the trailer in the event of an emergency during the trans-fill process.
- A sign indicating that the trailer head space must be connected to the liquid hydrogen system vent stack before transferring hydrogen to the system shall be installed at the liquid hydrogen connection.

C Active control systems or design functions beyond base code requirements that mitigate the risk of system leaks and failures shall be permitted to be used as a means to reduce separation distances where approved by the AHJ.

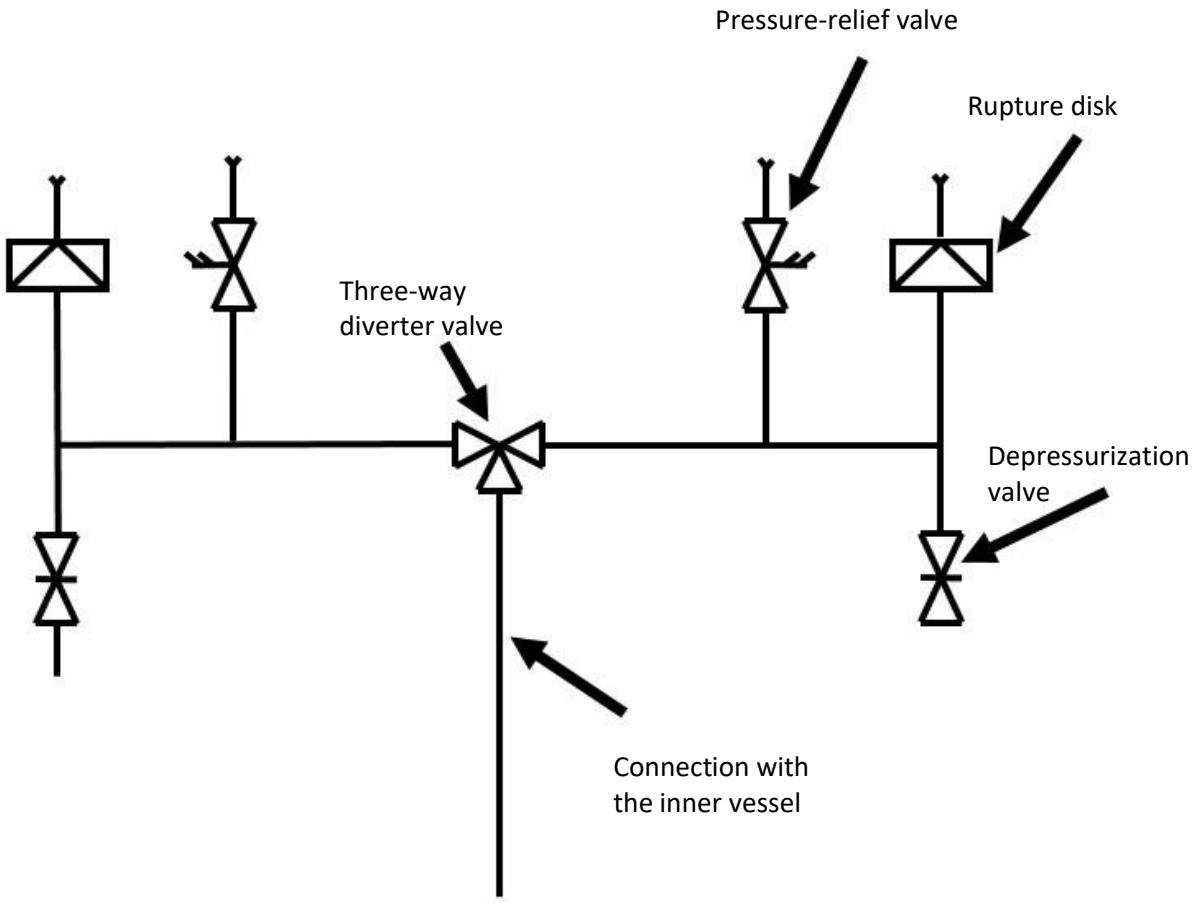

FIGURE 1 — PRESSURE-RELIEF VALVE AND RUPTURE DISK ASSEMBLY FOR INNER VESSELS OF THE LIQUID HYDROGEN STORAGE CONTAINERS
(Clause 8.5.1.2)

