CODE CHANGE PROPOSALS TO THE INTERNATIONAL BUILDING CODES ON HYDROGEN

PRESENTER: Guy Tomberlin, Chairman
ICC AD HOC Committee on Hydrogen

TARGET AUDIENCE: Interested parties on introduction of Hydrogen infrastructure into the model building codes

DATE/TIME: Wednesday, May 29, 2002. 1:30 pm

LOCATION: Fuel Cell Summit VI, University of Maryland Inn and Conference Center

PURPOSE: Introduce and discuss code change proposals submitted to the International Code Council family of codes on Hydrogen technology

OBJECTIVES:

As a result of this presentation participants will be able to:

- Identify code change proposals that were heard at the International Code Hearings in Pittsburgh PA, April 2002.
- Determine technical accuracy and merit of code change proposals to emerging hydrogen technologies.
- Understand the process for the proposals that will be heard in Fort Worth, Texas. September 29 – October 4, 2002.
- Develop support and understanding of code change proposals.
- Identify and offer enhancement suggestions to current proposals.

OUTLINE:

- Description of the International Code Change process.
- Overview of code change proposals provided in handout.
- Interactive discussion.

within the flammable range is added to the list of items that are not within the scope of the code.

Current items #3 and #4 are out of place in a list of items covered and are better stated in a text paragraph as explanatory material.

The proposed revision divides the current text into separate piping and equipment categories as suggested by current text. The list of "not covered" items is converted to a separate subsection for consistency with the text style of the code.

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

FG2-02
101.2

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

1. Revise as follows:

SECTION 101 (IFGC)
GENERAL

101.2 Scope.
This code shall apply to the installation of fuel gas piping systems, fuel gas utilization equipment, and related *accessories as follows:*

1. Coverage of piping systems shall extend from the point of delivery to the connections with gas utilization equipment. (See "point of delivery".)

2. Systems, <u>other than hydrogen systems</u>, with an operating pressure of 125 psig (862 kPa gauge) or less.

   Piping systems for gas-air mixtures within the flammable range with an operating pressure of 10 psig (69 kPa gauge)

   LP-Gas piping systems with an operating pressure of 20 psig (140 kPa gauge) or less.

3. Piping systems requirements shall include design, materials, components, fabrication, assembly, installation, testing, inspection, operation, and maintenance.

4. *Requirements for gas utilization equipment and* related accessories shall include installation, combustion and ventilation air and venting.

<u>5. Gaseous hydrogen systems shall be regulated by Chapter 7.</u>

This Code shall not apply to the following:

1. Portable LP-Gas equipment of all types that are not connected to a fixed fuel piping system.

2. Installation of farm equipment such as brooders, *dehydrators, dryers, and irrigation equipment.*

3. Raw material (feedstock) applications except for piping to special atmosphere generators.

4. Oxygen-fuel gas cutting and welding systems.

5. Industrial gas applications using gases such as acetylene and acetylenic compounds, hydrogen, ammonia, carbon monoxide, oxygen, and nitrogen.

6. *Petroleum refineries, pipeline* compressor or pumping stations, loading terminals, compounding plants, refinery tank farms, and natural gas processing plants.

7. Integrated chemical plants or portions of such plants where flammable or combustible liquids or gases are produced by chemical reactions or used in chemical reactions.

8. LP-Gas installations at utility gas plants.

9. *Liquefied natural gas (LNG) installations.*

10. Fuel gas piping in power and atomic energy plants.

11. Proprietary items of equipment, apparatus, or instruments such as gas generating sets, compressors, and calorimeters.

12. LP-Gas equipment for vaporization, gas mixing, and gas manufacturing.

13. Temporary LP-Gas piping for buildings under construction or renovation that is not to become part of the permanent piping system.

14. Installation of LP-Gas systems for railroad switch heating.

15. Installation of <u>hydrogen gas,</u> LP-Gas and compressed natural gas (CNG) systems on vehicles.

16. Except as provided in Section 401.1.1, gas piping, meters, gas pressure regulators, and other appurtenances used by the serving gas supplier in the distribution of gas, other than undiluted LP-Gas.

17. Building design and construction, except as specified herein.

18. Portable fuel cell appliances that are neither connected to a fixed piping system nor interconnected to a power grid.

SECTION 202 (IFGC)
GENERAL DEFINITIONS

FUEL GAS. ~~A natural, manufactured, liquefied petroleum or a mixture of these~~ Fuel gases include: natural gas, manufactured gas, liquefied petroleum gas, hydrogen gas and mixtures of these gases.

2. Add new text as follows:

GASEOUS HYDROGEN SYSTEM. An assembly of piping, devices and apparatus designed to generate, *contain, distribute or transport hydrogen in the* gaseous form and hydrogen-containing mixtures having a minimum of 5% hydrogen gas by volume. Such systems can consist of a compressed gas container or containers, reactors and appurtenances, including pressure regulators, pressure relief devices, manifolds, pumps, compressors and interconnecting piping and tubing and controls.

PORTABLE FUEL CELL APPLIANCE. A fuel cell generator of electricity, which is not fixed in place. A portable fuel cell appliance utilizes a cord and plug connection to a grid-isolated load and has an integral fuel supply.

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 Revisions to IFGC Section 101.2—Scope. The commercial products industry is moving toward the use of hydrogen in vehicles, generators and equipment to replace petroleum-based fuels in order to reduce atmospheric emissions and facilitate a shift to the use of renewable energy supplies. Furthermore, the commercialization of fuel cells, and the goal of sustainable development has propelled hydrogen supply technology to the forefront of clean energy applications for transportation and distributed and regenerative electric power.

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 such as a stationary fuel cell (as covered in the IFGC-§633, IMC-§924 and IRC-§M1903.1) or portable fuel cell appliances (as addressed in the IMC-§106.2 and IRC-§R105.2).

With regard to proposed Exception 18, the AHC feels that the reason to support this proposed change and related changes to the IMC (M1-01 Item 1, Approved as Submitted 11-0) and the IRC-Pluming/Mechanical (M1-01 Item 2, Approved as Submitted 8-0) approved during last year's cycle remains valid. Two specific stationary fuel cell power plant designs are commercially available now. An ANSI Z21.83 Standard exists for these stationary power plants and has been adopted by reference in the 2000 IMC and the 2001 Supplement to the 2000 IFGC. Regardless of the adoption and implementation of these standards and codes, the vast majority of building regulatory authorities in the U.S. has yet to see a stationary fuel cell or consider approving an installation.

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 important that the ICC provide building 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 (see "Comparison of Motor Fuels" attached).

The revisions proposed to Section 101.2 along with the more specific requirements detailed in this proposal clearly define gaseous hydrogen within the scope of the International Fuel Gas Code (IFGC), and allow gaseous hydrogen to be stored and generated indoors not unlike natural gas, provided specific safeguards are implemented. All portions of the system are designed to be fail safe to provide adequate safety under "worst case" conditions.

Proposed Definitions to IFGC Section 202, FUEL GAS. The AHC believes the current definition in the IFGC for FUEL GAS to be a potential source of nonuniform interpretation and nonuniform enforcement if this code were to cover gaseous hydrogen as a fuel gas. The current form of the definition reads as follows: *FUEL GAS. A natural, manufactured, liquefied petroleum or as a mixture of these.* The proposed definition adds clarity and is consistent with NFPA 54/ANSI Z223.1 National Fuel Gas Code (a.k.a., IFDS) which defines gases as follows: *GASES -- Include natural gas, manufactured gas, liquefied petroleum (LP) gas in the vapor phase only, liquefied petroleum gas-air mixtures, and mixtures of these gases, plus gas-air mixtures within the flammable range, with the fuel gas or the flammable component of a mixture being a commercially distributed product.* Through reasonable interpretation of the code text, the term "manufactured" as it pertains to gas, could be construed as applying to hydrogen. Alternatively, the word "hydrogen" or the phraseology "gas-air mixtures within the flammable range," could secure the same intent in the current form of the code.

GASEOUS HYDROGEN SYSTEM. Section 202 currently does not define GASEOUS HYDROGEN SYSTEM. In as much as the IFGC by interpretation applies to Hydrogen and would explicitly apply with the clarification provided in the prior definition proposed for FUEL GAS, it is imperative that the proposed definition be added to the IFGC. This definition is derived from the IFC Compressed Gases and NFPA 50A. It is the International Code Council Ad Hoc Hydrogen (H2) Committee's intent that appurtenant systems apply to natural gas piping, hydrogen de-sulfurizers, etc., necessary to support operation of the gaseous H_2 system.

PORTABLE FUEL CELL APPLIANCE Portable fuel cell appliances are quickly reaching their deployment potential and will be commercially available from neighborhood hardware and appliance stores shortly. To the extent that these devices become permanent, a reference to the exception and definition in the code specific to portable fuel cell appliances will provide the code official the necessary information to discern whether these appliances and their associated equipment are "stationary," as subject to the provisions of the IFGC or "portable," and therefore exempt.

In their reason for disapproval the 2001 IFGC Code Development Committee cited an inherent understanding on behalf of all code users that the IFGC does not intend to address "portable" appliances. The presumption that all code users hold this view as self evident, especially as it pertains to emerging fuel cell technologies, does nothing to assist building regulatory officials who enforce the IFGC to assess fuel cell installations proposed in their jurisdictions. Furthermore, if this view is indeed self evident, is there a need for existing Exceptions 1), 2), 4), and 15) to IFGC Section 101.2 as they pertain to "portable" LP-Gas equipment, farm equipment, welding systems, and vehicles, respectively?

In Summary. The AHC has developed these changes through the consultation of a diverse group of technical and advisory parties from various parties in 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 such that regulators have 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 hydrogen energy systems. The AHC urges your APPROVAL of this proposal "as submitted".

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

FG3-02

Proponent: John Terry, Chair; representing the International Existing Building Code Drafting Committee

1. Revise as follows:

102.2.1 Existing buildings. Additions, alterations, renovations or repairs related to building or structural issues shall be regulated by the *International* <u>*Existing*</u> *Building Code*.

102.4 Additions, alterations or repairs. ~~Additions, alterations, renovations or repairs to installations shall conform to that required for new installations without requiring the existing installation to comply with all of the requirements of this code. Additions, alterations or repairs shall not cause an existing installation to become unsafe, hazardous or overloaded.~~

~~Minor additions, alterations, renovations and repairs to existing installations shall meet the provisions for new construction, unless such work is done in the same manner and arrangement as was in the existing system, is not hazardous and is approved.~~

provision is less restrictive than the conditions or the listing of the equipment or appliance or the manufacturer's installation instructions, the conditions of the listing and the manufacturer's installation instructions shall apply.

Unlisted appliances approved in accordance with Section 301.3 shall be limited to uses recommended by the manufacturer and shall be installed in accordance with the manufacturer's installation instructions, the provisions of this code and the requirements determined by the code official.

Reason: The proposed change will bring uniformity to the ICC codes. The proposed text is found in Section 304.2 of the IMC and the 2002 Supplement Section 301.7 of the IPC.

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

FG15-02
305.2

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

1. Revise as follows:

305.3 (Supp) Elevation of ignition source. Equipment and appliances having an ignition source shall be elevated such that ~~the source of ignition~~ ignition source is not less than 18 inches (456 mm) above the floor in hazardous locations and public garages, private garages, repair garages, automotive service stations and parking garages where flammable liquids or flammable gases heavier than air are present. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exception: Elevation of the ignition source is not required for appliances that are listed as flammable vapor resistant and for installation without elevation.

2. Add new text as follows:

305.4 Hydrogen Generating and Refueling Operations. In rooms or spaces that contain hydrogen generating or refueling systems, equipment and appliances having an ignition source shall be located such that the ignition source is not less than 24 inches (457 mm) below the ceiling in hazardous locations and public garages, private garages, repair garages, automotive service stations and parking garages. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exception: This section shall not apply where rooms or spaces that contain hydrogen generating or refueling systems are ventilated in accordance with Section 502.15 of the *International Mechanical Code* and one of the following:

1. The ventilation system shall be designed to maintain the maximum concentration of flammable gas below 25 percent of the lower flammability limit of the substance for the expected room temperature; or

2. Continuous ventilation shall be provided at a rate of not less than 1 cubic foot per minute per square foot [(0.0051m3/(s x m2)] of floor area of the room.

