DRAFT PROPOSED CHANGES TO THE IFC – 2002 Code Development Cycle
TO ADD PROVISIONS FOR GASEOUS HYDROGEN
MOTOR-VEHICLE FUEL DISPENSING AND GENERATION STATIONS

Final DRAFT—December 18th, 2001

(Includes modifications approved by the AHC in Houston, TX, Editorial revisions by Staff of 11/13/01, and AHC Conference Call Comments of 12/14/01 to 'DRAFT' dated October 19th, 2001)

F01-02

2209 (NEW: Underlining removed for clarity)

Proponent: Guy Tomberlin, Chair, ICC Ad Hoc Committee for Hydrogen Gas

1. Add new text as follows and re-designate remaining section numbers:

SECTION 2209
HYDROGEN MOTOR-VEHICLE FUEL DISPENSING AND GENERATION STATIONS
[[Allows insertion of NEW 2209, Hydrogen Motor-Vehicle Fuel Dispensing and Generation Stations, as proposed and re-designation of current 2209, Marine Service Stations to a more appropriate location.]]

2209.1 General. Hydrogen motor-vehicle fuel dispensing and generation stations shall be in accordance with this section and Chapter 30. Where a fuel dispensing station also includes a repair garage, the repair operation shall comply with the requirements of this chapter for repair garages.

2209.1.1 Protection from vehicles. Guard posts or other approved means shall be provided to protect hydrogen storage systems; and use areas subject to vehicular damage in accordance with Section 312.

2209.2 Approvals. Equipment used for the storage, generation, compression or dispensing of hydrogen shall be designed for the specific application in accordance with Section 2209.2.1 and Section 2209.2.2.

2209.2.1 Approved equipment. Storage vessels, containers, pressure vessels, cylinders, pressure relief devices, including pressure valves, hydrogen vaporizers, pressure regulators and piping used for gaseous hydrogen systems shall be designed and constructed in accordance with Section 2703, NFPA 50A and NFPA 50B.

2209.2.2 Listed equipment. Hoses, hose connections, compressors, hydrogen generators, dispensers, detection systems and electrical equipment used for hydrogen shall be listed for use with hydrogen. Vehicle-fueling connections shall be listed and labeled for use with hydrogen.

2209.3 Location of dispensing operations and equipment. Generation, compression, storage and dispensing equipment shall be located outdoors, above ground.

Exceptions:

1. Generation, compression, storage or dispensing equipment in buildings of noncombustible construction, as set forth in the *International Building Code*, which are unenclosed for three quarters or more of the building perimeter.

2. Indoor hydrogen generation, compression, storage and dispensing equipment designed and constructed in accordance with Chapter 30. Such indoor locations shall be provided with mechanical ventilation in accordance with the applicable provisions for repair garages in accordance with Section 2210.7.

3. Gaseous hydrogen storage equipment installed in vaults as constructed in accordance with the applicable requirements of Chapter 34 and meeting all of the requirements of Section 2209.3.1. Where fully or partially enclosed, such locations shall be provided with mechanical ventilation in accordance with the applicable provisions for repair garages in accordance with Section 2210.7.

4. Commercial hydrogen vehicle refueling facilities containing less than 2000 scf of hydrogen storage.

2209.3.1 Location on property. In addition to the requirements of Section 2203.1, generators, compression, storage and dispensing equipment shall be located in accordance with Sections 2209.3.1.1 through Section 2209.3.1.5

2209.3.1.1 Outdoor exposures. Outdoor exposures shall require spacing to other fuels, buildings, public areas, or equivalent risks to life safety in accordance with Table 2209.3.1.1.

Exceptions:

1. Hydrogen storage, compression, generation equipment located in fully enclosed, underground vaults located no less than ten feet (10 ft.) from a lot line and constructed in accordance with Exception 3 to Section 2209.3.
2. Closed systems of 3,000 scf hydrogen or less.

TABLE 2209.3.1.1
EQUIPMENT OR FEATURE MINIMUM SEPARATION FOR GASEOUS HYDROGEN DISPENSERS, COMPRESSORS, GENERATORS AND STORAGE VESSELS