ANNEX A

(informative)
[non-mandatory]

RISK ASSESSMENT AND PUBLIC SAFETY

(Clauses 4.1 and 4.3.6)

Table A.1 lists the recommended risk assessment elements and associated purpose, and identifies the entity in charge of the assessment. In cases where a specific element is new to the assessing entity, training tools could be provided to aid the process.

An important element for ensuring public safety is the preparation and training of emergency responders. It is recommended that the Office of the Fire Marshal or gas authority oversee the training of assessors and emergency responders within the province or the territory to ensure that consistent high quality practices are initiated and maintained.

TABLE A.1

INFORMATION ON RECOMMENDED RISK ASSESSMENT ELEMENTS

Risk Assessment Element	Purpose	Assessed by	Tools Used	Period of Assessment
Site Quantitative Risk Assessment (QRA)	To measure selected site risks (hazard extent + frequency)	Gas authority or zoning authority	• Canadian standards such as CSA IEC 300-3-9 • Published provincial or territorial guidelines of acceptable risk • Training for assessors	When the requirements of this code cannot be met or when the regulators make special requests. Also used as a good practice.
Emergency Response Plan (ERP)	To detail a plan for execution should an emergency occur	Office of Fire Marshal or gas authority	• Training for assessors • Provincial or territorial standard elements	Continuous requirement
Control Recovery Register	To detail overall project measures (site + equipment + operations)	Office of Fire Marshal Office or gas authority	• Training for reviewers • Provincial or territorial standard elements	When the requirements of this code cannot be met or when the regulators make special requests. Also used as a good practice.
Insurance	To provide financial protection	Federal or local authority	• National, provincial, or territorial regulations	Continuous requirement
First Responder Training	To mitigate impact from incidents that may occur	Federal or local authority	• Federal, provincial or territorial regulations	Continuous requirement
Operation Inspections	To enforce safe operations and compliance to Codes & Standards (C&S)	Gas authority, building inspectors or others	• Training • Standards • Checklists	Continuous requirement

ANNEX B
(informative)
[non-mandatory]

INFORMATIVE REFERENCES

The references below are cited for information purposes in this document.

B.1 DOCUMENTS FROM STANDARDS BODIES

ASME (American Society of Mechanical Engineers) [www.asme.org]

ASME B16.5	*Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard*.

CSA Group [www.csagroup.org]

CSA B108	*Natural Gas Refuelling Stations Installation Code*.
CSA B149.1	*Natural Gas and Propane Installation Code*. (Code d'installation du gaz naturel et du propane.)
CSA IEC 300-3-9 NOTE — Withdrawn.	*Dependability Management — Part 3: Application Guide — Section 9: Risk Analysis of Technological Systems*. (Gestion de la sûreté de fonctionnement — Partie 3 : Guide d'application — Section 9 : Analyse du risque des systèmes technologiques.)

ISO (International Organization for Standardization) [www.iso.org]

ISO 13943	*Fire Safety — Vocabulary*. (Sécurité au feu — Vocabulaire.)
ISO 19880-1	*Gaseous Hydrogen — Fuelling Stations — Part 1: General Requirements*. (Carburant d'hydrogène gazeux — Stations-service — Partie 1 : Exigences générales.)

NFPA (National Fire Protection Association) [www.nfpa.org]

NFPA 2	*Hydrogen Technologies Code*.

NFPA 55 — *Compressed Gases and Cryogenic Fluids Code*.

NFPA 69 — *Standard on Explosion Prevention Systems*.

