

item #4 are a double negative. A careful reading warns someone against taking a safe action by not doing a dangerous action. Why should we be warned against a safe action?

noncombustible construction, as set forth in the *International Building Code*, which are unenclosed for three quarters or more of the building perimeter.

F176-02

2209

Proposed Change as Submitted:

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

Add new text as follows and re-number remaining section numbers:

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

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 ignitors and hot work such as welding and open flames.
- e. For storage volume greater than or equal to 15,000 scf.

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

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

- 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/ft² for a maximum of three minutes, exposures to noncombustible equipment are limited to no more than 8,000 Btuh/ft², exposures simulated at the property line are limited to no more than 500 Btuh/ft² 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.).

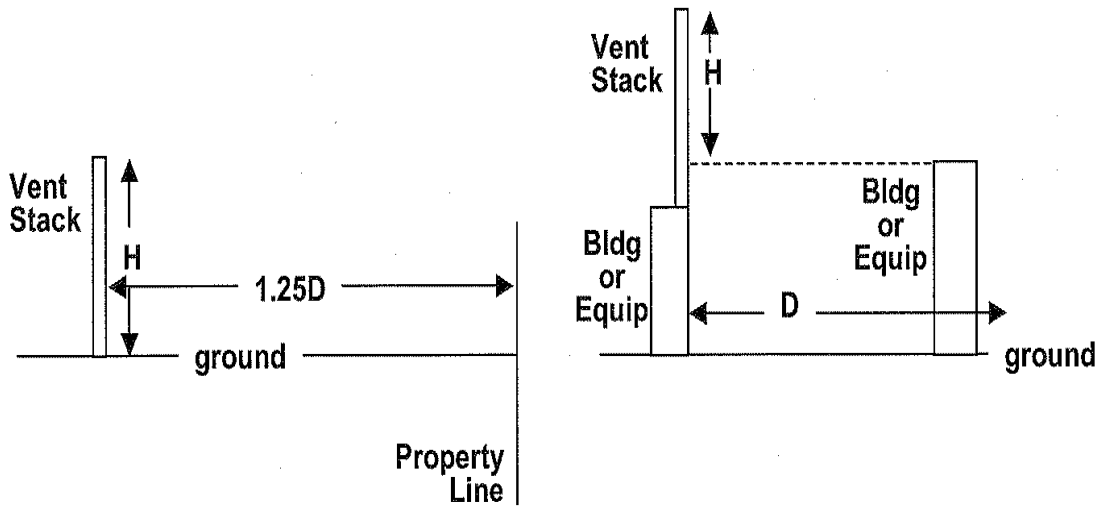
HEIGHT AND SEPARATION DISTANCE ^{a, b, c, d, e}

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.)	
	1	2	1	2	1	2	1	2	3	1	2	3	2	3
H (ft.)	8	8	8	8	12	12	17	12	13	25	25	22	36	36
D (ft.)	13	13	15	17	22	26	39	36	40	53	53	53	81	81

For SI: 1 foot = 304.8 mm.

- a. Minimum distance to property line is 1.25D.
- b. Designs seeking to achieve greater heights with commensurate reductions in separation distances shall be designed in accordance with accepted engineering practice.
- c. With this table personnel on the ground or on the building/equipment are exposed to a maximum of 1,500 BTU/hr. ft², 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.

Proponent’s 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 ignition 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 ANSI Z223.1, 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 liquefied 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/ft², with exposures to combustible equipment limited to no more than 8,000 Btuh/ft², and exposures simulated at the property line limited to no more than 500 Btuh/ft² (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 1/4 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".