SITE FEATURE	DISTANCE (feet)	*REASON* (*Origin or Derivation*)
Building—Noncombustible walls, sprinklered or nonsprinklered	*10*	*NFPA 50A—10 ft.*
Building—Combustible walls, sprinklered or nonsprinklered	*25*[b, e]	*NFPA 50A—10 ft. (for greater than 15,000 scfm storage)*
Building—Noncombustible walls, 2-hour fire barrier interrupts line-of-sight	*5*	—
Off-site sidewalks and on-site/off-site parked vehicles	*15* [a, b]	*NFPA 50A—10 ft. (reasonable interpretation)*
Lot line	*10*[a]	*NFPA 50A – 5ft., NFPA 52—10 ft.*
Air intake openings	*25* [c]	*NFPA 50A—50 ft.*
Wall openings located less than 25 ft. vertically above	*20* [c]	*NFPA 50 A—10 ft.*
Wall openings located greater than 25 ft. vertically above	*25*	*NFPA 50A—25 ft.*
Outdoor public assembly	*25* [a]	*NFPA 50A—50 ft.*
Ignition source [d]	*10*	*NFPA 50A—10 ft.* *Other than "hot work," no other ignition source requirement. People and vehicles are primary ignition sources (i.e., static discharge).*
Flammable or combustible liquid storage—Above ground, diked in accordance with Section 3404.2.9.6.	*20*	*Diking is advantageous.*
Flammable or combustible liquid storage—Above ground, not diked	*50*	*NFPA 50A—50 ft.*
Flammable or combustible liquid storage—Below ground, vent or fill opening	*20*	*NFPA 50A—25 ft.*
Flammable gas storage (non-hydrogen)—Above ground, with common shutoff	*25*	—
Flammable gas storage (non-hydrogen)—Above ground, no common shutoff	*50*	*A common shutoff system is advantageous.*
Combustible waste material (see Section 304.1.1)	*50*	*These materials should not be present presuming the code's General Precautions Against Fire are adhered to.*
Liquefied hydrogen storage—Distance to buildings, openings, lot lines, public ways and on-site/off-site parked vehicles	*25*[a]	*NFPA 52 criteria*

For SI: 1 foot = 304.8 mm.

a. A reduction to 5ft. shall be permitted where a 2-hour fire barrier interrupts the line of sight between the equipment and the exposure. The height of the barrier for vertical tanks shall be no less than one-third of the height of the tank measured vertically, and the length of the wall shall be 1.5 times the maximum diameter of the tank. The height of the barrier for vertical tanks shall be no less than one-third of the height of the tank measured vertically, and the length of the wall shall be 1.5 times the maximum diameter of the tank.

b. A reduction to 0 ft. shall be permitted for dispensing equipment and vehicles being refueled.

c. *Measured along the natural and unobstructed line of travel (e.g., around protective walls, around corners of buildings)*
d. *Ignition source. A flame, spark or hot surface capable of igniting flammable vapors or fumes. Such sources include appliance burner ignitors and hot work such as welding and open flames.*
e. *For storage volume greater than or equal to 15,000 scf.*

2209.3.1.2 Electrical classification. Such installations shall also follow provisions of the National Electrical Code NFPA 70 and applicable provisions of NFPA 497A.

2209.3.1.3 Overhead lines. The proximity to overhead lines shall be as follows:

1. Not less than fifty feet (15.2m) from the vertical plane below the nearest overhead wire of an electric trolley, train or bus line; and

2. Not less than five feet (1524 mm) from the vertical plane below the nearest overhead electrical wire.

2209.3.1.4 Canopies. Dispensing equipment need not be separated from canopies that are constructed in accordance with the International Building Code, in a manner that would prevent the accumulation of hydrogen gas.

2209.3.1.5 Rooftop locations. Gaseous hydrogen generation and storage equipment located on the roofs of buildings shall be supported on masonry, concrete, steel or other approved noncombustible construction; provided that, where such supports are located in the building, the supports shall be afforded a fire resistance rating of 2 hours, but not less than that required by the building type of construction. The roof assembly directly under such equipment shall also be afforded a fire resistance rating of 2 hours, but not less than that required by the building type of construction. Roof top air intakes shall be at least 15 feet from hydrogen storage equipment, be located no higher than the equipment, and shall face away from the equipment. Approved signage having 1-inch (25 mm) block letters shall be affixed at a conspicuous location on the building exterior stating: ROOF TOP HYDROGEN GENERATION AND/OR STORAGE.

2209.4 Private fueling of motor vehicles. Self-service hydrogen-dispensing systems, including key code and card-locked dispensing systems, shall be limited to the filling of permanently mounted fuel containers on hydrogen-powered vehicles.

In addition to the requirements in Section 2210, the owner of a self-service hydrogen-dispensing facility shall provide for the safe operation of the system through the institution of a fire safety plan submitted_ in accordance with Section 404, the training of employees and operators who use and maintain the system in accordance with Section 406, and provisions for hazard communication in accordance with Section 407.

2209.5 Valves. Piping to equipment shall be provided with a, readily accessible manual shut-off valve that is readily identifiable.

2209.6 Emergency shutdown. Emergency shutdown devices shall be located within 75 feet (22860 mm) of, but not less than 25 feet (7620 mm) from, dispensers and hydrogen generators, and shall also be provided in the compressor area. Upon activation, emergency shutdown shall automatically shut off the power supply to all hydrogen storage, compression, dispensing and generating equipment, shut off natural gas or other fuel supply to the hydrogen generator, and close valves between the main supply and the compressor and between the storage containers and dispensing equipment.