305.4.1 Natural Ventilation. Rooms or spaces located underneath or adjacent to habitable space and intended for hydrogen generating or refueling operations shall be provided with mechanical ventilation as required by the exception to Section 305.4 or shall communicate with the outdoors in accordance with Sections 305.4.1.1 through 305.4.1.2. The minimum cross-sectional dimension of air openings shall be 3 in. (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect.

305.4.1.1 Two openings. *Two permanent openings,* one commencing within 12 inches (305 mm) of the ceiling of the garage, and one commencing within 12 inches (305 mm) of the floor of the garage, shall be provided. The openings shall communicate directly with the outdoors. Each opening shall directly communicate with the outdoors horizontally, and have a minimum free area of ½ square foot per 1,000 cubic feet of garage volume.

305.4.1.2 Louvers and grilles. In calculating free area required by Section 305.4.1.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have 25 percent free area and metal louvers and grilles will have 75 percent free area. Louvers and grilles shall be fixed in the open position.

305.4.2 Specially engineered installations. As an alternative to the provisions of Section 305.4.1, the necessary supply of air for, ventilation and dilution of flammable gases shall be provided by an approved engineered system.

Reason:

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.

IFGC Section 305.2. Ventilation, whether natural or *mechanical, cannot remove all risk from combustible gas leaking* into a garage. Based on ongoing research into the dispersion characteristics of gaseous hydrogen, and conducted at the University of Miami, Coral Gables, ½ square foot of opening area per 1,000 cubic feet of garage volume greatly reduces risk, assuming upper and lower openings of approximately equal areas are used. In addition, relying entirely on natural (i.e., passive) ventilation, the ventilation exchange rate increases with increasing hydrogen concentration due to the buoyancy of hydrogen. This is in contrast to mechanical (i.e., active) ventilation, which remains at a constant rate despite any change in hydrogen concentration.

The following is a comparison of a ventilated garage with an unventilated garage, for three leakage rates. The leakage rates were 1.0, 4.0 and 13.0 SCFM. It should be stated clearly that the findings of the University of Miami are based on leakage at the refueling interface and not the vehicle fuel tank. The AHC feels this is a reasonable assumption given the very real potential for the future installation of remote home gaseous hydrogen refueling appliances.

The comparisons of hydrogen accumulation in the garage show the reduction in risk with garage ventilation. The comparisons were made after 20 minutes of leakage. If a garage has openings, the hydrogen accumulation has reached relative equilibrium after 20 minutes and does not continue to increase appreciably with time. If a garage is not ventilated the hydrogen will continue to accumulate with time and eventually produce a hazardous environment.

The two garages, in Figures C1 through C6, are identical with the exception that the first garage did not have an upper opening. Both garages have lower openings, which spanned the bottom of the garage door. The openings were sized at ½ ft^2/1000 ft^3 of garage volume. The leak was assumed to occur at the vehicle-filling interface, as this type of leakage is difficult to detect. The filling interface was located on the rear passenger side fender. The garage was 9 feet 2.5 inches high by 12 feet 2 inches wide by 21 feet long.

Figures C1 and C2 show the results of hydrogen leaking at 1 SCFM for 20 minutes. The garage without an upper opening is shown in figure C1. The red lines are a surface of constant 4.1% concentration. 4.1% concentration is the lean limit of combustion for hydrogen. It can be seen that a layer of burnable gases approximately 9 inches thick were trapped against the garage ceiling. The blue lines represent a surface of constant 0.82% hydrogen (20% of the lean limit of combustion). They exist down to a level approximately 28 inches below the ceiling. The result of using both lower and upper openings can be seen in figure C2. No appreciable burnable (4.1% hydrogen concentration) gases exist in the garage and the gases, which are richer than 20% of the lean limit of combustion, are only 21 inches thick. As the leak continues the upper garage will continue to fill with greater amounts of hydrogen while lower garage will stay at a relatively constant concentration.

As seen in figure C3 and C4, a 4.0 SCFM leak of hydrogen produces a burnable mixture in both garages. The layer of burnable gases in the lower garage (figure C4 with upper and lower openings) was about 11.0 inches thick, as opposed to 34 inches thick, and contained less than 1/10 the energy of the upper garage (figure C3). The severity of an accident would be substantially reduced by the lower energy content of the burnable gases in figure C4. The buoyancy of hydrogen created an 83 SCFM ventilation rate in the garage in figure C4.

As seen in figure C5, a 20-minute 13.0 SCFM leak of hydrogen almost completely filled the garage with a burnable mixture if no upper opening was provided. The ventilated garage (figure C6) contained a burnable layer approximately 22 inches thick. This was noticeably less than in the unventilated garage with a 4 SCFM leak (figure C4) and contained less than half the energy. The buoyancy of hydrogen created a 123 SCFM ventilation rate in the garage in figure C6.

The SAE Fuel Cell Vehicle (FCV) Standards Committee has been monitoring and contributing to the work of the AHC and is are aware of the AHC's decision to require additional natural or mechanical ventilation ONLY in rooms or spaces intended for hydrogen generating or refueling operations. To be explicitly clear it is NOT the intent of the AHC to require additional natural or mechanical ventilation in areas solely dedicated to the parking/storage of hydrogen-fueled vehicles (i.e., where no hydrogen generating or refueling operation is present).

Therefore, to inform the U.S. Building Regulatory Community of measures the SAE Fuel Cell Vehicle (FCV) Standards Committee plans to take to ensure safety, the Safety Working Group of the SAE FCV Standards Committee is currently preparing two "recommended practices". The following recommendations have been incorporated into drafts of these standards to address hydrogen safety for the situation cited above:

1. Fuel systems will be designed and built to appropriate standards and leak tested to demonstrate integrity.

2. Performance-based requirements related to parking an FCV in a single-bay residential garage have been established. The standard requires validation testing in a garage with very low natural ventilation (of only 0.2 air exchanges per hour) to ensure that the vehicle is normally capable of being safely stored in a residential garage.

3. The vehicle manufacturer (VM) is required to perform a Failure Mode and Effects Analysis (FMEA) for the vehicle. If a single failure could lead to hazardous event, the vehicle manufacturer is required to either modify the system to preclude the failure mode, add failsafe or redundant design measures to prevent the failure, or improve the integrity of components and systems such that risks of these failures are acceptably minimal.

4. If the vehicle manufacturer (VM) is unable to meet any of the above requirements, then the VM shall caution the owner/operator of the vehicle of any operating or parking restrictions.

SAE trusts that the U.S. Building Regulatory Community will find these measures suitable for product introduction. As operating experience is accrued with these new types of vehicles, both SAE and the ICC may need to reassess the situation and provide additional measures for FCV safety as necessary.

Thus, in crafting the proposed language specific to ventilation, the AHC has reviewed the findings of the University of Miami and takes the position that existing provisions for mechanical ventilation of residential garages are not enforced. In concert with these findings and our confidence in the SAE Safety Working Group's investigations into failure mode analyses for hydrogen-fueled vehicle design, the AHC has recommended both natural and mechanical ventilation alternatives for private garages located underneath living space and intended for hydrogen generating or refueling operations. For the natural ventilation alternative, the proposed ½ ft.^{2} of net free area per 1,000 cubic feet of garage floor area represents a minimum. This level of ventilation provides more than a 100 SCFM mechanical system would provide when the hydrogen leak is greater than 8 SCFM. Protection against higher leakage rates than those represented in the University of Miami study could be obtained by larger opening areas. In fact, the opening size and location criteria are not unlike those required to meet combustion air requirements.

In Summary. The AHC has developed these changes through the consultation of a diverse group of technical and advisory parties from various parties in 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 such that regulators have 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 hydrogen energy systems. The AHC urges your APPROVAL of this proposal "as submitted".

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

FG16-02
306.3

Proponent: Gary Miles, City of Plano, TX; representing Plumbing and Mechanical Advisory Board of the North Texas Council of Governments

Revise as follows:

306.3 Appliances in attics. Attics containing appliances requiring access shall be provided with an opening and unobstructed passageway large enough to allow removal of the largest component of the appliance. The passageway shall not be less than 30 inches (762 mm) high and 22 inches (559 mm) wide and not more than 20 feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the equipment. The passageway shall have continuous solid flooring not less than 24 inches (610 mm) wide. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the equipment. The clear access opening dimensions shall be ~~a minimum of 20 inches by 30 inches (508 mm by 762 mm), where such dimensions are~~ large enough to allow removal of the largest ~~component of the~~ appliance and not less than 20 inches by 30 inches (508 mm by 762 mm). Access to the attic space of dwelling units shall be provided by a permanent stair, a pull-down stair, or a vertical access door.

Exception: The passageway and level service space are not required where the appliance is capable of being serviced and removed through the required opening.

Reason: Attic access will be more safe for personnel if attic hatches are eliminated.

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

FG17-02
306.3

Proponent: Henry Webster, North Carolina Department of Insurance; representing SBCCI International Fuel Gas Code Action Committee

Revise as follows:

306.3 Appliances in attics. Attics containing *appliances requiring access shall be provided with an* opening and unobstructed passageway large enough to allow removal of the largest component of the appliance. The passageway shall not be less than 30 inches (762 mm) high and 22 inches (559 mm) wide and not more than 20 feet (6096 mm) in length when measured along the centerline of the passageway from the opening to the equipment.

The passageway shall have continuous solid flooring not less than 24 inches (610 mm) wide. A level service space not less than 30 inches (762 mm) deep and 30 inches (762 mm) wide shall be present at the front or service side of the equipment. The clear access opening dimensions shall be a minimum of 20 inches by 30 inches (508 mm by 762 mm), where such dimensions are large enough to allow removal of the largest component of the appliance.

National Standard on August 18, 2000.

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

FG41-02
Chapter 7

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

Add new text as follows:

SECTION 202 (IFGC)
GENERAL DEFINITIONS

HYDROGEN CUT-OFF ROOM. A room or space which is intended exclusively to house a gaseous hydrogen system.

HYDROGEN GENERATING APPLIANCE. A self-contained package or factory-matched packages of integrated systems for generating gaseous hydrogen. Hydrogen generating appliances utilize electrolysis, reformation, chemical, or other processes to generate hydrogen.

SECTION 416 (IFGC)
GASEOUS HYDROGEN SYSTEMS

401.1.2 General. The installation of gaseous hydrogen systems shall be in accordance with Chapter 7 and the *International Fire Code.*

CHAPTER 7
GASEOUS HYDROGEN SYSTEMS

SECTION 701 (IFGC)
GENERAL

701.1 Scope. The installation of gaseous hydrogen systems shall comply with this chapter and Chapters 30 and 35 of the *International Fire Code.* Compressed gases shall also comply with Chapter 27 of the *International Fire Code* for general requirements. Containers provided with pyrophoric material shall also comply with Chapter 41 of the *International Fire Code.* Containers having residual gaseous hydrogen shall be considered as full for the purposes of the controls required.

701.2 Permits. Permits shall be required as set forth in Section 106 and as required by the *International Fire Code.*

SECTION 702 (IFGC)
GENERAL REQUIREMENTS

702.1 Containers, cylinders and tanks. Compressed gas containers, cylinders and tanks shall comply with Chapters 30 and 35 of the *International Fire Code.*

702.1.1 Limitations for indoor storage and use. Flammable gas cylinders in occupancies regulated by the *International Residential Code* shall not exceed 250 cubic feet at Normal Temperature and Pressure (NTP).

702.1.2 Design and construction. Compressed gas containers, cylinders and tanks shall be designed, constructed and tested in accordance with the Chapter 27 of the *International Fire Code,* ASME Boiler and Pressure Vessel Code (Section VIII) or DOT 49 CFR, Parts 100-180.

702.2 Pressure relief devices. Pressure relief devices shall be provided in accordance with Sections 702.2.1 through 702.2.7. Pressure relief devices shall be sized and selected in accordance with CGA S-1.1, CGA S-1.2 and CGA S-1.3.

702.2.1 Valves between pressure relief devices and containers. Valves including shutoffs, check valves and other mechanical restrictions shall not be installed between the pressure relief device and container being protected by the relief device.

Exception: A locked-open shutoff valve on containers equipped with multiple pressure-relief device installations where the arrangement of the valves provides the full required flow through the minimum number of required relief devices at all times.

