TISEC INC.

COMPENDIUM

FUELLING STATIONS FOR HYDROGEN FUEL-CELL VEHICLES

(REVIEW OF APPLICABLE CODES, STANDARDS AND THE CANADIAN AND AMERICAN REGULATORY INFRASTRUCTURE)

Prepared for the

Codes and Standards Working Group
Canadian Transportation Fuel Cell Alliance

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BACKGROUND

The Canadian Transportation Fuel Cell Alliance (CTFCA) is a federal initiative to demonstrate and evaluate fuelling options for hydrogen fuel cell vehicles within Canada. Various combinations of fuels and fuelling systems for light, medium and heavy duty vehicles will be demonstrated by 2005. This initiative will also foster the development of required codes, standards, test procedures and technician training requirements related to fuel cell and hydrogen technologies. Natural Resources Canada (NRCan) has established a Core Committee, a Project Advisory Committee and five Working Groups that draw on the vision and energy of about 50 key partners, including representatives from industry; non-governmental organizations; federal, provincial and local governments; universities and consumer groups.

The five working groups deal with the following key areas:

- Studies and assessments
- Light-duty demonstrations
- Heavy-duty demonstrations
- Codes and standards
- Communications

The Codes and Standards Working Group (CAS) has two major tasks to assist the CTFCA in fulfilling its mandate. These are:

- To assess the adequacy of existing standards and to identify areas requiring standards development, to ensure that there will be appropriate safety standards in place to protect vehicle owners, filling station personnel, hydrogen transport workers and the general public, as the hydrogen fuelling station infrastructure evolves and expands.
- To ensure that appropriate federal, provincial, territorial, and municipal codes and regulations are in place to facilitate electrical, gas, pressure vessel, fire, building and plumbing approvals by the local authorities having jurisdiction, so that there are no impediments to the expedient implementation of the demonstration projects.

The authors have prepared two discussion papers as background documents for the CAS. The first paper, *Filling Stations for Hydrogen Fuel-Cell Vehicles (Status of Applicable Codes, Standards & Regulations)* was prepared for the first CAS meeting in Victoria, 2002-02-21, while the second paper, *Filling Stations for Hydrogen Fuel-Cell Vehicles (Review of Canadian Regulatory Requirements)* was prepared for the second CAS meeting in Halifax, 2002-05-24. At the second meeting, CAS requested that the authors combine both discussion papers into a single document that would serve as a background reference for committee members. This Compendium combines, reorganizes and updates information presented in both discussion papers into a single reference document for CAS members.

This Compendium addresses these two major CAS tasks by reviewing the Canadian regulatory infrastructure and the Canadian conformity assessment system; by assessing the six Canadian model safety codes and identifying code deficiencies that may impede the introduction of hydrogen fuelling stations and by reviewing the status of existing standards related to hydrogen fuelling stations and identifying areas requiring standards development. A prioritized action plan to achieve the inclusion of hydrogen fuel into the Canadian model codes is also included.

A new section has been included in this Compendium that was not in either previous document. This section presents a comparative review of the US regulatory infrastructure and the related US model construction codes. It also presents a recommended procedure for coordination of Canadian and US activities in including hydrogen in respective model codes.

In line with the CTFCA mandate, this Compendium addresses the fuelling of vehicles with compressed gas or hydride on-board storage of hydrogen. It does not address the fuelling of vehicles with on-board storage of liquid hydrogen. It does however address an infrastructure that includes the delivery of hydrogen to fuelling stations as compressed gas by tankers or pipeline and the delivery of liquid hydrogen by cryogenic tankers. It also addresses the generation of hydrogen, on-site by electrolysis or reforming as well as on-site storage in either compressed gas containers, hydride containers or cryogenic liquid containers. Finally it addresses the infrastructure required within a service station to meter and deliver gaseous hydrogen at on-board storage pressures of 35 MPa (5000 psig) and 70 MPa (10000 psig) for compressed gas storage and at normal plateau pressures for on-board hydride storage. This Compendium does not address the storage of hydrogen fuel-cell vehicles within residential garages, parking facilities or service and repair facilities.

The contents of this Compendium with some additional background are also posted for reference by CAS members at: www.hydrogensociety.net/ctfca.htm. To access this website, the user ID is ***filling*** while the password is ***station***.

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THE DEFINITION OF A HYDROGEN FUELLING STATION

The infrastructure for a fuelling station for hydrogen fuel-cell vehicles is quite complex. At this initial stage in hydrogen use, it is anticipated that there will be many design and configuration variations for hydrogen fuelling stations. This will depend on many factors including the available hydrogen sources, the proposed facility size, the location and the type of vehicle on-board hydrogen storage. As is noted, hydrogen can either be generated on-site or delivered to the station in bulk. (An additional alternative is a methanol station for vehicles with on-board fuel reformation to hydrogen.) The various functions and processes to be considered as part of the hydrogen fuelling station infrastructure are listed below.

- On-site hydrogen generation
- Bulk hydrogen delivery (metering/weighing)
- On-site bulk storage
- Compression to buffer storage at delivery pressure for vehicle fuelling
- Fuelling of vehicles with compressed gas storage (connection, pressure regulation, metering, mass flow measurement)
- Charging of hydride containers for bulk storage (connection, pressure regulation, metering, mass flow measurement)
- Refuelling of vehicles with on-board hydride containers (container exchange, fitting and connecting; fast charging of on-board hydride containers)

Canadian model codes and related provincial safety codes will require updating by including hydrogen use and storage to facilitate local approvals for fuelling station construction. Safety and performance standards are required for many of the above functions to facilitate station design and to promote the development of common, consistent provincial regulations. Additionally a fuelling station will require a number of specialized components including piping; hosing; connectors; metering, mass flow measurement and control devices; as well as special safety equipment, depending on the type of fuelling station. All of these also require appropriate standards. Transportation modes include delivery by pipeline, tube trailer or cryogenic trailer. Special vehicle refuelling trailers with composite hydrogen storage tanks and on-board pressure boosters to meet vehicle storage pressures are also being advocated as a fuelling alternative. Current standards and codes do not address this hydrogen transportation option.

On-site generation can be by electrolysis or reforming. On the supply side of the station, applicable standards differ depending on the source of supply. Most of the related standards for delivery and storage are already well established. On the fuelling side of the station the required standards will depend primarily on the type of on-board hydrogen storage and the peak storage pressure. Some standards development will be required in this area; however, development has already been initiated on many of the required standards. As is discussed later, many standards already exist for hoses, tubes, connectors, regulators, fittings, valves, meters and flow control devices for flammable gases and liquids. Many will be directly applicable while others may need to be developed or modified for the high fuelling pressures being considered for on-board hydrogen storage.

THE MATRIX OF CODES, STANDARDS AND REGULATIONS INFLUENCING THE CONSTRUCTION OF A HYDROGEN FUELLING STATION

Canadian and provincial safety codes, local regulation and related standards in a number of specific areas need to be considered to address the full fuelling station infrastructure from hydrogen delivery to a station or on-site hydrogen production to hydrogen sale to a vehicle owner. These can be organized into the following matrix:

Compliance with Local and Provincial Safety Codes and Related Regulations

- To obtain a building permit, the site plan and construction drawings must show that all aspects of the fuelling station comply with local safety and environmental codes and related regulations.
- In most cases, local authorities base their regulations on the provincial safety codes.
- The provincial safety codes, which are relatively consistent among the provinces and territories, are normally based on the six Canadian model safety codes. These include:
  - The Canadian Electrical Code (CSA Standard C22.10-99)
  - The National Gas Code (CSA Standards B149.1 and B149.2)
  - The National Building Code 1995
  - The National Fire Code 1995
  - The National Plumbing Code 1995
  - The Boiler, Pressure Vessel and Pressure Piping Code (CSA Standard B51-97)
- Once construction is completed inspection by local officials will ensure that there is compliance with requirement in all of the above areas.
- Local, provincial or federal environmental regulations regarding venting of by-products (H_2 & O_2 for on-site generation by electrolysis and CO_2 in the case of reformers), discharge of liquids and noise pollution all need to be satisfied before operation may begin.
- Requirements of Weights and Measures Acts, Measurements Canada for the mass metering of hydrogen and its sale to consumers.

