

2. Vented room heaters, wall furnaces, vented decorative appliances and decorative appliances for installation in vented solid-fuel burning fireplaces, provided that the room ~~is not a confined space and the building is not of unusually tight construction~~ meets the required volume criteria of Section 304.2.
3. A single wall-mounted unvented room heater equipped with an oxygen depletion safety shutoff system and installed in a bathroom provided that the input rating does not exceed 6,000 Btu per hour (1.76 kW) and the bathroom ~~is not a confined space~~ meets the required volume criteria of Section 304.2.
4. A single wall-mounted unvented room heater equipped with an oxygen depletions safety shutoff system and installed in a bedroom provided that the input rating does not exceed 10,000 Btu per hour (2.93 kW) and the bedroom ~~is not a confined space~~ meets the required volume criteria of Section 304.2.

Appliances installed in a dedicated enclosure in which all combustion air is taken directly from the outdoors, in accordance with Section 304.11. Access to such enclosure shall be through a solid door, weather-stripped in accordance with the exterior door air leakage requirements of the *International Energy Conservation Code* and equipped with an approved self-closing device.

**Commenter's Reason:** We support the committee action to remove the definitions of Confined Space, Unconfined Space, and Unusually Tight Construction, since these terms will no longer be used in Section 304. However, the terms are still used in Section 303.3, as was pointed out at the Public Hearing. This comment would modify Section 303.3 to eliminate the three terms and replace them with a functionally equivalent reference to the new combustion air coverage. The proposed references in 303.3 to the new coverage in 304.2 will provide the same or better coverage for appliances in bedrooms and bathrooms as does the current language.

## FG15-02

### 305.2

#### *Proposed Change as Submitted:*

**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 [(0.0051m<sup>3</sup>/(s x m<sup>2</sup>))] 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 1/2 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.**

**Proponent's 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<sup>2</sup>/1000 ft<sup>3</sup> 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 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.<sup>2</sup> 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".

**Committee Action:** **Disapproved**

**Committee Reason:** Disapproval is consistent with action taken on FG2-02. The proposed coverage needs to be technically improved before it is suitable for inclusion in the IFGC. The proposed text contains technical flaws and omissions of coverage.

**Assembly Action:** **Approved as Modified**

**1. No change to current Section 305.3 (current text of Section 305.3 remains unchanged)**

**2. Add new text as follows:**

**CHAPTER 7**  
**GASEOUS HYDROGEN SYSTEMS**

**SECTION 701 (IFGC)**  
**GENERAL**

~~305.4~~ **701.1 Hydrogen Generating and Refueling Operations.**  
(Remainder unchanged)

(Renumber remaining sections, text unchanged)

*Individual Consideration Agenda*

**This item is on the agenda for consideration because a public comment was submitted and an assembly action was successful.**

*Public Comment 1:*

**Gilbert Gonzales, Murray City Corp., requests Approved as Submitted.**

**Commenter's Reason:** The proposed text does not address every possible scenario nor is it a perfect document. However, as with any new technology the industry must have a reasonable and enforceable base from which to regulate the safe installation and delivery of hydrogen gas. The Ad Hoc Committee for Hydrogen Gas has made every conceivable attempt to provide the Fuel Gas Code Committee and the ICC membership with just that. The comment made in the committee reasoning that states the ad hoc committee had no members in tune with fuel gas issues is incorrect. The original proposal noted that "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." The fact that hydrogen is a fuel gas, would make the Fuel Gas Code the logical choice for these requirements. To address the code requirements for hydrogen gas through a separate code is both unreasonable and impractical.

*Public Comment 2:*

**ICC Ad Hoc Committee for Hydrogen Gas, requests Approved as Modified by this comment.**

**Modify proposal as follows:**

~~701.4~~ **703.1 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~~ Ventilation shall be required in accordance with Section 703.1.1, 703.1.2 or 703.1.3 in public garages, private garages, repair garages, automotive service stations and parking garages which contain hydrogen generating appliances or refueling systems. Such spaces shall be used for the storage of not more than three hydrogen-fueled passenger motor vehicles and have a floor area not exceeding 850 square feet. The maximum rated output capacity of hydrogen generating appliances shall not exceed 4 SCFM of hydrogen for each 250 square feet of floor area in such spaces. Such equipment and appliances shall not be installed in Group H occupancies unless the occupancy is specifically designed for hydrogen use; or in 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:~~ 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  $\{(0.0051\text{m}^3/(\text{s} \times \text{m}^2))\}$  of floor area of the room.

~~701.4.4~~ **703.1.1 Natural Ventilation.** ~~Rooms or spaces located underneath or adjacent to habitable space and indoor locations intended for hydrogen generating or refueling operations shall be provided with mechanical ventilation as required by the exception to Section 701.4.4.1 through 701.4.4.2~~ 703.1.1.2 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. In such locations, equipment and appliances having an ignition source shall be located such that the source of ignition is not less than 12 inches (228 mm) below the ceiling.

~~701.4.4.4~~ **703.1.1.1 Two openings.** ~~Two permanent openings, one commencing located entirely within 12 inches (305 mm) of the ceiling of the garage, and one commencing located entirely within 12 inches (305 mm) of the floor of the garage, shall be provided in the same exterior wall.~~ 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.