702.2.2 Installation. Valves and other mechanical restrictions shall not be located between the pressure relief device and the point of release to the atmosphere

702.2.3 Containers. Containers shall be provided with pressure relief devices in accordance with ASME *Boiler and Pressure Vessel Code, Section VIII,* DOTn and Section 702.2.7.

702.2.4 Vessels other than containers. Vessels other than containers shall be protected with pressure relief devices in accordance with ASME *Boiler and Pressure Vessel Code, Section VIII,* or DOTn.

702.2.5 Sizing. Pressure relief devices shall be sized in accordance with the specifications to which the container was fabricated. The relief device shall be sized to prevent the maximum design pressure of the container or system from being exceeded.

702.2.6 Protection. Pressure relief devices and any associated vent piping shall be designed, installed and located so that their operation will not be affected by

water or other debris accumulating inside the vent or obstructing the vent.

702.2.7 Access. Pressure relief devices shall be located such that they are provided with ready access for inspection and repair.

702.2.8 Configuration . Pressure relief devices shall be arranged to discharge unobstructed in accordance with Section 2209 of the *International Fire Code*. Discharge shall be directed to the outdoors in such a manner as to prevent impingement of escaping gas on personnel, containers, equipment and adjacent structures and to prevent introduction of escaping gas into enclosed spaces. The discharge shall not terminate, under eaves or canopies.

Exception: This section shall not apply to DOTn-specified containers with an internal volume of 2 cubic feet (0.057 m3) or less.

702.3 Venting. Relief device vents shall be terminated to an approved location in accordance with Section 2209 of the *International Fire Code*.

702.4 Security. Compressed gas containers, cylinders, tanks and systems shall be secured against accidental dislodgement in accordance with Chapter 30 of the *International Fire Code*.

702.5 Electrical wiring and equipment. Electrical wiring and equipment shall comply with the ICC Electrical Code.

SECTION 703 (IFGC)
USE AND HANDLING

703.1 Applicability. Use and handling of containers, cylinders, tanks and hydrogen gas systems shall comply with this section. Gaseous hydrogen systems,equipment and machinery shall be listed or approved.

703.1.1 Controls. Compressed gas system controls shall be designed to prevent materials from entering or leaving process or reaction systems at other than the intended time, rate or path. Automatic controls shall be designed to be fail safe in accordance with accepted engineering practice.

703.1.2 Piping systems. Piping, tubing, valves and fittings conveying gaseous hydrogen shall be designed and installed in accordance with ASME B31.3, Sections 703.1.2.1 through 703.1.2.5 and Chapter 27 of the *International Fire Code*. Cast-iron pipe, valves and fittings shall not be used.

703.1.2.1 Sizing. Gaseous hydrogen piping shall be sized in accordance with approved engineering methods.

703.1.2.2 Design and construction. Piping systems shall be suitable for hydrogen service and the use intended through the full range of pressure and temperature to which they will be subjected. Piping systems shall be designed and constructed to provide allowance for expansion, contraction, vibration, settlement and fire exposure.

703.1.2.2.1 Prohibited locations. Piping shall not be installed in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumbwaiter, or elevator shaft.

703.1.2.2.2 Piping in solid partitions and walls. Concealed piping shall not be located in solid partitions and solid walls, unless installed in a ventilated chase or casing.

703.1.2.2.3 Piping in concealed locations. Portions of a piping system installed in concealed locations shall not have unions, tubing fittings, right or left couplings, bushings, compression couplings and swing joints made by combinations of fittings.

Exceptions:

1. Tubing joined by brazing.
2. Fittings listed for use in concealed locations.

703.1.2.2.4 Piping through foundation wall. Underground piping shall not penetrate the outer foundation or basement wall of a building.

703.1.2.2.5 Protection against physical damage. In concealed locations, where piping other than stainless steel piping, stainless steel tubing, or black steel is installed through holes or notches in wood studs, joists, rafters or similar members less than 1 inch (25.4 mm) from the nearest edge of the member, *the pipe shall be protected by shield plates. Shield* plates shall be a minimum of 1/16-inch-thick (1.6 mm) steel, shall cover the area of the pipe where the member is notched or bored, and shall extend a minimum of 4 inches (102 mm) above sole plates, below top plates and to each side of a stud, joist or rafter.

703.1.2.2.6 Piping in solid floors. Piping in solid floors shall be laid in channels in the floor and covered in a manner that will allow access to the piping with a minimum amount of damage to the building. Where such piping is subject to exposure to excessive moisture or corrosive substances, the piping shall be protected in an approved manner. As an alternative to installation in channels, the piping shall be installed in a casing of schedule 40 steel, wrought iron, PVC or ABS pipe with tightly sealed ends and joints and

ventilated to the outdoors. Both ends of such casing shall extend not less than 2 inches (51 mm) beyond the point where the pipe emerges from the floor.

703.1.2.2.7 Piping outdoors. Piping installed aboveground outdoors shall be securely supported and located where it will be protected from physical damage. Piping passing through an exterior wall of a building, shall be encased in a protective pipe sleeve. The annular space between the piping and the sleeve shall be sealed from the inside such that the sleeve is ventilated to the outdoors. Where passing through an exterior wall of a building, the piping shall also be protected against corrosion by coating or wrapping with an inert material. Below-ground piping shall be protected against corrosion.

703.1.2.2.8. Settlement. Piping passing through interior concrete or masonry walls shall be protected against differential settlement.

703.1.2.3 Joints. Joints on piping and tubing shall be listed for hydrogen service, inclusive of welded, brazed, flared, socket, slip or compression fittings. Gaskets and sealants shall be listed for hydrogen service. Threaded or flanged connections shall not be used in areas other than hydrogen cut-off rooms or outdoors..

703.1.2.4 Valves and piping components . Valves, regulators and piping components shall be listed for hydrogen service , shall be provided with access , and shall be designed and constructed to withstand the maximum pressure to which they will be subjected.

703.1.2.4.1 Shutoff valves on storage containers and tanks. Shutoff valves shall be provided on all storage container and tank connections except for pressure relief devices. Shutoff valves shall be provided with ready access.

703.1.2.5 Testing. Testing for physical integrity shall be performed at not less than 150 percent of the maximum allowable working pressure, or in accordance with the requirements of ASME B31.3.

703.3 Upright use. Compressed gas containers, cylinders and tanks, except those with a water volume less than 1.3 gallons (5 L) and those designed for use in a horizontal position, shall be used in an upright position with the valve end up. An upright position shall include conditions where the container, cylinder or tank axis is inclined as much as 45 degrees (0.80 rad) from the vertical.

703.4 Material-specific regulations. In addition to the requirements of this section, indoor and outdoor use of hydrogen compressed gas shall comply with the material-specific provisions of Chapters 30 and 35 of the *International Fire Code.*

703.5 Handling. The handling of compressed gas containers, cylinders and tanks shall comply with Chapter 27 of the *International Fire Code.*

SECTION 704 (IFGC)
LOCATION OF GASEOUS HYDROGEN SYSTEMS

704.1 General. This section shall govern the location, and installation of gaseous hydrogen systems.

Exceptions:

1. Dispensing equipment need not be separated from canopies that are constructed in accordance with the International Building Code and in a manner that prevents the accumulation of hydrogen gas.
2. Gaseous hydrogen systems located in a separate building designed and constructed in accordance with the *International Building Code* and NFPA 50A.
3. Gaseous hydrogen systems located inside a building in a hydrogen cut-off room designed and constructed in accordance with Section 704.3 and the *International Building Code.*
4. Gaseous hydrogen systems located inside a building not in a hydrogen cut-off room where the gaseous hydrogen system is listed and labeled for indoor installation and installed in accordance with the manufacturer's installation instructions.
5. Gaseous hydrogen systems installed in vaults constructed in accordance with the applicable requirements of Chapter 34 of the *International Fire Code.* Such locations shall be provided with mechanical ventilation in accordance with the applicable provisions for repair garages in Chapter 5 of the *International Mechanical Code.*
6. Stationary fuel cell power plants in accordance with Section 623.0.

704.2 Location on property. Gaseous hydrogen systems shall be located in accordance with Chapter 22 of the *International Fire Code.*

704.3 Hydrogen cut-off rooms. Hydrogen cut-off rooms shall be designed and constructed in accordance with Sections 704.3.1 through 704.3.8 and the *International Building Code.*

704.3.1 Design and construction. Interior building openings shall be equipped with self-closing devices. Interior openings shall be electronically interlocked with the gaseous hydrogen system to prevent operation of the system when such openings are ajar or the room shall be provided with a mechanical exhaust ventilation system designed with a capture velocity at the opening of not less than 60 fpm. Operable windows are prohibited in interior walls.

704.3.2 Ventilation. Cut-off rooms shall be provided with mechanical ventilation in accordance with the

applicable provisions for repair garages in Chapter 5 of the *International Mechanical Code.*

Exception: This section shall not apply to rooms provided with ventilation systems meeting the requirements of Section 704.3.1.

704.3.3 Gas detection system. Hydrogen cut-off rooms shall be provided with an approved flammable gas detection system in accordance with Sections 704.3.3.1 through 704.3.3.3.

704.3.3.1 System design. The flammable gas detection system shall be listed for use with hydrogen and any other flammable gases used in the room. The gas detection system shall be designed to activate when the level of flammable gas exceeds 25 percent of the lower flammability limit (LFL) for the gas or mixtures present at anticipated temperature and pressure.

704.3.3.2 Operation. Activation of the gas detection system shall result in all of the following:

1. Initiation of distinct audible and visual alarm signals both inside and outside the cut-off room.

2. Activation of the mechanical ventilation system.

704.3.3.3 Failure of the gas detection system. Failure of the gas detection system shall result in, activation of the mechanical ventilation system, cessation of hydrogen generation, and a trouble signal to sound in an approved location.

704.3.4 Ignition source control. Open flames, flame-producing devices and other sources of ignition shall be controlled in accordance with Chapter 35 of the *International Fire Code.*

704.3.5 Explosion control. Explosion control shall be provided in accordance with Chapter 9 of the *International Fire Code.*

704.3.6 Standby power. Mechanical ventilation and gas detection systems shall be connected to a standby power system in accordance in accordance with Chapter 27 of the *International Fire Code.*

704.3.7 Smoking. Smoking shall be prohibited in hydrogen cut-off rooms. "No Smoking" signs shall be provided at all entrances to hydrogen cut-off rooms.

704.3.8 Housekeeping. The hydrogen cut-off room *shall be kept free from combustible debris and storage* at all times.

SECTION 705 (IFGC)
OPERATION AND MAINTENANCE OF GASEOUS HYDROGEN SYSTEMS

705.1 Maintenance. Gaseous hydrogen systems and detection devices shall be maintained in accordance with the *International Fire Code* and the manufacturers installation instructions.

705.2 Purging. Purging of gaseous hydrogen systems shall be in accordance with Section 2210.8 of the *International Fire Code.*

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.

Related Revisions to IFGC Section 101.2—Scope. The commercial products industry is moving toward the use of hydrogen in vehicles, generators and equipment to replace petroleum-based fuels in order to reduce atmospheric emissions and facilitate a shift to the use of renewable energy supplies. Furthermore, the commercialization of fuel cells, and the goal of sustainable development has propelled hydrogen supply technology to the forefront of clean energy applications for transportation and distributed and regenerative electric power.

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 important that the ICC provide building 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 revisions proposed in a related proposal to Section 101.2 along with the more specific requirements detailed in this proposal clearly define gaseous hydrogen within the scope of the International Fuel Gas Code (IFGC), and allow gaseous hydrogen to be stored and generated indoors not unlike natural gas, provided specific safeguards are implemented. All portions of the system are designed to be fail safe to provide adequate safety under "worst case" conditions.

Proposed Definitions to IFGC Section 202, HYDROGEN *CUT-OFF ROOM.* *Section 202 currently does not define* HYDROGEN CUT-OFF ROOM. The efforts of the International Code Council Ad Hoc Hydrogen (H2) Committee 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. Accordingly, the H2 committee finds it necessary to prescribe requirements for hydrogen gas fuel dispensing and generation stations that are similar in format to existing International Fire Code provisions specific to "lighter-than air" fuels. The proposed language is needed to support the work of the H2 committee as it pertains to the hydrogen infrastructure (i.e., service stations, parking garages, loading areas, on-site generation and refueling applications and similar uses). This definition is derived from the IMC and NFPA 50A definition for SPECIAL ROOM, see §3-2.2.

