HYDROGEN SAFETY AND PERMITTING HYDROGEN FUELING STATIONS

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ABSTRACT

Two key aspects of hydrogen safety are (1) incorporating data and analysis from research, development, and demonstration (RD&D) into the codes and standards development process; and (2) adopting and enforcing these codes and standards by state and local permitting officials. This paper describes work that the U.S. Department of Energy (DOE) is sponsoring to address these aspects of hydrogen safety. For the first, DOE is working with the automobile and energy industries to identify and address high priority RD&D to establish a sound scientific basis for requirements that are incorporated in hydrogen codes and standards. The high priority RD&D needs are incorporated and tracked in an RD&D Roadmap adopted by the Codes and Standards Technical Team of the FreedomCAR and Fuel Partnership. DOE and its national laboratories conduct critical RD&D and work with key standards and model code development organizations to help incorporate RD&D results into the codes and standards process. To address the second aspect, DOE has launched an initiative to facilitate the permitting process for hydrogen fueling stations (HFS). A key element of this initiative will be a Web-based information repository, a toolkit that includes information fact sheets, networking charts to encourage information exchange among code officials who have permitted or are in the process of permitting HFS, templates to show whether a proposed station footprint conforms to requirements in the jurisdiction, and a database of requirements incorporated in key codes and standards. The information repository will be augmented by workshops for code officials and station developers in jurisdictions that are likely to have HFS in the near future.

KEY WORDS

Hydrogen Safety
Permitting Hydrogen Fueling Stations
U. S. Department of Energy, Office of Hydrogen, Fuel Cells and Infrastructure Technologies
Codes and Standards Technical Team, FreedomCAR and Fuel Partnership

1.0 INTRODUCTION

Hydrogen has been used safely as a chemical feedstock and industrial gas for many years, and standards, codes, and regulations that govern its storage, distribution, and use at industrial sites are well established. The use of hydrogen as an energy carrier for consumer markets is expected to grow over the next decade, and codes and standards for this use must be developed and promulgated to establish a market-receptive environment for commercial hydrogen products and systems. Furthermore, requirements incorporated in these codes and standards must be based on scientific data and analyses so hydrogen facilities and technologies that serve the public are, to the extent possible, safe and commercially viable.

The U.S. Department of Energy (DOE), under its Hydrogen, Fuel Cells and Infrastructure Technologies (HFCIT) program, sponsors research, development, and demonstration (RD&D) to strengthen the scientific basis for technical requirements incorporated in national and international standards, codes, and regulations for hydrogen in consumer markets. DOE and its industry partners formed a Codes and Standards Technical Team (CSTT) under the FreedomCAR and Fuel Partnership to guide the RD&D that enables effective codes and standards to be developed for hydrogen applications. Information and data from this RD&D will be made available to standards and model code development organizations (SDOs), local authorities, and industry to facilitate the development of safe, performance-based technical codes and standards that will accommodate eventual changes in technology. This will minimize the need to develop new codes and standards as technologies evolve.

In the United States, the codes and standards development process is consensus-based and administered by various SDOs. The incorporation of safety RD&D into the development of codes and standards under a voluntary consensus process requires that members of technical committees that draft codes and standards must be familiar with recent RD&D results that are relevant to the codes and standards under consideration. Such familiarity, in turn, requires close interaction between the RD&D and codes and standards communities and a clear understanding by the latter of the implications of RD&D for requirements incorporated in codes and standards. An example of this interaction is the development of separation distance requirements for hydrogen fueling stations (HFS) by the International Code Council (ICC) and the National Fire Protection Association (NFPA) based on results of hydrogen jet release experiments and modeling conducted by Sandia National Laboratories.

Codes and standards in the United States are adopted and enforced under the jurisdiction of some 44,000 entities that include city, county, and state governments, as well as special districts such as port and tunnel authorities. The extremely decentralized enforcement of codes and standards means that the permitting process for HFS can be very time consuming; different jurisdictions have different requirements or developers of stations have to undergo a lengthy approval process each time a station is proposed. In most cases, HFS that are now located in the United States have had to endure a long and costly process to obtain the necessary permits. DOE is working with the energy and automobile industries and permitting officials from the fire and building code communities to develop tools to facilitate the permitting process and to discover ways to make the permitting process more timely and efficient to the benefit of industry and the codes and standards community.