Transport of Hydrogen to a Fuelling Station

There will be need for compliance with codes, standards and regulations related to:

- Vehicles for transport of gaseous hydrogen.
- Trailers for transport of gaseous hydrogen.
- Rail cars for transport of gaseous hydrogen.
- Vehicles for cryogenic transport of liquid hydrogen.
- Rail cars for cryogenic transport of liquid hydrogen.
- Transport of charged hydride containers by road or by rail.
- Pipelines for transport of gaseous hydrogen.

On-site Production of Hydrogen at a Fuelling Station

There will be need for compliance with codes, standards and regulations related to:

- Hydrogen generation using water electrolysis.
- Hydrogen generation by steam methane reforming.
- Hydrogen generation by partial oxidation of hydrocarbons.
- Hydrogen generation by coal gasification.

On-site Storage of Delivered or Produced Hydrogen

There will be need for compliance with codes, standards and regulations related to:

- Gaseous storage.
- Cryogenic liquid storage.
- Gaseous storage in metal hydrides.

Compression to Vehicle Delivery Pressure

There will be need for compliance with codes, standards and regulations related to:

- Hydrogen compression from bulk storage pressure to vehicle storage pressure.
- Buffer storage at vehicle delivery pressure.
- Delivery and compression by special fuelling trailers.

Hydrogen Distribution Within the Fuelling Station

There will be a need of compliance with codes, standards and regulations related to:

- Pipes and tubing.
- Flexible hoses for bulk delivery to storage vessels.
- Flexible hoses for delivery to vehicles.
- Couplings and connectors.
- Valves.
- Gaskets, o-rings and other sealing devices.
- Special quick connection devices:
  - for bulk delivery.
  - for vehicle refuelling.

Regulation, Metering and Safety Devices

There will be need for compliance with codes, standards and regulations related to:

- Pressure regulation and pressure monitoring devices.
- Flow control devices.
- Pressure relief devices.
- Mass monitoring devices for bulk delivery.
- Mass monitoring devices for refuelling and sale to vehicle owners.
- Hydrogen detection equipment.
- Ventilation control devices.
- Portable and fixed fire control and extinguishing devices for:
  - gaseous hydrogen systems.
  - liquid hydrogen systems.
  - hydride storage systems.

AN OVERVIEW OF THE CANADIAN NATIONAL STANDARSDS SYSTEM

The following is intended to provide required background on the Canadian National Standards System. This background will assist in identifying methods for standards development and product safety certification in new areas which arise during development of the Canadian hydrogen fuelling system infrastructure.

The Canadian Conformity Assessment System

Canada is unique in the way in which its voluntary system of conformity assessment is structured. Since the entire Canadian National Standards System is overseen and coordinated by one body, the Standards Council of Canada (SCC), this can do much to facilitate the timely development and updating of any codes, standards or regulations that may be required to build a Canadian hydrogen vehicle fuelling system infrastructure. Development of a similar system in some other countries, such as the U.S.A.may be much more difficult because of the many different agencies involved in conformity assessment and related enforcement.

Some of the major roles assumed by the SCC are:

- coordination of all Canadian standards development activities through ISO/IEC.
- accreditation of Canadian standards development agencies.
- accreditation of calibration and testing laboratories to the requirements of ISO/IEC 17025.
- accreditation of product certification bodies to the requirements of ISO/IEC Guide 65 and additional Canadian requirements (SCC CAN-P-1500J).
- accreditation of quality system registrars (ISO 9000 series).
- accreditation of environmental system registrars (ISO 14000 series).
- Accreditation of auditor certifiers and auditor course providers.
- coordination of product safety certifications conducted by accredited certification bodies with the appropriate Canadian, provincial and territorial bodies having jurisdiction.

Various Routes for Canadian Standards Development

There currently are four SCC accredited standards development organizations (SDOs) in Canada. These are:

- The Canadian General Standards Board (CGSB).
- The Canadian Standards Association (CSA).
- Underwriters' Laboratories of Canada (ULC).
- Bureau de normalisation du Québec (BNQ).

These bodies may submit standards to SCC for approval as National Standards of Canada. Additionally many of the standards development committees of these four SDOs approve the use of international (ISO) standards through a consensus process as part of their standards development activities.

Because of the often lengthy and costly process in the development of safety or performance standards for new products or processes, another approach is also possible in Canada. In new areas where current standards may not be fully applicable, any SCC accredited certification body (CB), using procedures as detailed in SCC CAN-P-1500J can develop *Other Recognized Documents* (ORDs) within areas of their accredited scope. Such ORDs, which are developed with the approval of an advisory council of the Canadian authorities having jurisdiction in a particular product safety area, can be developed relatively quickly. They are immediately available for the use of other CBs in the same product area. ORDs need to be forwarded to an SDO for formalization after a certain time period.

The above process may be of assistance in facilitating timely standards development in certain areas where needs are indicated within the proposed hydrogen fuelling station infrastructure.

Product Certification and Testing Requirements

SCC has currently accredited over 300 calibration and testing laboratories to the requirements of ISO/IEC 17025 and has accredited 25 product certification bodies. CBs are accredited to the requirements of SCC CAN-P-3G (ISO/IEC Guide 65) and the additional Canadian requirements of SCC CAN P-1500J. Of these 25 CBs, 10 have Canadian head offices and 15 have US head offices.

As a result of compliance with both international and national certification accreditation requirements, product certifications from any of these CBs who are accredited in the same product area are equivalent and are accepted as equivalent, both nationally and internationally. Additionally, as discussed below, Canadian authorities having jurisdiction accept product certifications from any CBs who are accredited in the same product area as equivalent.

The following SCC accredited CBs have scopes which include mechanical and electrical safety; fire safety and some specific specialty areas related to gas or liquid fuel safety:

- Canadian Standards Association, Etobicoke, Ontario
- Entela Canada Product Safety Group, Etobicoke, Ontario
- IAPMO Research and Testing, Walnut, California
- Intertek Testing Services NA Inc., Cortland, New York
- Intertek Testing Services NA Ltd., Lachine, Quebec
- MET Laboratories Inc., Baltimore, Maryland
- Quality Auditing Institute, Port Moody, British Columbia
- Southwest Research Institute, San Antonio, Texas
- TÜV Rheinland of North America Inc., Newtown, Connecticut
- TÜV Product Services Inc., Peabody, Massachussets
- Underwriters' Laboratories of Canada, Scarborough, Ontario
- Underwriters Laboratories Inc, Northbrook, Illinois

Specific scopes of accreditation for each are listed on the SCC website, www.scc.ca. At a later date, if CAS so desires, the authors will provide a detailed listing of the accredited scopes of the above CBs with names of appropriate contact personnel.

The Advisory Councils of the Authorities Having Jurisdiction

The establishment of a Canadian fuelling station infrastructure for hydrogen vehicles will require approvals by the various local and provincial authorities having jurisdiction and in some cases may require changes in local, provincial or federal legislation. In Canada, we are fortunate that in most cases, the provincial authorities having jurisdiction have formed Canada-wide councils to coordinate their activities.

Under the requirements of SCC CAN-P-1500J, these councils also play an advisory, coordination and approval role with all accredited Certification Bodies (CBs) that certify product safety according to regulated Canadian standards. A specific role, in this regard is the approval of Other Recognized Documents (ORDs) developed by CBs in new areas where appropriate product standards do not exist. (An ORD is defined as: *a normative document that is developed when a new product or product installation to be certified is not covered by a Canadian recognized standard. An ORD shall provide an equivalent level of safety or performance as provided for similar functions in existing standards and shall be acceptable to the applicable regulatory authority or industry association.*)

Five regulatory advisory councils have been established to coordinate provincial activities related to five of the Canadian model safety codes, as follows:

(1) **The Canadian Advisory Council on Electrical Safety (CACES)**
This regulatory advisory council has representatives of all provincial and territorial electrical inspection authorities. It also is a regulatory advisory committee to the Canadian Standards Association on Part I of the Canadian Electrical Code. The current Chair of CACES is:

Mr. Jean-Louis Robert, ing.
Régie du bâtiment du Québec
Direction de la normalisation
800, Place d'Youville, 14 ieme étage
QUÉBEC, QC
G1R 5S3

Telephone: 418-643-4879
Telefax: 418-646-9280
E-Mail: jean-louis.robert@rbq.gouv.qc.ca

(2) **The Interprovincial Gas Advisory Council (IGAC)**
This regulatory advisory council has representatives of all provincial and territorial gas inspection authorities. It is concerned with application of the Canadian gas codes. The current IGAC Chair, Gordon Williams, has noted that IGAC has discussed hydrogen fuel applications but still has not assumed that role. Apparently in Ontario, the Fuel Safety Division of the Technical Standards and Safety Authority (TSSA) has assumed the inspection role for hydrogen applications. (TSSA is a member of IGAC). In the absence of specific codes for hydrogen, TSSA has apparently recently decided to adopt CAN/CSA-B108-99, *Natural Gas Fuelling Stations Installation Codes* for hydrogen fuelling station use. This illustrates the urgency to of conducting appropriate research to develop clearance distance data for hydrogen, as adoption of data for other fuel gases may be quite inappropriate.