2209.7 Emergency venting of hydrogen systems. Hydrogen systems shall be equipped with venting that will relieve excessive internal pressure. Hydrogen systems shall not discharge inside buildings. All portions of the system shall be protected by pressure relieving devices.

2209.7.1 Vent pipe. A vent pipe that will divert the gas flow to atmosphere shall be installed on the vessel for purging operations. The vent pipe shall be designed and constructed as follows:

1. The piping shall be constructed of pipe or tubing materials approved for hydrogen service in accordance with ASME B31.3 for the rated pressure, volume and temperature. The vent piping shall be designed for the maximum back pressure within the pipe, but not less than 335 psig.

2. The vent pipe shall be properly supported and shall be provided with a rain cap or other feature which would not limit or obstruct the gas flow from venting vertically upward.

3. A means shall be provided to prevent water, ice and other debris from accumulating inside the vent pipe or obstructing the vent pipe.

4. Venting of hydrogen gases shall be as follows:

   4.1 The height (H) and separation distance (D) of the vent pipe shall meet the criteria set forth in Table 2209.7.1 for the combinations of maximum hydrogen flow rates and vent stack opening diameters listed; or

   4.2 The maximum emergency purging flow rate shall be specified for verification by the authority having jurisdiction. The maximum emergency purging flow rate shall be the pressure relief device release rate in accordance with CGA S-1.3 for a non-engulfing flame or the maximum on-site production rate, whichever is larger.

   4.3 Where alternative venting arrangements are proposed, an analysis of radiant heat exposures shall be provided showing (in a 30 ft./sec wind); exposures to employees are limited to no more than 1,500 Btuh/ft^2 for a maximum of three minutes, exposures to noncombustible equipment are limited to no more than 8,000 Btuh/ft^2, exposures simulated at the property line are limited to no more than 500 Btuh/ft^2 and that no equipment or personnel within D or H, or any property line within 1.25 D would be exposure to more than one-half of the lower flammable limit (LFL) for hydrogen (2 percent by volume).

5. At the connection fitting of the vent pipe and the hydrogen cylinder, a listed bi-directional detonation flame arrester shall be provided.

TABLE 2209.7.1 HYDROGEN VENT STACK HEIGHT (H) VERSUS DISTANCE (D) REQUIREMENTS

H = Minimum height of vent stack above the ground or above any structure/equipment within distance D where personnel may be present (ft.).

D = Distance to adjacent structure/equipment where personnel may be present (ft.).

HEIGHT AND SEPARATION DISTANCE [a, b, c, d, e]
VERSUS HYDROGEN FLOW RATE AND VENT PIPE DIAMETER

	0-500 SCFM Vent Dia (in.)		500-1000 SCFM Vent Dia (in.)		1,000-2,000 SCFM Vent Dia (in.)		2,000-5,000 SCFM Vent Dia (in.)			5,000-10,000 SCFM Vent Dia (in.)			10,000-20,000 SCFM Vent Dia (in.)	
	1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**3**	**2**	**3**
H (ft.)	8	8	8	8	12	12	17	12	13	25	25	22	36	36
D (ft.)	13	13	15	17	22	26	39	36	40	53	53	53	81	81

For SI: 1 foot = 304.8 mm.

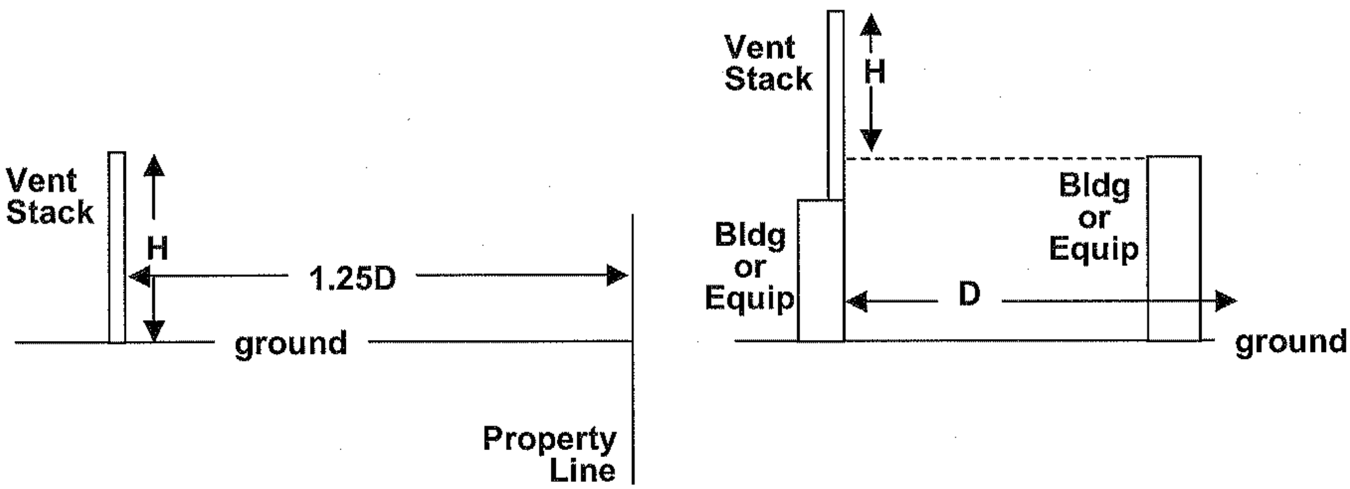
a. Minimum distance to property line is 1.25D.