HYDROGEN GENERATING APPLIANCE. Section 202 currently does not define HYDROGEN GENERATING APPLIANCE. The efforts of the International Code Council Ad Hoc Hydrogen (H2) Committee intend to address how future building codes can safely cover hydrogen applications. Most of the hydrogen now produced in the United States is on an industrial scale by the process of steam reforming, or as a byproduct of petroleum refining and chemicals production. However, there is growing interest in two different types of hydrogen generating appliances to produce hydrogen on-site at the customer's refueling facility or even at a private residence from either electricity or from natural gas, propane or other fuels. Hydrogen Generating Appliances based on electrolyzers separate the elements of water – hydrogen and oxygen- by charging water with an electrical current. Adding an electrolyte such as salt improves the conductivity of the water and increases the efficiency of the process. The electrical charge breaks the chemical bond between the hydrogen and oxygen and splits apart the atomic components. Hydrogen Generating Appliances based on chemical reformers separate out the hydrogen from fossil fuels such as natural gas, propane, gasoline, etc. This is the same high temperature chemical process used at large oil refineries to produce hydrogen. By generating the hydrogen on-site at the fueling station or customer's facility, these Hydrogen Generating Appliances avoid the high cost of either liquefying hydrogen and delivering it by cryogenic tanker truck, or installing a national hydrogen pipeline system that could cost many tens of billions of dollars. In effect, these on-site Hydrogen Generating Appliances take advantage of one of two existing energy infrastructures: either the natural gas distribution system or the electrical grid.

IFGC Section 416. Wherever possible, requirements for hydrogen gas fuel dispensing and generation stations that were similar to existing IFC content for "lighter-than air" fuels were intentionally correlated or reproduced in context. The newly proposed language is necessary to support the work of the H2 committee as it pertains to the hydrogen infrastructure (i.e., service stations, parking garages, loading areas, self-sustaining on-site generation and refueling applications and similar uses), for vehicle applications.

IFGC Section 701.1. Chapters 30 and 35 of the IFC address the hazards of compressed hydrogen gas systems including stored hydrogen gas in pressure vessels. These referenced code provisions are intended to reduce the risk posed by the inadvertent rupture of a pressure vessel and its hydrogen gas component or the leakage of the flammable gas associated with a piping rupture. The AHC felt that a reference to the commensurate IFC provisions appropriately serve to limit the quantities of compressed hydrogen gas present on both commercial and residential sites, and considers indoor and outdoor use aspects adequately. Reference to Chapter 41 covering pyrophoric materials is intended to address emerging *technology (now being contemplated by the automotive industry)* that allows for storage of higher densities of compressed hydrogen gas in containers with relatively lower applied pressures.

The AHC feels it appropriate to work under the assumption that liquid hydrogen issues related to gaseous hydrogen production are to be covered by a new Chapter 8. Thus, the correlation with a proposed new Chapter 7 for gaseous hydrogen is intentional. Furthermore, since NFPA50A and NFPA50B do not scope all of the issues specific to self-sustained commercial or remote refueling operations, the AHC proposes a new Chapter 7 as a tool for addressing the installation and approval of systems and equipment utilizing gaseous hydrogen as a fuel. For example, there are no system size limitations in the AHC's proposal. NFPA 50A does not cover single systems with a total hydrogen content less than 400 ft^3. Moreover, 50A does not apply to manufacturing plants or establishments other than "consumer premises." That is, plants and bulk distribution sites 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 are beyond the scope of NFPA 50A. See also, the *Source-Book For Hydrogen Applications* (Hydrogen Research Institute and National Renewable Energy Laboratory, 1998), pages 67-69 for detailed explanation.

IFGC Section 702.1. It is not the intent of the AHC to directly or indirectly limit container, cylinder, tank size to no more than 250 scf per tank outside of residential occupancies. The purpose of the reference to Chapter 35 of the IFC is solely for container, cylinder, tank construction criteria and to ensure that bulk cylinders are not stored in residential occupancies. (See proposed revisions to IFC Section 3503.1.1)

IFGC Section 702.1.1. Addition of this language avoids elimination of Section 3501.1, Exception 3 of the IFC. The AHC feels this is a cleaner way to address bulk cylinder size in garages and detached structure associated with occupancies regulated by the IRC and their accessory structures. The IFC

does not apply to occupancies regulated by the IRC and their accessory structures. None-the-less, elimination of the exception could be misinterpreted by subjecting occupancies regulated by the IRC to a number of requirements in the IFC that the committee does not necessarily feel are appropriate

IFGC Section 702.1.2. Consistent with NFPA 50A. For the design and construction of compressed hydrogen gas containers, a single reference to current IFC Section 2703.2.1 could be entertained here, but provides only general guidance (i.e., "in accordance with approved standards"). The structure of the proposed language is derived from IFC Section 3203.1.1. The AHC is not aware of any hydrogen containers meeting less than ASME VIII criteria. Provisions for alternative approval would address any nonstandard containers encountered.

The structure of proposed **IFGC Section 702.2** and subsections was derived from current IFC Section 3203.2. Standard CGA S-1.1 does not yet cover relief devices on metal hydride containers. At this point the issue is gaseous hydrogen and the circumstances surrounding container failure. While preliminary, CGA is currently addressing issues of container performance at failure (as similar to a Boiling Liquid, Expanding Vapor Explosion, BLEVE), and the particulate matter that may potentially foul the pressure relief device. However, from the standpoint of the AHC a metal hydride container is considered a gaseous hydrogen source. It is the AHC's intent that metal hydride containers be evaluated under provisions for alternative approval.

IFGC Section 702.2.1. The AHC's intent here is to require a pressure relief device (PRD) providing protection from over-pressure without obstruction. The presumption is that the PRD is sized correctly.

IFGC Section 702.2.3. This section is consistent with NFPA 50A as it requires PRD's only as dictated by the specifications to which the container was fabricated (i.e., ASME or DOTn).

IFGC Section 702.2.7. Regarding accessibility, the AHC did not intend to prohibit PRD's integral to the container or vessel. It is implicit, however, that the container or vessel standard will address the issue of "integral" PRD's]]

IFGC Section 702.3. 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."

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 te 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 by diking, rather than address the concept of the maximum hypothetical accident 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.

Regarding ventilation, proposed **IFGC Section 702.4** requires mechanical exhaust consistent with the applicable provisions for repair garages in Chapter 5 of the *International Mechanical Code*. The exhaust flow rates specified therein must be provided at all times and interlocked to respond to fan failure or hydrogen detection. 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 the credible leak exists. It should be made perfectly clear that the room or space shall be depressurized by means of exhaust rather than pressurized or otherwise diluted to achieve these levels.

The exception is specific to interior spaces harboring "Gaseous hydrogen systems." That is, Section 704.2 does not apply to your typical hydrogen-fueled vehicle parked in a garage, with or without a vehicle fueling appliance located in the garage. Note however, that the same concepts derived from the University of Miami research were utilized as the basis for this natural alternative. (See reason to IFGC Section 305.2).

Regarding the security arrangements required by proposed **IFGC Section 702.5**: The structure of this language was derived from current IFC Section 3003.3. The intent is to require "nesting" or locking of cylinders or cylinder groups. Site-perimeter security could be viewed as an approved alternative.

IFGC Section 703.1.2. The ASME Boiler and Pressure Vessel Code (Section II) discusses issues related to hydrogen service but does not make specific material recommendations. The *Source Book* and the *Safety Standard for Hydrogen and Hydrogen Systems* (NASA, 1997) provide more specific guidelines. The following information is a reasonably conservative summary of these guidelines.

For metallic materials: Aluminum and its alloys, austenitic stainless steels with greater than 7% nickel (such as 304, 304L, 308, 316, 321, 347), copper and its alloys (such as brass, bronze, and copper nickel), and titanium and its alloys are generally satisfactory for hydrogen service. Care must be taken to not over-stress components in systems as some of these materials may lose ductility if stressed beyond yield.

Nickel and nickel steels are generally not recommended. Ordinary carbon steels may be used in gaseous hydrogen service at ambient temperature. Carbon steels, low alloy steels, chromium, molybdenum, niobium, and zinc are not acceptable for cryogenic temperatures. Grey, ductile or cast iron should not be used in hydrogen service (NFPA 50A).

For welds: Welding requirements are given in the ASME Boiler and Pressure Vessel Codes and ANSI/ASME B31.3. Care must be taken as welds of some of the acceptable materials (listed above) are susceptible to hydrogen embrittlement and/or cracking if not properly executed.

For non-metallic materials: Use of elastomers and plastics should be limited in gasketing, packing or other sealing elements where failure as a result of fire could cause hydrogen leakage. Valve seat materials should be the materials of standard industrial practice for gaseous hydrogen near room temperature. Teflon™ or Kel-F™ can be used in cold gaseous hydrogen or liquid hydrogen systems for valve seats (although Fluorogreem™ preferred), coatings on metallic O-rings, gaskets for tongue and groove flanges, or gland packing or seals (only if maintained near ambient temperature). Kel-F™ is preferred rather than Teflon™ for liquid hydrogen service as it has a higher tensile strength and is less brittle. All Teflon™ gaskets must be totally contained to prevent cold flow and subsequent leakage. Valves for liquid service over 2.1 MPa (300 psia) should use metal-to-metal seats.

IFGC Section 703.1.2.5. Pressure testing in the ASME Boiler and Pressure Vessel Code may be either hydro or pneumatic. Hydro-tests are 150% of the maximum allowable working pressure (MAWP) times a temperature correction factor. In some situations, particularly when the hydrogen system contains catalysts or other materials which could be damaged by water, a pneumatic test is preferable to a hydro-test. This flexibility is therefore, intentional. A pneumatic test is typically conducted at 125% rather than 150% of the MAWP.

IFGC Section 704.1 defers to NFPA 50A for installation issues only, and in the absence of any exception. NFPA 50A does not outline requirements for establishments operated by a hydrogen supplier or the supplier's agent for the purpose of storing hydrogen and refilling portable containers, trailers, vehicles, supply trucks or tank cars (i.e., These examples are not considered "Consumer Sites" as referenced by the Standard). However, while both NFPA 50A and the criteria proposed herein for the International Codes are both based on the hazards associated with specific quantities and types of materials at consumer sites, the circumstances addressed here by exception, ensure coverage for the full range of available or anticipated technologies. Moreover, the circumstances addressed by exception are inclusive of the forecasted use of gaseous hydrogen as a fuel, and the quantities stored such that the materials will not represent an undue risk to personnel in the area or to the building or facilities with which they are associated.

IFGC Section 704.2 defers to Chapter 22 of the International Fire Code (IFC) specifically for locating hydrogen systems on property (See AHC's proposal and reason to Chapter 22 of the IFC). The IFC requirements are based on the hazards associated with the specific materials, e.g. compressed, flammable gas. These requirements are framed such that the location on the property is appropriate for use with this class of material, and will not represent an undue risk to personnel in the area or to the building or facilities with which they are associated.

IFGC Section 704.3. In the best interest of consistency, the AHC proposes to defer to the *International Building Code* for building construction requirements. The IBC requirements are based on the hazards associated with material-specific properties. For hydrogen, a flammable gas, there are specific requirements to ensure that the building is appropriate for use with this class of material. Sections 704.3.1 through 704.3.8 deal with fire safety provisions for use with hydrogen. Since the chapter associated with flammable gases in the International Fire Code exempts hydrogen systems which are regulated under the International Fuel Gas Code, these code sections are necessary in the IFGC to ensure the implementation of fire safety systems.

IFGC Section 704.3.1 intends to detail the design and construction criteria for the cut-off room. These requirements are loosely based on NFPA 50A requirements (Gaseous Hydrogen Systems at Consumer Sites) for "Special Rooms." To allow for broader applications (such as emergency generators using fuel cell technology), interior wall openings are allowed for easy access to the systems. The hydrogen generation shall be terminated if an interior door is opened through the use of interlocks to prevent the migration of flammable gas to an area which is not properly ventilated. In applications where it is not appropriate for interlocks to be installed (i.e., emergency generators), significant ventilation is required to ensure that a flammable mixture is not attained within the room.