2.0 SAFETY RD&D AND THE CODES AND STANDARDS DEVELOPMENT PROCESS

Many requirements found in codes and standards that are currently used to permit and ensure the safety of HFS cannot be traced to a body of scientific data that can justify these requirements. Even such a fundamental property of hydrogen behavior as its lower flammability limit is being questioned in spite of historical technical reports and data [2]. Some of the more difficult requirements to justify are those that concern separation distance. These requirements specify minimum distances of components from each other and from property lot lines within which the components are located, and, for the most part, seem to have evolved without being grounded on scientific data. As HFS evolve from one-of-a-kind facilities operated by trained personnel behind fences to retail stations in urban areas, separation distance requirements have emerged as a key issue for HFS developers and SDOs. Separation distance is difficult to justify objectively, as its relationship to safety and safe design is not obvious. Clearly, however, a good scientific understanding of hydrogen behavior under different unintended release scenarios is prerequisite and a necessary first step in establishing separation distances. Furthermore, even if such a scientific understanding is acquired, this understanding must be interpreted and incorporated into the codes and standards development process. This second step may be even more difficult than the first.

2.1 RD&D Roadmap for Hydrogen Safety, Codes and Standards

To take the first step in addressing the emerging need to establish better “science-informed” requirements for HFS and to minimize their footprint without compromising safety, the CSTT prepared a roadmap [1] to guide to the RD&D activities that will provide the data required by SDOs to develop performance-based codes and standards for a commercial hydrogen-fueled transportation sector in the United States. The roadmap provides an overall RD&D plan to develop a substantial and verified database of scientific information on the properties and behavior of hydrogen and the performance characteristics of new hydrogen technology applications needed to develop effective codes and standards for emerging hydrogen applications. The roadmap is organized into four focus areas:

- Hydrogen behavior

- Hydrogen-fueled vehicles
- Hydrogen fuel infrastructure
- Fuel-vehicle interface

Each focus area is subdivided into key target areas that identify important information needs that SDOs require to fully develop codes and standards, as shown in Figure 1.

Codes & Standards Focus Areas

Hydrogen Behavior	**Hydrogen Fuel Infrastructure**	**Fuel-Vehicle Interface**	**Hydrogen-Fueled Vehicles**
Key Target Areas	**Key Target Areas**	**Key Target Areas**	**Key Target Areas**
• Physical properties • Flammability • Material compatibility • Detection	•Production •Distribution & Delivery •Fueling Station	• Fueling nozzle & protocol • Fuel quality • X-cutting issues	• Onboard hydrogen storage • Onboard fuel handling • Parking requirements

Figure 1. Focus and Target Areas for RD&D

The roadmap enables DOE to support RD&D for safety, codes, and standards based on a common set of priorities that were determined jointly by government and industry. The first focus area, hydrogen behavior, also receives the most immediate attention, as better understanding of and data about how hydrogen behaves under different unintended release scenarios are fundamental to developing a better scientific foundation for requirements in hydrogen codes and standards. DOE is supporting a major R&D effort on hydrogen behavior, primarily at Sandia National Laboratories (SNL). In brief, the R&D on hydrogen behavior focuses on obtaining accurate and comprehensive information on circumstances under which hydrogen could ignite and characteristics of its combustion. Researchers at SNL are developing experimental verification of literature values and generating additional data, for example, on ignition characteristics and sources under realistic conditions, and on accurate heat transfer correlations to model the effects of hydrogen flame impingement and heat fluxes from an ignited jet or combustible cloud. Further R&D will be conducted to characterize the mixing of hydrogen with ambient air in jets and dispersed flows of varying velocities and duration (quantity) in confined, semi-confined, and unconfined spaces to enable potential impacts to be predicted.

An appendix of the roadmap includes a summary of this work and bibliographic references, and papers and reports on this R&D can be found in DOE's Hydrogen Safety Bibliographic Database [3]. SNL researchers presented an overview of the R&D at the 2005 DOE Annual Merit Review [4], and more information can be found on the SNL Web site (www.ca.sandia.gov).

Another key area of safety R&D addressed in the roadmap is materials compatibility for hydrogen applications. Here, too, SNL plays a leading role in the R&D by establishing a Technical Reference Web site (www.ca.sandia.gov/matlsTechRef) that was opened to public access in January 2005. Chapters in the Technical Reference provide a comprehensive summary of the materials compatibility of specific metal alloys in high-pressure hydrogen gas (or precharged under high-pressure hydrogen gas). Characteristics addressed include hydrogen transport, mechanical properties with emphasis on fracture properties, and the effects of materials processing on hydrogen embrittlement, such as how forging and welding affect the microstructure and materials behavior in high-pressure hydrogen gas.

Along with more data, for example, about hydrogen behavior at the anticipated scale of retail and consumer applications, the roadmap calls for additional RD&D to quantify consequences relative to this scale. Approaches to this RD&D might include scenario analyses and risk assessments, as well as experimentally generated data from production mockups to identify and analyze the potential hazards of these facilities. Instead of having to extrapolate hazard information and code requirements developed from or for larger industrial facilities, SDOs will be able to use data directly to write requirements that are suitable for consumer-scale applications.