Committee Action: **Approved as Modified**

Modify proposal 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. Hydrogen motor 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)
<i>Building—Noncombustible walls, sprinklered or nonsprinklered</i>	10	NFPA 50A—10 ft.
<i>Building—Combustible walls, sprinklered or nonsprinklered</i>	25 ^{b, e}	NFPA 50A—10 ft. (for greater than 15,000 scfm storage)
<i>Building—Noncombustible walls, 2-hour fire barrier interrupts line-of-sight</i>	5	—
<i>Offsite sidewalks and on-site/off-site parked vehicles</i>	15 ^{a, b}	NFPA 50A—10 ft. (reasonable interpretation)
<i>Lot line</i>	10 ^a	NFPA 50A—5 ft., NFPA 52—10 ft.
<i>Air intake openings</i>	25 ^c	NFPA 50A—50 ft.
<i>Wall openings located less than 25 ft. vertically above</i>	20 ^c	NFPA 50A—10 ft.
<i>Wall openings located greater than 25 ft. vertically above</i>	25	NFPA 50A—25 ft.
<i>Outdoor public assembly</i>	25 ^a	NFPA 50A—50 ft.
<i>Ignition source^d</i>	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).
<i>Flammable or combustible liquid storage—Above ground, diked in accordance with Section 3404.2.9.6.</i>	20	Diking is advantageous.
<i>Flammable or combustible liquid storage—Above ground, not diked</i>	50	NFPA 50A—50 ft.
<i>Flammable or combustible liquid storage—Below ground, vent or fill opening</i>	20	NFPA 50A—25 ft.
<i>Flammable gas storage (non-hydrogen)—Above ground, with common shutoff</i>	25	—
<i>Flammable gas storage (non-hydrogen)—Above ground, no common shutoff</i>	50	A common shutoff system is advantageous.
<i>Combustible waste material (see Section 304.1.1)</i>	50	These materials should not be present presuming the code’s General Precautions Against Fire are adhered to.
<i>Liquefied hydrogen storage—Distance to buildings, openings, lot lines, public ways and on-site/off-site parked vehicles</i>	25 ^a	NFPA 52 criteria

For SI: 1 foot = 304.8 mm.

- c. A reduction to 5ft. shall be permitted where a 2-hour fire barrier interrupts the line of sight between the equipment and the exposure. The height of the barrier for vertical tanks shall be no less than one-third of the height of the tank measured vertically, and the length of the wall shall be 1.5 times the maximum diameter of the tank. The height of the barrier for vertical tanks shall be no less than one-third of the height of the tank measured vertically, and the length of the wall shall be 1.5 times the maximum diameter of the tank.
- b. A reduction to 0 ft. shall be permitted for dispensing equipment and vehicles being refueled.
- c. Measured along the natural and unobstructed line of travel (e.g., around protective walls, around corners of buildings)
- d. ignition source. A flame, spark or hot surface capable of igniting flammable vapors or fumes. Such sources include appliance burner ignitors and hot work such as welding and open flames.
- e. For storage volume greater than or equal to 15,000 scf.

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

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

- 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/ft² for a maximum of three minutes, exposures to noncombustible equipment are limited to no more than 8,000 Btuh/ft², exposures simulated at the property line are limited to no more than 500 Btuh/ft² 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**

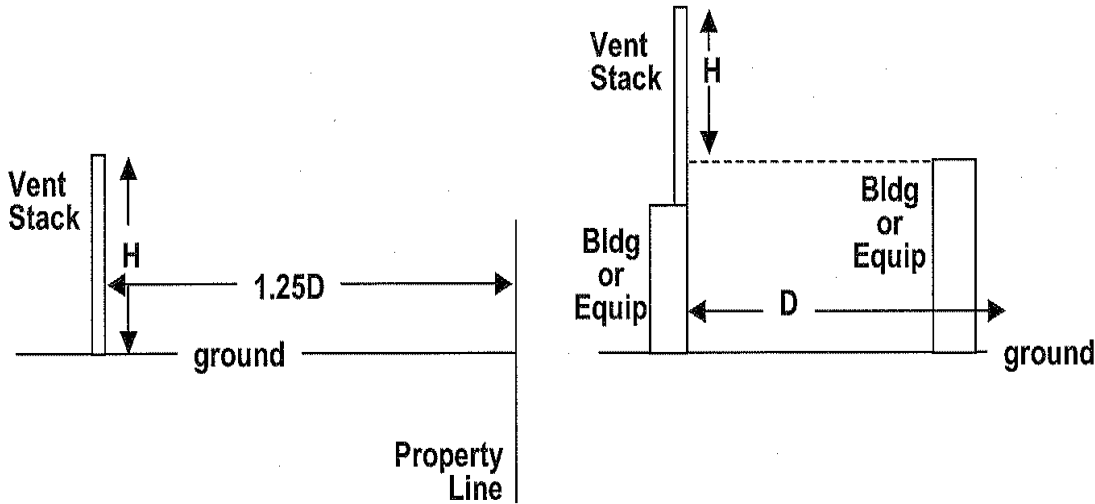
H = Minimum height of vent stack above the ground or above any structure/equipment within distance D where personnel may be present (ft.).
 D = Distance to adjacent structure/equipment where personnel may be present (ft.).