Mr. Williams has further noted that the British Columbia inspection authority is about to assume an inspection role related to hydrogen fuell applications, while changes in legislation may be required in most other provinces and territories. The current IGAC chair can be contacted as follows:

Mr. G. L. Williams
Chief Gas Inspector
SaskPower Corporation
Gas & Electrical Inspection Division
2025 Victoria Avenue, 6-C
REGINA, SK
S4P 0S1

Telephone:	306-566-2506
Telefax:	306-566-2906
E-Mail:	gwilliams@saskpower.sk.ca

(3) **The Council of Canadian Fire Marshals and Fire Commissioners (CCFM&FC)**
This advisory council represents federal, provincial and territorial fire inspection authorities who implement local fire codes. Since the National Fire Code of Canada addresses the storage and use of flammable products and liquids this will be an important liaison. The current chair of CCFM&FC is as follows:

Mr. R. Cormier, Fire Marshal
Department of Labour
P.O. Box 697
HALIFAX, NS
B3J 2T8

Telephone:	902-424-5721
Telefax:	902-424-3239
E-Mail:	cormierr@gov.ns.ca

(4) **The Canadian Advisory Council on Plumbing (CACP)**
This advisory council represents federal, provincial and territorial plumbing inspection authorities who implement local plumbing codes. The National Plumbing Code of Canada addresses all plumbing requirements in buildings. It is possible that some future changes in drain configurations may be required to accommodate the use of hydride storage containers. The current chair of CACP is as follows:

Mr. T. J. Macaulay
Manager, Environmental Health
Saskatchewan Health
T.C. Douglas Building
3475 Albert Street
REGINA, SK
S4S 6X6

Telephone:	(306) 787-7128
Telefax:	(306) 787-3237
E-Mail:	tmacaula@health.gov.sk.ca

(5) **Provincial/Territorial Committee on Building Standards (P/TCBS)**
The National Building Code of Canada is the model code on which all provincial and territorial building codes are based. The National Building Code references the National Fire Code. The building code is concerned about the general health and safety of building occupants, and in so doing assumes that all equipment within a building is tested and certified by recognized agencies. The current chair of P/TCBS is T. Ross as listed below.

Mr. T. Ross
Building Code Coordinator
Municipal Services Division
Department of Housing & Municipal Affairs
P.O. Box 216
HALIFAX, NS
B3J 2M4

Telephone:	902-424-8046
Telefax:	902-424-0821
E-Mail:	tross@gov.ns.ca

The Canadian Codes Centre

The Canadian Code Centre of the NRC Institute for Research in Production coordinates development and updates the Canadian Fire Code, the Canadian Plumbing Code and the Canadian Building Code. The Standards Council of Canada maintains close liaison with the Canadian Codes Centre

The current secretary of the P/TCBS is John Archer, the National Fire Code Advisor at the Canadian Codes Centre of the National Research Council. It has recently been decided that building code development will be assigned to a sub-group of P/TCBS called PTPACC. This is detailed in a new MOU among the provinces, the territories and the National Research Council, which is currently being finalized. John Archer in the future will be the appropriate contact for updates to the Canadian Building Code. He can be contacted as follows:

John W. Archer
National Fire Code Advisor
Canadian Codes Centre
National Research Council of Canada
Institute for Research in Construction
Montreal Road Campus, Building M-24
Ottawa, Ontario
K1A OR6

Telephone:	613-993-5569
Telefax;	613-952-4040
E-mail:	john.archer@nrc.ca

THE CANADIAN REGULATORY INFRASTRUCTURE

The following summarizes the organization of the Canadian regulatory infrastructure and discusses the six model safety codes which are the basis for most local regulations that will affect the construction of hydrogen fuelling stations in any locality.

The Role of the Standards Council of Canada

Although participation in the Canadian National Standards System is voluntary and the Standards Council of Canada (SCC) does not have any regulatory functions, SCC indirectly plays an important role in coordinating and harmonizing the regulations set by the various Canadian Authorities Having Jurisdiction. A number of SCC's voluntary programs, such as the accreditation of standards development organizations and the accreditation of certification bodies and calibration & testing laboratories provide the Authorities Having Jurisdiction with common Canadian sources of codes and standards for developing regulations and accredited organizations for conducting the conformity assessment activities that may be required by such regulations.

The Authorities Having Jurisdiction

In Canadian Safety Codes, an Authority Having Jurisdiction is defined as the governmental body responsible for the enforcement of any part of a regulated code or standard, or an agency designated by that body to exercise such a function. Canadian Authorities Having Jurisdiction in most cases are the provincial governments, with the responsibilities for the development and enforcement of specific safety regulations assigned to related departments. These regulations are then utilized by local officials, such as building inspectors or fire chiefs, who may be employed by a provincial or federal government department, a city, a municipality or a planning district. The person delegated with local responsibility for the regulatory decision varies from location to location.

The Canadian Safety Codes

As was previously discussed, a hydrogen fuelling station will need to be constructed in conformance with appropriate municipal, territorial or provincial regulations, or in the absence of such regulations, in conformance with the requirements of the national model safety codes, as follows

- The Canadian Electrical Code (CSA Standard C22.10-99)
- The National Gas Code (CSA Standards B149.1 and B149.2)
- The National Building Code 1995
- The National Fire Code 1995
- The National Plumbing Code 1995
- The Boiler, Pressure Vessel and Pressure Piping Code (CSA Standard B51-97)

The electrical, gas and pressure vessel codes are developed by the Canadian Standards Association (CSA) while the building, fire and plumbing codes are developed at the Codes Centre, Institute for Research in Construction, National Research Council of Canada. CSA is an SCC accredited standards development organization. As was previously discussed, for the first five codes, above, the Authorities Having Jurisdiction have formed Advisory Councils to coordinate the development and application of their codes. Since the individual codes have regulated the use of many specific safety standards, these Advisory Councils also liaise directly with any SCC accredited certification bodies certifying products according to the requirements of the regulated standards. As was discussed, these advisory councils are as follows:

- The Canadian Advisory Council on Electrical Safety (CACES)
- The Interprovincial Gas Advisory Council (IGAC)

- Provincial/Territorial Committee on Building Standards (P/TCBS)
- The Council of Canadian Fire Marshals and Fire Commissioners (CCFM/FC)
- Canadian Advisory Council on Plumbing (CACP)

A somewhat different situation exists in the regulation of pressure vessels. The CSA is the standards development organization producing Canadian pressure vessel standards. Such standards are based primarily on the requirements of the Boiler and Pressure Vessel Code of the American Society of Mechanical Engineers (ASME/BPVC). The base Canadian standard is CSA B51-97 which governs the design, registration and inspection of pressure vessels, related components and piping. The Authority Having Jurisdiction (a provincial government department) approves new vessel designs and allocates a Canadian Registration Number (CRN) to new designs. The CRN allocation is coordinated among provinces by the use of a decimal point system following the CRN with a unique provincial identifier. A committee of chief provincial inspectors also meets on an annual basis to coordinate activities among the provinces and territories. Additional CSA standards, also based on the ASME/BPVC, relate to the highway transport of dangerous goods such as compressed gases. Because of the common acceptance of similar designs for the highway transport of compressed gaseous hydrogen, or cryogenically cooled liquid hydrogen, in both Canada and USA, transport of gaseous or liquid hydrogen across provincial borders or international boundaries is a reality.

The following section reviews the six Canadian safety codes and indicates where immediate efforts should be concentrated on code updates to facilitate hydrogen fuelling station approvals.