b. Designs seeking to achieve greater heights with commensurate reductions in separation distances shall be designed in accordance with accepted engineering practice.

c. With this table personnel on the ground or on the building/equipment are exposed to a maximum of 1,500 BTU/hr. ft^2, and are assumed to be provided with a means to escape to a shielded area within three minutes, including the case of a 30 ft./sec. wind.

d. Designs seeking to achieve greater radiant exposures to noncombustible equipment shall be designed in accordance with accepted engineering practice.

e. The analysis reflected in this table does not permit hydrogen air mixtures would to exceed one-half of the lower flammable limit (LFL) for hydrogen (2 percent by volume) at the building or equipment, including the case of a 30 ft./sec. wind.



2209.7.2 Minimum rate of discharge. The minimum rate of discharge of pressure relief devices on the hydrogen storage tanks shall be in accordance with CGA S-1.3–except for the provision in 2209.7.3, or the *ASME Boiler and Pressure Vessel Code*, as applicable.

2209.7.3 Vent pipe flow rates. Where above ground storage of flammable or combustible liquids occurs and the tanks are diked, or no above ground storage of flammable or combustible liquids exists, the sizing of the maximum flow for the vent pipe need not include the vent flow as a result of an "engulfing fire" of the hydrogen storage tanks. The pressure relief valve(s) on the gaseous hydrogen storage tanks shall be sized to accommodate a hydrogen compressor that fails to shutdown or unload as a minimum.

Reason:

Introduction. Hydrogen energy safety is based on three primary elements: regulatory requirements, capability of safety technology and the systemic application of equipment and procedures to minimize risks. Groups involved in the industrial scale production of hydrogen (producers) currently implement many successful proprietary methodologies for safely generating and handling large amounts of hydrogen. Hydrogen users (e.g., NASA) depend on cryo-hydrogen as a fuel and have effectively proven the safety of large scale ground and vehicle systems which support the Space Shuttle Program.

The efforts of the International Code Council Ad Hoc Committee for Hydrogen Gas (AHC) intend to address how future building codes can safely cover hydrogen applications in fuel cell vehicles and hydrogen gas motor-vehicle fuel dispensing and generation stations. The AHC consists of a balanced membership of user, producer and regulatory interests working together with a diverse group of technical and advisory interests to propose changes as necessary to the ICC International Codes. This, and other, related proposals is a summation of their work.

Proposed NEW IFC Section 2209. The United States Department of Energy (DOE), in accordance with the Hydrogen Future Act of 1996, supports a program based on an industry-led cost sharing approach to a dedicated and growing Hydrogen Energy Program. In some markets, agencies of government have mandated that automakers to move ahead with production of alternative fueled vehicles to somewhat off-set the atmospheric implications of an economy almost entirely driven by petroleum-based fuels, and thereby facilitate a shift to the use of renewable energy supplies. Hydrogen is one of those alternative fuels, and the commercial products industry is responding. As more vehicles use alternative fuels, codes will have to be modified to address the safe use, dispensing, storage, and generation of hydrogen fuels. The new criteria proposed as IFC Sections 2209 and 2210.8, along with the existing provisions of IFC Chapter 30, and inclusive of the more specific requirements detailed in this proposal clearly define gaseous hydrogen refueling and generating stations within the scope of the *International Fire Code*.

In many cases the hydrogen fuel is utilized, with air, within a fuel cell to produce electricity and in some cases co-generate heat. Typically, building officials will be faced with two classes of equipment – those that generate hydrogen (for use by other devices) and those that utilize hydrogen as their energy input.

In many cases, hydrogen will be utilized in a manner similar to the current use of natural gas. However, there are two important differences that cause the requirement to amend the ICC codes. First, both hydrogen and natural gas are lighter than air, but hydrogen is lighter than natural gas and is both more diffusive and more buoyant than natural gas. This means that in well-ventilated situations (e.g. outdoors) hydrogen will dissipate more quickly than natural gas, and much more quickly than either propane or gasoline, both of which have fumes that are heavier than air and will linger at an accident site. However, hydrogen and natural gas can both accumulate in unventilated pockets at the top of indoor structures and could represent a risk in such situations. Similarly, propane and gasoline fumes can accumulate at the floor level in unventilated spaces, posing a different risk. Thus ignition sources must be averted at the top of any unventilated spaces for hydrogen and natural gas, while ignitions sources must be precluded near the floor for gasoline or propane vehicles indoors. Second, hydrogen is odorless, colorless and burns with a flame that is not visible to the human eye. This means that it is unlikely that people will be able to detect unsafe conditions (without appropriate instrumentation) if they develop (similar to CO accumulation in a structure).