**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.)	
	1	2	1	2	1	2	1	2	3	1	2	3	2	3
H (ft.)	8	8	8	8	12	12	17	12	13	25	25	22	36	36
D (ft.)	13	13	15	17	22	26	39	36	40	53	53	53	81	81

For SI: 1 foot = 304.8 mm.

- Minimum distance to property line is 1.25D.
- Designs seeking to achieve greater heights with commensurate reductions in separation distances shall be designed in accordance with accepted engineering practice.
- With this table personnel on the ground or on the building/equipment are exposed to a maximum of 1,500 BTU/hr. ft², 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.
- Designs seeking to achieve greater radiant exposures to noncombustible equipment shall be designed in accordance with accepted engineering practice.
- 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.

Committee Reason: The code change is needed to address new technology that is already being used.

Assembly Action: **No Motion**

Individual Consideration Agenda:

This item is on the agenda for individual consideration because a public comment was submitted.

Public Comment:

Larry Fluer and Kevin Scott, Fluer, Inc. and Kern County California Fire Department, respectively, representing Compressed Gas Association and Kern County Fire Department, respectively, request Approved as Modified by this Public Comment.

Modify proposal as follows:

**SECTION 2209
HYDROGEN MOTOR FUEL DISPENSING AND
GENERATION STATIONS**

2209.1 General. Hydrogen motor fuel dispensing and generation stations shall be in accordance with this section and Chapter 35. 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 containers and tanks,~~ 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 ~~27033003, 3203,~~ NFPA 50A ~~and or~~ NFPA 50B as applicable.

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. Hydrogen motor 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.

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~~ Generation, compression and dispensing equipment. ~~Outdoor exposures shall require spacing to~~ Generation, compression, and dispensing equipment shall be separated from 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**

SITE FEATURE	DISTANCE (feet)
Building — Noncombustible walls <u>Types I and II construction</u> , sprinklered or nonsprinklered	10
Building — <u>Combustible walls, Types III, IV or V construction</u> , sprinklered or nonsprinklered	25 ^{b-e}
Building—Noncombustible walls, 2-hour fire barrier interrupts line-of-sight	5
Offsite sidewalks and on-site/off-site parked vehicles	15 ^{a, b}
Lot line	10 ^a
Air intake openings	25 ^c
Wall openings located less than 25 ft. vertically above <u>grade</u>	20 ^c
Wall openings located greater than 25 ft. vertically above <u>grade</u>	25
Outdoor p Public assembly	25 ^a
Ignition source ^d	4015
Flammable or combustible liquid storage or use—Above ground, diked in accordance with Section 3404.2.9.6.	20
Flammable or combustible liquid storage or use—Above ground, not diked in accordance with Section 3404.2.9.6	50
Flammable or combustible liquid storage—Below ground, from vent or fill opening	20
Flammable gas storage (non-hydrogen)—Above ground, with common shutoff	25
Flammable gas storage (non-hydrogen)—Above ground, no common shutoff	50
Combustible waste material (see Section 304.1.1)	50

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 Cylinders, containers and tanks used for storage. Cylinders, container and tanks used for storage of hydrogen shall be separated from exposures in accordance with NFPA 50A or 50B.