Boiler, Pressure Vessel and Pressure Piping Code
Among the six Canadian safety codes, only the Boiler, Pressure Vessel and Pressure Piping Code (CSA Standard B51-97) and related CSA pressure vessel standards, all of which are based on the ASME/BPVC, consider hydrogen. These standards and related regulations address the storage and transportation of hydrogen, as both a compressed gas and a cryogenic liquid. (They do not address the transport and storage of gaseous hydrogen in metal hydrides.) New designs of pressure vessels and pressure piping components for use in hydrogen fuelling stations will require provincial approvals and Canadian registration. No changes in pressure vessel codes or standards should be required (except in the case of hydride storage containers) and no new provincial legislation should be needed to accommodate pressure vessel and related pressure piping approvals for hydrogen fuelling stations. Future revisions to technical standards will be required once container technology has been developed to significantly increase storage pressures for compressed gaseous hydrogen. Additional future revisions will also be required to accommodate the use of alternate types of containers, such as aluminium, carbon fibre reinforced tubes for the bulk transport of compressed hydrogen gas.

Summary: No changes are currently needed to the Code for Pressure Vessels and Pressure Piping to accommodate fuelling station development. Requirements for hydride storage containers, for high pressure compressed gas storage (70 MPa (10000 psig)) containers and for alternate types of containers for the bulk transport of compressed hydrogen will need to be incorporated at a future date, once standards are developed.

The Canadian Electrical Code
Since 1996, both the Canadian Electrical Code (CEC) and the US National Electrical Code (NEC) have recognized the European zone classification system for Class I hazardous locations as an alternative method for classifying hazardous locations with flammable gases, vapours or liquids. These locations are as follows:
(a) Class I, Zone 0 - A location in which explosive gas atmospheres are present continuously or for long periods of time.
(b) Class I, Zone 1 - A location in which explosive gas atmospheres are likely to exist in normal operation or may exist frequently because of repairs, maintenance operations, and leakage or where equipment breakdowns could release gases or vapours and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition.
** This can also be a location adjacent to a Zone 0 location, from which ignitable concentrations of vapours can be communicated unless communication is prevented with adequate positive pressure ventilation from a source of clean air, with effective safeguards against ventilation failure.*
(c) Class I, Zone 2 - A location in which explosive gas atmospheres are not likely to occur in normal operation and, if they do occur, will exist for a short time only; or where volatile flammable liquids, flammable gas, or flammable vapours are handled, processed, or used, but are normally confined within closed containers or systems from which they can escape only as a result of accidental rupture or breakdown of the containers or system, or as a result of abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or where ignitable concentrations of flammable gases or vapours are normally prevented by adequate ventilation, but which may occur as a result of failure or abnormal operation of the ventilation system.
** This can also be a location adjacent to a Zone 1 location, from which ignitable concentrations of vapours can be communicated*

unless communication is prevented with adequate positive pressure ventilation from a source of clean air, with effective safeguards against ventilation failure.

The CEC and the NEC currently provide classifications of the sizes and shapes of Class 1, Zone 0, 1 and 2 locations around various standard components in garages, service stations and bulk storage stations handling propane, natural gas and standard liquid fuels. These codes also provide the required ventilation rates to enable maintenance of specific boundary locations between different hazardous zones. The installation of appropriate types of electrical equipment within each zone, based on CEC requirements and ventilation design to declassify specific areas and to safely remove hazardous gases or vapours are critical elements in obtaining a building permit. Inclusion of the same types of data for hydrogen fuelling stations in the CEC should enable acceptance of hydrogen in all provinces, since the CEC is already a regulated code and revisions to the code are overseen by CACES as the CSA Regulatory Authority Committee.

CACES is also the most active Regulatory Advisory Committee liaising with accredited certification bodies on the use of regulated codes and standards. There currently are nine SCC accredited certification bodies certifying hazardous location equipment. The process of developing ORDs through CACES in areas where existing regulated test standards may not be suitable for certifying equipment in hydrogen environments can also expedite the development of appropriate regulations.

Under a planned study proposed by Natural Resources Canada, TISEC Inc., Ballard Power Systems, Stuart Energy Systems and the Hydrogen Research Institute, various fuelling station components will be modeled to track development of hydrogen concentrations reaching lower flammability limit concentrations for selected ventilation rates. Results of this modeling will be incorporated into recommendations provided in *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2*, API Recommended Practice 505, First Edition, November 1997. This will enable the team to provide comparative hazardous zone recommendations for inclusion in the CEC, as are currently provided for propane and natural gas. Incorporation of the recommendations into the CEC are planned to be coordinated through the Chair of the CSA Section 20 Committee on the Canadian Electrical Code, Part I (Flammable Liquid and Gas Dispensing and Service Stations, Garages, Bulk Storage Plants, Finishing Processes and Aircraft Hangars) and through the Chair of CACES.

Through personal discussion with the Chair of CACES, who is also a member of the Section 20 Committee of the CEC and the Regulatory Authority Committee to the CEC, update of the CEC to include hydrogen is a critical first step in facilitating regulatory approval for hydrogen fuelling stations. Such an update will also be transferable to the NEC and related European codes because of the common acceptance of hazardous location classifications.

Summary: Update of the CEC to include hydrogen is an immediate priority. A plan is in place. Additional ongoing coordination is required with CACES and the appropriate CEC code committees.

The National Fire Code of Canada

The storage of fuel within buildings is addressed in the National Fire Code of Canada 1995. Storage restrictions in the National Fire Code of Canada relate primarily to meeting the requirements for electrical safety as detailed in Part 1 of the Canadian Electrical Code. The National Fire Code references the CEC in 11 different locations, all related to hazardous locations, including ventilation rates to maintain concentrations of flammable vapours at levels below 20 % of the lower explosive limit (LEL[1]). Update of the CEC to include hydrogen will automatically update the National Fire Code to deal with hazardous locations related to hydrogen storage and use, once the new CEC reference date is added. Additionally, since hydrogen use is currently not specifically addressed in the National Fire Code, but since the fire code references many National Fire Protection Association , Inc (NFPA) standards, in such cases local authorities will accept requirements of NFPA standards such as NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites, 1999 Edition*; NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites 1999 Edition* ; NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment1998 Edition*; NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages 2000 Edition* and NFPA 68, *Guide to Venting Deflagrations 1998 Edition.* Reference to NFPA standards, such as these, should facilitate fuelling station development while the fire code is being updated.

Summary: Update of the CEC to include hydrogen will also update the National Fire Code, once the new CEC reference date is included in the National Fire Code. This combined with reference to appropriate NFPA standards is sufficient. No action is required.

The National Building Code of Canada

The National Building Code of Canada 1995, the model code document on which provincial and territorial building codes are based, references the National Fire Code of Canada 1995. As a result it also does not currently address hydrogen use. Additionally, it also has no requirements related to the use of metal hydride hydrogen storage containers within a residence. Since the building code is generally concerned with issues of health and safety for occupants, it however assumes that any devices used within a residence such as hydride storage containers are tested and certified by an accredited body before installation within a residence. Since the Building Code references both the Fire Code and the CEC, and since there is a Building Code/Electrical Code Liaison Committee on the CEC, update of the CEC will automatically update the Building Code.

Summary: Update of the CEC to include hydrogen will also update the Building Code. No action is required.

The Canadian National Gas Code

The Canadian National Gas Code is contained in two Canadian Standards Association standards, CSA Standard B149.1, *Natural Gas and Propane Installation Code* and CSA Standard B149.2, *Propane Storage and Handling Code*. Related documents are: CSA B149.1HB, *Natural Gas and Propane Installation Handbook*; CSA B149.3, *Code for the Field Approval of Fuel-Related Components on Appliances and Equipment* and B149.5, *Installation Code for Propane Fuel Systems and Tanks on Highway Vehicles.*

<u>CSA B149.1</u> applies to the installation of appliances, equipment, components and accessories where gas (natural gas, propane and related mixtures) is used as a fuel. It also applies to the installation of vehicle-refuelling appliances and associated equipment, meeting the requirements of general purpose appliances to fill natural-gas-fuelled vehicles. <u>It does not relate to the installation of natural gas vehicle fuel systems, containers and fuelling stations.</u>

<u>CSA B149.2</u> applies to the storage handling, transportation and transfer of propane. This includes the installation of appliances, equipment, components, accessories and containers on highway vehicles,

[1]It should be noted that the CEC and the NEC use only the LEL and the upper explosive limit (UEL) and define them as the lower and upper percentages by volume of a gas in a gas-air mixture that will form an ignitable mixture. Hence in the case of hydrogen, LEL actually refers to the lower flammability limit (LFL).

recreational vehicles, mobile housing and the installation of containers and equipment to be used for propane distribution locations and filling plants.