It is essential that the ICC provide code officials with the necessary tools so that they can continue to ensure public safety as the public sector begins to adopt sources of hydrogen within the energy infrastructure. Therefore, the AHC has detailed a foundation for code requirements which will allow the safe handling and use of hydrogen as a fuel. Throughout their work, the AHC has sought consistency with existing codes and standards wherever possible. Where hydrogen standards in place today, do not cover the full scope of use or range of available or anticipated technologies, the AHC actively worked with a diverse group of technical and advisory parties from industry to establish criteria in the model codes to cover the installation and integration of these technologies with the building or facilities with which they are associated.

It is important to note that a given volume of natural gas has more than three times the energy of the same volume of hydrogen. Therefore, a given volume of pipe containing natural gas will contain the same energy (potential hazard) as a three times larger volume of hydrogen.

The AHC intends that the term “refueling” be interpreted similarly to that defined in the IFC. However, it is not the intent to allow gaseous hydrogen vapors to escape during the refueling operation. Therefore, the AHC supports an approach to interpretation similar to that taken by such standards as ANSI/IAS NGV4.1-1999, NGV Dispensing Systems, NFPA 58-1998, Liquefied Petroleum Gas Code for LPG vehicles, and ANSIZ223.1, Fuel Gas Code for CNG vehicles, when defining the transfer of fuel at the refueling interface.

IFC Section 2209.2. Faced with an ever emerging stream of innovative materials and design methodologies for the use and handling of hydrogen, and the lack of any singular set of established criteria to evaluate, assess or certify specific equipment and components for hydrogen use, the AHC has proposed language not unlike what currently exists in the IFC regarding General Requirements for systems, equipment and processes (IFC Section 2703).

Therefore, the AHC endorses a position where caution is exercised when considering the approval of what—for the time being—may be unlisted and unlabeled equipment used for the storage, generation, compression or dispensing of hydrogen. As with any unlabeled appliance or piece of equipment, approval must be based upon documentation that demonstrates compliance with the appropriate standards or, where no product standards exist, that the appliance is appropriate for the intended use, and will provide the same level of performance as would be provided by a listed and labeled equivalent. The AHC still holds to the fundamental principle of the code where reliance upon the listing and labeling process assures performance, and approvals granted on an “Alternative” basis must be well justified with supporting documentation.

IFC Section 2209.2.1. Design requirements for storage vessels, containers, pressure vessels, cylinders, pressure relief devices, including pressure valves, hydrogen vaporizers, pressure regulators and piping used for hydrogen are directly dependent on the type, conditions of use and quantity of material involved. This section is intended to rely on design requirements for this equipment as referenced in the General Requirements of Chapter 27 and as referenced throughout the *International Fire Code*. Both the design and construction requirements must be approved by the code official where a specific standard is not referenced.

IFC Section 2209.2.2. Similar to associated piping, hoses, hose connections, compressors, hydrogen generators, dispensers, detection systems and electrical equipment used for hydrogen service must be built to approved standards and compatible with the material handled.

The ASME B31.3, *Code for Chemical Plant and Petroleum Refinery Piping* or CGA G-5.4, *Standard for Hydrogen Piping Systems at Consumer Locations* which references ASME B31.3 may be appropriate for design and construction of the piping involved in hydrogen service, and are examples of common standards employed by industry for piping, tubing and associated distribution equipment involving hazardous materials. Though not specifically referenced here, there are other ASME and industry standards providing further guidance and considered appropriate for many aspects of gaseous and liquefied hydrogen systems.

IFC Section 2209.3. The goal of these provisions is to never permit the maximum concentration of flammable contaminants in air to exceed more than 25% of the LFL for hydrogen during the period that a credible leak exists. This can be accomplished using natural or mechanical ventilation, but always to assure adequate ventilation to prevent a hazardous buildup of hydrogen gas in buildings or confined spaces (i.e., underground vaults).

While the opportunity exists for integrated safety features that may reduce the risk involved without the need to install additional apparatus on site emerging technologies will require careful installation in accordance with manufacturer's instructions to ensure the level of safety designed. Accordingly, the AHC has proposed several alternatives to minimize the risk of a hydrogen incident until the technology matures. To the extent that these safety devices become commonplace, the proposed language gives the code official the necessary information to approve and locate generation, compression, storage and dispensing equipment installations.

As identified in Exception Four; Two thousand standard cubic feet of hydrogen is roughly the equivalent quantity of hydrogen stored in one vehicle, and these vehicles will be distributed everywhere and operating without limitations.