DOE also supports RD&D in other focus areas of the roadmap, particularly that for the fuel-vehicle interface. This includes hydrogen fuel quality and hydrogen sensor testing and validation. These and other RD&D efforts, like those for hydrogen behavior, are described in the roadmap and will provide data that will improve the scientific foundation for requirements in codes and standards related to the RD&D. Even as these efforts generate data, a critical issue emerges about how these data can be incorporated into the codes and standards development process, which is driven by established publication and revision cycles and which has relied to a large extent on historical precedence and expert opinion.

2.2 Incorporating RD&D in the Codes and Standards Development Process

In 2000, with support from DOE, the ICC created the Ad hoc Committee on Hydrogen Gas (AHC) to systematically develop provisions for safe hydrogen use in its family of model codes [5]. The committee included fire safety and building code officials and hydrogen safety experts from industry, academia, and nongovernmental organizations. Beginning with the 2003 code cycle, the AHC proposed a number of changes to the International Fire Code (IFC), International Building Code, International Fuel Gas Code, and International Mechanical Code. Perhaps the most significant contribution of the AHC was the development of Section 2209 of the IFC, Hydrogen Motor Fuel Dispensing and Generation Facilities, which, among other things, sets minimum separation distances as shown in Table 1for gaseous hydrogen dispensers, compressors, generators, and storage vessels)[6].

The AHC attempted to incorporate results of ongoing R&D about hydrogen behavior into this table by having SNL researchers present and discuss research results at its meetings. Although numerous meetings were held with the researchers and despite the active participation of leading hydrogen safety experts on the committee, the AHC was not able to develop separation distances based fully on the best available scientific data and analysis made available to its leading researchers in hydrogen behavior.

A major barrier to incorporating recent scientific data into the determination of separation distances is the different and, to a large extent, incompatible time requirements of SDOs and researchers. Under the ICC's established procedures, new editions to its family of model codes are published every three years, and ICC committees must adhere to strict deadlines that govern submittal of code change proposals so adequate public review can be allowed and so public hearings can be arranged and scheduled. The revision cycle takes place over an 18-month period that encompasses the deadline for receipt of proposed code proposals and the publication of amendments or of a new edition of a model code [7]. In contrast, R&D, although not open-ended, cannot be scheduled to provide definitive results by a certain deadline. For most R&D projects, time and schedule depend on the nature of the problem being assessed and the resources available. For the AHC, time constraints imposed by the code development cycle were severe, and, in the end, it could not fully incorporate data provided by current research to determine separation distances included in Table 2209.3.1.

Another key issue that emerged from the interaction of AHC members and researchers was the appropriate role of researchers. The researchers' role was to present the data, the experiments that were conducted, and analysis of the implications of the data—including uncertainties—for separation distances. The researchers were careful to state that as scientists their role did not include making recommendations on what the separation distances should be for any specific application or situation; rather, it was to provide the best scientific data relevant to the setting of separation distances. The role of the AHC members was to assess the data and arrive at a consensus based on their collective expertise on what the separation distances should be. The mutually supporting but distinct roles were sometimes blurred during the meetings, but, in the end, they were acknowledged and adhered to. The result of the AHC effort was a much-needed updating of the family of ICC model codes to systematically incorporate hydrogen applications, even though ongoing R&D on hydrogen behavior