IFGC Section 704.3.2 intends to prevent a dangerous accumulation of flammable gas in the room through the use of an exhaust ventilation system. The Source-Book for Hydrogen Applications recommends ventilation at the rate of 1 CFM per square foot of floor area, which is relative to the requirements in Chapter 5 of the IMC. The exception in 704.3.2 is provided to allow exhaust systems which are designed with a capture velocity of 60 fpm at the door opening. This capture velocity exceeds the requirements found in Chapter 5 of the IMC. Since hydrogen is non-toxic, if a release can be kept below its flammable limit, there is minimal hazard. The ventilation requirements are designed to perform that function.

There are no requirements for gas detection in NFPA 50A. The AHC believes gas detection appropriate and integral to life safety. Therefore, **IFGC Section 704.3.3** was derived from current IFC Section 2210.7.2, and intends to address the fact that early detection of the presence of a flammable gas will allow adequate safeguards to be taken. Hydrogen fires are not normally extinguished until the supply of hydrogen has been shut off because of the danger of re-ignition or explosion. A gas detection system in the room or space harboring a gaseous hydrogen system provides for early notification of a leak that is occurring before the escaping gas reaches hazardous exposure concentration levels. The required local alarm is intended to alert the occupants to an emerging hazardous condition in the vicinity. The monitor control equipment must also initiate operation of the mechanical ventilation system in the event of a leak or rupture in the gaseous hydrogen system to prevent an accumulation of flammable gas. Systems shall be designed to be "fail-safe" such that all safety systems shall be activated to alert any occupants that a problem exists and to prevent more hydrogen from being generated by any appliances in the room.

IFGC Section 704.3.4 is intended to prevent any flammable gas releases from finding ignition sources. These requirements are identified in the IFC in locations where flammable gases are stored or used. The requirements are consistent with NFPA 50A and the Sourcebook for Hydrogen Applications. The energy required for ignition of hydrogen-air mixtures is extremely small, and every effort must be made to control ignition sources until the area can be properly ventilated, thus removing the hazard.

IFGC Section 704.3.5 is intended to prevent a catastrophic failure of the cut-off room. It is the final safeguard in case other prevention methods fail (ventilation, alarms). An ignited hydrogen mixture produces large quantities of heat causing a rapid expansion of the surrounding air. This can cause a pressure increase in a confined space and a catastrophic failure. Explosion control methods are identified in the IFC to prevent such a catastrophic failure. The explosion control requirements for hydrogen are consistent with the requirements in NFPA 50A, the IFC, and the Sourcebook for Hydrogen Applications.

IFGC Section 704.3.6 intends to ensure that safety systems remain active in the event of a power failure of the primary power supply. Hydrogen is a colorless, odorless gas and a release may go undetected if detection systems are not functioning. The accumulation of hydrogen in an unventilated area can lead to mixtures in the flammable range if safety systems mechanical ventilation systems are not in operation. Chapter 27 of the IFC addresses emergency and standby power requirements for emergency systems. It also allows an exception to the requirement for systems which are fail safe (see IFC Section 2704.7 Exception 4). This exception may be utilized in cut-off rooms where hydrogen is generated, but not stored. Any storage of hydrogen within the cut-off room would not qualify for the exception, because in the event of a power failure, there will be no way to detect or ventilate a release from a storage vessel.

IFGC Section 704.3.7 intends to augment the requirement in Section 704.3.4. The intent is the same as is in the ignition source control section.

IFGC Section 704.3.8 intends to protect the cut-off room from the storage of other materials which may ignite and cause an exposure fire in the room. Preclusion of combustible materials eliminates this hazard and protects the equipment and storage containers.

IFGC Section 705.1. This section refers to the IFC for maintenance of hydrogen systems. More specifically, Section 2703.2.6 of the IFC details required maintenance activities for hazardous materials storage and use. This includes maintenance of alarms, cylinders, ventilation systems and other devices needed to ensure safety of the gaseous hydrogen system. Failure to properly maintain any of these systems increases the likelihood of a hydrogen release and compromises the safety of the operation. This section is also consistent with the general maintenance provision of the IFC identified in Section 107.1.

In Summary. The AHC has developed these changes through the consultation of a diverse group of technical and advisory parties from various parties in 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 such that regulators have 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 hydrogen energy systems. The AHC urges your APPROVAL of this proposal "as submitted".

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

FG42-02
Chapter 7

Proponent: John Taecker, Underwriters Laboratories, Inc.; representing UL

Revise as follows:

CHAPTER 7

UL

UL 127-96 Factory Built Fireplaces 620.7
with Revisions through ~~January 1988~~ November 1999

Reason: This proposal makes the reference to UL 127 in the IFGC consistent with the reference to UL 127 in the IBC, IMC and IRC.

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

FG43-02
Chapter 7

Proponent: John Taecker, Underwriters Laboratories, Inc.; representing UL

Revise as follows:

CHAPTER 7

UL

441—96 Gas Vents 502.1
– with Revisions through ~~October 1997~~ April 1999

Reason: UL 44-96 with Revisions through December 30, 1999 includes the most recent revisions and is an ANSI approved standard using the continuous maintenance process.

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

FG44-02
Chapter 7

Proponent: John Taecker, Underwriters Laboratories, Inc.; representing UL

Revise as follows:

CHAPTER 7

UL

641—95 Low Temperature Venting 502.1
Systems, Type L – with Revisions through April 1999

Reason: This proposal makes the reference to UL 641 in the IFGC consistent with the reference to UL 641 in the IMC as updated in the 2001Supplement for the most recent ANSI approved revisions.

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

FG45-02
Chapter 7

Proponent: John Taecker, Underwriters Laboratories, Inc.; representing UL

Revise as follows:

CHAPTER 7

UL

795-~~95~~99 Commercial-Industrial Gas 609.1
Heating Equipment *617.1*
630.1

Reason: This proposal makes the reference to UL 795 in the IFGC consistent with the reference to UL 795 in the IMC as updated in the 2001 Supplement for the most recent ANSI approved revisions.

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

FG46-02
Chapter 7

Proponent: John Taecker, Underwriters Laboratories, Inc.; representing UL

Revise as follows:

CHAPTER 7

UL

959-~~95~~01 Medium Heat Appliance 506.3
Factory Built Chimneys~~– with Revisions through April 15, 1998.~~

Reason: UL 959-01 includes the most recent revisions and is an ANSI approved standard using the continuous maintenance process.

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

FG47-02
Chapter 7

Proponent: John Taecker, Underwriters Laboratories, Inc.; representing UL

Revise as follows:

CHAPTER 7

UL

1738-93 Venting Systems for Gas 502.1
Burning Appliances, Categories II, III and IV with Revisions through December 2000.

Reason: UL 1738-93 with Revisions through December 6, 2000 includes the most recent revisions and is an ANSI approved standard using the continuous maintenance process.

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

FG48-02
Chapter 8

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

Add new text as follows:

CHAPTER 8 (IFGC)
DESIGN OF LIQUIFIED HYDROGEN SYSTEMS ASSOCIATED WITH HYDROGEN VAPORIZATION OPERATIONS

801.1 General. The design of liquefied hydrogen systems shall comply with Chapter 32 of the *International Fire Code.*

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.

IFGC Section 801.1. It is anticipated that large consumers of hydrogen as a fuel gas will ultimately utilize liquid hydrogen storage as the supply. While the storage, handling and vaporization of liquid hydrogen is no more technically sophisticated than the storage, handling and vaporization of liquefied petroleum gas (LPG) which the IFGC allows now, the design requirements for liquid storage, handling, and vaporizers are different from what is addressed in the AHC's related proposal to Chapter 7. Therefore, the AHC believes that until the technology for bulk-commercial liquefied hydrogen refueling systems matures, the current edition of NFPA-50B will prove an effective resource for design guidance. It is envisioned that when such equipment is eventually provided for commercial or residential occupancies, it will be in the form of listed packages similar to LPG.

In Summary. The AHC has developed these changes through the consultation of a diverse group of technical and advisory parties from various parties in 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 such that regulators have 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 hydrogen energy systems. The AHC urges your APPROVAL of this proposal "as submitted".

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

2000 *International Fire Code®*. Specifically, Chapter 22, Section 2209.3.3, Hoses and Nozzles, page 191.

1. It is felt the addition of allowing fuel dispensing nozzles to have a latch-open device will prevent individuals fueling their marine craft from using makeshift or other unsafe devices to hold open the latch.
2. A survey of the coastal area of Mississippi has found several marine service stations with fuel dispensing nozzles having latch-open devices, yet there appears to be no recorded or reported incidents that connected the latch-open devices to a negative incident. In other words, the rate of negative incidents involving fuel dispensing nozzles at these locations do not appear to be greater than the rate of negative incidents at locations that do not have a latch-open device on the marine service station fuel dispensing nozzle.
3. In NFPA Handbook, *Flammable and Combustible Liquids Code Handbook*, NFPA 30-1987, NFPA30A-1987, Third Edition,1987, page 313, the following is cited for fuel delivery nozzles at motor vehicle type fuel dispensing stations:
   "*Chapter 8-1 Fuel Delivery Nozzles.*
   8-1.1 A listed automatic-closing type hose nozzle valve, with or without latch-open device, shall be provided on island-type dispensing of Class I liquids.

   Explanation: The words "with or without latch-open device" were added to the1981 edition of NFPA 30, *Flammable and Combustible Liquids Code.* Prior to this change, latch-open devices were not permitted on nozzles unless the dispensing was performed by the service station attendant. At self-service stations, where the public had access to nozzles, latch-open devices were prohibited.
   There were several reasons for this change. Enforcing authorities advised that many citizens chocked open the nozzles with whatever device was at hand, including the gas cap from the automobile. Some enterprising individuals even marketed a combination key holder and latch-open device for one's personal use. Enforcement of the ban on latch-open devices proved extremely difficult. In locations where latch-open devices were allowed, no unusual fire incidents were reported to NFPA. Finally, several consumers complained that the prohibition of the latch-open device inconvenienced the consumer, questioned his intelligence, and gave more credit for common sense and concern for safety to the service station attendant than to the public at large.
   For all these reasons, the change was made. By using the wording "with or without," latch-open devices become optional and the final decision to allow them rests with the local authority having jurisdiction. The Technical Committee decided that there was insufficient justification for continuing the outright ban on the use of the latch-open device."
4. Using the same rational reasoning as addressed in the explanation in item number 3 above, it is felt permitting the latch-open devices for marine fuel dispensing service stations for Class I flammable liquids presents no greater risk of negative incidents than does the latch-open devices located at motor vehicle fuel dispensing service stations that dispense Class I flammable liquids.
5. As required by the 2000 *International Fire Code®*, Chapter 22, Section 2209.3.2, page 191:
   "Supervision - Marine service stations shall have an attendant or supervisor who is fully aware of the operation, mechanics and hazards inherent to fueling boats on duty whenever the station is open for business. The attendant's primary function shall be to supervise, observe, and control the dispensing of Class I, II, or IIIA liquids or flammable gases."

   Most marinas we have contacted state that when a marine craft requests fuel, an employee is sent to the fueling location, sets the ful dispensing pump for discharge, hands the nozzle and hose to the marine craft occupant and then stands by until the fueling process is completed. Then the process is reversed. This "at location" supervision prevents unsafe fueling practices and most times is more aware of what is happening with the fueling process than are the attendants at motor vehicle fuel dispensing stations that have to wait on customers buying various groceries, drinks, and motor vehicle supplies. If something was to happen at either of these two locations due to a fueling nozzle mishap, it is felt the marine service station attendant can act quicker to the mishap than his/her counter part at the motor vehicle service station. Yet, the marine fueling nozzle must be free of a latch-open device.
6. The 2000 *International Fire Code®*, Chapter 22, Section 2206.7.6, page 188, Fuel Delivery Nozzles, states the following:
   "2206.7.6 **Fuel Delivery Nozzles.** A listed automatic-closing-type hose valve nozzle with or without a latch-open device shall be provided on island-type dispensers used for dispensing Class I, II, or IIIA liquids.
   Overhead-type dispensing unit shall be provided with a listed automatic-closing-type hose nozzle without a latch-open device.