2209.3.1.3 Electrical classification. ~~Such installations shall also follow provisions of the National Electrical Code NFPA 70~~ Electrical wiring and equipment shall be installed and maintained in accordance with the International Electrical Code and applicable provisions of NFPA 497A.

2209.3.1.4 Overhead lines. ~~The proximity to Generation, compression, storage and dispensing equipment shall be separated from 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.

2209.3.1.5 Canopies. ~~Dispensing equipment need not be separated from canopies that are~~ Where overhead noncombustible construction is provided for sheltering outdoor dispensing areas, such dispensing shall not be considered indoors when the area is constructed in accordance with the International Building Code Section 414.6.1, in a manner that ~~would prevent~~ the accumulation of hydrogen gas.

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 Emergency shutoff valves. Piping to equipment shall be provided with a. A readily accessible manual emergency shut-off valve ~~that is readily identifiable~~ shall be provided to shut down the gas supply to the piping system.

2209.5.1 Marking. Emergency shutoff valves shall be marked so as to be readily identifiable.

2209.6 Emergency shutdown controls. A remotely activated emergency shutdown control shall be provided. Emergency shutdown ~~devices~~ controls shall be located within 75 feet (22860 mm) of, but not less than 25 feet (7620 mm) from, dispensers, hydrogen generators, and compressors. ~~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.~~

2209.6.1 System Requirements. Upon activation, emergency shutdown shall automatically shut off the power supply to 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 Pressure relief. Portions of the piping system subject to overpressure shall be protected by pressure relieving devices.

2209.7.2 Discharge. Hydrogen venting systems shall not discharge inside buildings or under canopies used for weather protection.

2209.7.3 Installation. Pressure relief devices used to protect cylinders, containers and tanks used for the storage of liquefied or gaseous hydrogen shall be designed and installed in accordance with the requirements of CGA S-1.1, S-1.2 or S-1.3.

2209.7.4 Vent pipe. ~~When vent pipes that will be installed to divert the gas flow to atmosphere shall be installed on the vessel for purging operations. The vent pipes 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. The vent pipe shall be located away from obstructions that would obstruct the gas from dispersing vertically upward.
- ~~3.4.~~ A means shall be provided to prevent obstructions or restrictions to the design capacity of the vent pipe due to water, ice and other debris from accumulating inside the vent pipe or obstructing the vent pipe or by placing restrictions into the vent pipe system that would alter the design capacity.
- ~~4.5.~~ Venting of hydrogen gases shall be as follows: The height (H) and separation distance (D) of the vent pipe shall meet the criteria set forth in Table 2209.7.4 for the combinations of maximum hydrogen flow rates and vent stack opening diameters listed; or .
 - ~~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/ft² for a maximum of three minutes, exposures to noncombustible equipment are limited to no more than 8,000 Btuh/ft², exposures simulated at the property line are limited to no more than 500 Btuh/ft² 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.
- ~~6.~~ When cylinders are used to supply the hydrogen system a listed bi-directional detonation flame arrester shall be provided at the point of connection to the vent line.

TABLE 2209.7.4 2209.7.4

HYDROGEN VENT STACK HEIGHT (H) VERSUS DISTANCE (D) REQUIREMENTS^{a, b, c, d}

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.)	
	1	2	1	2	1	2	1	2	3	1	2	3	2	3
H (ft.)	8	8	8	8	12	12	17	12	13	25	25	22	36	36
D (ft.)	13	13	15	17	22	26	39	36	40	53	53	53	84	84

Flow Rate	0-499 scfm	500-999 scfm	1,000-1,999 scfm	2,000-4,999 scfm	5,000-9,999 scfm	10,000-20,000 scfm
H (ft.)	8	8	12	17	25	36
D (ft.)	13	17	26	40	53	81

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.).

For SI: 1 foot = 304.8 mm.