In developing the criteria for minimum separation distances depicted in **IFC Table 2209.3.1.1**, the AHC consulted with hydrogen producers, and their corresponding gas and equipment group—engineering safety departments. The AHC also sought consistency with existing codes and standards wherever possible and in the best interest to safety personnel, fire departments, code officials and other emergency personnel. This included a review of the National Fire Protection Association's *Standard for Gaseous Hydrogen Systems at Consumer Sites* (NFPA 50A), *Standard for Liquefied Hydrogen Systems at Consumer Sites* (NFPA 50B), and *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems* (NFPA 52). (See discussion to Table 2209.3.1.1 included in the body of the proposed table and also reasons to IFC Section 2209.7 and Subsections)

Note that both NFPA 50A and 50B are limited in scope as they apply to gaseous and liquified hydrogen systems for which the hydrogen supply to the consumer site originates outside the consumer premises (i.e., as delivered by mobile equipment). The standards therefore, do not apply to hydrogen manufacturing plants or other establishments operated by a hydrogen supplier or the supplier's agent for the purpose of storing hydrogen and refilling portable containers, trailers, mobile supply trucks, tank cars or motor vehicles.

It is this realization that further demonstrates the need for the efforts of the AHC for Hydrogen Gas as they intend to address how future building codes can safely cover hydrogen applications in fuel cell vehicles and motor-vehicle fuel dispensing and generation stations. The vision of such fuel dispensing and generation stations will likely take form and function as a "self-sustaining" facility, capable of operating independently of other energy sources for two to three days at a time, using fuel stored in an underground tank. A 5-kW (AC) stationary fuel cell power plant would use natural gas, hydrogen or naphtha fuel, to supply the station with its electricity. In the event of a natural disaster, such as an earthquake, hurricane, tornado or flood, these stations will be able to supply hydrogen, oil or even gasoline for emergency operations and other critical use needs.

IFC Section 2209.4. This provision provides commensurate regulations for the use (dispensing) of gaseous hydrogen. The dispensing facility owner must demonstrate minimum competency and control of the dispensing of hydrogen including training and supervision for the employees and operators that use and maintain the system.

IFC Section 2209.5. To prevent spillage and to allow servicing of equipment a remote accessible manual shutoff valve must be installed. This valve is independent of the emergency shutdown equipment required in Section 2209.6.

IFC Section 2209.6. Two emergency shutdown devices must be installed, one in the compressor area and the other no closer than 25 feet (7620 mm) nor farther than 75 feet (22 860 mm) from the dispenser. These devices must shut down the power supply to the compressor and close the valves leading to and from the compressor and those between the storage containers and the dispensers in the event of an emergency. In fact, the gaseous hydrogen system may be located more than 300 ft. from the dispensing operation, but activation of any one device would activate total shutdown of all generation and dispensing operations on site

IFC Section 2209.7 and Subsections.
Emergency venting will ensure that there are no excessive buildups of pressure in the system and that the gas will be vented to the outside. In developing provisions for the venting of hydrogen systems the AHC consulted with hydrogen

producers, and their corresponding gas and equipment group—engineering safety departments. In general, four general hydrogen design considerations are included in the design of all hydrogen process vent piping: 1) Vent to a safe area, 2) Ignition likely, 3) Design for thermal radiation from flame, and 4) Design to prevent (un-ignited) flammable mixtures from reaching personnel areas and ignition sources. While these considerations are general in nature and intended for use by designers, fabricators, installer, users and maintainers of hydrogen piping systems, the AHC also sought consistency with existing codes and standards wherever possible and in the best interest to safety personnel, fire departments, code officials and other emergency personnel. This included a review of the Compressed Gas Association's *Standard for Hydrogen Piping Systems at Consumer Locations*, CGA G-5.4. CGA G-5.4 specifies that piping systems should be designed in accordance with ASME B31.3, *Chemical Plant and Petroleum Refinery Piping*.

Reference is made to radiant heat exposure data as developed by the gas and equipment group—engineering safety department of Air Products and Chemicals, Inc., one of the world's largest combined gases and chemicals company. The analysis of radiant heat exposures reflected in Table 2209.7.1 is based on *Jet Dispersion-Flammability Plume Centerline Profiles* (Elevation vs. Center-Line Distance) depicting radiation exposure and an LFL limits in a 30 ft./sec (20.5 mph) wind, and having a factor of safety (FS) of 1.3 (see examples of *Jet Dispersion-Flammability Plume Centerline Profiles* attached). Wherever possible, exposures to employees are limited to no more than 1,500 Btuh/ft^2, with exposures to combustible equipment limited to no more than 8,000 Btuh/ft^2, and exposures simulated at the property line limited to no more than 500 Btuh/ft^2 (Maximum radiant exposure criteria taken from American Petroleum Institute's API 521, *Guide for Pressure-Relieving and Depressurizing Systems*, 2nd Ed., 1982). Furthermore, the analysis reflects conditions where no equipment or personnel within distance (D), or any property line within 1¼ D would be exposed to more than one-half of the lower flammable limit (LFL) for hydrogen (2 percent by volume).