   EXCEPTION: A listed automatic-closing-type hose nozzle valve with latch-open device is allowed to be used on overhead-type dispensing units where the design of the system is such that the hose nozzle valve will close automatically in the event the vale is released from a fill opening or upon impact with a driveway."
   It appears the 2000 *International Fire Code®* also agrees with NFPA 30, *Flammable and Combustible Liquids Code Handbook*, Third Edition, 1987 and allows latch-open devices on dispensing systems for Class I, II, and IIIA liquids for motor vehicle use. *The2000 International Fire Code® is now being asked to extend* the use of latch-open device for dispensing motor vehicle fuels.

BIBLIOGRAPHY:
Flammable and Combustible Liquids Code Handbook, Third Edition, NFPA 30-1987
Flammable and Combustible Liquids Code, NFPA 30A Automotive and Marine Service Station Code, Robert P. Benedetti, Editor,1987, page 313
2000 International Fire Code, *Chapter 22, Section 2206.7.6, Fuel* Delivery Nozzles, page 188, Publication Date December 1999

Public Hearing: Committee AS AM D
Assembly: ASF DF

F176-02
2209 (new)

Proponent: Guy Tomberlin, County of Fairfax; representing ICC Ad Hoc Committee for Hydrogen Gas

Add new text as follows:

SECTION 2209
HYDROGEN MOTOR-VEHICLE FUEL DISPENSING AND GENERATION STATIONS

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*	*—*
Offsite 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 igniters 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:

a. 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

b. 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.).

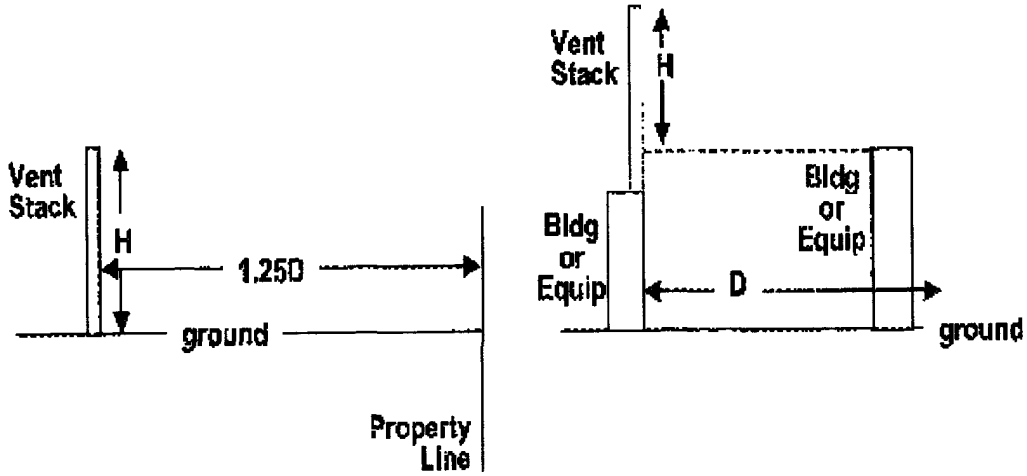
HEIGHT AND SEPARATION DISTANCE [a, b, c, d, e] VERSUS HYDROGEN FLOW RATE AND VENT PIPE DIAMETER

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

H (ft.)	36
D (ft.)	53

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

F177-02
2210

Proponent: Guy Tomberlin, County of Fairfax; representing ICC Ad Hoc Committee for Hydrogen Gas

Add new text as follows:

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.

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

F178-02
2210.6

Committee at the Portland Code Hearings for inclusion in the IFC.

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

M4-02
202

Proponent: Maureen Traxler, representing the City of Seattle

Delete without substitution:

SECTION 202
DEFINITION

~~**EXHAUST AIR.** Air removed from a space and not reused.~~

Reason: The IMC contains two definitions of "**EXHAUST AIR**". Section 202 also contains a definition of "**AIR, EXHAUST**" which is more complete than the definition we propose to delete because it includes air removed from appliances and equipment as well as spaces, and requires that the air be conveyed directly to the atmosphere, thus prohibiting reuse.

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

M5-02
301.14

Proponent: Terry Granderson, State of Arkansas, representing the SBCCI Mechanical Code Action Committee

Delete without substitution:

~~**301.14 Prohibited location.** Mechanical systems shall not be located in an elevator shaft.~~

Reason: This section is identical to Section 303.8, which is the more appropriate location for this requirement. It is not needed in both places.

Analysis: Consistent action is required for related proposal M6-02.

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

M6-02
303.8

Proponent: Cordell Tobin, Fairfax County, VA, representing Virginia Plumbing and Mechanical Inspectors Association & Virginia Building Code Official Association

Delete without substitution:

~~**303.8 Elevator shafts.** Mechanical systems shall not be located in an elevator shaft.~~

Reason: This is redundant text that already appears in Section 301.14. The placement in the General section is consistent format with the IPC and the IFGC.

Analysis: Consistent action is required for related proposal M5-02.

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

M7-02
304.3 (IRC M1307.3)

Proponent: ICC Ad Hoc Committee for Hydrogen Gas

THIS PROPOSAL IS ON THE AGENDA OF THE IMC AND THE IRC MECHANICAL CODE DEVELOPMENT COMMITTEES. SEE THE TENTATIVE HEARING ORDERS FOR THESE COMMITTEES.

Revise as follows:

1. IMC 304.3 Location ~~Elevation~~ of ignition source. Equipment and appliances having an ignition source and located in hazardous locations and public garages, private garages, repair garages, automotive service stations, and parking garages where flammable liquids or flammable gases heavier than air are present shall be elevated such that the ~~source of~~ ignition source is not less than 18 inches (457 mm) above the floor surface on which the equipment or appliance rests. Such equipment and appliances shall not be installed in Group H occupancies or control areas where open-use, handling or dispensing of combustible, flammable or explosive materials occurs. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Add new text as follows:

304.4 Hydrogen Generating and Refueling Operations. In rooms or spaces that contain hydrogen generating or refueling systems, equipment and appliances having an ignition source shall be located such that the ignition source is not less than 24 inches

(457 mm) below the ceiling in hazardous locations and public garages, private garages, repair garages, automotive service stations and parking garages where gaseous hydrogen is present. Such equipment and appliances shall not be installed in Group H occupancies or control areas where open-use, handling or dispensing of combustible, flammable or explosive materials occurs. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exceptions:

1. Where rooms or spaces that contain hydrogen generating or refueling systems are ventilated in accordance with Section 304.4.1

2. Where rooms or spaces that contain hydrogen generating or refueling systems are ventilated in accordance with Section 502.15 of the *International Mechanical Code* and the following:

   2.1. The ventilation system shall be designed to maintain the maximum concentration of flammable contaminants below 25 percent of the contaminant's lower flammability limit; or

   2.2. Continuous ventilation shall be provided at a rate not less than 1 cubic foot per minute per square foot [(0.0051m3/(s x m^2)] of floor area of the room.

3. Where rooms or areas that contain hydrogen generating or refueling systems are ventilated in accordance with Section 304.4.2

304.4.1 Natural Ventilation. Rooms or spaces located underneath or adjacent to habitable space and intended for hydrogen generating or refueling operations shall be provided with mechanical ventilation as required by the exception to Section 304.4 or shall communicate with the outdoors in accordance with Sections 304.4.1.1 through 304.4.1.2. The minimum cross-sectional dimension of air openings shall be 3 in. (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect.

304.4.1.1 Two openings. Two permanent openings, one commencing within 12 inches (305 mm) of the ceiling of the garage, and one commencing within 12 inches (305 mm) of the floor of the garage, shall be provided. The openings shall communicate directly, or by ducts, with the outdoors. Each opening shall directly communicate with the outdoors horizontally, and have a minimum free area of ½ square foot per 1,000 cubic feet of garage volume.

304.4.1.2 Louvers and grilles. In calculating free area required by Section 304.4.1.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have 25 percent free area and metal louvers and grilles will have 75 percent free area. Louvers and grilles shall be fixed in the open position.

304.4.2 Specially engineered installations. As an alternative to the provisions of Section 304.4.1, the necessary supply of air for, ventilation and dilution of flammable gases shall be provided by an approved engineered system.

(Renumber remaining sections)

SECTION 202
GENERAL DEFINITIONS

HYDROGEN GENERATING APPLIANCE. A self-contained package or factory-matched packages of integrated systems for generating gaseous hydrogen. Hydrogen generating appliances utilize electrolysis, reformation, chemical, or other processes to generate hydrogen.

Revise as follows:

2. IRC 1307.3 Location ~~Elevation~~ of ignition source. Appliances having an ignition source ~~of ignition~~ shall be elevated such that the ignition source is not less than 18 inches (457 mm) above the floor in garages where flammable liquids or flammable gases heavier than air are present. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the garage.

Add new text as follows:

1307.4 Hydrogen Generating and Refueling Operations. In rooms or spaces that contain hydrogen generating or refueling systems, equipment and appliances having an ignition source shall be located such that the ignition source is not less than 24 inches (457 mm) below the ceiling in garages where gaseous hydrogen is present. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exceptions:

1. Where rooms or spaces that contain hydrogen generating or refueling systems are ventilated in accordance with Section 1307.4.1
2. Where rooms or areas that contain hydrogen generating or refueling systems are ventilated in accordance with Section 502.15 of the *International Mechanical Code* and one of the following:

   1. The ventilation system shall be designed to maintain the maximum concentration of flammable gas present below 25 percent of the lower flammability limit of the substance for the expected room temperature; or

   2. Continuous ventilation shall be provided at a rate not less than 1 cubic foot per minute per square foot [(0.0051m3/(s x m2)] of floor area of the room.

3. Where rooms or areas that contain hydrogen generating or refueling systems are ventilated in accordance with Section M1307.4.2

1307.4.1 Natural Ventilation. Rooms or spaces located underneath or adjacent to habitable space and intended for hydrogen generating or refueling operations shall be provided with mechanical ventilation as required by the exception to Section M1307.4 or shall communicate with the outdoors in accordance with Sections M1307.4.1.1 through M1307.4.1.2. The minimum dimension of air openings shall be not less than 3 in. (76 mm). Where ducts are used, they shall be of the same cross-sectional area as the free area of the openings to which they connect.

1307.4.1.1 Two openings. Two permanent openings, one commencing within 12 inches (305 mm) of the ceiling of the garage, and one commencing within 12 inches (305 mm) of the floor of the garage, shall be provided. The openings shall communicate directly, or by ducts, with the outdoors. Each opening shall directly communicate with the outdoors horizontally, and have a minimum free area of ½ square foot per 1,000 cubic feet of garage volume.

1307.4.1.2 Louvers and grilles. In calculating free area required by Section 1307.4.1.1, the required size of openings shall be based on the net free area of each opening. If the free area through a design of louver or grille is known, it shall be used in calculating the size opening required to provide the free area specified. If the design and free area are not known, it shall be assumed that wood louvers will have 25 percent free area and metal louvers and grilles will have 75 percent free area. Louvers and grilles shall be fixed in the open position.

1307.4.2 Specially engineered installations. As an alternative to the provisions of Sections M1307.4.1, the necessary supply of air for, ventilation and dilution of flammable gases shall be provided by an approved engineered system.

(Renumber remaining sections)

CHAPTER 202
DEFINITIONS

Hydrogen Generating Appliance. A self-contained package or factory-matched packages of integrated systems for generating gaseous hydrogen. Hydrogen generating appliances utilize electrolysis, reformation, chemical, or other processes to generate hydrogen.

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.

IRC Section 1307.4. Ventilation, whether natural or mechanical, cannot remove all risk from combustible gas leaking into a garage. Based on ongoing research into the dispersion characteristics of gaseous hydrogen, and conducted at the University of Miami, Coral Gables, ½ square foot of opening area per 1,000 cubic feet of garage volume greatly reduces risk, assuming upper and lower openings of approximately equal areas are used. In addition, relying entirely on natural (i.e., passive) ventilation, the ventilation exchange rate increases with increasing hydrogen concentration due to the buoyancy of hydrogen. This is in contrast to mechanical (i.e., active) ventilation, which remains at a constant rate despite any change in hydrogen concentration.