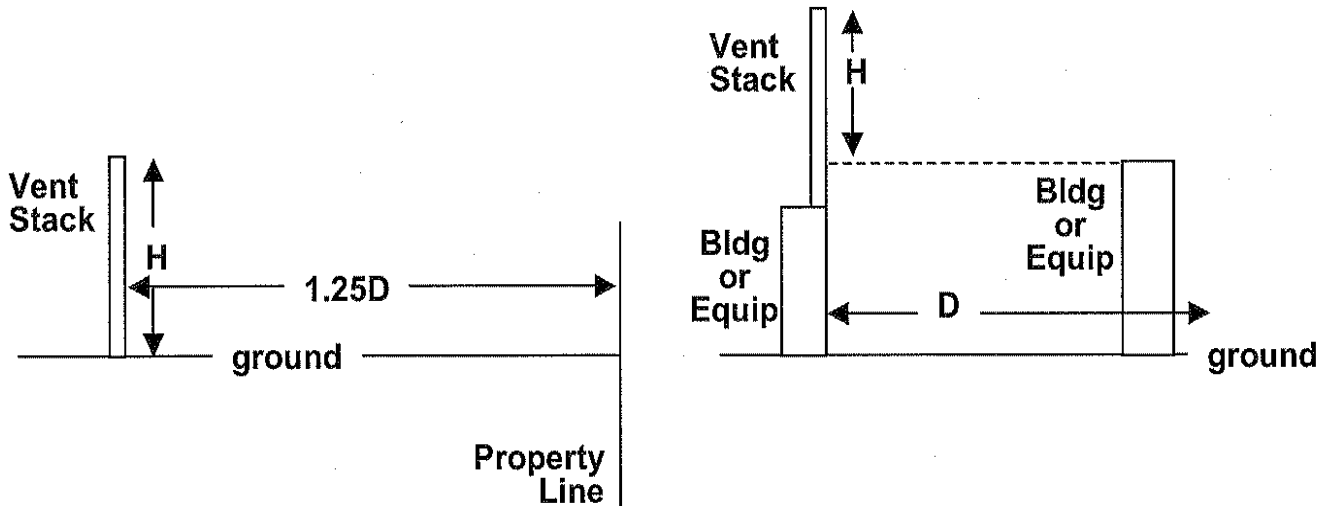
a. Minimum distance to property lot line is 1.25D.

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. ft², 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.



2209.7.4.1 Alternative venting systems. Where alternative venting arrangements are proposed, an analysis of exposure to radiant heat and hydrogen concentrations shall be provided.

2209.7.4.1.1 Radiant Heat Exposure. The analysis of exposure to radiant heat shall assume a wind speed of 30 feet/second and provide a design that limits maximum radiant heat exposure to the values in Table 2209.7.4.1.1.

Table 2209.7.4.1.1
Maximum Radiant Heat Exposure

Exposed Object	Maximum Radiant Heat	Time Duration (minutes)
Personnel	1,500 Btu/hr. ft ²	3
Noncombustible equipment	8,000 Btu/hr. ft ²	Any
Lot line	500 Btu/hr. ft ²	Any

2209.7.4.1.2 Hydrogen concentration exposure. The analysis of exposure to hydrogen concentration shall provide a design that limits the maximum hydrogen concentration exposure to the values in Table 2209.7.4.1.2.

**Table 2209.7.4.1.2
Maximum Hydrogen Concentration Exposure**

Exposed Object	Maximum Hydrogen Concentration
Personnel, buildings or equipment	50% LFL within a distance of D and H of Table 2209.7.4
Lot line	50% LFL within 1.25 times the distance of D and H of Table 2209.7.4

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 Btu/hr.ft² for a maximum of three minutes; exposures to noncombustible equipment are limited to no more than 8,000 Btu/hr.ft²; exposures simulated at the property line are limited to no more than 500 Btu/hr.ft² 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-

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.

Commenter’s Reason: 2209.1 has been revised to reference Chapter 35 rather than Chapter 30. Chapter 35 addresses flammable gases and is the appropriate reference in this general section. You still get to Chapter 30 because Section 3501.1 refers to Chapter 30.