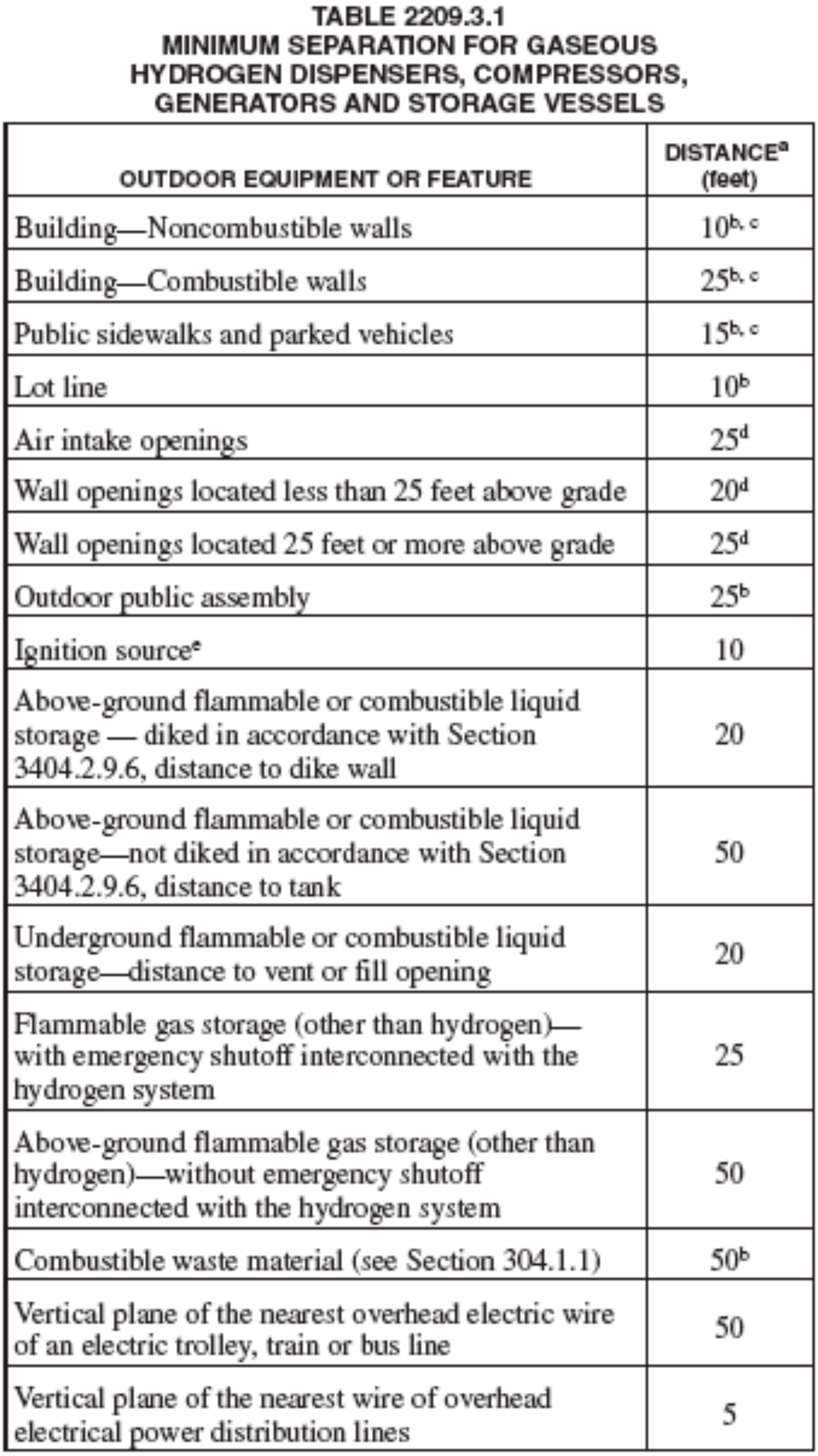

TABLE 2209.3.1
MINIMUM SEPARATION FOR GASEOUS HYDROGEN DISPENSERS, COMPRESSORS, GENERATORS AND STORAGE VESSELS

OUTDOOR EQUIPMENT OR FEATURE	DISTANCE[a] (feet)
Building—Noncombustible walls	10[b, c]
Building—Combustible walls	25[b, c]
Public sidewalks and parked vehicles	15[b, c]
Lot line	10[b]
Air intake openings	25[d]
Wall openings located less than 25 feet above grade	20[d]
Wall openings located 25 feet or more above grade	25[d]
Outdoor public assembly	25[b]
Ignition source[e]	10
Above-ground flammable or combustible liquid storage — diked in accordance with Section 3404.2.9.6, distance to dike wall	20
Above-ground flammable or combustible liquid storage—not diked in accordance with Section 3404.2.9.6, distance to tank	50
Underground flammable or combustible liquid storage—distance to vent or fill opening	20
Flammable gas storage (other than hydrogen)—with emergency shutoff interconnected with the hydrogen system	25
Above-ground flammable gas storage (other than hydrogen)—without emergency shutoff interconnected with the hydrogen system	50
Combustible waste material (see Section 304.1.1)	50[b]
Vertical plane of the nearest overhead electric wire of an electric trolley, train or bus line	50
Vertical plane of the nearest wire of overhead electrical power distribution lines	5

Table 1. International Fire Code, 2006, Table 2209.3.1

could not be fully incorporated into the updates. The lesson learned from this effort was that R&D activities and results are very difficult to fit into specific code revision cycles, so a much longer timeline to try to synchronize R&D and the code and standards development process is needed. The code revision process and R&D planning need to be integrated from the start and cover more than a single code revision cycle. Needs for R&D and for code revisions or additions must be identified and articulated at the same time so the inherently different timelines can be reconciled to the extent possible.