Also a consideration in the AHC's work, is the most modern view of many members of the CGA S-1.1 Committee (CGA S-1.1, Pressure Relief Device Standards—Part 1—Cylinders for Compressed Gases) which will most likely be reflected in the next edition of CGS A-1.1:, and that is: "The 'engulfing fire case' shall not be included in the approach to hydrogen safety." Therefore, the AHC has adopted the intent that it is far more effective to mitigate the risk of an engulfing fire through diking, rather than address the concept of the maximum hypothetical accident (including hydrogen and other fuels on site) directly. Typically the normal sizing of PRD's for other demands (e.g., a runaway hydrogen compressor) is much smaller than the engulfing fire case, hence the height and distances criteria for the vent stack are easier to accommodate without truly sacrificing safety. Under such circumstances, the pressure relief devices would be sized at or above the maximum compressor flow rate. Hence the minimum vent flow rate to be used in Table 2209.7.1 to meet the thermal radiation and unignited vapor criteria would be the nameplate rating of the hydrogen compressor.

In Summary. The AHC has developed these changes through the consultation of a diverse group of technical and advisory parties from a variety of interests representing the hydrogen community, inclusive of industry, professional associations, testing laboratories, agencies of government, academic and research institutions and believes it important to provide a template for thorough coverage in the International Codes of equipment, appliances and vehicles that will utilize hydrogen as a fuel. The effort affords regulators a sound technical basis on which to verify installation and to uphold the standard of health and safety for the citizens of their jurisdictions.

Industry is ready to commercialize systems fueled predominantly using hydrogen energy. The AHC urges your APPROVAL of this proposal "as submitted".

Public Hearing:	Committee:	AS	AM	D
	Assembly:	ASF	DF	

F02-02

2210 (NEW: Underlining removed for clarity)

Proponent: Guy Tomberlin, Chair, ICC Ad Hoc Committee for Hydrogen Gas

1. Add new text as follows and re-designate remaining section numbers:

SECTION 2210
REPAIR GARAGES

2210.8 Defueling of hydrogen from motor vehicle fuel storage containers. The discharge or defueling of hydrogen from motor vehicle fuel storage tanks for the purpose of maintenance, cylinder certification, calibration of dispensers or other activities shall be in accordance with Section 2210.8.1

2210.8.1 Methods of discharge. The discharge of hydrogen from motor vehicle fuel storage tanks shall be accomplished through a closed transfer system in accordance with Section 2210.8.1.1 or an approved method of atmospheric venting in accordance with Section 2210.8.1.2

2210.8.1.1 Closed transfer system. A documented procedure that explains the logic sequence for discharging the storage tank shall be provided to the code official for review and approval. The procedure shall include what actions the operator will take in the event of a low-pressure or high-pressure hydrogen release during discharging activity. Construction documents shall be provided illustrating the arrangement of piping, regulators and equipment settings. The construction documents shall illustrate the piping and regulator arrangement and shall be shown in spatial relation to the location of the compressor, storage vessels and emergency shutdown devices.

2210.8.1.2 Atmospheric venting of hydrogen from motor vehicle fuel storage containers. The discharge of hydrogen from motor vehicle fuel storage tanks for the purposes of maintenance, cylinder certification, calibration of dispensers or other activities shall be in accordance with Sections 2210.8.1.2.1 through 2210.8.1.2.4.

2210.8.1.2.1 Defueling equipment required at vehicle maintenance and repair facilities. All facilities for repairing hydrogen systems on hydrogen vehicles will have a facility to defuel the vehicle storage tank(s). Vehicle storage tanks for defueling to a vent pipe shall be connected to the vent pipe by way of equipment supplied by the vehicle manufacturer. The rate of flow shall not exceed 1,000 scfm (2.5 kg/min) and shall be controlled via the supplied equipment, at low pressure and without adjustment. The vent pipe for defueling shall not be used for or flow into a vent pipe for any other purpose. The defueling vent pipe shall have a diameter of 1 inch and terminate in accordance with Section 2209.7.1; with a minimum height (H) of at least 8 ft. and a minimum distance (D) to exposures of 15 ft. The minimum design pressure of the vent piping shall be 335 psig.

2210.8.1.2.2 Construction documents. Construction documents shall be provided illustrating the location of the means for vessel support, piping, the method of grounding and bonding, and other requirements specified herein.

2210.8.1.2.3 Tank and cylinder stability. A method of rigidly supporting the vessel during the discharge or defueling of hydrogen shall be provided. The selected method shall provide not less than two points of support and shall prevent the horizontal and lateral movement of the vessel. The system shall be designed to prevent the movement of the vessel based on the highest gas-release velocity through valve orifices at the vessel's rated pressure and volume. The structure or appurtenance shall be constructed of noncombustible materials as set forth in the *International Building Code.*

2210.8.1.2.4 Grounding and bonding. The structure or appurtenance used for supporting the vessel shall be grounded in accordance with the *ICC Electrical Code*. The valve of the vehicle storage tank shall be bonded prior to the commencement of discharge or defueling operations.