The Inter-provincial Gas Advisory Council (IGAC), which represents all the provincial and territorial gas inspection authorities, has apparently only briefly discussed hydrogen fuelling applications. It is understood that changes in legislation will be required in most Canadian provinces to permit the use and operation of hydrogen fuelled vehicles and the set up of related fuelling facilities. The timely update of the Canadian Gas Codes to accommodate hydrogen fuel is of major importance in the development of a hydrogen vehicle fuelling station infrastructure.

Summary: Timely update of the Gas Codes requires planning and action.

The National Plumbing Code of Canada

The National Plumbing Code of Canada addresses specific requirements for plumbing, drainage and related ventilation for residential and commercial facilities. These requirements may be supplemented by additional local requirements. It is doubtful if these basic requirements would differ among automotive fuelling stations for liquid petroleum fuels, propane, natural gas or hydrogen fuels. Floor drain requirements in the National Plumbing Code may need modification once standards are developed for the placement of hydride storage tanks for the storage of gaseous hydrogen in a fuelling station. At present no such changes are anticipated since such need would depend on the properties of specific metal hydrides and their means of containment.

Summary: No action required at present.

Zoning
Municipalities, cities and towns enforce zoning ordinances to promote the health, safety, convenience and general welfare of inhabitants, to protect and conserve the value of the property within an area, to increase amenities and to secure protection from hazards and congestion. This is done by limiting the height, number of stories, size of buildings and structures, size and width of lots, the percentage of lot that may be occupied, the size of yards, courts and other open spaces, the density of population and the location and use of buildings, structures and land for trade, business, industry, agriculture, residence or other purposes. Normally, municipalities are zoned into residential, commercial, office and industrial districts. A zoning certificate is normally required to change the intended use of an area. For example, if a hydrogen fuelling station is to be located in a residential area, a zoning certificate would be required. The process for obtaining zoning deviations differs among jurisdictions. Information is available from city zoning departments and in many cases from city websites.

Environmental Review
Depending on the location and jurisdiction, an environmental review may also be required. This will address items such as potential noise, air and water pollution. Approvals may be required for CO_2 releases from reformers; normal and emergency H_2 venting; planned and accidental discharges into the sewer system and noise produced by processing equipment and vehicle traffic.

Obtaining a Building Permit
Once zoning and environmental concerns have been resolved, the next step in constructing a hydrogen fuelling station in a specific location is obtaining a building permit from the local municipality, planning district, town or city, depending on the local authority responsible for authorizing construction. This is not a "do-it-yourself" project. It will require retaining a professional engineer, architect or engineer/architect team, familiar with local requirements. The requirements for a structural engineer or an architect or both, depends on local ordinances and provincial regulations concerning joint use of seals. These professionals know the individual steps required for local approval to obtain a building permit in a specific area. Once any zoning variances have been resolved, a site plan and detailed structural drawings have to be prepared and submitted. The drawings, which must be signed and sealed by a licensed engineer or architect or both, must demonstrate compliance to the locally regulated portions of the six Canadian safety codes as well as any other locally enforced federal, provincial or municipal requirements. Construction cannot proceed until a building permit is obtained.

Because of the current deficiencies in the Canadian safety codes with respect to hydrogen utilization, and general ignorance about hydrogen safety, a hydrogen safety engineer will probably also need to be retained as an additional part of the team seeking the building permit. For example, the local fire chief will be a key person in approving the building permit. Permit approval may require reference to safety codes or standards that have not been locally regulated to convince a fire chief that the station design safely contains stored hydrogen and maintains hydrogen concentrations in the air at safe levels; that all electrical equipment is appropriately designed for the location in which it operates and that the station contains appropriate first and second lines of defence for fire control. Although sprinkler installation is mandated, sprinklers may be inappropriate in storage rooms using metal hydrides and other types of fire extinguishing media may be required. External placement of compressed hydrogen tanks requires appropriate clearances from buildings, adjacent properties, and parked vehicles. Since such requirements may not yet be addressed in Canadian safety codes or local regulations, reference by the safety engineer to related codes, standards or other documents and appropriately signing and sealing a safety assessment prepared for the fire chief, may be necessary until Canadian safety codes are appropriately updated.

Final Inspections
Once construction has been completed, final inspections are required by the various local, provincial or federal authorities, before the fuelling station can be put into operation. The types of inspection and the individuals involved will depend on the location and may include fire safety, electrical safety, mechanical safety, plumbing, weights and measures, environment, etc. This is also best coordinated with the engineer in charge of construction.

The electrical safety inspection process is used as an illustrated example of what types of final inspection may be required. As was discussed, the Canadian model code for electrical safety is the *Canadian Electrical Code*. Part I of the code (CSA Standard C22.1) is a safety standard for electrical installations, while part II of the code is a series of specific safety standards related to electrical products. All of the Canadian provinces and territories have adopted the Canadian Electrical Code, with some small variations to Part I of the code, in some provinces. The administration of the provincial regulations that are based on the code is coordinated to provide a consistent system throughout Canada. As was discussed, CACES has been set up as a regulatory advisory council of all the provincial and territorial inspection agencies to coordinate code application. Different local agencies may be in charge of code application depending on the fuelling station location. For example in Ontario it is the Ontario Electrical Safety Authority, while in Quebec it is the Régie du bâtiment du Québec.

The Canadian electrical code requires that all electrical products and components rated at more than 30V receive safety certification from an accredited third party certification body. As was noted there are a number of SCC accredited CBs that perform electrical product certifications. Electrical safety regulations in the Canadian provinces and territories specify product certification by an SCC accredited CB. Product certification relates to the labelling of products by an accredited CB, as they leave the manufacturing plant. In the case of large one-of -a kind products (such as specialized, on-site, hydrogen generation systems) that are designed from certified components but which need to be assembled and installed on-site, most CBs also operate a special *field approval program*, which involves on-site inspection and special field labelling.

An additional installation inspection by a provincial electrical inspector is also required in the case of installations receiving special field approvals. This inspector will examine the connection to the power supply and the locally installed interconnections between the labelled components. This inspector will not go beyond the field inspection label installed by a CB.

The above example illustrates the Canadian approval system for electrical safety. As is discussed later, somewhat similar systems are in place for mechanical, gas, fire and building safety approvals. Issuance of a business license occurs upon satisfactory completion of all inspections.

MEETING LOCAL REQUIREMENTS – AN EXAMPLE, THE CITY OF MISSISSAUGA

The following provides an example of some of the provincial and local approvals that may be required when opening a hydrogen fuel-cell vehicle fuelling station. This example assumes on-site hydrogen generation at a fuelling station in downtown Mississauga, Ontario. Similar types of approvals may be anticipated in other cities in other provinces but the names of the related departments will differ.

Product and Component Certifications:

- Product and component certification by a Standards Council of Canada (SCC) accredited certification body (CB) for any items manufactured according to the requirements of *regulated mechanical or electrical safety standards*.
- Field approvals by an accredited CB for any one-of-a-kind equipment that is fabricated with certified components but assembled on site to meet the requirements of *regulated safety standards*.

The above required certifications will be verified by the various provincial electrical, gas, fire and building inspectors.

Provincial Approvals

The following types of provincial approvals may be required::

- Application to Ontario Electrical Safety Authority for safety inspection and operating permit
- Application to Ontario Ministry of Labour for facility inspection and approval
- Application to Ontario Ministry of the Environment for approval of any releases from the production process.
- Applications to the Ontario Technical Standards and Safety Authority, Fuel Safety Division for:
  - permits or approvals for any variations or deviations
  - appliance field approvals
  - approval to operate emergency standby power (system components and fuel storage tanks require product certifications)
  - approval of high pressure systems
- Application to Ontario Building Materials Evaluation Committee
  - verifies safety certification of all pressure components as required by regulated standards
- Application to Ontario Fire Marshall's Office
  - verifies safety certifications as required by the fire

Local Approvals

The following types of local approvals may be required:

- Fire Department approvals for gas storage
- Planning Department approval of building permit
- Regional approvals concerning wastewater

A Comparison
In comparison to Canada, the situation in the U.S.A with respect to codes and standards that will impact the development of the hydrogen fuelling station infrastructure can best be described as confused and fragmented. It is characterized by hundreds of differing local custom-made codes overlain by several different model code development organizations competing for acceptance of their codes by state, city and related authorities.