The ICC disbanded the AHC in 2005, as it had fulfilled its charter. With hydrogen applications provided for in its family of model codes, the ICC will rely on its standing technical committees for each of its model codes to accommodate future code changes for hydrogen. In 2006, the ICC, NFPA, and the National Hydrogen Association (NHA), with support from DOE, formed the Hydrogen Industry Panel on Codes (HIPOC) to coordinate proposals for code changes to both the ICC family of model codes and to NFPA model codes and standards [8]. The primary objective of the HIPOC is to harmonize the requirements in ICC and NFPA model codes and standards for hydrogen applications. An ancillary benefit of HIPOC activities will be the early identification of R&D that may be needed to reconcile differences between ICC and NFPA requirements for similar hydrogen applications.

DOE also works with and supports the NFPA Research Foundation to address priority R&D needs related to the hydrogen codes and standards identified by industry. For example, DOE co-funded a study with industry to develop data to support new requirements for hydrogen stored in cylinders housed in passively vented, noncombustible enclosures. Hydrogen releases from such cylinders were modeled with a computational fluid dynamics (CFD) code [9]. This work was conducted in conjunction with the code revision cycle for NFPA 55 **(**Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks) and guided by a technical committee of representatives from industry, government, and academia. The study examined only the consequences of hydrogen releases (flammable vapor cloud formation, radiative flux from ignited plumes, overpressures from detonations) and recommended larger separation distances than are currently stipulated in NFPA 55. These recommendations are based on the CFD modeling, and stimulated discussion between the technical committee members about the appropriateness of including such recommendations in a technical report that was intended to provide data for a particular code revision cycle. One member argued that only the data and analysis should be presented in the report and that deriving separation distances based on the data and analysis should be left to the NFPA 55 committee members. Another member agreed in principle with this position, but recommended that the report address implications of the study for separation distances without specifying what these distances should be. In the end, the recommendations for separation distances remained in the report with carefully worded caveats about the limitations of the recommendations.

A key caveat of the recommendations in the report is that the separation distances are based solely on the consequences of select failure events. The combined likelihood of a hydrogen release and the presence of an ignition source was not considered. In other words, the report did not assess risk in developing recommended separation distances. A quantitative risk assessment (QRA) would provide a more complete picture of the relationship between safety and separation distances by incorporating scenarios of unintended hydrogen releases and identifying risk contributors as well as mitigation measures. Furthermore, QRA includes the likelihood, or probability, of occurrence of an event or events leading to a given consequence. Separation distances based only on consequences tend to be large, and, in effect, are based on the assumption that all events have an equal likelihood of occurrence and must be accommodated. DOE supports work on QRA in conjunction with the development of codes and standards for hydrogen applications, and a paper presented at the first ICHS provides a background of this work [10]. Another paper presented at this conference discusses the possibility of applying QRA in conjunction with hydrogen behavior R&D to determine separation distances for HFS [11].

2.3 Hydrogen Technologies Code

An example of an effort to incorporate hydrogen behavior R&D and QRA in the codes and standards development process is underway by NFPA to compile all its hydrogen provisions into a single document, NFPA 2, Hydrogen Technologies Code, to be published in 2010. The technical committee responsible for drafting NFPA 2 has created task groups to develop specific sections or to address key issues that confront such a new comprehensive code for hydrogen as an energy carrier. Given the importance of defining adequate but safe separation distances and the relatively long period of time available, Task Group 6 is addressing separation distances that will be incorporated into NFPA 2 from the ground up, that is, beginning with available data, models, and QRA tools. The task group has defined an approach to identify, assess, and select a set of measures and criteria that will enable it to specify separation distances for HRS that are based on a foundation of scientific and technical data, analysis, modeling, and QRA.

Although the technical committee for NFPA 2 held its first meeting in November 2006 and its work is in a very preliminary stage, the approach taken by Task Group 6 may provide a template for how R&D can be better integrated into the codes and standards development process. The objective of Task Group 6 is to validate or revise the prescriptive hydrogen separation distances in NFPA 55 by using new research and investigating the use of risk informed processes. One of the first steps the task group took was to create a joint effort with the technical committee of NFPA 55 to integrate technical experts on the task group with other experts who were responsible for establishing the separation distances for hydrogen storage. The task group delineated a step-by-step process to address separation distances and started with outdoor, aboveground gaseous storage systems. For such systems, the task group is considering separate tables for different pressure regimes, e.g., 15 to 250 psi; >250 to 3,000 psi; >3,000 to 7500 psi; and >7500 to 15,000 psi (1.03 to 17.2 bar; >17.2 to 207 bar; 207 to 517 bar; and >517 to 1,034 bar) as storage pressure is a key factor for hydrogen behavior during unintended releases.

Another key factor that affects separation distance is the size of the leak. It is expressed as a diameter for the simplest case and depends on the hazard scenario, such as a fuel hose breaking or being disconnected from the dispenser. The task group is examining data that relate leak size to frequency of leaks to determine the leak sizes it should use to construct a table of separation distances. Unfortunately, such data are not readily available for hydrogen systems, and surrogates must be used. For example, the size of piping typically decreases as the system pressure increases, and leak size can be defined in terms of the flow area as a percentage of the pipe diameter. In a large leak scenario, a pipe is damaged in such a way that a leak size equivalent to 20% or the diameter is assumed, whereas for a “small leak,” the flow area may be much smaller percentage of the pipe diameter.