2209.2.1 revised to bring consistency between this section and the general requirements of Chapters 30 and 32 regulating compressed and cryogenic gases. The use of the terms storage vessels and pressure vessels is not consistent with terms otherwise defined by the code.

2209.3.1.1 has been revised to clarify the items being addressed.

2209.3.1.1 As currently drafted the section would require “exposures” to be separated from systems rather than requiring systems to be separated from exposure hazards which is the norm within the context of the code. The section has been revised to separate the system from the hazard. Siting of bulk storage has been the subject of regulation by national standards, e.g., NFPA 50A and 50B for many years. The distances required by the referenced standards vary depending on the capacity of the storage system. Recent testing and modeling of hydrogen releases from bulk systems suggests that the distances required by these standards may be modified. Member companies within the Compressed Gas Association are evaluating the required distances based on recent data. Until such time as the evaluation has been completed and justifications for change established the use of current standards should be maintained. The triggering language to the use of Table 2209.3.1.1 has been modified to limit the use of the table to generators, dispensers and compressors. Section 2209.3.1.2 has been added to refer to NFPA 50A and 50B for locating the “storage” systems.

2209.3.1.1 Exception #1 was deleted to correlate with committee action that removed the allowance to locate these facilities inside buildings.

Exception 2 has been deleted as it is in conflict with NFPA 50A and 50B as well as with the requirements of Chapter 35. Exempting 3,000 cubic feet of hydrogen from the requirements for exposure protection is not justified.

Table 2209.3.1.1 was revised as follows:

- Row 1 - Noncombustible buildings are described by the Building Code as being of Type I and II construction.
- Row 2 - Combustible buildings are described by the Building Code as being of Type III, IV or V construction.

Row 3 - Consistency with the building code.

Row 4 - The term “on-site/off-site” parking was deleted. The hazards of parking are the same regardless of where the vehicles are located. By deleting the term all parking is included.

Rows 7 and 8 - The term “grade” was added to establish the point where measurements are to be taken. As originally submitted it may have focused on vent pipes from storage tanks. By deferring to NFPA 50A and B the focus now becomes compression and/or dispensing or generating equipment. The use of grade is appropriate as a means to establish the basis for measurement.

Row 9 - The concern is location with respect to large numbers of people. Whether an assembly is outdoors or indoors makes little difference with respect to areas where people intensive uses will occur. A public assembly could be held in a tent and be viewed as being indoors. Having such an assembly in a tent should not be the foundation to allow encroachment.

Rows 11, 12 and 13 - The concern is not limited to storage of flammable or combustible liquids. Use must be considered as well. Above ground systems could include the use of protected tanks or other above ground systems.

Row 17 - Requirements for storage of liquefied hydrogen have been referred to NFPA 50B by the addition of proposed Section 2209.3.1.2.

Table 2209.3.1.1 Footnote a was revised to address dispensing, compression equipment and generators. The use of walls to address the needs of bulk storage systems is integral to NFPA 50A and 50B.

Table 2209.3.1.1 Footnote e was deleted because it specified storage in excess of 15,000 cubic feet and based on provisions found within NFPA 50A and 50B tied to quantity. The footnote is no longer needed.

2209.3.1.2 was revised to reference the IEC.

2209.3.1.3 was revised to clarify the items being addressed with the requirements in that section.

2209.3.1.4 was revised to allow dispensing under canopies to be considered to be other than indoors when canopies were designed to prevent the accumulation of hydrogen.

2209.5 was revised to clarify that the shutoff valve required is to serve as an emergency valve to isolate the supply from the system.

2209.5.1 was added to require the marking of the emergency shutoff valve required by Section 2209.5.

2209.6 was revised to clarify that the required device is a “control” rather than a valve, and that the control is to be designed to be accessed from a location outside of the immediate area where dispensing occurs. The operability requirements for the control have been extracted and relocated to a new Section 2209.6.1.

2209.6.1 was added to separate the requirements for performance of the remote shut off control from the requirement of the control proper.