The Authorities Having Jurisdiction
The 10th Amendment to the US Constitution gave states the right to legislate for protection of public health, safety and welfare. This state right is known as the "police power" of the state and resides in the state legislature. It allows for the passage of laws such as building codes and is the source of all authority to act and enforce the codes. A state may delegate a portion of this power to local governments such as cities or towns that are formed by the state legislature. Currently about one-half of the states have enacted state-wide building codes that pre-empt local government authority to enact their own codes. The authority for administration and enforcement of state codes is usually delegated to local authorities.

State-wide building codes may be enacted that:

- regulate specific classes of buildings
- regulate buildings based on specific construction methods
- regulate all construction except single-family dwellings
- regulate only one aspect of building construction such as fire safety
- regulate all construction

Local governments traditionally enact codes that reflect local political climates and priorities. The result is a bewilderingly complex body of regulations that varies from town to town. Although there is a move towards adopting model codes to replace local, custom-drafted codes, even this is difficult as there are a number of competing model codes from which to choose. Indeed the situation is so confusing that many states participate in the National Conference of States on Building Codes and Standards (NCSBCS), an outgrowth of the National Governors Association. Engineers and architects can purchase annual memberships in NCSBCS, which provides updated lists of the codes accepted by various jurisdictions in those states that participate in this group. NCSBCS can be reached at www.ncsbcs.org.

The International Code Council
The International Code Council (ICC) was established in 1994 as a not-for-profit organization dedicated to developing one set of coordinated US model construction codes. The founders of ICC are Building Officials and Code Administrators International, Inc. (BOCA); International Conference of Building Officials (ICBO) and Southern Building Code Congress International, Inc. (SCBCCI). The latter three not-for-profit organizations had previously developed three different sets of competing US model construction codes. ICC has currently developed the following US model codes:

- International Building Code
- International Energy Conservation Code
- International Fire Code
- International Fuel Gas Code
- International Mechanical Code

- International Plumbing Code
- International Private Sewage Disposal Code
- International Property Maintenance Code
- International Residential Code
- International Zoning Code

Although ICC is accredited by the American National Standards Institute (ANSI) as a standards development organization, its narrow scope of standards development relates to building construction and architectural features and does not cover its model code development activities. ICC code development activities apparently do not meet ANSI consensus guidelines, as only certain active BOCA, ICBO and SBCCI members are eligible to vote and specific industry groups can exceed one-third of the voting membership. ICC can be reached at www.intlcode.org.

The International Association of Plumbing and Mechanical Officials
A second set of model construction codes, primarily used by jurisdictions "West of the Mississippi", is developed and administered by The International Association of Plumbing and Mechanical Officials (IAPMO) in cooperation with the National Fire Prevention Association (NFPA) and the Western Fire Chiefs' Association, Inc (WFCA). Both IAPMO and NFPA are accredited by ANSI as standards development organizations. Since the code development activities of IAPMO are within its accredited scope, all ANSI consensus guidelines are complied with in IAPMO code development. As a result, both the Uniform Plumbing Code and the Uniform Mechanical Code, as detailed below, are scheduled to become American National Standards in 2003 and various NFPA codes such as the National Fuel Gas Code and the National Electrical Code already are American National Standards.

IAPMO is a not-for-profit organization; a separate division, IAPMO Research and Testing is accredited by both SCC and ANSI as a certification body. IAPMO, NFPA and WFCA collectively produce the following model codes, all of which are sold by NFPA:

- Uniform Plumbing Code (IAPMO)
- Uniform Mechanical Code (IAPMO)
- Uniform Solar Energy Code (IAPMO)
- Uniform Swimming Pool Spa and Hot Tub Code (IAPMO)
- Uniform Fire Code (WFCA) – "West of the Mississippi"
- National Electrical Code (NFPA)
- NFPA Fire Prevention Code (NFPA)
- Liquified Petroleum Gas Code (NFPA)
- National Fuel Gas Code (NFPA) – with American Gas Association
- NFPA 5000 Building Code (NFPA).

IAPMO can be reached at www.iapmo.org, NFPA can be reached at www.nfpa.org and WFCA can be reached at www.wfca.com.

Proposed Coordination of Canadian and US Activities
At the Halifax CAS meeting several working group members expressed their views that it would be important to participate with ICC committees since ICC is working on inclusion of hydrogen in its construction codes. At the recent World Hydrogen Energy Conference, a speaker made a similar observation. In both cases no mention was made of the codes developed by the IAPMO/NFPA/WFCA groups. While working with ICC is useful in coordinating CAS activities with US needs, an equally important if not even more essential and effective way of

coordinating CAS activities with US model code group needs, is by working with appropriate NFPA committees. This is for the following reasons:

- NFPA already has many standards addressing the use of hydrogen fuels. These are referenced in the Canadian model codes and are accepted by Canadian authorities in lieu of specific hydrogen requirements in Canadian model codes.
- NFPA develops the US National Electrical Code (NEC). As with update of the CEC to include hazardous location data for hydrogen, a similar (and identical) update is required in the NEC and is considered the most important update to US model codes to facilitate hydrogen fuelling station development. The CEC code committee already has a permanent NFPA member to facilitate coordination with NEC.
- The group of model codes developed by IAPMO, NFPA and WFCA address all fuelling station requirements. By not including the NEC, the ICC codes are clearly deficient.
- At least four of the model codes developed by IAPMO, NFPA and WFCA will soon be classified as American National Standards.
- Much of the current hydrogen vehicle activity in the US is centred in California and includes groups such as the California Fuel Cell Partnership, with whom CAS needs to establish liaison. The California Building Standards Law accepts only the model codes developed by IAPMO, NFPA and WFCA as are currently used "West of the Mississippi".

RECOMMENDATIONS

Based on recent successful experiences in obtaining a building permit for a hydrogen R&D facility in an industrial area not zoned for such activity, the authors recommend as follows:

(1) Until the six Canadian model safety codes are all updated to include hydrogen storage and use, obtaining a building permit for a hydrogen fuelling station will need the services of a hydrogen safety engineer in addition to the required local structural engineers/architects.

(2) Updating the Canadian Electrical Code to include hydrogen in a similar way as propane and natural gas are currently included is the most critical code update required to facilitate development of a fuelling station infrastructure. As is noted, a planned process has been proposed and discussion initiated with the Chair of CACES

(3) Provincial gas codes in most cases currently do not accommodate the use of hydrogen. This situation needs to be addressed. Discussions have also been initiated with the Chair of IGAC.

(4) Canadian efforts should be coordinated with American and European requirements to ensure on behalf of manufacturers that there is international uniformity in requirements. Since similar hazardous location definitions are accepted in Canadian, US and European electrical codes, update of the Canadian Electrical Code to incorporate hydrogen will facilitate initiation of similar updates in US and European codes.

ANNEX I

A PARTIAL LIST OF APPLICABLE STANDARDS AND REGULATIONS

The following table provides a list of currently available standards for the storage, handling and delivery of combustible gases and liquids. Some have been written specifically for gaseous or liquid hydrogen, while others apply to fuels such as propane, liquid natural gas, compressed natural gas or other propane products. The standards have been grouped according to the previously discussed matrix; standards with specific hydrogen content are noted. An effort has been made to concentrate only on Canadian standards in areas (such as transportation) where the current standards requirements appear to be satisfied. While the list in this table is not exhaustive, it provides background to assist CAS with its activities.