For a given pressure and leak size, separation distance tables are being constructed around exposure categories. These categories include components or elements of a facility; for example, air intakes for HVAC systems, lot lines, openings in buildings, structures, and equipment that require protection from potential hazard scenarios because of unintended hydrogen releases and other events that could create hazards at the facility. These hazard scenarios include hydrogen gas release and subsequent entrainment or accumulation, fire spreading to or from adjacent equipment or structures, and ignition of an unignited release or venting of hydrogen. Exposures are then matched with hazard scenarios against which the exposure must be protected.

For each exposure category and its accompanying hazard scenario or scenarios, the task group identified consequence parameters that provide measurable criteria on which separation distances can be based. These parameters are the decay distance of an unignited plume of hydrogen to 4% volume fraction in air, the radiative heat flux level of an ignited hydrogen jet, and the flame length of an ignited jet. These parameters will vary with pressure and leak size as well as the physical and environmental conditions at the site when the event occurs. The radiative heat flux parameter provides a way to measure the severity of a hazard against which a separation distance is intended to protect. A radiative flux of 1.6kW/m^2 can be considered as a “no-harm” level as it is essentially equivalent to exposure to the sun on a clear day, whereas a flux 4 to 5 kW/m^2 can cause second-degree burns within 20 seconds of exposure, and 25 kW/m^2 can cause structural damage, significant injury within 10 seconds, and death within 60 seconds [12]. If a given level of radiative heat flux is the most appropriate consequence parameter to measure the degree of protection a separation distance should provide for a given exposure category and hazard scenario, the distance at which the heat flux subsides to that level will be equivalent to the separation distance. For example, at lot lines the heat flux should not harm people and should be set no higher than 1.6 kW/m^2, whereas for buildings and structures made of noncombustible materials, a heat flux as high as 25 kW/m^2 could be allowed. On the other hand, for the exposure category of air intakes, the decay distance of an unignited hydrogen plume to 4% volume fraction is the most appropriate consequence parameter. The separation distance from a potential leak source to an air intake can be determined by assessing the flammable vapor cloud formation characteristics of the potential leak through modeling and experiment based on the volume and pressure of the leak source, the leak size and location, and the physical and environmental conditions at the site.

Separation distances for aboveground gaseous hydrogen systems based solely on consequence parameters can be reduced through mitigation measures such as barrier walls and noncombustible enclosures. The task group will evaluate the effects of mitigation measures through experiments, modeling, and analysis. The task group will also apply QRA techniques to meet its objective. These techniques and their applications to separation distances for HFS are thoroughly described in detail in another paper for this conference [11] and will not be discussed in detail here.

The approach described in the preceding paragraphs may be more successful for incorporating recent R&D results and state-of-the-art modeling and analysis in the code development process because of several factors:

- The timeline to develop and publish NFPA 2 was set from the beginning to allow sufficient time for supporting R&D, modeling, and analysis to be performed. Thus, R&D and code development are better synchronized than when R&D has to fit into a code revision cycle that is already underway. This scheduling process was made simpler in a new document (NFPA 2) but can also be adequately addressed by coordinating R&D efforts with document publication schedules.
- The creation of task groups composed of technical committee members as well as outside experts as needed to address key issues allows for better interaction and comprehension between researchers and code development experts, particularly in the case of Task Group 6, which formed a joint effort with technical committee members of NFPA 55. This aspect is particularly important as the basis for code content becomes more technical in addition to reliance on professional experience.
- DOE has supported critical R&D for safety codes and standards and the work of key SDOs such as NFPA for a number of years; this support has fostered good working relationships at both the institutional and the personal levels among researchers and codes and standards experts.

3.0 FACILITATING PERMITTING OF HYDROGEN FUELING STATIONS

The first part of DOE’s effort to incorporate safety in the permitting of HFS involved incorporating the best available R&D, modeling, and analysis to develop requirements for codes and standards that govern HFS permitting. The second part of DOE’s effort is to facilitate the permitting of HFS so that this process can be more timely and cost effective for HFS developers and code officials. A more timely and consistent permitting process has emerged as a key issue for industry and a priority item for both the FreedomCAR-Fuel Partnership and DOE’s Hydrogen Technical Advisory Committee, which advises the Secretary of Energy. DOE has responded by defining and launching a project to facilitate the permitting process for HFS. Although DOE has for many years supported the major SDOs in the United States to develop key hydrogen codes and standards, it has not directly addressed the permitting process, which in the United States is highly decentralized and enforced by state and local jurisdictions.