2209.7 was revised to correlate with committee action which deleted inside locations. It was further altered to itemize specific items being required.

2209.7.1 was extracted from 2209.7.

2209.7.2 was extracted from 2209.7. Although dispensing is not permitted inside of buildings there is no provision to restrict a designer from taking a vent into a building or from venting under a canopy. By

establishing a prohibition it clarifies the intent that vents remain external to buildings or canopies regardless of the location of the dispensing, generation, compression or storage equipment.

2209.7.3 was extracted in part from 2209.7.1 item 4.2 and modified to add referenced standards that address cylinders, containers and tanks. These reference standards are included in Chapter 45 of the IFC. The criteria for fire exposure and overpressure venting are found in the standards for relief devices within CGA S-1.1 through S-1.3.

2209.7.4 (formerly 2209.7.1) was revised to provide requirements for all vent pipes.

2209.7.4 Item 2 was revised and split into Items 2 and 3. This separates the issue of providing a rain cap and the requirement to allow for vertical dispersion of the gas. A rain cap that will stop the rain will not allow for vertical travel of the gas. By separating the two issues it can be clarified.

2209.7.4 Item 4.1 was revised by deleting "or" at the end of the sentence. All of the items in this list need to be complied with; it is not a choice of one or the other because Item 4.3 has been relocated.

2209.7.4 Item 4.2 was deleted. Section 2209.7.3 sends the user to referenced standards regarding the application of vent system design for storage containers. Section 2209.7.4 and its related table provide the needed criteria to include all other vents.

2209.7.4.1.1 was added to provide requirements for alternative venting systems. Sections 2209.7.4.1.1 and 2209.7.4.1.2 and their related tables were created from the content of Section 2209.7.1 item 4.3 as it appears in the Report of Public Hearings.

2209.7.4 item 5 was relocated to become item 6.

Table 2209.7.4 (Formerly Table 2209.7.1) was revised in several instances as follows:

1. The duplicate headings were reduced to one heading.
2. The legend for 'H' and 'D' was relocated to after the table.
3. The entries on the Table have been simplified. In the majority of the cases it made little difference what size vent was installed, or it was only a matter of several feet difference. Therefore, the distances have been combined to make for easier application of the table.
4. Footnotes and d were revised to refer to lot line rather than property line as lot line is that used within the ICC system.
5. Footnote c has been deleted since it is explanatory information and not regulatory requirements.

Public Comment 2:

Kevin H. Scott, Kern County Fire Department, requests Approved as Modified by this Public Comment.

This comment affects section numbers and titles only.

Modify proposal as follows:

SECTION 2209 Hydrogen Motor Fuel Dispensing and Generation Stations

2209.1 General.

2209.2 ~~Approvals~~ Equipment.

2209.2.1 Approved equipment.

2209.2.2 Listed equipment.

~~2209.2.3~~ ~~2209.3.1.2~~ Electrical classification equipment.

~~2209.3~~ ~~2209.3.1~~ Location on property.

~~2209.3.1~~ ~~2209.3.1.1~~ Outdoor exposures.

TABLE ~~2209.3.1~~ ~~2209.3.1.1~~ Minimum Separation for Gaseous Hydrogen Dispensers, Compressors, Generators and Storage Vessels

~~2209.3.2~~ ~~2209.3~~ Location of dispensing operations and equipment.

~~2209.3.3~~ ~~2209.3.1.4~~ Canopies.

~~2209.3.4~~ ~~2209.3.1.3~~ Overhead lines.

~~2209.4~~ ~~Private fueling of~~ Dispensing into motor vehicles at self-service stations.

~~2209.5~~ Safety precautions.

~~2209.5.1~~ ~~2209.5~~ Valves.

~~2209.5.2~~ ~~2209.4.1~~ Protection from vehicles.

~~2209.5.3~~ ~~2209.6~~ Emergency shutdown.

~~2209.5.4~~ ~~2209.7~~ Emergency venting of hydrogen systems.

~~2209.5.4.1~~ ~~2209.7.1~~ Vent pipe.