Number	Name	Specialty Area	H_2 Content
	Transportation of Hydrogen		
CAN/CSA[2]-B620-98 (R2000)	Highway Tanks and Portable Tanks for the Transportation of Dangerous Goods	Gaseous and Cryogenic	yes
CAN/CSA-B622-98 (R2000)	Selection and Use of Highway Tanks, Multi-unit Tank car Tanks and Portable Tanks for the Transportation of Dangerous Goods, Class 2	Gaseous and Cryogenic	yes
CSA B340-97	Selection and Use of Cylinders, Spheres, Tubes and Other Containers for the Transportation of Dangerous Goods, Class 2	Gaseous	yes
CAN/CSA B339-96	Cylinders, Spheres and Tubes for Transportation of Dangerous Goods	Gaseous	yes
	On-Site Production of Hydrogen at a Fuelling Station		
ISO[3]/WD 22734 (2001)	Hydrogen Generators Using Water Electrolysis Process	Generation	yes
MODUK[4] DEF STAN 68-129	Methanol Water Mixture for Hydrogen Generators Joint Service Designation AL-140 Interim Issue 1 (11.90)	Generation	yes
NATO[5] STANAG 4168 ED 1 AMD 1	(Active Historical) Characteristics of Hydrogen Generating Equipment	Generation	yes
NATO STANAG 4168 ED 1 AMD 4	Characteristics of Hydrogen Generating Equipment Amendment 4, 3/25/98	Generation	yes
	On-Site Storage of Delivered or Produced Hydrogen		
CSA B51-97	Boiler, Pressure Vessel and Pressure Piping Code	Storage	yes
CSA B51-97, Part 2	High-Pressure Cylinders for the Onboard Storage of Natural Gas as a Fuel for Automotive Vehicles	Storage	
ANSI[6] NGV2-2000	Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers	Storage	
CGA[7] P-25	Guide for Flat Bottomed LOX/LIN/LAR Storage Tank Systems	Cryogenic Tanks	
CGA PS-4	CGA Position Statement for the Periodic Proof Testing of Stationary Cryogenic Tanks	Cryogenic Tanks	
CGA PS-8	CGA Position Statement on the Protection of Cryogenic Storage Tanks from Overpressure During Operator-attended Refill	Delivery	
CGA P-31	Tanker Loading System Guide	Delivery	
NFPA[8] 50A	Standard for Gaseous Hydrogen Systems at Consumer Sites 1999 Edition	Hydrogen Safety	yes

[2] Canadian Standards Association
[3] International Organization for Standardization
[4] Ministry of Defense, UK
[5] North Atlantic Treaty Organization
[6] American National Standards Institute
[7] Compressed Gas Association
[8] National Fire Protection Association

NFPA 50B	Standard for Liquefied Hydrogen Systems at Consumer Sites 1999 Edition	Hydrogen Safety	yes
	Compression to Vehicle Delivery Pressure		
	See on-site storage. No compression standards found		
	Hydrogen Distribution Within the Fuelling Station		
CAN/CGA[9]-8.1-M86 (R2001)	Elastomeric Composite Hose and Hose Couplings for Conducting Propane and Natural Gas	Hoses, Couplings	
CAN1-8.3-77 (R2001)	Thermoplastic Hose and Hose Couplings for Conducting Propane and Natural Gas	Hoses, Couplings	
ASME[10]-B31-1-01	Power Piping	Piping	
ASME-B31.3-99	Process Piping	Piping	
CSA B51-97	Boiler, Pressure Vessel and Pressure Piping Code	Piping	yes
CAN/CGA-12.2-M92 (R1997)	Propane Fuel System Components for Use on Highway Vehicles	Components	
ANSI/AGA[11] NGV3.1-1995/CGA 12.3-M95 (R2000)	Fuel System Components for Natural Gas Powered Vehicles	Components	
CGA G-5.4-2001	Standard for Hydrogen Piping at Consumer Locations	Piping, Components	yes
CGA G-5.5-1966	Hydrogen Vent Systems	Hydrogen Safety	yes
CGA P-7	Standard for Requalification of Cargo Tank Hose used in the Transfer of Carbon Dioxide Refrigerated Liquid	Elastomer Hose	
CGA G-6.6	Standard for Elastomer-Type Carbon Dioxide Bulk Transfer Hose	Elastomer Hose	
CGA V-1	Compressed Gas Association Standard for Compressed Gas Cylinder Outlet Valve and Inlet Connections	Connections	
CGA V-6	Standard Cryogenic Liquid Transfer Connections	Connections	
CGA SB-26	Cylinder Connections on Portable Liquid Cryogenic Cylinders	Connections	
CGA TB-9	Guidelines for the Proper Handling and Use of the CGA 630/710 Series "Ultra High Integrity Service" Connections	Connections	
CAN1-12.4-M84 (R1996)	Dispensing Devices for Propane Fuel for Highway Vehicles	Dispensing	
ANSI/IAS[12] NGV4.1-1999/CSA 12.5-M99	NGV Dispensing Systems	Dispensing	
CGA 12.6-M94 (R1999)	Vehicle Refueling Appliances	Refueling	
ANSI Z21.83-1998	Fuel Cell Power Plants	Fuel Cells	
ANSI/IAS NGV4.2-1999/CSA 12.52-M99	Hoses for Natural Gas Vehicles and Dispensing Systems	Hoses, Dispensing	
ANSI/IAS NGV4.4-1999/CSA 12.54-M99	Breakaway Devices for Natural Gas Dispensing Hoses and Systems	Hoses, Couplings, Dispensing	
ANSI/IAS NGV4.6-1999/CSA 12.56-M99	Manually Operated Valves for Natural Gas Dispensing Systems	Valves	
ANSI/AGA NGV1-1994/CGA NGV1-M1994 (R1999)	Compressed Natural Gas Vehicle (NGV) Fuelling Connection Devices	Refuelling, Connectors	
ANSI/IAS NGV1a-1997/CGA NGV1a-M97 (R1999)	Addendum 1 to ANSI/AGA NGV1-1994/CGA NGV1-M94, Compressed Natural Gas Vehicle (NGV) Fuelling Connection Devices	Refuelling, Connectors	
ANSI/IAS NGV1b-1998/CGA NGV1b-M98 (R1999)	Addendum 2 to ANSI/AGA NGV1-1994/CGA NGV1-M94 and ANSI/IAS NGV1a-1997/CGA NGV1a-M97,Compressed Natural Gas Vehicle (NGV) Fuelling Connection Devices	Refuelling, Connectors	
CAN/ULC[13]-S634-1999	Swivel Hose Connectors	Connectors	

[9] Canadian Gas Association
[10] American Society of Mechanical Engineers
[11] American Gas Association
[12] International Approval Services

ORD[14] (ULC)-C842-1984	Valves	Valves	
CAN/ULC-S620-1999	Valves for Flammable and Combustible Liquids	Valves	
NFPA 496	Standard for Purged and Pressurized Enclosures for Electrical Equipment 1998 Edition	Electrical Safety	yes
NFPA 68	Guide for Venting Deflagrations 1998 Edition	Fire Safety	yes
NFPA 30A	Code for Motor Fuel Dispensing Facilities and Repair Garages 2000 Edition	Fire and Electrical Safety	
UL[15] 21	Standard for Safety for LP-Gas Hose	Hoses	
UL 330	UL Standard for Safety for Hose and Hose Assemblies for Dispensing Flammable Liquids	Hoses	
UL 495	UL Standard for Safety for Power-Operated Dispensing Devices for LP-Gas	Dispensing	
UL 79	Power-Operated Pumps for Petroleum Dispensing Products	Dispensing	
UL 109	Tube Fittings for Flammable and Combustible Fluids, Refrigeration Service and Marine Use	Fittings, Couplings	
UL567	Pipe Connectors for Petroleum Products and LP Gas	Connectors	
UL 569	Pigtails and Flexible Hose Connectors for LP Gas	Connectors	
UL 536	Flexible Metallic Hose	Metallic Hose	
UL 860	Pipe Unions for Flammable and Combustible Fluids and Fire-Protection Service	Connectors	
UL 842	UL Standard for Safety for Valves for Flammable Fluids	Valves	
UL 1238	Control Equipment for Use with Flammable Liquid Dispensing Devices	Dispensing	
CAN/ULC-S644-1990	Emergency Breakaway Fittings	Connectors	
CAN/ULC-S651-2000	Emergency Valves	Valves	
ORD (ULC) –C536-1998	Flexible Metallic Hose	Metallic Hose	
ULC-S606-1963	Hose for Conducting LP-Gas	Hoses	
CAN/ULC-S612-1999	Hose for Flammable and Combustible Liquids	Hoses	
CAN/ULC-S644-1990	Emergency Breakaway Fittings	Connectors	
ULC-S608-1964	Pigtails, Expansion Coils and Flexible Hose Connectors for LP-Gas	Connectors	
ORD (ULC)-C567-1974	Pipe Connectors for Flammable Liquid and LP-Gas	Connectors	
	Regulation, Metering and Safety Devices		
ANSI/IAS PRD 1-1998	Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers	Pressure Relief	
ANSI/IAS PRD 1a-1999	Addendum 1 to ANSI/IAS PRD 1-1998, Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers	Pressure Relief	
CGA G-5.5	Hydrogen Vent Systems	Ventilation	yes
ORD (ULC)-C404-1974	Pressure Indicating Gauges for Compressed Gas Service	Gauges	
ASME-PTC 25-94	Pressure Relief Devices	Pressure Relief	
CGA S-1.1	Pressure Relief Device Standards – Part 1 – Cylinders for Compressed Gases	Pressure Relief	
CGA S-1.2	Pressure Relief Device Standards – Part 2 – Cargo and Portable Tanks for Compressed Gases	Pressure Relief	
CGA S-1.3	Pressure Relief Device Standards – Part 3 – Stationary Storage Containers for Compressed Gases	Pressure Relief	
ORD (ULC)-C144-1975	Pressure Regulating Valves for LP-Gas	Regulators	
UL 25	Meters for Flammable and Combustible Liquids and LP Gas	Metering	
UL 144	LP-Gas Regulators	Regulators	
ORD (ULC)-C25-1992	Meters for Flammable and Combustible Liquids and Propane	Metering	
ORD (ULC)-C407-1975	Compressed Gas Pressure Regulators	Regulators	
	Compliance with Special Codes and Regulations		

[13] Underwriters' Laboratories of Canada
[14] Other Recognized Document
[15] Underwriters Laboratories Inc.