The following is a comparison of a ventilated garage with an unventilated garage, for three leakage rates. The leakage rates were 1.0, 4.0 and 13.0 SCFM. It should be stated clearly that the findings of the University of Miami are based on leakage at the refueling interface and not the vehicle fuel tank. The AHC feels this is a reasonable assumption given the very real potential for the future installation of remote home gaseous hydrogen refueling appliances.

The comparisons of hydrogen accumulation in the garage show the reduction in risk with garage ventilation. The comparisons were made after 20 minutes of leakage. If a garage has openings, the

hydrogen accumulation has reached relative equilibrium after 20 minutes and does not continue to increase appreciably with time. If a garage is not ventilated the hydrogen will continue to accumulate with time and eventually produce a hazardous environment.

The two garages, in Figures C1 through C6, are identical with the exception that the first garage did not have an upper opening. Both garages have lower openings, which spanned the bottom of the garage door. The openings were sized at ½ ft^2/1000 ft^3 of garage volume. The leak was assumed to occur at the vehicle-filling interface, as this type of leakage is difficult to detect. The filling interface was located on the rear passenger side fender. The garage was 9 feet 2.5 inches high by 12 feet 2 inches wide by 21 feet long.

Figures C1 and C2 show the results of hydrogen leaking at 1 SCFM for 20 minutes. The garage without an upper opening is shown in figure C1. The red lines (dark lines) are a surface of constant 4.1% concentration. 4.1% concentration is the lean limit of combustion for hydrogen. It can be seen that a layer of burnable gases approximately 9 inches thick were trapped against the garage ceiling. The blue lines (grey lines) represent a surface of constant 0.82% hydrogen (20% of the lean limit of combustion). They exist down to a level approximately 28 inches below the ceiling. The result of using both lower and upper openings can be seen in figure C2. No appreciable burnable (4.1% hydrogen concentration) gases exist in the garage and the gases, which are richer than 20% of the lean limit of combustion, are only 21 inches thick. As the leak continues the upper garage will continue to fill with greater amounts of hydrogen while lower garage will stay at a relatively constant concentration.

As seen in figure C3 and C4, a 4.0 SCFM leak of hydrogen produces a burnable mixture in both garages. The layer of burnable gases in the lower garage (figure C4 with upper and lower openings) was about 11.0 inches thick, as opposed to 34 inches thick, and contained less than 1/10 the energy of the upper garage (figure C3). The severity of an accident would be substantially reduced by the lower energy content of the burnable gases in figure C4. The buoyancy of hydrogen created an 83 SCFM ventilation rate in the garage in figure C4.

As seen in figure C5, a 20-minute 13.0 SCFM leak of hydrogen almost completely filled the garage with a burnable mixture if no upper opening was provided. The ventilated garage (figure C6) contained a burnable layer approximately 22 inches thick. This was noticeably less than in the unventilated garage with a 4 SCFM leak (figure C4) and contained less than half the energy. The buoyancy of hydrogen created a 123 SCFM ventilation rate in the garage in figure C6.

The SAE Fuel Cell Vehicle (FCV) Standards Committee has been monitoring and contributing to the work of the AHC and is are aware of the AHC's decision to require additional natural or mechanical ventilation ONLY in rooms or spaces intended for hydrogen generating or refueling operations. To be explicitly clear it is NOT the intent of the AHC to require additional natural or mechanical ventilation in areas solely dedicated to the parking/storage of hydrogen-fueled vehicles (i.e., where no hydrogen generating or refueling operation is present).

Therefore, to inform the U.S. Building Regulatory Community of measures the SAE Fuel Cell Vehicle (FCV) Standards Committee plans to take to ensure safety, the Safety Working Group of the SAE FCV Standards Committee is currently preparing two "recommended practices". The following recommendations have been incorporated into drafts of these standards to address hydrogen safety for the situation cited above:

1. Fuel systems will be designed and built to appropriate standards and leak tested to demonstrate integrity.

2. Performance-based requirements related to parking an FCV in a single-bay residential garage have been established. The standard requires validation testing in a garage with very low natural ventilation (of only 0.2 air exchanges per hour) to ensure that the vehicle is normally capable of being safely stored in a residential garage.

3. The vehicle manufacturer (VM) is required to perform a Failure Mode and Effects Analysis (FMEA) for the vehicle. If a single failure could lead to hazardous event, the vehicle manufacturer is required to either modify the system to preclude the failure mode, add failsafe or redundant design measures to prevent the failure, or improve the integrity of components and systems such that risks of these failures are acceptably minimal.

4. If the vehicle manufacturer (VM) is unable to meet any of the above requirements, then the VM shall caution the owner/operator of the vehicle of any operating or parking restrictions.

SAE trusts that the U.S. Building Regulatory Community will find these measures suitable for product introduction. As operating experience is accrued with these new types of vehicles, both SAE and the ICC may need to reassess the situation and provide additional measures for FCV safety as necessary.

Thus, in crafting the proposed language specific to ventilation, the AHC has reviewed the findings of the University of Miami and takes the position that existing provisions for mechanical ventilation of residential garages are not enforced. In concert with these findings and our confidence in the SAE Safety Working Group's investigations into failure mode analyses for hydrogen-fueled vehicle design, the AHC has recommended both natural and mechanical ventilation alternatives for private garages located underneath living space and intended for hydrogen generating or refueling operations. For the natural ventilation alternative, the proposed ½ $ft.^2$ of net free area per 1,000 cubic feet of garage floor area represents a minimum. This level of ventilation provides more than a 100 SCFM mechanical system would provide when the hydrogen leak is greater than 8 SCFM. Protection against higher leakage rates than those represented in the University of Miami study could be obtained by larger opening areas. In fact, the opening size and location criteria are not unlike those required to meet combustion air requirements.

In Summary. The AHC has developed these changes through the consultation of a diverse group of technical and advisory parties from various parties in 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 such that regulators have 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 hydrogen energy systems. The AHC urges your APPROVAL of this proposal "as submitted".