2210.8.2 Repair of hydrogen piping. Piping systems containing hydrogen shall not be opened to the atmosphere for repair without first purging the piping with an inert gas to achieve one percent hydrogen or less by volume. Defueling operations and exiting purge flow shall be vented in accordance with Section 2210.8.1.2.

2210.8.3 Purging. Each individual manufactured component of a hydrogen generating, compression, storage, or dispensing system shall have a label affixed as well as a description in the installation and owners manuals describing the procedure for purging air from the system during start-up, regular maintenance and for purging hydrogen from the system prior to disassembly (to admit air).

For the interconnecting piping between the individual manufactured components the pressure rating must be at least 20 times the absolute pressure present in the piping when any hydrogen meets any air. [Example: hydrogen meets air in an interconnecting pipe at 3 psig. 3 psig is 17.5 psia. The minimum pressure rating of the pipe would have to be 20 x 17.5 = 350 psia or 335 psig.]**2210.8.3.1 System purge required.** After installation, repair or maintenance, the hydrogen piping system shall be purged of air in accordance with the manufacturer's procedure for purging air from the system.

302.1.1

3. Revise IBC as follows:

Table 302.1.1
INCIDENTAL USE AREAS

ROOM OR AREA	SEPARATION
Hydrogen defueling and discharge rooms	2-hour fire barriers and floor-ceiling assemblies.

Reason:

Introduction. Hydrogen energy safety is based on three primary elements: regulatory requirements, capability of safety technology and the systemic application of equipment and procedures to minimize risks. Groups involved in the industrial scale production of hydrogen (producers) currently implement many successful proprietary methodologies for safely generating and handling large amounts of hydrogen. Hydrogen users (e.g., NASA) depend on cryo-hydrogen as a fuel and have effectively proven the safety of large scale ground and vehicle systems which support the Space Shuttle Program.

The efforts of the International Code Council Ad Hoc Committee for Hydrogen Gas (AHC) intend to address how future building codes can safely cover hydrogen applications in fuel cell vehicles and hydrogen gas motor-vehicle fuel dispensing and generation stations. The AHC consists of a balanced membership of user, producer and regulatory interests working together with a diverse group of technical and advisory interests to propose changes as necessary to the ICC International Codes. This, and other, related proposals is a summation of their work.

IFC Section 2210.8. Because of the emerging attraction of alternative fuels and the differences in their properties, repair garages must be designed for the anticipated vehicles and the materials fueling them. This section includes the provisions for many different fuels, including lighter-than-air fuels. Accordingly, if a repair garage makes hydrogen, a lighter-than-air fuel, available for dispensing to motor vehicles, the repair garage must also meet the applicable requirements and compensating hazard mitigation criteria for a repair garage servicing hydrogen-fueled vehicles.

IFC Section 2210.8.1. Under consultation with the Society of Automotive Engineers, the AHC has continued to monitor the progress of the Society's Safety and Interface working groups as affiliated with SAE's Strategic Alliance to Develop Fuel Cell Vehicle Standards. "Best practice" procedures under consideration by SAE and noted by the AHC in their recommendations include both General Vehicle (e.g., crash-worthiness, vehicle immersion, hazards leading to failure, common-mode failures, grounding locations, visual recognition of vehicles, etc.) and General Safety (e.g., design for leakage, detection of leakage, protection from debris, design of vents, short- vs. long-term parking scenarios, and underground/enclosed parking) criteria.

The SAE's Safety Working Group intends to standardize the defueling connections on vehicles as well as the means to limit the defueling flow to 1,000 scfm at 5,000 psig storage pressure.

Provisions for limiting the use of the defueling vent pipe result from safety concerns and risk of backflow from any other venting into the defueling area.

The minimum vent pipe heights (H) and separation distances (D) will provide safe radiation levels and unignited hydrogen concentrations without ignition.

IFC Section 2210.8.3 places the burden of purging requirement on the equipment manufacturer. Commensurately, these requirements can be verified by the code official before, during and after installation. Requirements for rating the interconnecting piping at 20 times the initial pressure assures that a detonation will not rupture the vent piping.

In Summary. The AHC has developed these changes through the consultation of a diverse group of technical and advisory parties from a variety of interests representing the hydrogen community, inclusive of industry, professional associations, testing laboratories, agencies of government, academic and research institutions and believes it important to provide a template for thorough coverage in the International Codes of equipment, appliances and vehicles that will utilize hydrogen as a fuel. The effort affords regulators a sound technical basis on which to verify installation and to uphold the standard of health and safety for the citizens of their jurisdictions.

Industry is ready to commercialize systems fueled predominantly using hydrogen energy. The AHC urges your APPROVAL of this proposal “as submitted”.

Public Hearing:	Committee:	AS	AM	D
	Assembly:	ASF	DF	