TABLE ~~2209.5.4.1~~ ~~2209.7.1~~ Hydrogen Vent Stack Height Versus Distance Requirements

~~2209.5.4.2~~ ~~2209.7.2~~ Minimum rate of discharge.

~~2209.5.4.3~~ ~~2209.7.3~~ Vent pipe flow rates.

Commenter's Reason: This proposal was approved by the committee with several comments regarding additional work needed. This is one step in accomplishing that work. The intent of this comment is only to reformat the Sections into a logical sequence that is consistent with the remainder of the IFC. There is no change to any of the text in the sections. Only the section titles have been shown to simplify this comment.

Two section titles have been revised. Section 2209.2 has been revised because the sections do not use the word approvals, but they all deal with equipment. Section 2209.2 has been revised because the section does not deal with classification, it is a general reference to the electrical code. Section 2209.4 has been revised because the section addresses self-service fueling operations and does not specify private.

Public Comment 3:

ICC Ad Hoc Committee for Hydrogen Gas requests Approved as Modified by this Public Comment.

Modify proposal as follows:

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 shall be allowed in buildings of noncombustible construction, as set forth in the International Building Code, which are unenclosed for three quarters or more of the perimeter and constructed in a manner that prevents the accumulation of hydrogen gas.
2. Generation, compression, storage and dispensing equipment shall be allowed indoors in accordance with Chapter 30 and as set forth in the International Building Code and International Fuel Gas Code.

(No modification to remainder of code change)

Commenter's Reason: This code change was APPROVED as MODIFIED at the Pittsburgh code hearings in that the exceptions to 2209.3 and provisions for rooftop locations be removed. At that time there were four exceptions to 2209.3 related to interior storage and use of hydrogen. The AHC has reworked two of these exceptions in response to clarifications requested by the IFC Committee, and wishes to have them APPROVED as MODIFIED by this PUBLIC COMMENT (AMPC).

The exceptions proposed are intended for the purpose of clearly establishing provisions already allowed by other sections of the IBC and IFC. For example, the reference to NFPA 50A, *Gaseous Hydrogen Systems*, in IFC 3501.1 permits the installation of hydrogen systems indoors given special considerations for ventilation, type of construction and location of openings. Revised Exception 1 is written in language similar to that addressing weather protective canopies serving Natural Gas Vehicle (NGV) fuel-dispensing stations (IFGC 2208.3) and as set forth in IBC 406 for motor vehicle service station canopies. Exception 2 relates to the existing provisions within the code which allow up to the exempt amount of a flammable gas to be stored and/or used indoors. Additionally, where a maximum allowable quantity threshold in the IFC is exceeded, the proposed language would require the construction of the appropriate H occupancy to accommodate such indoor generation or refueling operations.

By eliminating these exceptions entirely, provisions for hydrogen gas could be interpreted as more restrictive than existing IFC/IBC code language which allows these operations to exist under canopies or indoors. Note also, that the dispensing of hydrogen to a vehicle is an entirely closed-transfer process, similar to current provisions for NGV fuel-dispensing operations, whereby no hydrogen is allowed to escape to the atmosphere. To minimize risk further, a coordinated proposal to IBC-G and the IFGC (see FG41-02, Items 1 & 3) requires installation of such equipment in HYDROGEN CUT-OFF ROOMS, with special

considerations for ventilation, separation, type of construction and location of openings all in the interest of public safety.

The AHC has also addressed and resolved the technical issues identified by the IFGC Committee directly as modified by this and other coordinated public comments to all hydrogen-related proposals (F176, M7, FG2, FG15, FG41 & FG48). The supporting Reason to FG2-02 provides a brief explanation of each solution.

The ICC AHC for Hydrogen Gas requests your Approval as Modified by this Public Comment (AMPC).

F177-02

2210

Proposed Change as Submitted:

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

Add new text as follows and re-number remaining section numbers:

SECTION 2210 REPAIR GARAGES

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

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

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

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

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

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

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

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

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