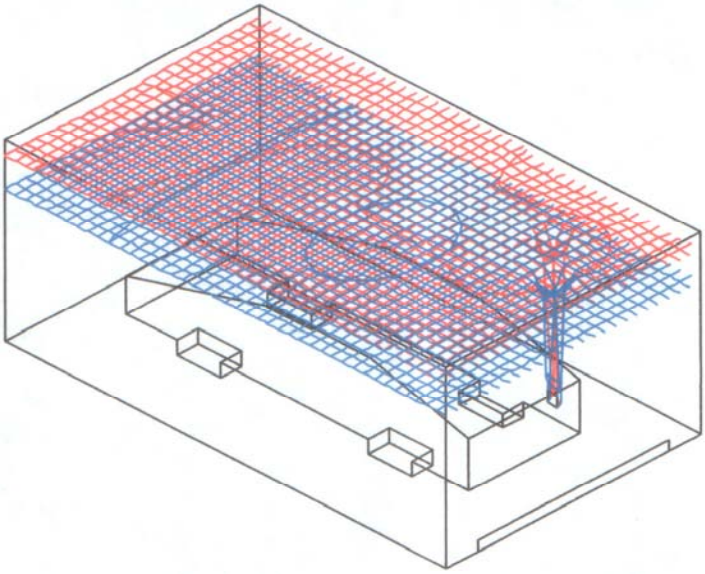


Figure C 1 - Unvented garage, 1 SCFM hydrogen leak for 20

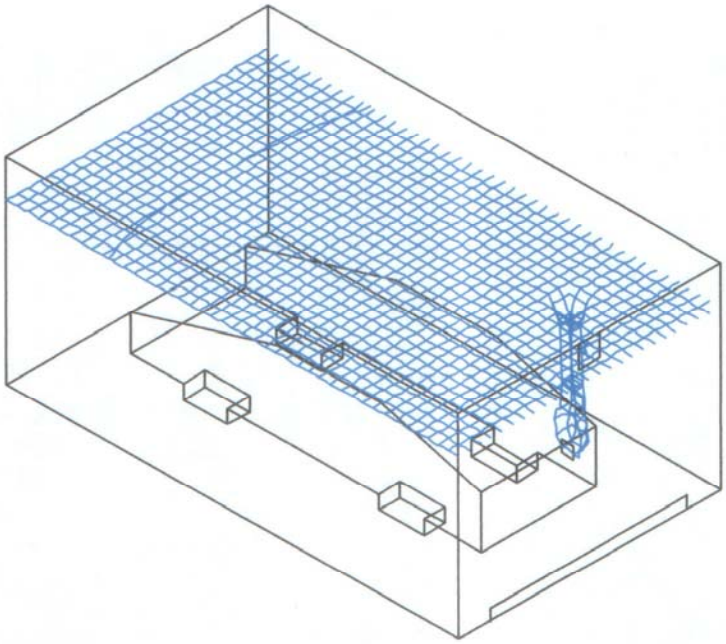


Figure C 2 - Vented garage, 1 SCFM hydrogen leak for 20

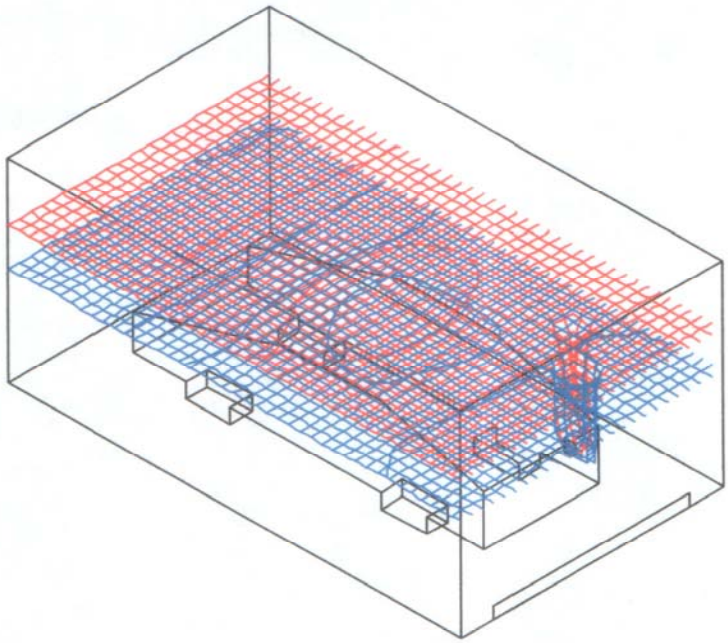


Figure C 3 - Unvented garage, 4 SCFM hydrogen leak for 20

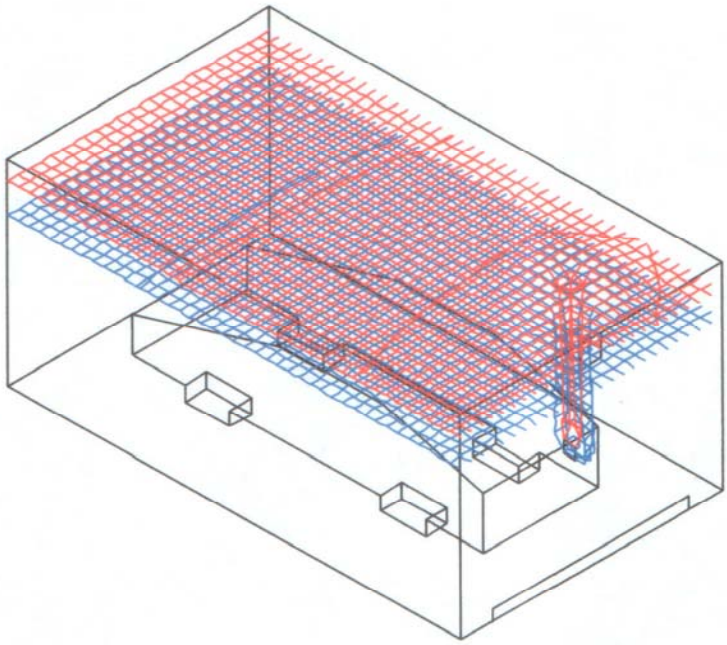


Figure C 4 - Vented garage, 4 SCFM hydrogen leak for 20

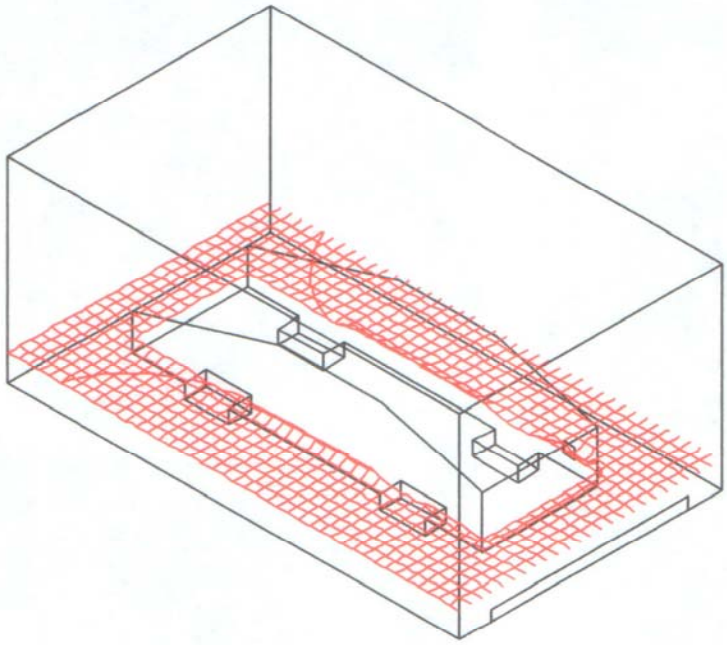


Figure C 5 - Unvented garage, 13 SCFM hydrogen leak for 20

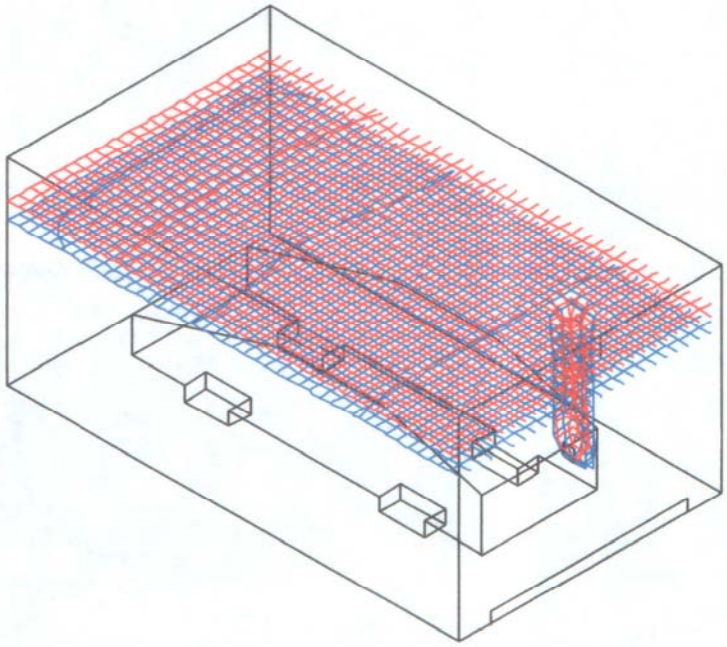


Figure C 6 - Vented garage, 13 SCFM hydrogen leak for 20

Item 1:
Public Hearing: Committee: AS AM D
Assembly: ASF DF
Item 2:
Public Hearing: Committee: AS AM D
Assembly: ASF DF

M8-02
304.3 (IRC R1307.3)

Proponent: Robert D. Lee, Town of Cave Creek, representing the Arizona Building Officials

THIS PROPOSAL IS ON THE AGENDA OF THE IMC AND THE IRC MECHANICAL CODE DEVELOPMENT COMMITTEES. SEE THE TENTATIVE HEARING ORDERS FOR THESE COMMITTEES.

Revise as follows:

1. IMC 304.3 Elevation of ignition source. Equipment and appliances having an ignition source and located in hazardous locations and public garages, private garages, repair garages, automotive service stations and parking garages shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor surface on which the equipment or appliance rests. Such equipment and appliances shall not be installed in Use Group H occupancies or control areas where open use, handling or dispensing of combustible, flammable or explosive materials occurs. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate directly with a private garage through openings shall be considered to be part of the private garage.

Exception: Clothes dryers installed in private garages.

2. IRC M1307.3 Elevation of ignition source. Appliances having an ignition source shall be elevated such that the source of ignition is not less than 18 inches (457 mm) above the floor in garages. For the purpose of this section, rooms or spaces that are not part of the living space of a dwelling unit and that communicate with a private garage through openings shall be considered to be part of the garage.

Exception: Clothes dryers installed in private garages.

Reason: In the definition of clothes dryers, it specifically calls a clothes dryer an appliance. ICBO has had a longstanding opinion that a clothes dryer was a portable appliance and therefore not subject to this requirement. Other types of portable appliances such as clothes washers, freezers and refrigerators are not regulated and clothes dryers present no greater hazard.

Analysis: If a clothes dryer is a portable appliance, it is not covered by this code since this code specifically excludes portable appliances. Since clothes dyers are addressed in Chapter 9, it is apparent that the IMC does not consider clothes dryers to be portable.

Item 1:
Public Hearing: Committee: AS AM D
Assembly: ASF DF
Item 2:
Public Hearing: Committee: AS AM D
Assembly: ASF DF

M9-02
304.9

Proponent: Rene Beliveau, City of Golden, representing Colorado Chapter of ICBO

Revise as follows:

304.9 Guards. Guards shall be provided where appliances, equipment, fans or other components that require service are located within 10 feet (3048 mm) of a roof edge or open side of a walking surface and such edge or open side is located more than 30 inches (762 mm) above the floor, roof or grade below. The guard shall extend not less than 30 inches (762 mm) beyond each end of such appliance, equipment, fan or component. Guards shall also be provided at the elevated walking surfaces of the approved means of equipment access as required by the International Building Code. ~~and t~~The top of the guard shall be located not less than 42 inches (1067 mm) above the elevated surface adjacent to the guard. The guard shall be constructed so as to prevent the passage of a 21-inch-diameter (533 mm) sphere and shall comply with the loading requirements for guards specified in the *International Building Code*.

Reason: Currently the code is clear that the service area for elevated equipment is required to be protected. However, the code is not as clear about the protection of the roof access area to hatches and penthouses and the walking surfaces of the "permanent means of access" required by Sections 306.5 of the IMC and 306.5 of the IFGC. While Section 1003.2.12 of the IBC can be interpreted that protection of these areas is required, this additional language needs to be added for uniformity, clarity, and the life safety of service personnel and fire or other emergency personnel that may use these areas. There have been several occasions where roof top hatches have been installed at an exterior wall location where service persons are forced to come dangerously close to a roof edge. There also have been occasions where the walking surfaces of the means of access

HOUSING FORM

★★★ ★★★

CODES FORUM CONFERENCE
BOCA ★ ICBO ★ SBCCI
SEPTEMBER 29 - OCTOBER 4, 2002

Mail completed form to:
2002 Codes Forum
4051 W. Flossmoor Road
Country Club Hills, IL 60478-5795

Fax completed form to:
1-708-799-7790

To register on-line:
www.bocai.org ★ www.icbo.org
www.sbcci.org ★ www.intlcode.org

For your convenience, make your hotel reservation on-line and receive and print your confirmation immediately. Reservations that are faxed or mailed will be handled on a first-come, first-served basis. Additional hotel information is shown on the on-line housing form.
Reservations must be received by Friday, August 30, 2002.

First Name: _____ Last Name: _____

Company/Organization: _____

Street Address: _____

City: _____ State: _____ ZIP: _____

Phone: _____ Fax: _____

E-mail: _____ **Arrival Date:** _____ **Departure Date:** _____

Number Hotel choices in order of preference. ⬇	HOTELS	SINGLE 1 bed/ 1 person	DOUBLE 1 bed/ 2 persons	DBL/DBL 2 beds/ 2 persons	TRIPLE 2 beds/ 3 persons
	Clarion Hotel	$109	$109	$109	$109
	Courtyard by Marriott	$119	$119	$119	$119
	Hilton Garden Inn	$101	$101	$101	$101
	Holiday Inn North	$86	$86	$86	$86
	Radisson Plaza	$127	$137	$147	$157
	Ramada Plaza	$94	$94	$94	$94
	Renaissance Worthington	$139	$139	$139	$139

Roommates: (List all occupants of room. Indicate if arrival or departure dates are different.)

1) _____ 3) _____

2) _____ 4) _____

☐ Wheelchair Accessible ☐ Special Requests: _____

Guarantee to: VISA _____ MASTERCARD _____ AMERICAN EXPRESS _____ DINERS CLUB _____ DISCOVER _____

Card Number: _____ *Exp. Date:* _____
(Number must be exact or your reservation will be forfeited)

Name: (As it appears on credit card) _____

Signature: _____

Check or Money Order Deposits

After you receive your hotel acknowledgment from the FWCVB/ICC Housing Bureau, make your deposit **check payable to the hotel** directly and mail the deposit check back with a copy of your acknowledgment to FWCVB/ICC Central Housing, 415 Throckmorton, Fort Worth, TX 76102. All deposits are required by Friday, August 30th, or your reservation will be dropped. The FWCVB will send all deposit checks to the hotel, after the housing cutoff date, along with the final rooming lists.

ANNUAL CONFERENCE REGISTRATION FORM

Register by August 1, 2002, to qualify for the Early-Bird Drawing.

REGISTRATION TYPE

DELEGATE INFORMATION (The information provided below is what appears on your badge.)

☐ **Delegate - $350** Includes all business, education and social functions.

☐ **Education Only - $100** Includes education programs on Monday and Tuesday.

☐ Check here if this is your first Conference

☐ **BOCA** ☐ **ICBO** ☐ **IFCI** ☐ **SBCCI** **Membership Number:** _____

Delegate's Name: _____

Name to Appear on Badge: _____

Title: _____

Organization: _____

Street Address: _____

City/State/Province: _____ ZIP: _____

Phone: ( ) _____ Fax: ( ) _____

E-mail: _____ Arrival Date: _____ Departure Date: _____

BRINGING A COMPANION? (Fill out this section) ☐ Check here if this is your companion's first Conference

☐ **Companions' Program - $250**
Includes all business, companion and social functions.

☐ **Companions' Basic Program - $175**
Includes all events **EXCEPT** Tour and Companions' Breakfast

Companion's Name: _____ Name to Appear on Badge: _____

For the "Companions' Tours" on Wednesday, October 2, 2002, choose one of the three off-site programs.
Please designate first, second, third choice (see page 10 for more information):

___ **Tour 1** Heard It Through the Grapevine

___ **Tour 2** Cowboys and Culture

___ **Tour 3** A Moment in History

Photographers will be documenting all of the conference events and activities. These photos may be used in future issues of various magazines, web sites, and promotional materials. Your registration serves as a release. If you do not wish to be photographed, please make this fact known to the photographers.

PAYMENT OPTIONS

☐ **VISA** ☐ **MASTERCARD** ☐ **AMERICAN EXPRESS** ☐ **BILL ME (Members Only)** ☐ **PAYMENT ENCLOSED**
Please enclose check or municipal voucher made out to 2002 Codes Forum, c/o BOCA International, Inc.

Credit Card No: ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ Exp. Date: ☐☐ ☐☐
month year

Signature: _____

Billing Address: _____

NOTICE: If you or your companion require special accommodations to participate fully, please attach a written description of your needs.

Mail completed form to:
2002 Codes Forum
4051 W. Flossmoor Rd.
Country Club Hills, IL
60478-5795

Register on-line at:
www.bocai.org
www.icbo.org
www.sbcci.org
www.intlcode.org

Fax completed form to:
1-708-799-7790

Registrations are not accepted over the phone

GUY TOMBERLIN
CHIEF PLUMBING INSPECTOR
COMMERCIAL INSPECTIONS DIVISION

EMAIL: gtombe@co.fairfax.va.us

(703) 324-1910
(703) 324-1611
FAX (703) 324-1846

DEPARTMENT OF PUBLIC WORKS & ENVIRONMENTAL SERVICES
OFFICE OF BUILDING CODE SERVICES
12055 GOVERNMENT CENTER PARKWAY, SUITE 630
FAIRFAX, VIRGINIA 22035-5504