CSA C22.10-99	Canadian Electrical Code, Part I	Electrical Safety	
	National Fire Code of Canada, 1995	Fire Safety	
	National Building Code of Canada, 1995	Building Safety	
	National Plumbing Code of Canada, 1995	Plumbing	
CSA B51-97	Boiler, Pressure Vessel and Pressure Piping Code	Pressure Vessels	yes
CSA-B149.1-00	Natural Gas and Propane Installation Code	Codes	
CSA-B149.2-00	Propane Storage and Handling Code	Codes	
CAN/CSA-B108-99	Natural Gas Fuelling Installation Code	Codes	
CSA-B109-01	Natural Gas for Vehicles Installation Code	Codes	
CSA-149.3-00	Code for the Field Approval of Fuel-Related Components on Appliances and Equipment	Codes	
CSA-B149.5-00	Installation Code for Propane Fuel Systems and Tanks on Highway Vehicles	Codes	
NFPA 50A	Standard for Gaseous Hydrogen Systems at Consumer Sites, 1999 Edition	Safety	yes
NFPA 50B	Standard for Liquefied Hydrogen Systems at Consumer Sites, 1999 Edition	Safety	yes
NFPA 30A	Motor Fuel Dispensing Facilities and Repair Garages	Safety	
NFPA 57	Liquefied Natural Gas (LNG) Vehicular Fuel Systems	Safety	
NFPA 58	Liquefied Petroleum Gas Code	Safety	
NFPA 59	Utility LP-Gas Plant Code	Safety	
NFPA 54	National Fuel Gas Code	Safety	
NFPA 52	Compressed Natural Gas (CNG) Vehicular Fuel Systems	Safety	
CGA G-5	Hydrogen	Safety Summary	yes
Canadian Regulation	General Industry Safety Orders, Group 20, Flammable Liquids, Gases and Vapours, Article 144, Service Stations.	Includes Piping, Valves, Fittings, Plumbing, Fuel Dispensing Systems, Fuel Dispensing Units	
Industry Canada, Weights and Measures S-A-01, ACC-7-E	Device Types for the Purposes of the Accreditation Program	Addresses all types of solid, liquid and gaseous dispensing & metering systems (mass flow and volumetric flow)	

ANNEX II

A PARTIAL LIST OF HYDROGEN FUEL CELL CODES, STANDARDS AND REGULATIONS UNDER DEVELOPMENT (COURTESY AMERICAN PETROLEUM INSTITUTE)

The following table presents a list codes and standards related to hydrogen fuel cell vehicles that are currently under development.

Number	Name	Specialty Area	H_2 Content
NHA[16], Working Group 2	Initiating standards on safety and performance of metal hydride storage containers	Metal hydrides	yes
ISO TC 197, WG	Gaseous hydrogen – Hydrogen generators using the water electrolysis process	Hydrogen production	yes
ICC[17], Section 2209	Gaseous Hydrogen Motor-Vehicle Fuel Dispensing and Generation Stations	Hydrogen fuelling	yes
NFPA, Vehicular Alternative Fuel Systems WG	Will combine NFPA 52, Compressed Natural Gas and NFPA 57, liquefied Natural Gas and include hydrogen fuel.	Hydrogen Fuelling	yes
NFPA 853	Standard for the Installation of Stationary Fuel Cell Power Plants 2000	Fuel Cell Power Plants	yes
NFPA 55	Standard for the Storage, Use and Handling of Compressed and Liquefied Gases in Portable Cylinders (will combine NFPA 50A and NFPA 50B)	Hydrogen Storage	yes
European Integrated Hydrogen Project, Phase II	Draft regulations for uniform provisions concerning liquid and compressed gaseous hydrogen (for UN ECE WP.29)	Draft Regulations	yes
SAE[18] J2600	Compressed Hydrogen Surface Vehicle Refuelling Connection Devices	Hydrogen Fuelling	yes
SAE J22601	Compressed Hydrogen Surface Vehicle Refuelling Communications	Hydrogen Fuelling	yes
SAE J2572	Recommended Practice for Measuring the Fuel Consumption and Range of Fuel Cell Powered Electric Vehicles Using Compressed Gaseous Hydrogen	Fuel Consumption Measurement	yes
SAE J2678	Recommended Practice for General Fuel Cell Vehicle Safety	Hydrogen Safety	yes
SAE J`2679	Recommended Practice for Fuel Systems in Fuel Cell Vehicles	Hydrogen Safety	yes
SAE J2574	Terminology	Hydrogen Fuel Cell Terminology	yes
SAE J2616	Fuel Processor Subsystem Performance Test Standard	Hydrogen Fuel Cells	yes
ISO 6469	Electric road vehicles: Safety specifications	Hydrogen Vehicle Safety	yes
ISO TC 22/SC 21/WG 1	Safety standard on fuel cell powered electric road vehicles	Hydrogen Vehicle Safety	yes
ISO TC 22/SC 21/WG 2	Terminology – Definitions and methods of measurement of energy consumption	Fuel Consumption Measurement	yes
ISO/PWD 17374	Measurement of hydrogen emissions during battery charging from the mains	Hydrogen Safety	yes
ECE[19] Regulation 100 (WG 1 N 75)	Hydrogen emission limitation during procedures of traction battery charging	Hydrogen Safety	yes
ISO TC 197/WG 1	Liquid hydrogen – Land vehicle fuel tanks	Vehicle Fuel Storage	yes
ISO TC 197/WG 5	Gaseous hydrogen blends and hydrogen fuel – service stations and filling connectors	Hydrogen Fuelling	yes
ISO TC 197/WG 6	Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	Vehicle Fuel Storage	yes
ISO TC 197/WG 7	Basic considerations for the safety of hydrogen systems	Hydrogen Safety	yes
JEVA[20], WG 3	Interface standards	Vehicle Fuelling	yes

[16] National Hydrogen Association
[17] International Codes Council
[18] Society of Automotive Engineers
[19] Economic Commission for Europe

JEVA, WG X	Performance standards	Vehicle Performance	yes
JEVA	Hydrogen fuel properties and acceptability	Vehicle Fuel	yes
IEC[21] TC 105/WG 1	Terminology	Vehicle Fuel Cells	yes
IEC TC 105/WG 2	Fuel cell modules	Vehicle Fuel Cells	yes
IEC TC 105/WG 3	Stationary Safety	Vehicle Fuel Cells	yes
IEC TC 105/WG 4	Performance	Vehicle Fuel Cells	yes
IEC TC 105/WG 5	Installation	Vehicle Fuel Cells	yes
IEC TC 105/WG 6	Propulsion	Vehicle Fuel Cells	yes
IEC TC 105/WG 7	Portable Fuel Cells	Vehicle Fuel Cells	yes
ANSI Z21.83	Fuel Cell Power Systems	Vehicle Fuel Cells	yes
CSA	Residential fuel cell power generators, portable fuel cell power generators, fuel cell modules	Fuel Cell Generators	yes
UL 2265	Replacement fuel cell power units for appliances	Fuel Cells	yes
UL 2264	Hydrogen generators	Hydrogen Generators	yes
ASME PTC 50	Performance test code for fuel cell power system performance	Fuel Cells	yes
IEEE[22] SC 21	Interconnection standards	Fuel Cells	

[20] Japanese Vehicle Standards Association
[21] International Electrotechnical Commission
[22] Institute of Electrical and Electronics Engineers