As a first step, DOE asked NREL to identify an integrated set of critical tools and activities to facilitate the permitting of HFS in the United States, and NREL identified the following:

- Fact sheets that provide basic information on HRS in the United States—locations, typical layouts/footprints, key codes and standards applied in the permit approval process, and essential contacts for more information.
- A network chart that provides a directory of code officials who have made decisions on permitting HRS in their jurisdictions. This includes a brief section on “lessons learned” by code officials from these previous permitting decisions.

- A flowchart of HRS permitting requirements that maps such requirements in key codes and standards, such as Section 2209 (Hydrogen Motor Fuel Dispensing and Generation Facilities) of the International Fire Code and NFPA 55 and 52. Requirements in other codes, such as those referenced in Section 2209, will also be mapped.
- An HRS Permitting Compendium that includes the first three items and that will serve as a reference document of requirements to permit HRS in states and localities that have or are likely to have HRS in the near term (1 to 5 years).
- A kickoff workshop for select key code officials, HRS developers, and SDO/CDO representatives to identify critical issues, review the path forward proposed by DOE and NREL, and to derive a consensus approach to achieve the objectives of this effort.
- Regional workshops for code officials to address HRS permitting concerns, with a focus on requirements in standards, codes, and regulations that govern the permitting of HRS in jurisdictions in the region where the workshop will be held.

3.1 US DOE Initiative on Permitting HFS

To launch this effort, DOE and NREL conducted a kickoff workshop in February 2007 that brought together HFS developers, state and local code officials, and other interested parties [13]. During the workshop, developers of HFS in Washington, D.C.; Detroit, Michigan; and Oakland, California gave presentations on their experience obtaining permits for these stations. These stations provide a cross-section of HFS station types as well as geographic and jurisdictional locations. Presentations were then given by code officials who permitted these stations. In this way, examples of HFS permitting experiences were presented from the perspectives of the developers and permitting officials so lessons learned could be shared, discussed, and built upon to improve the permitting process from both perspectives. The key output from the workshop was a set of findings and recommendations to DOE about how it could help to facilitate the permitting of HFS. The key recommendations to DOE were to:

- Develop an information repository for HFS with validated “third party” data and information.
  - Identify applicable codes and standards (specific safety requirements) and make them more accessible to permitting officials.
  - Develop a detailed process flowchart for permitting HFS.
- Develop a template for code officials to navigate the permitting process.
- Note best practices for application of codes and standards for HFS.
  - Develop fact sheets about hydrogen technologies/HFS equipment for permitting officials
  - Develop a permitting pathway from “behind the fence” stations to retail stations.

Given these recommendations, DOE (through NREL) began to develop a Web-based information repository that incorporates the items included in the recommendations as well as those identified by NREL earlier. A schematic of the repository is shown in Figure 2. Specific items in the repository, such as fact sheets, are shown in brackets { } and will be downloadable. As presently conceived, the repository will consist of three sections (shown by the dashed lines in Figure 2). The first section will lay out, to the extent possible, a generic HFS permitting process or processes at the state and local levels that include all the major steps in applying for such a permit, including one or more process flowcharts that capture the essential information requirements for HFS permit applications. The second section will address the physical layout and major subsystems and components of a retail HFS. Fact sheets with basic information will be available for each subsystem and component, and links where the user can obtain more detailed information will be provided. The repository will include a tool through which an HFS footprint can be mapped. The third section will contain a database that includes excerpts of key codes and standards linked to the other two sections so the user can refer to the requirements in the codes and standards that govern the permitting process.

As a reference tool, the repository will include requirements of all key standards, codes, and regulations for HRS in these states and localities. DOE and NREL must negotiate with SDOs to obtain permission to post relevant excerpts from these codes and standards. Where gaps in codes and standards are encountered in permitting HRS, such as, for example, 70 MPa dispensing stations with onsite hydrogen generation, the repository will include consensus “best engineering practices” to address such cases. The repository will be a “living document” that will be updated and augmented as needed.

DOE will conduct workshops like the one described earlier in areas of the United States where the automobile and energy industries will concentrate efforts in launching hydrogen-fueled vehicles and infrastructure. Possible locations include the west (California, Nevada, Arizona), northeast (New York, Pennsylvania, Washington, D.C.), southeast (Florida, South Carolina), and north central (Michigan, Illinois). DOE and NREL will also conduct two national workshops later this year in conjunction with the annual conferences of the National Association of State Fire Marshals and the National Conference of Building Codes and Standards. Both of these organizations will augment DOE’s education and outreach efforts for this project.