~~701.4.4.2~~ **703.1.1.2 Louvers and grilles.** In calculating free area required by Section 703.1.1.1, 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.

**703.1.2 Mechanical ventilation.** Indoor locations intended for hydrogen generating or refueling operations shall be ventilated in accordance with Section 502.15 of the *International Mechanical Code*.

**704.1.2 703.1.3 Specially engineered installations.** As an alternative to the provisions of Sections 704.1.4, 703.1.1 and 703.1.2 the necessary supply of air for, ventilation and dilution of flammable gases shall be provided by an approved engineered system.

**Commenter's Reason:** The AHC has addressed and resolved the technical issues identified by the Code Development 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).

*Public Comment 3:*

**Jim Ranfone, American Gas Association, requests Disapproved.**

**Commenter's Reason:** The American Gas Association (AGA) supports the IFGC Committee action for disapproval. In addition to the Committee Reason for disapproval documented in the Report on the Public Hearing, additional reasons addressed in the public hearing testimony by AGA and others include the following:

1.) The IFGC scope covers "fuel gas piping systems, fuel gas utilization equipment, and related accessories" as listed in Section 101.2. Ventilation air listed in this section applies to required ventilation of the gas utilization equipment in the course of its operation, not ventilation required to mitigate gaseous releases. The proposed provisions should be proposed under Chapter 4 of the *International Mechanical Code* (IMC), which covers general ventilation requirements and related mechanical systems.

2.) Gaseous dispersion analysis supporting the ventilation requirements, although cited in the original proposals, was not presented in a form that can be reviewed by someone skilled in gaseous releases and design of hazard mitigation. The technical credibility of these measures is therefore subject to question as raised in discussion of the proposal at the public hearing. In addition, the analysis presented in support was based on dispersion of pure gaseous hydrogen, which is unique and disperses differently than hydrogen mixtures under the proposed definition of hydrogen under FG2-02. This definition, in fact, would include hydrogen mixtures that could be heavier than air, not lighter than air like pure gaseous hydrogen.

3.) It is unclear that ventilation requirements of Section 502.15 of the IMC are applicable to the mitigation of combustion hazards as applied in this section. Such systems should be required to use motors and other components that meet code-referenced ignition resistance requirements (e.g., Class 1, Division 2 of the National Electric Code). Section 502.15 does not stipulate these requirements.

AGA supports the development of sound code or standards coverage of hydrogen and hydrogen systems under the ICC. AGA advocates the expeditious development of a separate, stand-alone code or standard for hydrogen systems. In order to maintain the integrity of ICC documents as model codes, proponents of code coverage for hydrogen and hydrogen systems need to address deficiencies identified in the current proposals.

## FG31-02

### 501.1.1

*Proposed Change as Submitted:*

**Proponent:** Guy Tomberlin, Fairfax County, VA; representing VA Plumbing and Mechanical Inspectors Association/VA Building and Code Officials Association

**Revise as follows:**

**505.1.1 (Supp) Commercial cooking appliances vented by exhaust hoods.** Where commercial cooking appliances are vented by means of the Type I or Type II kitchen exhaust hood system that serves such appliances, the exhaust system shall be fan powered and the appliances shall be interlocked with the exhaust hood system to prevent appliance operation when the exhaust hood system is not operating. ~~Where automatically operated appliances such as water heaters are vented through natural draft kitchen exhaust hoods, dampers shall not be installed in the exhaust system.~~

~~**Exception:** An interlock between the cooking appliance and the exhaust hood system shall not be required for appliances that are of the manually operated type and are factory equipped with standing pilot burner ignition systems.~~

**Proponent's Reason:** The revision to the main paragraph is to ensure that "natural draft" hood/exhaust systems will never be utilized to vent any fuel burning appliances. Natural draft hood systems are typically field fabricated and installed. They do not even come close to complying with any listing requirements for venting systems provided for in Chapter 5. Natural draft hood systems are designed to remove heat, steam and odors, not potentially hazardous flue gases. Natural draft hood systems are not 100 percent reliable for draft. For example, a hood system might not draft if located in a climate with comparatively warm outside temperatures. Furthermore and most importantly, this section is requiring appliances to interlock with hood systems. If there is no fan, with what are the appliances to interlock?

Section 501.2 requires that EVERY appliance discharge the products of combustion to the outdoors except those listed in Section 501.8. When you look in 501.8, there are absolutely no appliances that can come close to the hundreds of thousands of Btu's that would be allowed to be unvented by this exception to 501.1.1. The code should not be making different rules for equipment because of the way the burners are ignited. Chapter 5 covers venting systems not ignition systems. Some comments to this proposal have been in reference to equipment being unsafe to re-light. The gas industry needs to address the safety issue of lighting equipment, even the residential outside gas grill has a "safe to use" push button ignition system that is manually operated and permits daily operation. What about the home owner who shuts off the gas supply to a manually lit water heater when they go out of town, are we now to believe it is unsafe for them to re-light these appliances when they return? This method of interlock is similar to the shut down of gas supply required upon fire suppression activation, already required by the code. If lighting equipment was truly a hazard, I would suggest that the industry take a serious look at this issue and correct it. The answer is not to allow these appliances to be exempt from the venting requirements, which is the intent of Chapter 5 of the IFGC.

Other comments to this issue have been the need to provide