SAE International [www.sae.org]

SAE J2601 — *Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles*.

SAE J2799 — *Hydrogen Surface Vehicle to Station Communications Hardware and Software*.

ULC (Underwriters Laboratories of Canada) [www.ulc.ca]

CAN/ULC-S114 — *Standard Method of Test for Determination of Non-Combustibility in Building Materials*.
(Méthode d'essai normalisée pour la détermination de l'incombustibilité des matériaux de construction.)

UNECE (United Nations Economic Commission for Europe) [www.unece.org]

GTR No. 13 — *Global Technical Regulation on Hydrogen and Fuel Cell Vehicles.*
(Règlement technique mondial sur les véhicules à hydrogène à pile à combustible.)

B.2 OTHER DOCUMENT

PASMAN, Hans. *Risk Analysis and Control for Industrial Processes — Gas, Oil and Chemicals*, Elsevier, Texas, 2015, 458 p.

ANNEX C
(informative)
[non-mandatory]

BIBLIOGRAPHY

The references below can be consulted for more information on the topics covered in this document.

C.1 DOCUMENTS FROM STANDARDS BODIES

ASTM International [www.astm.org]

ASTM A105/A105M	*Standard Specification for Carbon Steel Forgings for Piping Applications*.
ASTM A106/A106M	*Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*.
ASTM A182/A182M	*Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service*.
ASTM A213/A213M	*Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes*.
ASTM A269	*Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*.
ASTM A276	*Standard Specification for Stainless Steel Bars and Shapes*.
ASTM A312/A312M	*Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*.

ASTM A333/A333M	*Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service and Other Applications with Required Notch Toughness*.
ASTM A334/A334M	*Standard Specification for Seamless and Welded Carbon and Alloy-Steel Tubes for Low-Temperature Service*.
ASTM A350/A350M	*Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components*.
ASTM A479/A479M	*Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels*.
ASTM A511/A511M	*Standard Specification for Seamless Stainless Steel Mechanical Tubing and Hollow Bar*.

CGA (Compressed Gas Association) [www.cganet.com]

CGA G-4.1	*Cleaning of Equipment for Oxygen Service*.

CSA Group [www.csagroup.org]

CSA C282	*Emergency Electrical Power Supply for Buildings*. (Alimentation électrique de secours des bâtiments.)

IEC (International Electrotechnical Commission) [www.iec.ch]

IEC 62282-5-100	*Fuel Cell Technologies — Part 5-100: Portable Fuel Cell Power Systems — Safety*. (Technologies des piles à combustible — Partie 5 : Systèmes à piles à combustible portables — Sécurité.)

ISO (International Organization for Standardization) [www.iso.org]

ISO 11114-4	*Transportable Gas Cylinders — Compatibility of Cylinder and Valve Materials with Gas Contents — Part 4: Test methods for Selecting Steels Resistant to Hydrogen Embrittlement*. (Bouteilles à gaz transportables — Compatibilité des matériaux et des robinets avec les contenus gazeux — Partie 4 : Méthodes d'essai pour le choix des aciers résistants à la fragilisation par l'hydrogène.)

ISO 16111 — *Transportable Gas Storage Devices — Hydrogen Absorbed in Reversible Metal Hydride*.

ISO/TS 19883 — *Safety of Pressure Swing Adsorption Systems for Hydrogen Separation and Purification*.

NFPA (National Fire Protection Association) [www.nfpa.org]

NFPA 30A — *Code for Motor Fuel Dispensing Facilities and Repair Garages*.

C.2 GOVERNMENT DOCUMENT

MAJOR INDUSTRIAL ACCIDENTS COUNCIL OF CANADA**.** *Hazardous Substances Risk Assessment: a Mini-Guide for Municipalities and Industry*, Ottawa, [Online], 1994, 39 p. [https://archives.bape.gouv.qc.ca/sections/mandats/Train_Est/documents/DQ5.4.pdf].

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