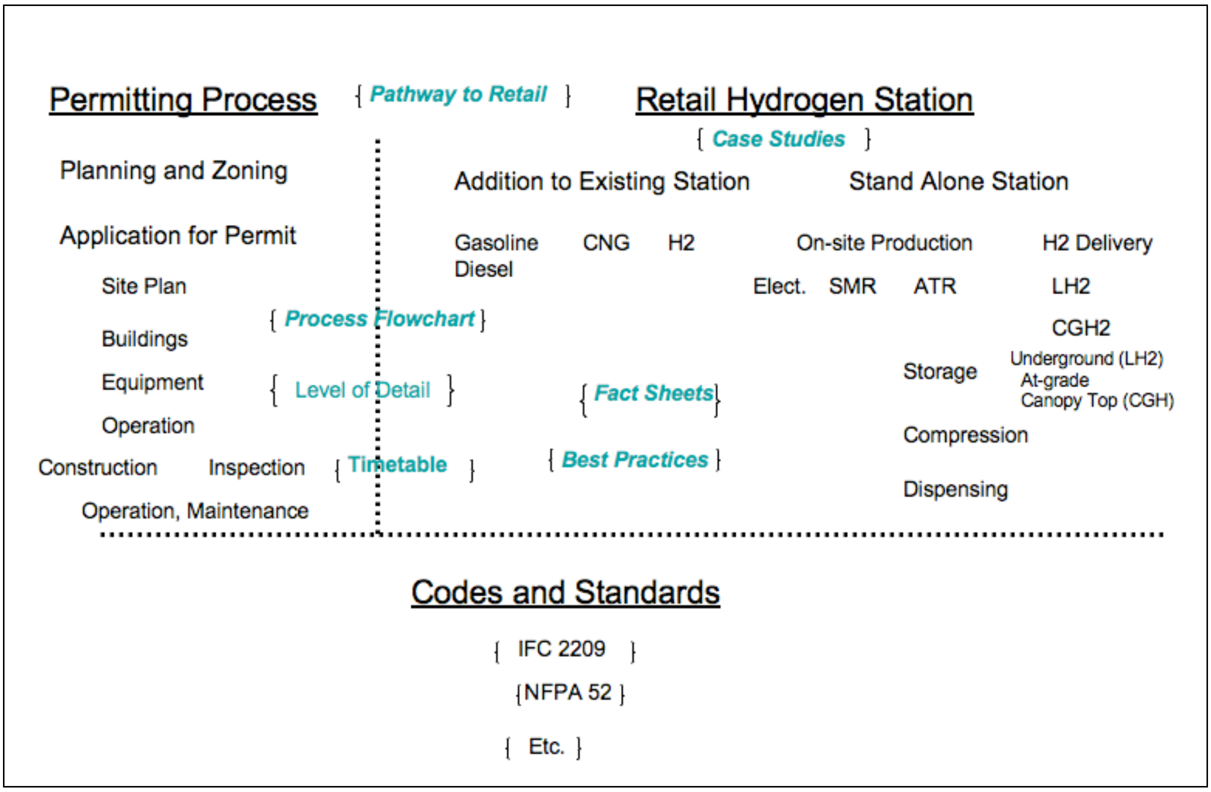

Figure 2. Concept for an Information Repository for Permitting HFS

4.0 SUMMARY

A key barrier to widespread market entry of hydrogen and fuel cell technologies is the ready availability and consistent application of codes and standards whose requirements are based on a solid foundation of RD&D, modeling, and analysis. DOE has for a number of years supported critical RD&D to help establish this foundation. DOE has also supported key SDOs to help accelerate the development of critical codes and standards. More recently, DOE has begun to address the intersection of these two efforts in general and the permitting of HFS in particular. Any attempt to incorporate RD&D into the codes and standards development process is immediately confronted by long-establish code revision timetables that SDOs must adhere to and the complementary but different roles of the researchers and code development experts. An attempt to incorporate RD&D in a code revision cycle that was already underway was not completely successful. A second effort in which the RD&D has been accommodated in the organizational structure and timetable of a code development cycle has the potential to succeed and become a template for the integration of the two distinct but complementary elements of safe hydrogen use.

The experience in the United States to date on permitting HFS has shown that the permitting process must be less time consuming and more efficient for HFS developers and code officials to successfully introduce hydrogen vehicles into the marketplace. DOE will attempt to facilitate the permitting of HFS by working with HFS developers and the fire and building code communities to develop a Web-based information repository. The repository will contain information about the permitting process, HFS subsystems and components, and the codes and standards that govern this process, at least in the key states, regions, and localities where HFS are expected to be located in the near future. The DOE will also conduct workshops with HFS developers, code officials, and other interested parties to review the structure, content, and usefulness of the repository as it is developed and applied.

5.0 ACKNOWLEDGEMENTS

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6.0 REFERENCES

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